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CREATION OF A DIGITAL CORPUS OF BULGARIAN DIALECTS

Nikola Ikonomov, Milena Dobreva

Abstract: The paper presents our considerations related to the creation of a digital corpus of Bulgarian dialects.

The dialectological archive of Bulgarian language consists of more than 250 audio tapes. All tapes were recorded between 1955 and 1965 in the course of regular dialectological expeditions throughout the country. The records typically contain interviews with inhabitants of small villages in Bulgaria. The topics covered are usually related to such issues as birth, everyday life, marriage, family relationship, death, etc. Only a few tapes contain folk songs from different regions of the country.

Taking into account the progressive deterioration of the magnetic media and the realistic prospects of data loss, the Institute for Bulgarian Language at the Academy of Sciences launched in 1997 a project aiming at restoration and digital preservation of the dialectological archive. Within the framework of this project more than the half of the records was digitized, de-noised and stored on digital recording media. Since then restoration and digitization activities are done in the Institute on a regular basis. As a result a large collection of sound files has been gathered.

Our further efforts are aimed at the creation of a digital corpus of Bulgarian dialects, which will be made available for phonological and linguistic research. Such corpora typically include besides the sound files two basic elements: a transcription, aligned with the sound file, and a set of standardized metadata that defines the corpus. In our work we will present considerations on how these tasks could be realized in the case of the corpus of Bulgarian dialects. Our suggestions will be based on a comparative analysis of existing methods and techniques to build such corpora, and by selecting the ones that fit closer to the particular needs. Our experience can be used in similar institutions storing folklore archives, history related spoken records etc.

Keywords: phonology, corpus, corpus linguistics, audio archive, digitization, restoration, metadata, alignment, transcription, phonetics

Definition of a Corpus

In the broad sense *corpus* means a collection of data, either written texts or a transcription of recorded speech which can be used for linguistic description or language studies. According to this definition we still cannot speak about a digital corpus of Bulgarian dialects, because all we have on hand at the moment are… a pile of magnetic tapes and numerous audio files stored on digital media, which represent the dialectological archive of the Institute for Bulgarian language.

The Dialectological Archive

The dialectological archive of the Bulgarian language consists of over 250 audio tapes. All tapes were recorded between 1955 and 1965 in the course of regular dialectological expeditions throughout the country. Interviewers are dialectology researchers. The records typically contain interviews with aged people from small villages in Bulgaria. The topics covered are usually related to such issues as birth, everyday life, marriage, family relationships, death, etc. Only a few tapes contain folk songs from different region of the country.

The First Project

In 1997 the Institute for Bulgarian Language started a 2-years project with the support of the British council the following basic aims:

- to secure the further preservation of the audio tapes;
- to start digitization of the records and their storage on a digital recording media

In order to secure the preservation of the audio archive we re-considered following basic issues, which are relevant when handling and storing sound recordings:

- that they be kept free of any foreign matter deposits;
- that they be kept free of any pressure that might cause deformations; and
- that they be stored in a stable, controlled environment.

Till 1997 none of these requirements has been met. The results of the inspection have forced us to take urgent measures to ensure suitable storage conditions for the tapes. At the same time we started to digitize the archive records and to store the digital content on CD's. In the framework of the Project more than 30% of the records have been digitized.

The workflow included the following steps:

- Digitization (sampling frequency of 44.1 KHz,16 Bits, Stereo, using a professional sound card equipped with a high end ADC);
- Digital restoration (elimination of most frequently encountered disturbances: impulsive disturbances, wideband noise, and harmonic disturbances);
- Recording on a CD-R.

The current situation

Since 1999 digitization activities have been done in the Institute for Bulgarian Language on a regular basis Recently we changed the output format of the digital records from "wav" to "mp3" in order to save storage space. We also changed the recording media from CD-R to DVD for the same reasons. Due to the lack of financing the number of non-digitized tapes is still considerable (about 40%). The digitized records are not published electronically. Doing dialectological research under such circumstances is not easier than it was in the 50's.

What to do?

The solution is obvious – to create a digital dialectological corpus and make it available to the research community in a variety of formats:

- digitized sound (partly available);
- standard orthographic transcription;
- phonetic transcription;
- various levels of tagged text, all aligned.

Who will benefit from such an endeavor? First of all this will be the scientific community especially in such branches as:

- Arts and Humanities (cultural theory; history/geography and gender studies, linguistics, corpus linguistics, historical linguistics, speech recognition, text synthesis; dialectology);
- Sociology, social history and sociolinguistic research;
- Ethnography and cultural studies.

On the other hand, the experience which will be acquired throughout the project will serve the needs of various institutions with similar audio archives – folklore archives, history related records, etc. Last but not least the wide access to the data within the dialectological corpus will provide valuable information for lay persons, especially members of the local communities.

Coding and coding standards

According to the basic requirements each speech corpus designed for phonological research must as a minimum consist of the following:

- A sound file;
- An orthographic transcription aligned with the sound file;
- A set of standardized metadata that defines the corpus.

Sound files

For the completeness of the corpus all available tapes in the archive have to be further digitized and restored. It must be taken into account that the restoration and processing of the digital audio files are aimed only at making their content available; hence the playback quality is not a relevant parameter. In other words, cost reasons will specify the depth of the restoration efforts.

The transcriptions

Transcription is the conversion into written form, of a spoken language source. There are different types of transcription:

- Orthographic transcription, which is done according to the basic orthographic rules of a corresponding language;
- Phonetic or phonemic transcriptions, which is the process of matching the sounds of human speech to special written symbols (IPA and its ASCII equivalent, SAMPA for example) using a set of exact rules, so that these sounds can be reproduced later. Phonetic transcriptions present three well known problems. They are hugely time-consuming and subjective in the sense that different transcribers typically produce different representations for a given speech segment. As the size of the corpus grows, so does the difficulty of maintaining consistency of practice across the transcription.

For cost as well as reliability reasons, the basic transcription of the sound file must be orthographic. But even if orthographic transcriptions are less costly and more reliable, defining standards for consistent transcription of speech by means of standard orthography is not trivial, and must be addressed. Transcription and sound must be aligned, so that the sound corresponding to a specific part of the transcription can be easily accessed.

Depending on the goals of a specific project, other types of transcriptions, such as phonetic or phonemic transcription, may be added, but they should not supplant the orthographic transcription. Different projects will have different needs for phonological tiers, depending on different kinds of use. The number of tiers is in principle limited, but a recommended list of relevant tiers might be useful.

A basic problem with all transcriptions is that they are products of interpretation. The result is that people do not trust each others transcriptions. Within a more long term perspective, the possibility of automatic transcriptions, which will make transcriptions at least more objective, (but not necessarily more correct), should be investigated.

The Metadata

Researchers need standards for coding of metadata in order to be able to work on each other's databases. Two basic questions have to be answered:

- What are the relevant metadata?
- How should they be coded?

In other words a specification of the relevant metadata is needed before we can decide how to code them. Here the question arises whether it is possible to define a set of metadata that is relevant for all projects, and whether project specific need to code additional metadata should be catered for by means of a set of general guidelines. Our research has shown that the IMDI[1] (ISLE[2] Meta Data Initiative) already offers a standard for different kinds of metadata.

How should metadata be coded? Up to now it has been a standard practice for corpus creators to define their own representational standards. The drawback of such an approach is that they are not easily portable. In response various standards have been proposed. The currently dominant one is the Text Encoding Initiative (TEI). However there are two basic problems with TEI for representation of phonetic /phonological corpora:

- The TEI recommendation for linguistics corpora is vestigial, and needs to be further developed if it is to be useful for any but the most basic representations.
- The overabundance of XML tags makes TEI-encoded corpora difficult to use directly, and requires development of XML-based analytical applications. Few of these exist currently.

Pending their appearance, we have accepted TEI as an archiving standard. We expect that TEI will be supplemented by provision of XSLT[3], tools which translate TEI representation into formats usable by existing non-XML-aware applications like relational databases.

As to the coding itself, XML should be recommended. It is flexible, and allows users to define their own tags. An important question is whether only standards for coding metadata should be recommended, or whether the

[1] http://www.mpi.nl/IMDI/

[2] ISLE stands for International Standard for Language Engineering

[3] eXtensible Stylesheet Language Transformations

coding standards should be extended to the linguistic content as well. The latter position implies that tags will reflect theoretical positions.

Digital Corpus of Bulgarian Dialects (DCBD)

The content of the Digital Corpus of Bulgarian Dialects (DCBD) will be provided in several types of representation:

- Audio (partly available);
- orthographic transcription;
- part-of-speech tagged orthographic transcription;
- phonetic transcription.

The orthographic transcription of DCBD will contain a complete orthographic transcription of the audio recordings. The transcription process will consist of several (up to four) passes through the audio files. The first pass will produce a base text. The next passes (usually the second and the third) are correction passes aimed at improving the transcription accuracy. The last pass will be used for establishing uniformity of the transcription algorithm across the entire corpus. To avoid pre-judging discourse structure, capitalization and punctuation will not be used in the transcription. As a general principle, the DCBD will use the Standard Bulgarian orthography. In genuinely dialectal segments, it will use the Bulgarian dialect dictionary (in preparation).

The part-of-speech tagged transcription is a morphological - syntactic annotation. It represents the basic linguistic analysis. It will be done automatically using software tools called taggers. The tagger for Bulgarian texts is called "GrammLab"and is distributed freely by BACL (Bulgarian Association of Computer Linguistics).

The phonetic transcription is in fact discretization of the analog speech signal into phonetic segment sequences. DBCD will contain phonetic transcriptions of all the interviews. The process will include following basic steps:

- Selection of transcription scheme, that is, a set of symbols each of which represents a single phonetic segment (for example IPA)
- Partition of the linguistically-relevant parts of the analog audio stream such that each partition is assigned a phonetic symbol.
- The result will be a set of symbol strings each of which will represent the corresponding interview phonetically. These strings can then be compared and processed.

The usefulness of the DBCD would be enhanced by provision of an alignment mechanism to relate the representational types to one another, so that corresponding segments in the various types can be conveniently identified and simultaneously displayed. The first task in this process is the necessity to define how large the alignment segments should be - phonetic segment by phonetic segment, word-by-word, sentence by sentence, or utterance by utterance? The answer has to take into account two basic factors: the research utility, and the feasibility in terms of cost.

All interviews consist of a sequence of "interviewer-question, interviewee-answer" pairs in which the utterance boundaries are generally clear-cut; rarely there is some degree of overlap on account of interruption and third-party intervention. The format of the interviews makes alignment at the granularity of utterance the natural choice.

In practice the alignment process has to take into account, that time is a meaningful parameter only for the audio level of representation in the corpus, and that text has no temporal dimension.

A time interval t is selected, and the audio level is partitioned into some number n of length-t audio segments s,

$s(t \times 1)$, $s(t \times 2)$...$s(t \times n)$, '$\times$' denotes multiplication.

Corresponding markers are inserted into the other levels of representation such that they demarcate substrings corresponding to the audio segments. In XML such marker could be the <anchor> tag), where, the 'id' attribute will specify a real-time offset from the start of the audio file.

Future cooperation

The future cooperation in the field will be achieved in the frames of the network *European Corpus Phonology Group (CorPho)*. It will assemble researchers and research teams interested in combining insights from theoretical phonology, both diachronic and synchronic, linguistic variation studies, phonetics, and corpus linguistics.

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USE OF KNOWLEDGE TECHNOLOGIES FOR PRESENTATION OF BULGARIAN FOLKLORE HERITAGE SEMANTICS*

Detelin Luchev, Desislava Paneva, Konstantin Rangochev

Abstract: Preserving and presenting the Bulgarian folklore heritage is a long-term commitment of scholars and researchers working in many areas. This article presents ontological model of the Bulgarian folklore knowledge, exploring knowledge technologies for presenting the semantics of the phenomena of our traditional culture. This model is a step to the development of the digital library for the "Bulgarian Folklore Heritage" virtual exposition which is a part of the "Knowledge Technologies for Creation of Digital Presentation and Significant Repositories of Folklore Heritage" project.

Keywords: Knowledge Technologies, Ontology, Digital Libraries, Bulgarian Folklore, Ethnology.

ACM Classification Keywords: I.2.4 Knowledge Representation Formalisms and Methods, H.3.7 Digital Libraries – Collection, Dissemination, System issues.

Introduction

Preserving and presenting the Bulgarian folklore heritage is a long-term commitment of scholars and researchers working in many areas. From centuries every generation is aimed at keeping record about the work and life, so

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that it could be revised and studied by the next generations. For a long time this heritage has been maintained in libraries, museums and research laboratories, where not everyone was able to access this wealth. New information and multimedia technologies that have been developed during the past couple of years introduced new methods of preservation, maintenance and distribution of the huge amounts of collected material.

In the first ICT Work Programme under the Seven Framework Programme of the European Community for Research and Technological Development (FP7), which defines the research priorities for 2007-2008, cultural heritage research is part of Challenge 4, named "Digital Libraries and Content". Its main objective is the development of "large-scale European-wide digital libraries of cultural and scientific multi-format and multi-source digital objects, assisting communities of practice in the creative use of content in multilingual and multidisciplinary contexts, and based on robust and scalable environments, cost-effective digitisation processes, semantic-based search facilities and tools for digital preservation" [ICT, '07].

The "Knowledge Technologies for Creation of Digital Presentation and Significant Repositories of Folklore Heritage" (FolkKnow) project follows this idea and aims to build a multimedia digital library with a set of objects/collections, selected from the fund of the Institute for Folklore of the Bulgarian Academy of Science, which corresponds to the European and world requirements for such activities, and is consistent with the specifics of the presented artefacts. The project will use the knowledge technologies and digital libraries as they are the most suitable tools for semantic description and virtual multimedia presentation of cultural historical artefacts.

This paper presents the first stage of the work done on module 3 of the project, named "Development of Digital Libraries and Information Portal with Virtual Exposition "Bulgarian Folklore Heritage"". It tracks out the creation of Bulgarian folklore ontology, describing the knowledge about Bulgarian folklore objects and their main features, technical data or context. This ontology is the backbone of the subsequent work of folklore digital library development. Section 2 of the paper is a short description of the main issues of the FolkKnow project. In section 3, a brief outlook of the project's digital library is included. Section 4 summarises the current state of ontology development. Sections 5 and 6 deal with different aspects of the Bulgarian folklore ontology including its scoping, conceptions, relations, and its implementation and utilization in the project.

Knowledge technologies for creation of digital presentation and significant repositories of folklore heritage

The aim of the project "Knowledge Technologies for Creation of Digital Presentation and Significant Repositories of Folklore Heritage" is to build a multimedia digital library with a set of objects/collections, selected from the fund of the Institute for Folklore of the Bulgarian Academy of Science, which corresponds to the European and world requirements for such activities, and is consistent with the specifics of the presented artefacts. The complex structure and the multi-layer characters of the folklore objects require innovative approach for knowledge representation. The rich-in-content Web-presenting of the Bulgarian folklore knowledge defines the usage of modern methods and technologies for digital archive developing, which will be used not only for preservation and access to the information, but as a tool for scientific research analysis development. The main tasks is to create a digital library and information artery using knowledge-based technologies and Semantic web approach, in order to present in virtual form the valuable phenomena of the Bulgarian folklore heritage. The realization of the project gives possibility for wide social applications of the multimedia collections for the purposes of Interactive distance learning/self-learning, research activities in the field of Bulgarian traditional culture, and for the cultural and ethno-tourism in Bulgaria.

We assume that when Bulgarian folklore heritage is digitalized and presented virtually there will be a need of contemporary information technologies that allow complex multimedia presentations and descriptions, as well as broad and flexible access method. We believe that the digital libraries and Semantic web meet those requirements because they are powerful technologies for digitalization, semantic description, access provisioning, preservation, and virtual representation of cultural and historic values and especially of Bulgarian folklore heritage. The approach for building the module is formed as a result of the research experience of the team of Institute of Mathematics and Informatics and its know-how in multimedia applications gained in numerous European Information Society projects. It includes analytical research, choice and usage of suitable methods, tools and environments for digital representation and preservation of significant cultural and historical artefacts and their exposure into the global information space. This approach allows the integration of the idea of the traditional Bulgarian culture and folklore in the European culture space, while completely preserving its identity and diversity [Bogdanova et al. '06].

Digital library of Bulgarian folklore heritage

Digital libraries are a contemporary conceptual solution for access to information archives. They contain diverse hypertext-organized collections of information (digital objects such as text, images, and media objects) that are organized thematically and are managed by complex specialized services such as semantic-based search, multi-layer and personalized search, context-based search, relevance feedback, resource and collection management, metadata management, indexing, semantic annotation of digital resources and collection, grouping and presenting digital information, extracted from a number of locations, services for digital information protection and preservation, *etc.* [Pavlov&Paneva, '06].

Besides that the flexibility, the automatic adaptation, the access anywhere and anytime, the decentralization, the wide variety of digital objects and collections, the information security, *etc.* are already key requirements for the advanced multimedia digital libraries [Pavlova-Draganova et al., '07] [Paneva et al., '05] [Pavlov et al., '06a] [Pavlov et al., '06b].

Information about the actual state of the research of the architecture of digital libraries, informational access to audio-visual and non-traditional objects and semantic interoperability is contained in the FP6 project DELOS "A Network of Excellence on Digital Libraries" (http://www.delos.info).

Having in mind this variety of useful properties and characteristics of the large-scale repositories of digitized knowledge their use for presentation of the valuable phenomena of the Bulgarian folklore is not casual. There are some national investigations and projects concerning the virtual existence and the digitalization of ethnographic and folklore artefacts, for example, experimental digital archive "Bulgarian Ethnographic Treasury" (http://mdl.cc.bas.bg/ethnography/) [Luchev, '05] [Luchev, '06], project "Yuper" (http://yuper.hit.bg/), project "Folklore Motives and Anthologies" (http://liternet.bg/), project "WebFolk Bulgaria" (http://musicart.imbm.bas.bg/EN/Default.htm), project "Living Human Treasures" (http://www.treasures.eubcc.bg/main.php), project "Virtual Encyclopaedia of Bulgarian Iconography" (http://mdl.cc.bas.bg/), *etc.*

The FolkKnow multimedia digital library can be similar valuable gallery of artefacts and knowledge for Bulgarian culture, art and folklore that will present a relatively limited number of specimens of different folklore narrative types (songs, rituals, faith, knowledge, proverbs, magic, *etc.*) and their audio-visual documentation. Until now, the Bulgarian folklore is always shown partially only with text, sound or image, but the authors' demand is for joint unities of words, music and motions. This possibility can be provided by contemporary multimedia environments. The ambitions of the authors are the demonstration of unique music dialects from different local folklore areas and advanced approaches for folklore content prescription representation through authentic sounds, videos, and photos of live rituals. Part of the Bulgarian folklore specimens will be presented from asynchronous point of view; other will be in their diachrony – unique materials, saved for years. Another task is the different record technique demonstration – inquiry, interview, inclusive observation, *etc.*

Multimedia digital library of Bulgarian folklore expects a wide range of potential users – professionals and scientists, non-professionals, connoisseurs and viewers, *etc.*

Ontological presentation of folklore knowledge

Originally, the term ontology comes from philosophy where it is employed to describe the existence of beings in the world. In 1993, Gruber's definition becomes the most referenced on the knowledge technologies literature: "an ontology is a formal, explicit specification of a shared conceptualization" [Gruber, '93]. Conceptualization refers to an abstract model of phenomena in the world by having identified the relevant concepts of those phenomena. Explicit means that the type of concepts used and the constraints on their use are explicitly defined. Formal refers to the fact that the ontology should be machine readable, which excludes natural language. Shared reflects the notion that an ontology captures consensual knowledge, that is, it is not private to some individual, but accepted by a group.

Ontologies can be used for many different purposes. The literature on knowledge representation contains research on the use of ontologies for data-interchange, for data-integration, for data-querying or for data visualization. In general, visualization of information can be seen as a two-step process. In a first step, information is transformed into some intermediate semantic structure. This structure organizes the raw information into a meaningful structure. In a second step, this semantic structure is used as the basis for a formal visual representation. We will use this approach in our work on the Bulgarian folklore ontology development.

Tools for building ontologies usually provide a graphical user interface that allows ontologists to create ontologies without using directly a specific ontology specification language. Some tools have been created for merging and integrating ontologies [Fensel, '04].

Recently, many ontology languages have been developed in the context of the World Wide Web: Resource Description Language (RDF), RDF Schema, Simple HTML Ontology Extensions (SHOE), Ontology Exchange Language (XOL), Ontology Markup Language (OML), Web Ontology Language (OWL), Ontology Inference Layer (OIL), DAML+OIL, *etc.* Their syntax is based on XML, which has been widely adopted as a 'standard' language for exchanging information on the web [Fensel, '04].

To efficiently represent the folklore annotation framework and to integrate all the existing data representations into a standardized data specification, the folklore ontology need to be represented in a format (language) that not enforce semantic constraints on folklore data, but can also facilitate reasoning tasks on folklore data using semantic query algebra. This motivates the representation of Bulgarian folklore ontology model in Web Ontology Language (OWL). OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF, and RDF Schema by providing additional vocabulary along with a formal semantics. Knowledge captured from folklore data using OWL is classified in a rich hierarchy of concepts and their inter-relationships. OWL is compositional and dynamic, relying on notions of classification, reasoning, consistency, retrieval and querying. We investigated the use of OWL for making Bulgarian folklore ontology using Protégé OWL Plug-in.

Ontology of Bulgarian folklore

Since one of the targets of the FolkKnow project is to present the valuable phenomena of the Bulgarian folklore in suitable virtual form using knowledge technologies, we have to observe and specify the experience that has been gained in the last 500 years in the area of traditional folklore *i.e.* to construct Bulgarian folklore domain ontology.

FolkKnow annotator/indexers using this ontology will semantically describe and index the raw audiovisual content in order to create and maintain reusable digital objects.

The ontology will be used also to realize semantic-based access to concrete digital objects, representing folklore objects, described by their main features, technical data or context. All this information is included within the Folklore Ontology Concept – the root concept for the ontology.

The process of building of the Bulgarian folklore ontology for the FolkKnow project is necessarily iterative. The first activity is the definition of the scope of the ontology. Scoping has been mainly based on several brainstorming sessions with folklorists and content providers. Having these brainstorming sessions allowed the production of most of the potentially relevant terms. At this stage, the terms alone represented the concept, thus concealing significant ambiguities and differences of opinion.

A clear issue that arose during these sessions was the difficulty in discovering of definite number of concepts and relations between these concepts. The concepts listed during the brainstorming sessions were grouped in areas of work corresponding naturally arising sub-groups. Most of the important concepts and many terms were identified. The main work of building the ontology was then to produce accurate definitions.

Description of the conceptions

The scientific classification and documentation of folklore objects provide folklorists and content generators with a rich knowledge background with plenty of multidimensional data and metadata. There is a special relation among the metadata, which reveals all the knowledge concerning the folklore object obtained from the classification procedure.

The folklore object is related to three levels of knowledge, enriched with a set of sub-levels of the data classification. All these levels of knowledge or "thematic entities" in the ontology conception are supported by the scientific diagnosis results and the related documentation.

The entity "Identification and description" consists of general historical data, identifying aspects such as title, language, archival signature, period, current location of the folklore object, annotation, first level description, second level description, *etc.*,

The entity "Technical" includes technical information both revealing the technologies used for folklore object capturing and recording, record situation, record type, record place, record date, main participants in the process (record maker and informant), *etc.*

These main entities and their metadata are supported, documented and provided by the scientific diagnosis, which has been applied to the folklore objects.

Ontological model

We will present the Bulgarian folklore ontological model using classes of concepts, organized in taxonomy and table with properties.

Taxonomies are used to organize ontological knowledge using generalization and specialization relationships through which simple and multiple inheritances could be applied. Properties are an interaction between individuals of the domain-classes and the range-classes.

Figure 1 depicts the main concepts and properties in the Bulgarian folklore ontological model.

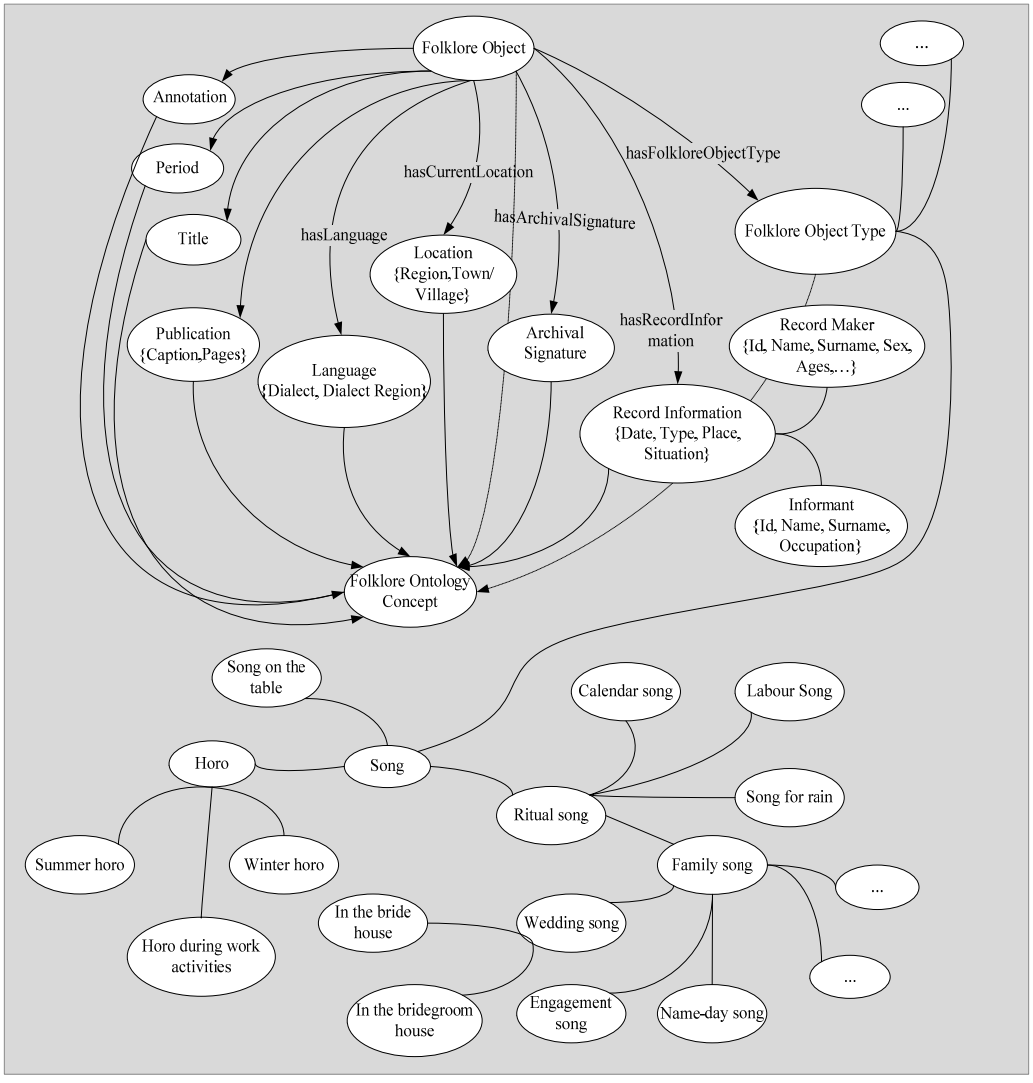

Figure 1: Part of the concepts and properties in Bulgarian folklore ontology

The most representative concepts have been defined first and then they have been specified appropriately in order to get a representation of the knowledge stored in the databases. The Bulgarian folklore ontology is composed of 70 concepts and 82 properties.

OWL properties represent semantic relationships between classes of objects. Below, a piece of the Bulgarian folklore ontology code, defining the property *isRecordPlaceOf* is presented. Here the declaration of the transitivity condition and the definition of property *hasRecordPlace* as its inverse can be seen.

```
<owl:ObjectProperty rdf:ID="isRecordPlaceOf">
  <rdfs:domain rdf:resource="#Record_Place"/>
  <owl:inverseOf>
    <owl:ObjectProperty rdf:ID="hasRecordPlace"/>
  </owl:inverseOf>
```

```
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
        Represents that the element “Record_Place” is a record place of the folklore object.
    </rdfs:comment>
    <rdfs:range rdf:resource="#Folkore_Object"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:about="#hasRecordPlace">
    <rdfs:range rdf:resource="#Record_Place"/>
    <rdfs:domain rdf:resource="#Folkore_Object"/>
    <owl:inverseOf rdf:resource="#isRecordPlaceOf"/>
    <rdfs:comment rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
        Represents that the element “Folklore_Object” has a record place.
    </rdfs:comment>
</owl:ObjectProperty>
```

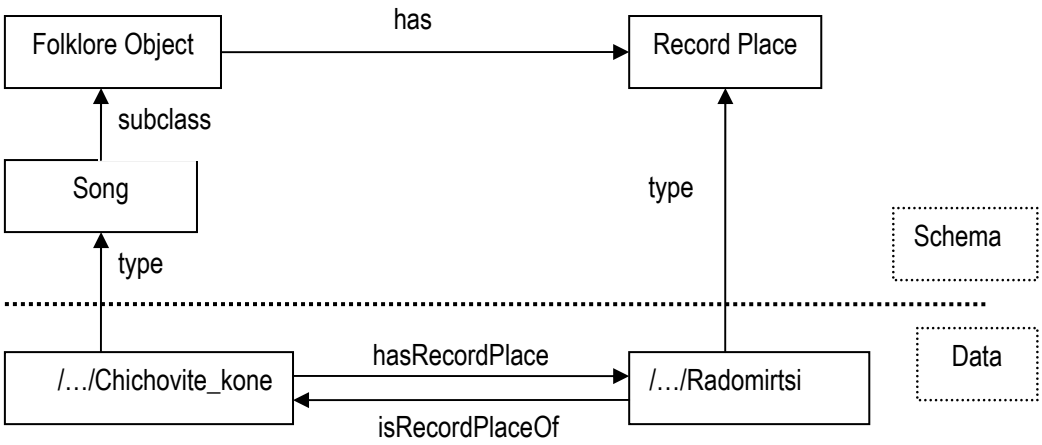

Figure 2: Scheme of relationships between classes of objects in Bulgarian folklore ontology

Implementation of Bulgarian folklore ontology

Knowledge about Bulgarian folklore heritage and oral tradition is interesting not only for the wide audience of professionals (historians, philologists, psychologists, ethnologists etc), but also for non-professionals and institutions dealing with these problems. Folklore heritage specialists will reach to organized objects and semantically structured knowledge for their investigations. For example, the searching for an object “Ritual”, semantically connected with an object “Festival”, can give back not only the all rituals of the festival, but also the “Songs”, “Faith and Knowledge”, “Magic”, “Food”, *etc.*, semantically bound up with both “Ritual” and “Festival”. Cultural institutions and organizations, as well as non-professionals will be able to find information for semantically joined complexes of folklore objects on the base of starting points as “Location”, “Period”, “Language/Dialect”, *etc.*

The ontology gives the ability to describe the semantics of folklore content and to use new knowledge management services such as semantic search across aggregations of varied and complex sub-classes and objects in a robust, rich and user-friendly manner, personalized search, context-based search, multi-criteria search, metadata management, *etc.*

The semantically annotated objects can also be used as a base for eLearning courseware development; for example, folklore objects can be easily discovered and grouped in learning lessons, modules or parts of them.

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TOWARDS CONTENT-SENSITIVE ACCESS TO THE ARTEFACTS OF THE BULGARIAN ICONOGRAPHY

Desislava Paneva, Lilia Pavlova-Draganova, Lubomil Draganov

Abstract: This paper presents an ontological model of the knowledge about Bulgarian iconographical artefacts. It also describes content-sensitive services for access, browse, search and group iconographical objects, based on the presented ontology that will be implemented in the multimedia digital library "Virtual encyclopedia of Bulgarian iconography".

Keywords: Ontology, Bulgarian Iconography, Digital Libraries, Content-sensitive services.

ACM Classification Keywords: I.2.4 Knowledge Representation Formalisms and Methods, H.3.7 Digital Libraries – Collection, Dissemination, System issues.

Introduction

East-Christian icon art is recognised as one of the most significant areas of the art of painting. Regrettably, it is neglected in the digital documentation and the registry of the art of painting. This tendency is suspended by the team from the Institute of Mathematics and Informatics (Bulgarian Academy of Sciences) with the development of the multimedia digital library "Virtual encyclopedia of the Bulgarian iconography" (http://mdl.cc.bas.bg/). This valuable galleria of knowledge and specimens of East-Christian culture and art is created during the project "Digital libraries with multimedia content and its applications in Bulgarian cultural heritage" [Pavlov et al., '06b] [Pavlova-Draganova et al., '07] and includes several hundred specimens of Bulgarian icons and artefacts from different artists, historical periods, and schools [Pavlov&Paneva, '06] [Paneva et al., '05].

The impending development of the digital library points to the investigation and implementation of new techniques and methods for description of the semantics of iconographical artefacts and collections in order their valuable knowledge to be easy accessed and found. Knowledge technologies and Semantic web can provide these opportunities. Adopting them we make the first development steps of the "Bulgarian iconographical artefacts" ontology. This article presents the process of its consideration, scoping, and conceptualization, the ideas for its implementation in the "Virtual encyclopedia of the Bulgarian iconography". The interpretations of the iconographical knowledge do not have to be considered isolated from the standards and specifications in the field of cultural information representation. Therefore, section 2 summarizes the most important standard in the field of cultural heritage representation - CIDOC object-oriented Conceptual Reference Model (CIDOC CRM) and its use. Sections 3 deals with different aspects of the ontology development, based on CIDOC CRM concepts and properties. Section 4 discusses content-sensitive services for access, browse, search and group of iconographical objects, based on the presented ontology that are in a process of implementation in the multimedia digital library "Virtual encyclopedia of Bulgarian iconography".

Ontological presentation of iconographical knowledge

One of the targets of the multimedia digital library "Virtual encyclopedia of the Bulgarian iconography" is to create rich context-based virtual presentation of the Bulgarian icon art and culture. Therefore, we observed and specified the experience that has been gained in the last 1000 years in the area of iconography to develop "a formal, explicit specification of a shared conceptualization" [Gruber, '93] about the iconography world - the ontology "Bulgarian iconographical artefacts". The annotator/indexers using this ontology will semantically describe and index the raw audiovisual iconographical content in order to create and maintain digital objects.

The interpretations of the iconographical knowledge do not have to be considered isolated from the standards and specifications in the field of cultural information representation because the goal is to maximize the reusability and portability of the designed ontological model. The most significant new development is the CIDOC Conceptual Reference Model, "object-oriented domain ontology" for expressing the implicit and explicit concepts in the documentation of cultural heritage. Since 9/12/2006 it is official standard ISO 21127:2006. It is the culmination of more than a decade of standards development work by the International Committee for Documentation of the International Council of Museums. Its role is to enable information exchange and integration between heterogeneous sources of cultural heritage information. CRM aims at providing the semantic definitions and clarifications needed to transform disparate, localised information sources into a coherent global resource. More specifically, it defines and is restricted to the underlying semantics of database schemata and document structures used in cultural heritage and museum documentation in terms of a formal ontology. It explains the logic of what they actually currently document, and thereby enables semantic interoperability. It intends to provide an optimal analysis of the intellectual structure of cultural documentation in logical terms.

The CRM is domain ontology in the sense used in knowledge technologies. It has been expressed as an object-oriented semantic model that can be readily converted to machine-readable formats such as RDF Schema, KIF, DAML + OIL, OWL, STEP, *etc.* It can also be implemented in any relational or object-oriented schema.

Real ontologies for concrete worlds of art objects are often developed as (conceptual at least) specializations of the CIDOC CRM ontology. During the creation of the "Bulgarian iconographical artefacts" ontology we observe the concepts and properties of CIDOC ontology and part of them we use in our ontology, other part we transform in order to fit for the iconography domain and several concepts don't belong to the CIDOC CRM ontology.

Concepts and properties in "Bulgarian iconography artefacts" ontology	CIDOC CRM chains
Dimension Iconographical object → has dimension → Dimension Dimension → was observed in → Unit of Measurement Dimension → has width value → Number Dimension → has height value → Number Dimension → has length value → Number	E70 Thing (E22 Man-Made Object) → P43 has dimension (is dimension of) → E54 Dimension E54 Dimension → P40 was observed in → E16 Measurement (Unit of measurement of the dimension in our ontology) E54 Dimension → P90 has value → E60 Number (value of the dimensions of our ontology)

Table 1: The concept Dimension and its properties in the "Bulgarian iconographical artefacts" ontology and the respective chain of CIDOC CRM concepts and properties

A juxtaposing example is shown in Table 1 for the concept 'Dimension' and its properties in the "Bulgarian iconographical artefacts" ontology and the respective chain of CIDOC CRM concepts and properties. The iconographical object can be adopted as a subset of the E22 Man-Made Object class. Ontology's concept 'dimension' is the same as CIDOC CRM E54 Dimension concept. The relationship between the iconographical object and its dimension is indicated by P43 has dimension property. In our ontology we adopted the 'Dimension→was observed in→Unit of Measurement' chain that is similar in CRM – 'E54→P40→E16'. In our ontology we split the 'E54→P90→E60' in three layers for the width, height and length of the iconographical objects [Pavlova-Draganova et al., '07].

Description of the semantics of the Bulgarian iconographical artefacts

Bulgarian iconographical domain contains a rich knowledge base that has to be semantically described. For this aim we observe and specify the experience in the area of iconography and start the development of the ontology presenting iconographical knowledge and artefacts.

The first activity in the process of the development of "Bulgarian iconographical artefacts" ontology is the definition of the scope of the ontology. Scoping has been mainly based on several brainstorming sessions with artists and content providers. It depends on the future implementation of the ontology in the multimedia digital libraries "Virtual encyclopedia of the Bulgarian iconography". These brainstorming sessions allowed the production of most of the potentially relevant terms. At this stage, we also juxtaposed these concepts to the available concepts in CIDOC CRM, thus concealing significant ambiguities and differences of opinion. A clear issue that arose during these sessions was the difficulty in discovering of definite number of concepts and relations between these concepts. The concepts listed during the brainstorming sessions were grouped in areas of work corresponding naturally arising sub-groups. Most of the important concepts and many terms were identified. The main work of building the ontology was then to produce accurate definitions.

The iconographical object is related to three levels of knowledge, enriched with a set of sub-levels of the data classification. All these levels of knowledge or "thematic entities" in the ontology conception are supported by the scientific diagnosis results and the related documentation [Pavlova-Draganova et al., '07].

- The entity "Identification" consists of general historical data, identifying aspects such as title, type, author, clan, iconographic school, period, dimensions, current location, description of the iconographical object/collection,
- The entity "Description" consists of information concerning the descriptive details of the theme and forms of representation, providing a better understanding of the context, such as characters and scenes, participation of characters in scenes, *etc*.
- The entity "Technical" includes technical information both revealing the techniques and the base materials used in the creation of the iconographical object/collection, and also concerning examinations of the condition, such as diagnosis or conservation treatments history.

These main entities and their metadata are supported, documented and provided by the scientific diagnosis, which has been applied to the iconographical objects and collections.

Figure 1 depicts the main classes and relations related to the concept 'Iconographical Object' in the ontology.

As it is shown on figure 1 in the "Bulgarian iconographical artefacts" ontology the concept 'Iconographical Object' is described with its title, author appellation, its clan and iconographic school, its current location and the period (time-span) of its creation, used base material and iconographic techniques, overall description. The ontology also captures the characters and scenes depicted on the iconographical object (icon, plastic iconographical object,

mural painting, iconostasis, iconographic element in Psalm-book, *etc.*) in order to be defined its compoundness. Figure 2 depicts the main subclasses of the 'Character" class.

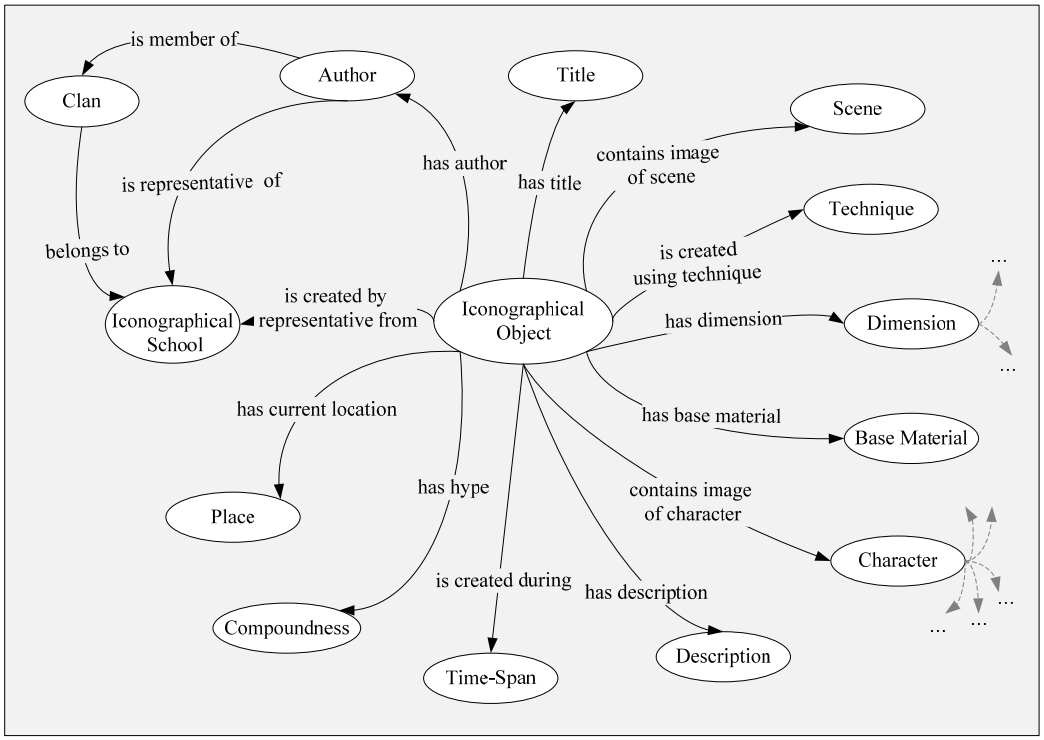

Figure 1: Main classes and relations related to the 'Iconographical Object' in the "Bulgarian iconographical artefacts" ontology

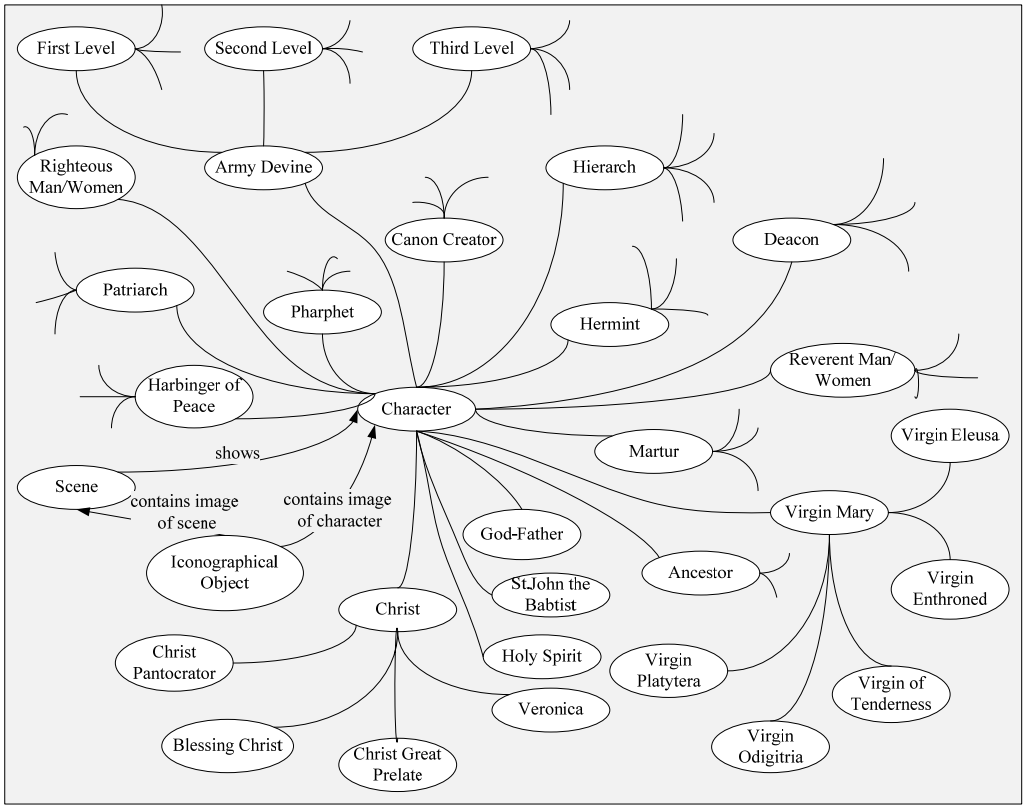

Figure 2: "Character" class and its subclasses in the "Bulgarian iconographical artefacts" ontology

New content-sensitive and customizing services in Virtual encyclopedia of the Bulgarian iconography

Multimedia digital library "Virtual encyclopedia of the Bulgarian iconography" currently provides its users with several services for present and search iconographical artefacts. But, the development of the "Bulgarian iconographical artefacts" ontology allows the inclusion of new semantic-based and content-sensitive access services with customizing elements in it.

One of them is "semantic-based search with grouping" depicted on a figure 3. It provides searching for iconographical artefacts that are created by representatives from chosen iconographic school, for example "Tryavna iconographic school". The results are lists of artefacts grouped according the several chosen criteria: authors, title, period, location, base material, depicted characters and scenes. This grouping opportunity will be very helpful for quick find of definite artefact in the iconographical object repository. During the search process the semantic-based service traces nodes of the ontological tree and presents instances of checked classes.

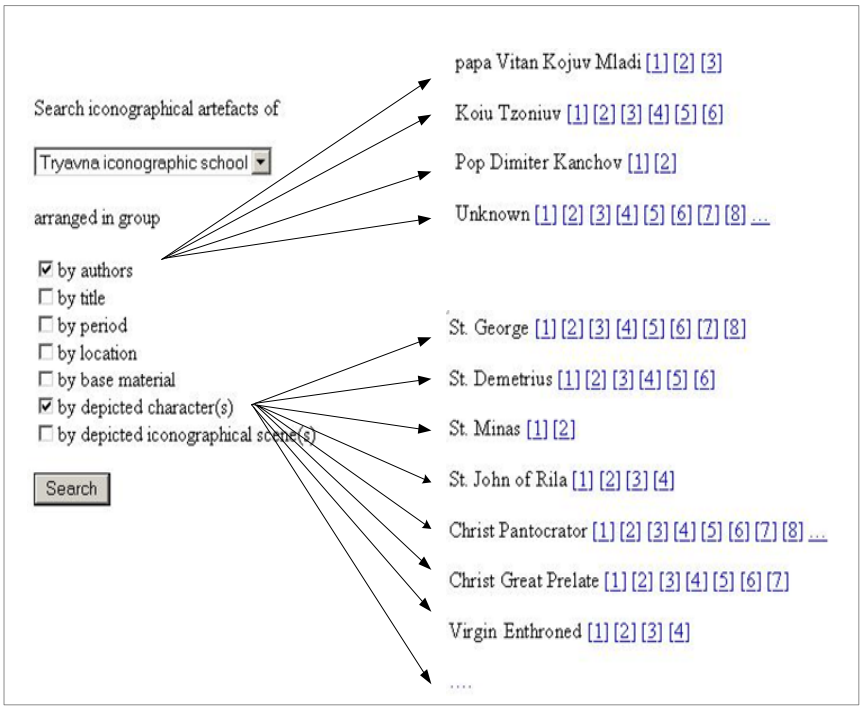

Figure 3: "Semantic-based search with grouping" in multimedia digital library "Virtual encyclopedia of the Bulgarian iconography"

Similar service could provide this grouping artefacts functionality during the multi-criteria search (at present available in the digital library), but the desired grouping criteria have to be selected by the user during its personal profile creation. This action dictates the proper iconographical object observation style [Paneva, '06].

Another content-sensitive service is the "content browsing". It will display the ontology information graphically in order to support artists to easily navigate and browse through the concepts. Moreover, it provides them with information about the concepts and other related issues concerning the ontology. This service will be particularly useful to artists who are not familiar with concept searching and want to browse the information resources in a user-friendly way.

The displayed concepts will be obtained querying the ontology. If the artist requires the concrete content associated to any of the concepts displayed by the iconographical content browsing service, another query is done, this time, on the content database. In such way, the artist gets the information requested with the precise content to build his story.

Conclusion

The "Bulgarian iconographical artefacts" ontology tries to capture the knowledge in the iconography domain in order to provide tool for semantically description and indexing of the raw audiovisual iconographical content digital objects in the multimedia digital library "Virtual encyclopedia of the Bulgarian iconography". This ontology can be use for realization semantic-based access and search of concrete iconographical objects, as it shown in this paper. The future development of the digital library will continue to improve and extend the "Bulgarian iconographical artefacts" ontology and the DL services based on it.

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AUTOMATIC CREATION OF LEXICAL RESOURCES FOR AN INTERLINGUA-BASED SYSTEM[4]

Juan Bekios, Igor Boguslavsky, Jesús Cardeñosa, Carolina Gallardo

Abstract: The Universal Networking Language (UNL) is an interlingua designed to be the base of several natural language processing systems aiming to support multilinguality in internet. One of the main components of the language is the dictionary of Universal Words (UWs), which links the vocabularies of the different languages involved in the project. As any NLP system, coverage and accuracy in its lexical resources are crucial for the development of the system. In this paper, the authors describes how a large coverage UWs dictionary was automatically created, based on an existent and well known resource like the English WordNet. Other aspects like implementation details and the evaluation of the final UW set are also depicted.

Keywords: Lexical Resources, Wordnet.

ACM Classification Keywords: J.5. Arts and Humanities; H.2.8 Database Applications;

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Introduction

The Institute of Advanced Studies of the United Nations University launched the UNL Program under the UN auspices in 1996. It had an ambitious goal: to break down or at least to drastically lower the language barrier for the Internet users. The project embraced 14 groups from different countries representing a wide range of languages: Arabic, Chinese, German, French, Japanese, Hindi, Indonesian, Italian, Mongolian, Portuguese, Russian, Spanish and Thai.

The UNL Program pivots on the *Universal Networking Language*, a meaning representation language designed to represent informational content conveyed by natural languages. The complete specifications of the language are public and freely downloadable from Internet (see [Uchida et al., 2005]). One of the major applications of UNL is to serve as an interlingua between different natural languages. Besides that, UNL can also be used for other applications such as information retrieval, text summarization and the like. In fact, the specifications have known several versions, from version 1.0 in 1997 to current version of 2005, due to the fact that the language accommodates itself to new uses.

The UNL is composed of three main elements: universal words (UWs hereafter), relations and attributes. UWs form the vocabulary of the interlingua; relations express thematic roles and attributes represent the context and speaker dependent information. Formally, a UNL expression can be viewed as a semantic net, whose nodes are UWs, linked by arcs labeled with UNL relations. Universal Words are expanded by the attributes.

The complete set of UWs composes the UNL dictionary. The UNL dictionary is complemented with bilingual dictionaries, connecting UWs with words of different natural languages. Local dictionaries are formed by pairs of the form <Word, UW> where Word is any word of a given natural language and UW is the corresponding representation of one of its senses in UNL. The UNL dictionary constitutes a common lexical resource for all natural languages currently represented in the project, so that word senses of different natural languages become linked via their common UWs. Therefore, the UNL Dictionary can serve as an important lexical resource to construct multilingual dictionaries or other resources like thesauri, being UWs the pivot among the vocabulary of natural languages.

However, there is an apparent drawback in the UNL dictionary. The set of UWs is not formally defined, that is, the specifications do not provide either a complete knowledge base or precise instructions to create UWs. The absence of formalization of the lexical part of the language prevents the construction of a common dictionary of UWs for all the members of the project, the management of dictionaries and lexical resources being the hardest part of the project.

This paper presents a methodology and an application that tries to solve the main problems in the UNL dictionary management, namely, the standardization of the definition of UWs and the automatic construction of the common UNL dictionary on the basis of the existing lexical resources.

Data Analysis

As already said, UWs constitute the vocabulary of the language. Broadly speaking, a UW is an English word modified by a series of semantic restrictions. The main purpose of semantic restrictions is to eliminate lexical ambiguity present in natural languages. Besides that, they establish major lexical relations with other words and specify an argument frame. In this way, UNL gets an expressive richness from the natural languages but without their ambiguity. For example, the verb "land" in English has several senses and different argument frames. In a sentence like "*The plane landed at the Geneva airport*", the corresponding UW for the sense of this verb would be land(icl>do, plt>surface, agt>thing, plc>thing). This UW is divided in two parts: the headword and the list of semantic restrictions enclosed in parenthesis and separated by commas, as shown in figure 1.

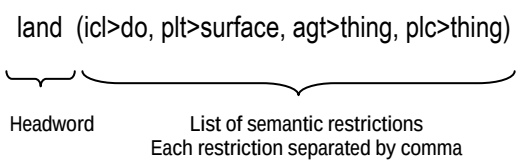

Figure 1. Parts of a UW

This UW corresponds to the definition “To alight upon or strike a surface”. The proposed semantic restrictions stand for:

- icl>do: (where *icl* stands for *included*) establishes the type of action that “lands” belongs to, that is, actions initiated by an agent.
- plt>surface: (where *plt* stands for *place to*) expresses an inherent part of the verb meaning, namely that the final direction of the motion expressed by “land” is onto a surface.
- agt>thing, plc>thing: (where *plc* stands for *place*) establish the obligatory semantic arguments of the predicate “land”.

As can be seen from this example, UNL semantic restrictions are based on lexical relations among terms, namely, the *hyponymy* relation (by means of “icl” relation), *synonymy* (“equ” relation) and *meronymy* (“pof” relation). Besides, the semantic arguments of predicates (that is, verbs, adjective and some nouns) must be specified. Since UWs are described by means of relations between terms, the result is a connected net of UWs, constituting the UW system. A more comprehensive view of the UW system is described in [Boguslavsky et al, 2005].

The organizing principles of the UW system are based on well-known lexical relations, like those present in Wordnet [Fellbaum, 1998]. Wordnet is a large lexical database of English, freely downloadable from Internet (http://wordnet.princeton.edu/). As opposed to most lexicographic works and similarly to the UW system, Wordnet is not ordered alphabetically but conceptually, by means of semantic relations. The main organizing relation in Wordnet is the synset, defined as a group of cognitive synonyms that expresses a single concept. Besides, synsets are interconnected by means of other lexico-semantic relations like hyperonymy (hierarchical relation between class and subclass), antonymy (an opposite term), metonymy (part-of) and other relations like *relative_to*, sentence frames for verbs, etc. Figure 2 shows two samples of Wordnet that illustrate the relations of hyperonymy and antonymy for the synset “male child, boy”.

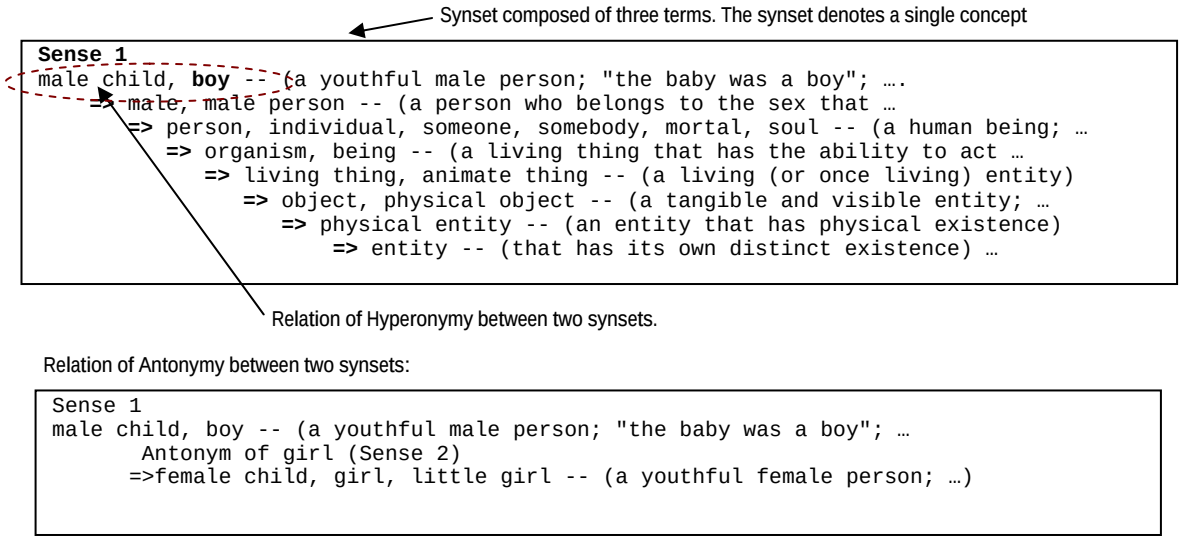

Fig 2. Two samples of Wordnet

Wordnet includes nouns, adjectives, adverbs and verbs. Other categories like prepositions, determiners or conjunctions are spelled out from Wordnet, since they do not denote any semantic concept.

The use Wordnet as an ancillary resource to support the process of automatic dictionaries creation is not new in the UNL framework. The generation of UNL-English dictionaries for specific texts is depicted in [Bhattacharyya et al, 2004]. We have made use of the similarity of Wordnet and the UW system to use Wordnet as the main source to define and create a complete UW dictionary. The complete process and the final UW dictionary are described in the next sections.

Design Issues

The main design issue when considering a UW Dictionary and Wordnet as the main source of data is that the structure of lexical relations in Wordnet can be used to construct the list of restrictions of UWs. To do that, we must first establish the main similarities between Wordnet and the UW system. Such similarities are exposed in

table 1, where the first column describes lexical relations in Wordnet and the second column states their equivalent semantic restrictions in the UW system.

Table 1 shows how any word included in Wordnet can be used to represent the headword of a UW. Each different sense of an English word is delimited by means the set of synonyms, hypernyms, antonyms and other lexical relations associated to that word, in the same way that the sense of a headword in UNL is delimited by its list of semantic restrictions.

SIMILARITY RELATIONS	
WordNet 2.1	UW System
An English Word.	Headword
Synset	Relation equ>
Hyperonym	Relation icl>
Antonym	Relation ant>
Relative to	Relation com>

Table 1. Similarity Relations between Wordnet and the UW system

What is really important for us is that from these similarity relations, it is possible to devise a method that defines UWs in a systematic way using Wordnet. The method is described in figure 3.

```
1. Extract a Word from Wordnet
2. Obtain each of the senses of the Word
3. For each sense of the word, do the following:
    3.1. Assign the Word to the Headword of UW
    3.2. Depending on the syntactic category (noun, adjective, adverb, verb)
         and on the data obtained from WordNet; for each sense, apply a set
         of rules that will generate semantic restrictions.
    3.3. Taking the Headword and the obtained restrictions, construct the
         complete Universal Word.
    3.4. Store the UW in the dictionary.
4. If more UWs are to be constructed, return to step 1. Otherwise, finish.
```

Fig. 3. Method to define UWs from Wordnet

There are two aspects that require further explanations in this method. First, the number of UWs that are created per word and second the set of rules mentioned in step 3.2 of the method.

The method will generate one UW per word sense. For example, the word “bank” as a noun has 10 senses and thus generates 10 different UWs. In some cases, when the difference between the senses is too subtle, Wordnet relations are not sufficient to differentiate between them. In these cases, the method will generate identical UWs for different senses. These “duplicate” UWs must be treated in a special way.

On the other hand, the method is based on the similarity relations of table 1 along with a set of rules to systematically yield a dictionary of UWs. These rules are presented in the next section.

Set of Rules

Only six rules are required to create the semantic restrictions of UWs. A rule takes as input a Wordnet word (that is, the set of senses for the word and the lexical relations each word is engaged in) and yields a semantic restriction suitable for the UW that is being created. The six rules are:

1. Rule for the Construction of Headword (HW)

   Definition: This rule turns a WordNet word into a Headword for a candidate Universal Word.

   Example: The word “*banking company*” in Wordnet returns the Headword “*banking_company*”.

2. Immediate Hypernym Rule (RHper)

   Definition: For a sense of a word, take its most immediate hypernym and establish an icl> relation type.

   Example: For the first sense of the word “*bank*” as a noun, take its immediate hypernym (“*financial institution)* and create a semantic restriction with icl>. The result is: “icl> financial_institution”

3. Immediate Hyponym rule (RHpo)

   Definition: For a sense of a word, take its most immediate hyponym and establish an icl< relation type. Use this relation only when there are duplicate UWs.

Example: For the first sense of the word "*bank*" as a noun, it is possible to obtain navigating through WordNet an immediate hyponym ("for example *credit_union")* and create a semantic restriction with icl<. The result is: "icl<credit_union"

4. Rule of First Synonym (RSyn)

Definition: For a sense of a word, if the word is not the first element of the synset, take the first word of the synset and establish an equ> relation.

Example: For the first sense of the word "*bank*", it synset is {*depository financial institution*, *bank*, *banking concern*, *banking company*}. Since "bank" is not the first element, create the following semantic restriction: "equ> depository_financial_institution"

5. Rule of First Antonym (RAnt)

Definition: For a sense of a word, take its associated antonym (if any) and establish an "ant>" relation.

Example: For the adjective "*good*" in its first sense, the antonym associated to its first sense is "*bad*", therefore the generated restriction will be: "ant>bad"

6. Rule of Relative_to (RRel)

Definition: For a sense of a word (usually adjectives), take the associated noun by means of relation "pertains to" (if any) and establish an "com>" relation

Example: For "the *legal*" adjective, WordNet establishes a relation belongs to the noun "*law*", therefore the following restriction is obtained: "com>law"

These rules are independent of each other and can be executed in any order. When constructing the complete UWs dictionary, the application of rules will depend on the syntactic category of the headword (that is, not all rules are relevant for a given syntactic category). For example, when working with verbs, the application of the Antonym rule is irrelevant, since the meaning of a verb is not characterized by its antonyms. Table 2 summarizes the rules that are triggered for each syntactic category.

Syntactic category	*Executed rules*
Noun	HW, RHper, RSyn, RAnt
Adjective	HW, RHper, RAnt, RSyn, RRel,
Adverb	HW, RSyn, RAnt, RRel

Table 2. Set of rules relevant for each syntactic category

That is, a given noun may produce at most 4 semantic restrictions. For example, the noun "boy" in its first sense produces the following semantic restrictions:

- icl>male>thing (by means of RHper)
- equ>male_child (by means of RS)
- ant>girl (by means of RA)

The final UW is the concatenation of the generated semantic restrictions following the same order of table 2:

boy(icl>male>thing, equ>male_child, ant>girl)

The order of semantic restrictions implicit in table 2 is a convention followed by all the team members of the project. A different ordering will not imply different semantics of the UW.

Verbs are treated in a different way. Whereas all the information required for creating good UWs for nouns, adverbs and adjectives is present in the Wordnet, the mapping between verbal UWs and verbs in Wordnet is not so straightforward. This is due to the following reasons:

- Verbal UWs are categorized into three basic types of events: "do", "occur" and "be". This categorization is absent in Wordnet.
- Verbal UWs should be provided with its semantic arguments. Verbs in Wordnet are assigned a Sentence Frame, which is a, often incomplete, description of syntactic arguments for verbs.

Since there is no one-to-one relation between verbal UWs and the verbs, it was necessary to infer the type of event and the semantic arguments from the scarce information present in Wordnet. For that, we made use of the so-called lexicographic files which define broad ontological categories. Some of these categories are "verbs of dressing and bodily care", "cognition verbs", "verbs of being and having". The combination of the ontological category together with the sentence frame of a verb gives us a hint about its type of event and semantic arguments. Table 3 shows an excerpt of the combinations that have been used to define verbal UWs.

Wordnet		UNL		
Ontological category	Sentence Frame	Event Type	Semantic Arguments	Example
verbs of being, having, spatial relations	Somebody ----s to somebody	be	aoj>thing,obj>thing	conform(icl>be,aoj>thing,obj>thing)
verbs of weather	Somebody ----s	occur	obj>thing	steam(icl>occur,obj>thing)
verbs of creation	Somebody ----s something	do	agt>thing,obj>thing	cut(icl>do,agt>thing,obj>thing)

Table 3. Combinations to define verbal UWs.

The Dictionary Application

The complete application is composed of the following modules, graphically shown in figure 4:

- Conversion Module: This component converts words from Wordnet into UWs. This module uses the Rules and the Wordnet data. The generated Universal Words are served to the Database Manager.
- Database Manager: This component manages all the communications to and from the Database. Thus, this module receives the set of generated UWs from the Conversion Module and serves them to the Database. On the other hand, this module manages the processes of searching, modifying, deleting and inserting UWs as requested by users through the Web Browser. This component was developed in Java, using the special library Hibernate. (www.hibernate.org). In the near future, the UW Dictionary is expected to store the translations of UWs not only into English but into the other languages of the project.
- Web Browser: It refers to any existent web browser like Explorer, Firefox, Opera, etc. which will be used by users in order to interact with the UW Dictionary.

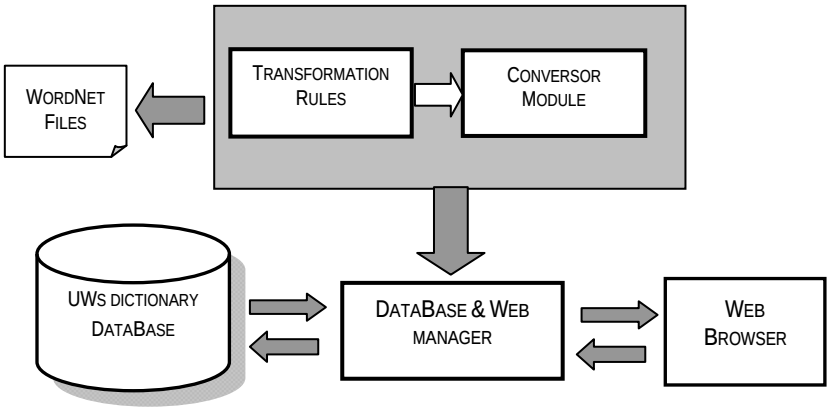

Fig 4. Components and relations of dependency of the Dictionary of Universal Words

The application can be accessed at the following address: http://www.unl.fi.upm.es/unlweb/

Results

All the UWs of the resulting UW Dictionary have been created automatically, without human intervention. Obtained results for a total amount of 207016 words that have been processed are summarized in table 4, where the total amount of generated UWs divided in syntactic categories is shown. The percentage of duplicate UWs for each syntactic category is also specified.

	Nouns	Adjectives	Adverbs	Verbs
Unique UWs	142343	26784	4958	23716
Duplicate UWs	2761	4518	762	1174
Total	145104	31382	5728	24890
% duplicate UWs	1,9%	14,39%	13%	4,7%

Table 4. Obtained results

Since nouns are by far the most elaborated category in Wordnet, we considered as correct UWs the set of unique UWs, and as incorrect the set of duplicate UWs. As can be seen from table 4, the rate of duplicate UWs for nouns is less than 2%, a good result for the most polysemous syntactic category. Surprisingly, the results for verbs is rather good (less that 5% of error rate), although we assume that semantic arguments of verbs require human revision. On the other hand, both adjectives and adverbs yield an error rate quite high (around 14%). The possible reason for such an error rate may lie in the fact that the main lexical relations present in Wordnet are synonymy and hypernym, natural relations for nouns but not for predicates like adjectives or adverbs.

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A COGNITIVE SCIENCE REASONING IN RECOGNITION OF EMOTIONS IN AUDIO-VISUAL SPEECH

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Abstract: In this report we summarize the state-of-the-art of speech emotion recognition from the signal processing point of view. On the bases of multi-corporal experiments with machine-learning classifiers, the observation is made that existing approaches for supervised machine learning lead to database dependent classifiers which can not be applied for multi-language speech emotion recognition without additional training because they discriminate the emotion classes following the used training language. As there are experimental results showing that Humans can perform language independent categorisation, we made a parallel between machine recognition and the cognitive process and tried to discover the sources of these divergent results. The analysis suggests that the main difference is that the speech perception allows extraction of language independent features although language dependent features are incorporated in all levels of the speech signal and play as a strong discriminative function in human perception. Based on several results in related domains, we have suggested that in addition, the cognitive process of emotion-recognition is based on categorisation, assisted by some hierarchical structure of the emotional categories, existing in the cognitive space of all humans. We propose a strategy for developing language independent machine emotion recognition, related to the identification of language independent speech features and the use of additional information from visual (expression) features.

ACM Classification Keywords: *I.2 Artificial Intelligence, 1.2.0.Cognitive simulation, 1.2.7. Natural language processing - Speech recognition and synthesis*

Introduction

Traditional human machine interaction is normally based on passive instruments such as keyboard, mouse, etc. Emotion is one of the most important features of humans. Without the ability of emotion processing, computers and robots cannot communicate with humans in a natural way. It is therefore expected that computers and robots should process emotion and interact with human users in a natural way. Affective Computing and Intelligent Interaction is a key technology to enable computers to observe, understand and synthesize emotions, and to behave vividly. Affective computing aims at the automatic recognition and synthesis of emotions in speech, facial expressions, or any other biological communication channel (Picard, 1997). In fact, existing automatic speech recognition systems can benefit from the extra information that emotion recognition can provide (Ten Bosch, 2003; Dusan and Rabiner, 2005). In (Shriberg, 2005), the authors emphasize the importance of modelling non-linguistic information embedded in speech to better understand the properties of natural speech. Such understanding of natural speech is beneficial for the development of human-machine dialog systems. Several applications call for recognition only of the emotions in the speech, without processing the linguistic content. Such systems should be language independent.

During the last years the research concentrated in all these problems. As example, we can site the HUMAINE (Human-Machine Interaction Network on Emotion) a Network of Excellence in the EU's Sixth Framework Programme IST (Information Society Technologies). The thematic priority of HUMAINE aims to lay the foundations for European development of systems that can register, model and/or influence human emotional and emotion-related states and processes - 'emotion-oriented systems'. For the proposed reasoning herein, we used several analyses and results of this research network, available on [http://emotion-research.net/].

Automatic emotion recognition

Automatic recognition of emotions in speech aims at building classifiers (or models) for classifying emotions in unseen emotional speech. The data-driven approaches to the classification of emotions in speech use supervised machine learning algorithms (neural networks, support vector machines, etc.) that are trained on patterns of speech prosody. The training is performed with utterances or other speech instances, labelled with a previously chosen set of emotions. Such labelled speech instances are taken from databases of emotional speech. Machine learned classifiers (ML-classifiers) can categorize other speech instances from the same database, according to the labels, used in the training procedure.

In general, the systems for speech analysis (speech recognition, speaker verification, emotion recognition) use techniques for *extraction* of *relevant* characteristics from the raw signal. Concerning emotions, the relevant information is the *Prosody* (broadly determined as: *Intonation* – the way in which pitch changes over time, *Intensity* – the changes in intensity over time and *Rhythm* – segment's durations vs. time) and in the *Voice quality (*measured in spectral characteristics).

Table 1. Feature set used in the AIBO approach (Oudeyer, 2003).

Acoustic features	Derived series of:	Statistics on the der. series,
-intensity -lowpass intensity -highpass intensity -pitch -norm of absolute Vector derivative of the first 10 MFCC Components *(MFCC - Mel-frequency cepstral coefficients)*	-minima, -maxima, -durations between local extrema - the feature series itself	-Mean, -maximum, -minimum, -range, -variance, -median, -first quartile, -third quartile, -inter-quartile range, -Mean absolute value of the local derivative

In Table 1 lists the features used in one of the contemporary feature extraction approaches developed for the Sony's robotic dog AIBO (Oudeyer, 2003). Table 2 illustrates another feature set used for the "segment based approach" (SBA) (Shami and Kamel, 2005). The size of the feature-vectors, provided as an input to the machine learning algorithm is practically not limited. One of the strategies applied for building a ML-classifier is to construct a feature vector with "everything that can be calculated" according to the reasoning that "the more information is collected from the raw signal, the better it is". This strategy is often used in the practice. There exist classifiers with feature vectors of hundreds of values. The big length of the input vector reduces the performance of the classifier. The next step in this strategy is to discover the features which discriminate the speech data (to the training labels) and to discard the non-discriminative features.

Table 2 Feature set used in the Segment-based approach (SBA) (Shami and Verhelst, 2007)

Pitch	Intensity	Speech Rate
-Variance	-Variance	-Sum of Absolute Delta MFCC
-Slope	-Mean	-Var. of Sum of Abs. Delta MFCC
-Mean	-Max	
-Range		-Duration
-Max		
-Sum of Abs Delta		

Speech research is already at a mature stage. Some studies focus on finding the most relevant acoustic features of emotions in speech as in (Fernandez and Picard, 2005; Cichosz and Slot, 2005). Other studies search for the best machine learning algorithm to use in constructing the classifier or investigate different classifier architectures. Lately, research has shifted towards investigating the proper time scale (utterances, segments) to use when extracting features as in (Shami and Kamel, 2005; Katz et al., 1996). Segment based approaches try to model the shape of acoustic contours more closely. There are also attempts to take into account phoneme-level prosodic and spectral parameters. (Lee S. et all., 2006(b), Lee, C.M. et all, 2004, Bulut et all 2005) All these efforts have lead to better and better ML-classifiers.

In all of the mentioned studies the classifiers were trained on one single speech corpus. It is known that ML-classifiers do not perform well on samples from other databases. There are no studies concerned with the problem of dependency of classifiers on the used speech corpora.

Multi-corpora recognition

A recent study, conduced at VUB-ETRO (Shami M., Verhelst W., 2007) treats the problem of multi-corpus training and testing of ML-classifiers. The study is based on the use of four emotional speech corpora: *Kismet, BabyEars* (both in American English), *Danish* (in Danish), and *Berlin* (in German). The four databases were grouped in two pairs: 1. Kismet-BabyEars pair, which contains infant directed affective speech, and 2. Berlin-Danish pair, containing adult directed emotional speech. The other difference between the two database pairs (DB-pairs) is in the length of the utterances (the infant-directed DB-pair contains shorter utterances).

Two approaches, corresponding to the two feature vectors (tables 1 and 2), were used - the segment based approach SBA and the utterance based approach AIBO. The two considered main questions have been: "When a classifier is trained to recognize a given emotion in one database, does it recognize the considered emotion in another database?" and "How does an ML-classifier perform if it is trained and tested on merged corpora, in other words – can it generalize?" The "behaviour" of the classifiers described in Shami and Verhelst (2007) lead to several fundamental questions concerning the recognition of emotion in speech.

The speech entities in the four corpora contain speech instances for different sets of basic emotions, some of them overlapping. Table 3 and table 4 give the emotion labels (E-labels) and the numbers of speech instances labelled with them in each of the databases.

For the multi-corporal testing of classifiers, first the speech instances of the non-corresponding E-labels in each pair were removed from the initial databases. In this way "reduced" databases were obtained with only the common E-labels for the pair classes. The following experiments were done:

Table 3 Emotion Classes in Kismet and BabyEars databases (Shami and Verhelst, 2007)

Kismet		Baby Ears	
*Approval	185	*Approval	212
*Attention	166	*Attention	149
*Prohibition	188	*Prohibition	148
*Soothing	143		
*Neutral	320		

Table 4 Emotion Classes in Berlin and Danish databases (Shami and Verhelst, 2007)

Berlin		Danish	
*Anger	127	*Angry	52
*Sadness	52	*Sad	52
*Happiness	64	*Happy	51
*Neutral	78	*Neutral	133
*Fear	55	*Surprised	52
*Boredom	79		
*Disgust	38		

Between-corpora experiment: Training on the one and testing on the other database of the pair. The results are not surprising: it seems that training on one database and testing on another database is not possible in general with the existing approaches.

Integrated corpus experiment: Merge databases into one "Integrated corpus" (for each pair).

First condition: Merge the classes from the corresponding E-label into a joint "common" class. For example, the instances from Kismet*Approval and from Baby ears*Approval were fused in a novel class: Integrated*Approval. The ML-classifiers were trained and tested on the fused classes. They "learned" them and "performed" the recognition task surprisingly well (classification accuracies: 74.60% for Kismet-Baby Ears and 72.2 % for Berlin-Danish[5]).

Second condition: Keep in the Integrated corpus the classes as they were in the initial databases of the pairs. The ML-classifiers were trained and tested in the integrated corpora on the old classes.

The classification accuracies obtained in the two "integrated" conditions were similar: the accuracy of the classifiers in an "integrated corpus" could be seen as average of the accuracies in the one and in the other databases of the pair. So, the use of a heterogeneous corpus does not lead to a notable deterioration in classification accuracy. This is a very good practical result, as it is known that the less uniform the training corpus is, the less accurate the classifier is. And, on the other hand, a classifier learned using heterogeneous corpora is more robust. One important conclusion, given in this study, is that the existing approaches for classification of emotions in speech are efficient enough to construct a single classifier, based on larger training data from different corpora. From the practical point of view, the result gives a solution for building classifiers in integrated corpora with shared emotion classes.

Here the results have been analysed from the point of view of another interesting finding, related to the representation of the emotion classes in the feature space. The result is seen in the Second "integrated" condition, were the emotion-classes have been preserved as they were in the initial databases of the pairs.

Table 5. Confusion matrix of Berlin-Danish Integrated corpus (Shami and Verhelst 2007)

A	B	C	D	E	F	G	H	←	classified as
74	1	2	1	0	0	0	0	A	Berlin*Neutral
3	36	0	25	0	0	0	0	B	Berlin*Happy
4	0	48	0	0	0	0	0	C	Berlin*Sadness
1	25	0	101	0	0	0	0	D	Berlin*Anger
0	0	0	0	106	2	17	8	E	Danish*Neutral
0	0	0	0	7	29	2	13	F	Danish*Happy
0	0	0	0	21	4	27	0	G	Danish*Sad
0	0	0	0	11	16	2	23	H	Danish*Angry

[5] The results were also compared for different machine-learning algorithms, not given here

For the Berlin-Danish integrated corpus, it turned out that classifiers never "confuse" for example Berlin*Anger and Danish*Angry. The confusion matrix of the Berlin-Danish pair is given in Table 5. It is seen that instances belonging to one of the databases are never "taken" as instances belonging to the other database. Automatic clustering (using the K-means clustering algorithm) showed that the same emotion-classes from the two databases are represented on different clusters and even that the entire databases doesn't share any cluster.

For the Kismet- BabyEars pair there was a small tendency of generalization over the emotions, as some instances of BabyEars were "confused" with the equivalent emotion in Kismet (but never the reverse). Automatic clustering showed that the two databases share four (of the six) clusters and that when there are classes from both databases on one cluster, these classes represent one and the same emotion.

Why these results? This could be linked to the language in which the emotions are expressed. Or to the nature of the emotions - Kismet/BabyEars contains infant directed communicative intents, generally regarded as culture and language independent (Fernald, 1992). In any case, the question which arises at this point is related to the recognition accuracy (RA) of humans on this task.

Comparison with cognitive processes

Human capacity to recognize emotions only from speech, reported in the literature, is between 60% and 85%, depending on the experiments, the emotion classes and other additional circumstances. For example, human listening recognition accuracy has been evaluated to be 79% for stimuli from the BabyEars database (Shami M., Verhelst W., 2006). On Danish database it is 67% (Engberg and Hansen, 1996). What about the vagueness of the different expressed emotions for the listeners? The reported experimental results in the literature show that, depending on the experiment, listeners recognize with unequal success the emotions Anger, Disgust, Fear, Happiness, Sadness, and Surprise, often supported as being basic for humans. For example, human RA is best for Anger and worse for Happiness in the experiment of Lee (Lee C.M. et all, 2004). In Danish database, humans recognise best Sad and worst Happy. The abundance of such examples leads to doubt that the target emotions are well expressed. One can also wonder whether participants share one and the same concept for the label "Sad".

The important point is that, in almost all last year's reported mono-corporal results, the recognition accuracy of the classifiers is comparable with the human categorization capacities for the samples, stored in the corresponding databases. The resemblances between the classifiers and the human evaluators within the same database goes further: as it has been reported by Shami and Verhelst in (Shami and Verhelst, 2007), the use of the SBA approach on the Danish database lead to a classifier which makes the same mistakes as humans. Listeners recognise best *Sad, the classifier does the same; listeners confuse *Surprise with *Happiness and *Neutral with *Sadness, the classifier does the same. From the modelling point of view, that means that the used feature-space is a good projection of the human cognitive space, which contains also models of acoustic parameters of speech emotions. The hope is that such a kind of mapping will be available for the multi-corporal experiment. Unfortunately, that is not the case.

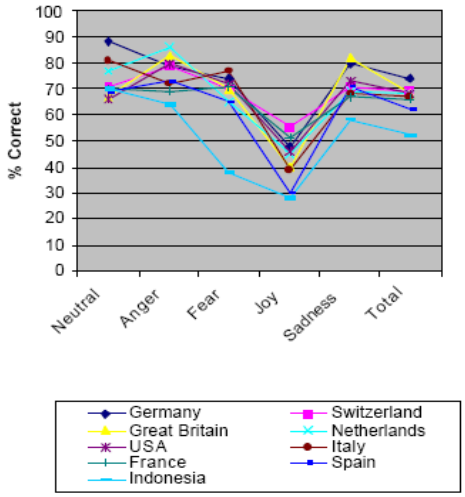

Fig.1. Result for human recognition of speech-emotion across languages and cultures (Scherer K., 2000)

Suppose that the aim is to build a multilingual emotional classifier. The corpus should include labelled classes of speech instances from several databases. A classifier will "learn" Danish*Anger, German*Angry, Polish*Angriness etc. These classes could be fused in one class; the classifier will learn the image of this composed class and will become more robust. As it is demonstrated with the multi-corporal experiments, classifiers "learn" quite well the images of composed emotion-classes, represented on non intersecting clusters in the feature space. One may speculate and fuse Danish*Sad with Berlin*Happy to train the classifier on the novel class "Integrated*Potatoes". The expectation, looking at the confusion matrix of Berlin/Danish pair, is that the classifier will "learn" that class.

A known work in the domain of speech and emotion is the study of Klaus Scherer (Scherer K., 2000, Scherer et all 2001), reporting results (fig. 1) of a multi-language emotion encoding/decoding experiment. Scherer used a set of basic emotions: {*fear*, *joy*, *sadness, anger and neutral*} and tested human recognition accuracy on samples of emotional speech, containing content-free utterances composed of phonological units from many different Indo-European languages. That was done in nine countries, on three continents. In all cases human recognition accuracy was substantially better than chance and showed an overall accuracy of 66% across all emotions and countries, suggesting the existence of similar inference rules from vocal expression across cultures. This key-suggestion is widely accepted in the speech-emotion scientific domain. So, it turns out that there are common acoustic images of emotional speech in the human cognitive space, and they are applied with a good result even for utterances of a never heard or even invented[6] language.

Scherer's study found differences in the results across the countries: the highest accuracies were obtained by native speakers of Germanic languages (Dutch and English), followed by Romanic languages (Italian, French, and Spanish). The lowest recognition rate was obtained for the only country studied that does not belong to the Indo-European language family, Indonesian.

Here a hypothesis could be made: the worse recognition result is obtained when using only the basic "perceptive" features which permit to categorize speech-emotions in the cognitive space.

The better recognition accuracy of the listeners from the other language groups can in this case be explained in two ways: 1. listeners perceive in the samples features *in addition* of the basic perceptive features; 2. the emotion categories in the cognitive space of these listeners were better fitting with the emotion-labels of the samples.

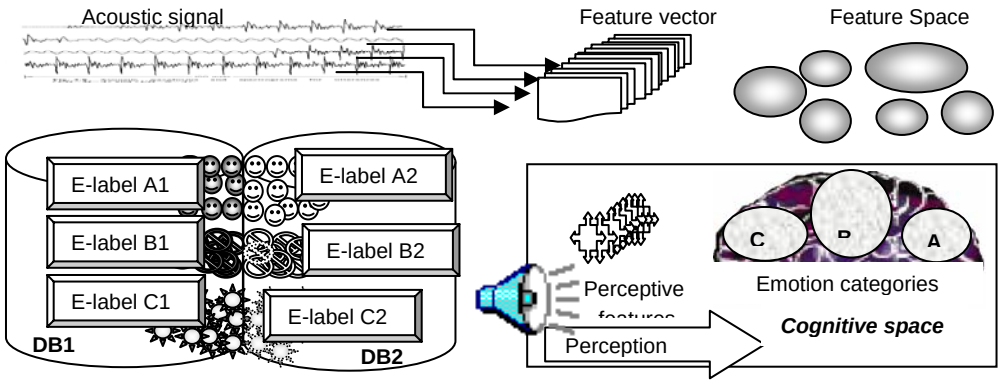

Fig 2. Scheme of the analogy between cognitive process and machine recognition.

The results of the multi-corporal machine leaning experiment are not comparable to the results in the Scherer's experiment. Figure 2 illustrates an analogy between the machine recognition and the human recognition. Classifiers depend exclusively on the labelled training data and humans perform the task without being trained. It is clear that the perceptive features used by humans permit generalisation and categorization of the signal, but the features extracted for the machine classifier do not allow that. If an ideal feature space could be employed, similar emotions belonging to different databases should be assigned to the same clusters, as humans do.

Several atomic hypotheses could be made at this point. For example:

A. There is not enough emotion-relevant information captured by the feature vector.
B. There is language dependent information captured by the feature vector.
C. The perceptual features allow humans to categorize to more general categories. The cognitive space has a structure which permits them to path the sub-category, used in the proposed label.

Concerning the first two hypotheses, a lot of efforts have been made to ameliorate the feature extraction and to find relevant feature vectors. Acoustic correlates of specific emotional categories are investigated in terms of pitch, energy, temporal and spectral parameters, on suprasegmental, segmental and even on phoneme level. This is in aim to extract more and more emotion-relevant information (HUMAINE, 2004a). The question about the language dependence of the used features stays open. Language dependent information is incorporated at all

[6] This is used also in the domain of synthesis of emotional speech – the produced speech is not in any language,

levels of speech prosody. Newborns discriminate different languages. Babies do that without relying on phonemic cues, but on the basis of rhythmic and intonational cues only (Ramus, F., 2002). We may expect that machine-learned classifiers do the same – they discriminate languages. So, the task is to present to the classifier only language independent information. A classic idea is to look for acoustic correlates of emotion in music, which corresponds a lot to Scherer's reasoning. There is a lot of research in this direction (Kim 2004; Kim et all 2004). But the speech signal is much more complex. How could the language dependent and the language independent ingredients of the extracted features be separated, and how to do this on the suprasegmental, the segmental and, why not, on the phoneme level in order to take only the features with pure information about emotions only? Humans can do that. So, it should be possible to do so. Obviously, such a task demands a lot of specific research.

Hypothesis C. requires a separate approach. The C hypothesis explains the good performance of humans in speech emotion recognition with the structure of the cognitive space of emotion categories.

Emotions

To study relations between speech and emotion, it is necessary to derive methods describing emotion. Although there have been numerous studies with regards to both the psychological and the engineering aspect of emotions, it is still not clear how to define and how to categorize human emotions. There are two basic approaches used.

The first approach is "discrete" (Fig. 3). Emotion categories are determined as entities with names and descriptions. Several theorists argue that a few emotions are basic or primary (Ekman, 1992; Izard, 1993). The emotions of anger, disgust, fear, joy, sadness, and surprise are often supported as being basic from evolutionary, developmental, and cross-cultural studies. That theoretical approach is convenient for the purposes of machine learning, as it provides directly labels for the training data. In speech emotion recognition, the attempts have mostly concentrated on a small number of discrete, extreme emotions, in aim to obtain maximally distinguishable prosodic profiles.

Fig. 3. Emotion categories -Labels

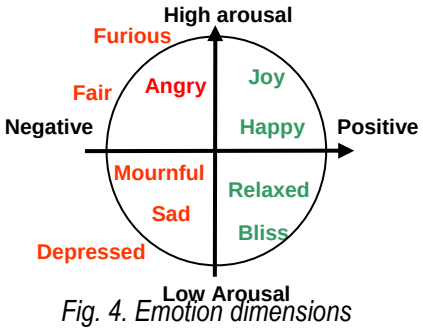

Fig. 4. Emotion dimensions

The other approach is "continuous". The basic properties of the emotional states are described in a continuous space of "emotion dimensions" (fig. 4). The most frequently encountered emotion dimensions are activation (the degree of readiness to act) and evaluation ("valence" in terms of positive and negative). They provide a taxonomy allowing simple distance measures between emotions.

The central question for the experts in the field of speech emotion is: what should be recognized, *emotional categories and/or dimensions*. The performance of human participants and the performance of an automatic recognition system are totally dependent on the number and the degree of differentiation of the emotion categories/dimensions that have to be discriminated. The consensus of the experts from HUMAINE is that "labelling schemes based on traditional divisions of emotion into 'primary' or 'basic' categories is not relevant" (HUMAINE 2004, b). So, the task has turned to cluster the emotional states with names in the continuous space. Several approaches have been developed for this purpose (Douglas-Cowie, et al. 2003; Devillers et al. 2005).

A large study was conducted within the international project AMI (Wan et al., 2005) to determine the most suitable emotion labels for the specific context of *meetings*. One of the contemporary labelling schemes *FeelTrace* (Cowie et al. 2000), which is based on the above mentioned emotion dimensions, was used. A listing of 243 terms describing emotions was compiled from the lists of three research centres. These emotion-labels were first *clustered by meaning* by the project's experts. After that, participants from various companies and professions

evaluated the position of the separate emotions on the axes. Figure 5 gives the plot of the participant's evaluation of the emotions from one meaning-cluster.

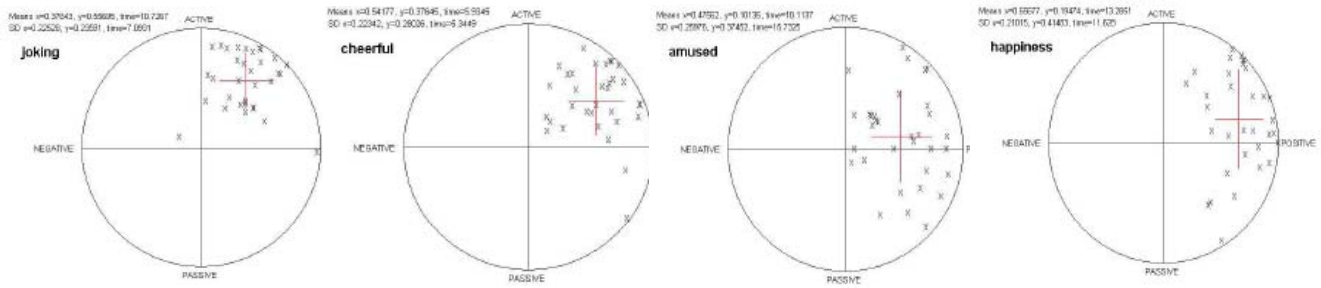

Fig. 5. Results of landmark placement survey for joking, amused, cheerful and happiness (Wan et all, 2005)

The first observation when analysing this experiment is that one can cluster emotion-names *by meaning*. The second observation is that the others agree on the same meaning-cluster, as they locate the emotions' names from the cluster on approximately the same place. The last observation is that the dispersion of participants' evaluations covers "semicircles" and quarters of the plane. One may suppose that in the cognitive space there exist "generalized" categories, in correspondence of the clusters. In any case, the agreement of the participants on the meaning of the axes is evident. Where meaning and categories appear, there should be an attempt to analyse the cognitive processes underlying emotion.

A Possible Cognitive Science Reasoning

At a first stage one should check if there are physiological phenomena, leading human beings to "innate" perception of the dimensions of emotion properties. Emotion-related biological changes are well documented. Recent studies (Kim 2004, Kim at all. 2004) also showed that parameters from measurements as cardiograms, encephalograms, respiration and skin conductivity, are highly correlated with the emotional dimensions. The study was conduced by provoking emotive states using music stimuli. As it is illustrated in fig. 6, on the Arousal axe there are two well distinguishable clusters, obtained when hearing songs inducing {joy and anger} for the right cluster and {sadness and bliss} for the left cluster.

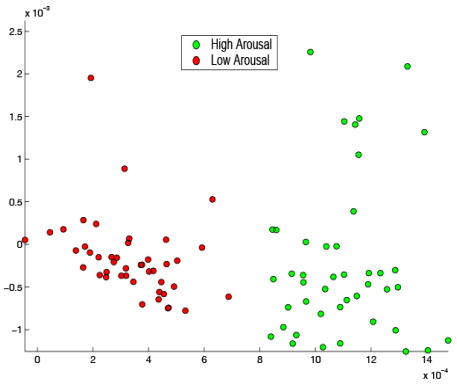

Fig. 6 Physiological clusters on the Arousal axe (Kim et all 2004)

So, there exists some innate knowledge about the emotion dimensions, as no-one learns how to feel when listening to music and what would be the heart rhythm at that moment. The hypothesis that in the cognitive space "general" emotional categories exist is supported by the results, as the obtained physiological clusters correspond to quadrants of the plane on figure 4. The set of stimuli and the reactions suggest that humans distinguish such general categories.

These "general" categories do not obligatory have names. It is known in cognitive science that humans divide perceptual continuums intervals and then give names to the intervals. One example is the perception of colours and their names. The continuum of light frequencies is perceived in the same way by human being. But different cultures divide this continuum into intervals in different manner (and gave them names as "red" or "blue"). There are cultures in which the named-intervals for what we call "white" are nine and cultures which have only two names of colours for the entire spectrum.

The hypothesis that humans perceive features in emotive speech that allow them to categorize to more general categories seems reliable. These categories do not necessarily have names in the language(s). But when presenting to someone a sample of positive active speech and the labels {angry, sad, happy, fear and neutral}, she will certainly decide that it is "happy".

The problem is how to shape the feature space of multilingual classifiers of emotions.

The most convenient for machines are taxonomies and tree structures. Imagine the plane arousal-valence is covered with specific emotions, as it shown in figure 7, for example with the labels E1 to E8 (This precise

positioning is purely geometrical; the labels are just covering the quadrants and the neutral positions). Assume the position of these labels corresponds to precise emotions like Anger, Happiness etc. By the way, the names of those places can be determined.

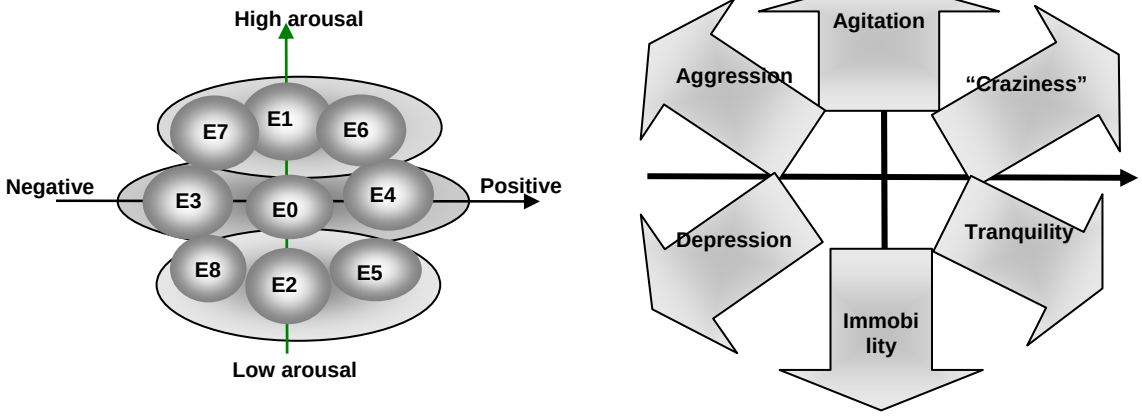

Figure 7 (a). Lower level of the taxonomical trees; (b) Tendencies of behaviour in the emotions' space.

Suppose these areas are leafs of a taxonomial tree. The upper level of the tree corresponds to general categories. As shown in figure 8, the taxonomic structure of general categories and more concrete emotions could be in two ways: 1. division to general categories depending on the arousal and to more concrete states following the valence – positive, neutral or negative (figure 8(a)); 2. division to general categories according to the valence and to concrete states following the arousal - positive, neutral or negative (figure 8(b)). As it is shown in figure 7(b), the 'general' level of classification could be useful for determining the tendency of the subject's behaviour.

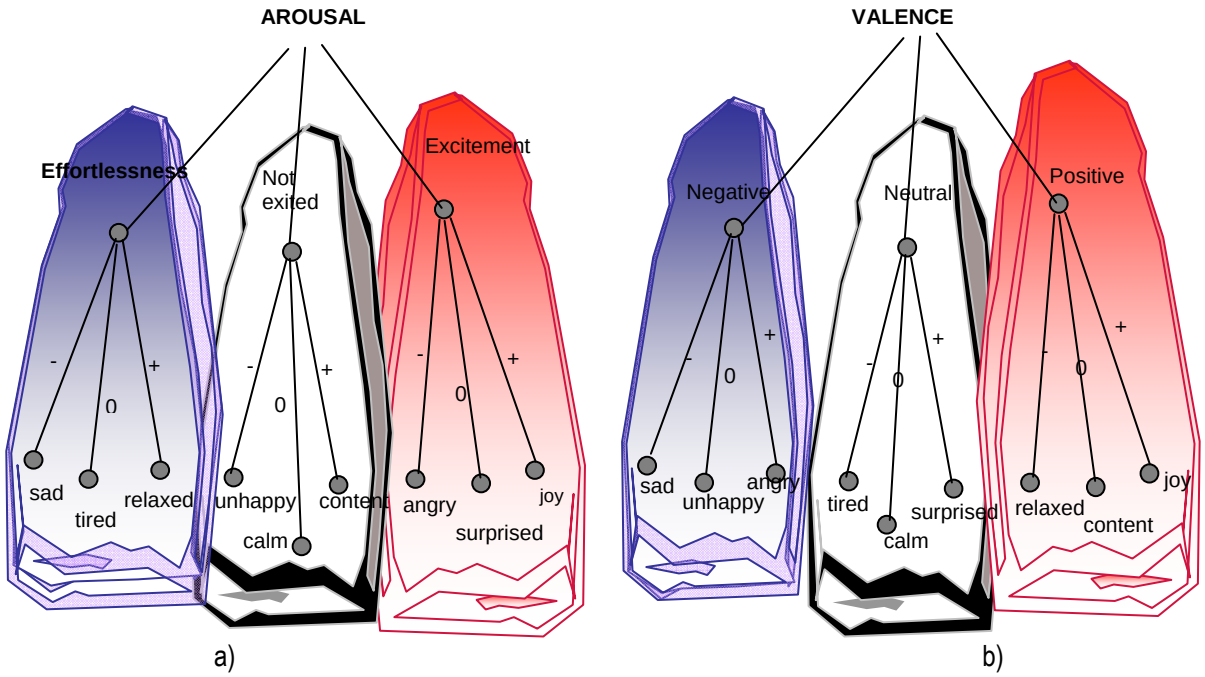

Figure 8. Taxonomies of general emotional categories and less general emotions.

Suppose that the set of language independent features, which leads to the classification to the general categories, is known. The proposal is to use the same strategy as humans seem to do. That leads to the following "algorithm":

- Take into account only language independent features.
- Classify to which general category belongs the speech signal.
- If we have information on the language, use additional information and classify to a leaf.

This strategy demands a kind of double classification – first to the general category and after that - to a leaf. But it avoids big mistakes. Such a classifier wouldn't need more and more data to be trained.

From a general point of view, the capacities of a machine-learned classifier are never as perfect as human capacities for recognition and categorisation. It is obvious that the use of additional channels of information for the machine recognition, such as visual (expression) features, will be very helpful.

Conclusion

In this paper it was assumed that language dependence is an important factor explaining why machine learned classifiers in (Shami and Verhelst, 2007) did not generalize from one database to the next. It should be noted, however, that the explanation more likely lies with the different ways in which the emotions are expressed in the different databases in general. Besides language and cultural differences, such differences could also have several other causes like the social setting in which the emotion occurs, the emotion as a permanent state of mind or induced by a specific exceptional event, etc. In (Shami and Verhelst, 2007), no generalization was found when the classifier was trained on the Danish database and tested on the German database or vice versa. However, in the Danish database, the emotions with a same label are usually more subtly expressed and more varied than in the German database, whose samples often sound over-acted, and it is not at all clear that this is language related. Further, there was only very little generalization between the two English databases even though, besides the English language, both databases shared a motherese style of expressiveness. Therefore, it is not proven that "existing approaches for supervised machine learning lead to database dependent classifiers which can not be applied for multi-language speech emotion recognition ... because they discriminate the emotion classes following the used training language".

The field of speech emotion recognition has achieved several promising results. However, the data-driven approaches lead to machine learned classifiers that are database dependent. The problem can be solved by means of merging emotion-speech corpora and training with more and more data.

Experimental results for human emotion recognition showed that the underlying cognitive mechanisms allow language independent categorisation although the information about the used language is deeply involved in the speech signal. The analysis suggested also that the cognitive process uses some internal structure of the emotional categories, existing in the cognitive space.

In this paper, we elaborated a general strategy for developing language independent emotion recognition, which does not need large amount of training samples in all languages. The proposed approach provides a basis for a future research and experimental work. The study should first consider the identification of language independent speech features and culture independent information from parallel modalities such as visual (expression) features. In a second step we would analyse several classifiers, by considering the general categories of emotion. Parallel to that we will investigate the relationship/dependencies between the emotion categories and language(s) for the classification of leafs (if necessary). A comparison with state-of-the art of automatic emotion classifiers will be made.

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CULTURE ASPECTS OF INFORACTION

Krassimir Markov, Stoyan Poryazov, Krassimira Ivanova, Ilia Mitov, Vera Markova

Abstract: The adequate attitude to the information models and information objects in the culture context is one of the main problems to be investigated on the threshold of information society. The goal of this paper is to outline some problems connected with the main styles of perceiving of the mental and artificially generated information models stored in the information objects and used in the processes of the Information Interaction or simply – in the Inforaction. The culture influence on inforaction is discussed.

Keywords: General Information Theory, Inforaction, Information Models, Artificial Information Models

ACM Keywords: A.1 Introductory and Survey

Introduction

The world common information bases make possible to exchange information of any kind. Some information could not be proved easy, some is assumed as "clear". In addition, now we have a new phenomenon – artificially created information objects which need to be treated in eligible way.

What is the proper approach to the perceiving of the ocean of information we exchange during the information interaction?

The adequate attitude to the information objects in the culture context is one of the main problems to be investigated on the threshold of information society. The information interaction is not isolated process. All culture phenomena influence to the styles of perceiving the information objects. The interrelations between two main opposite – scientific and non-scientific – styles of perceiving the information models need to be discussed.

The investigation in this paper is provided from point of view of the Theory of Inforaction (a part of the General Information Theory (GIT) [Markov et al, 2007]). The goal of this paper is to outline the main styles of perceiving of the mental and artificially generated information models stored in the information objects used in the processes of the Information Interaction or simply – the *Inforaction*.

Our further explanation needs of remembering some basics from the General Information Theory (GIT) [Markov et al, 2007].

The information models

The concept "model" has been used for denotation of the very large class of phenomena: mechanical, theoretical, linguistic, etc. constructions. Marx Wartofsky gave a good definition of the model relation and made clear the main characteristics of the model [Wartofsky, 1979]. This definition is as follow:

The model relation is triple M:

$$M: (S, x, y)$$

where "S" is subject for whom "x" represents "y". In other words only in this relation and only for the subject "S" the entity "x" is a model of the entity "y".

As we point in [Markov et al, 2007], the interaction between two entities is a specific theirs relationship. If there exist information witness (W) of the interaction between two entities as well as of the existence of the information about the first entity (A) in the second entity (B), W became as subject for whom the information in the second entity (B) represents the first one (A) (the information of A in B represents A). In other words, there exists relation

$$M: (W_{BA}, I_{BA}, A),$$

where "A" and "B" are entities, and the W_{BA} is the information witness, which proofs that the assertion "$I_{BA} \subset B$ is information in B for A" is true. In the relation (W_{BA}, I_{BA}, A) the information I_{BA} is a model of A.

The entities of the world interact continuously in the time. It is possible, after any interaction, the other one may be realized. In this case, the changes received by any entity, during the first interaction, may be reflected by the new entity. This means the *secondary (transitive, external) reflection* exists. The chain of the transitive reflections is not limited.

Let A, B and C are entities. Let A and B interact and after that B interacts with C.

Let there exist the relations:

- M_{BA}: (W_{BA}, I_{BA}, A), where W_{BA} is the information witness, which proofs that the assertion "$I_{BA} \subset$ B is information in B for A" is true; i.e. I_{BA} is information of A in B.
- M_{CB}: (W_{CB}, I_{CB}, B), where W_{CB} is the information witness, which proofs that the assertion "$I_{CB} \subset$ C is information in C for B" is true; i.e. I_{CB} is information of B in C.
- $M_{C(B)A}$: ($W_{C(B)A}$, $I_{C(B)A}$, A), where $W_{C(B)A}$ is the information witness, which proofs that the assertion "$I_{C(B)A} \subset$ C is information in C for information in B for A" is true; i.e. $I_{C(B)A}$ is transitive information of A in C.

In such case, from point of view of the $W_{C(B)A}$ the information $I_{C(B)A}$ is a model of A. In other hand, because of transitive reflection, $I_{C(B)A}$ is created as reflection of the sign I_{BA} but not directly of A. This means that $I_{C(B)A}$ is a model of the information in B for A, i.e. $I_{C(B)A}$ is an ***information model*** in C for A [Markov et al, 2001].

The collecting of information models for given entity in one resulting entity may exist as a result of the process of interaction between entities. Such process is in the base of the *Information modeling*.

The possibility of self-reflection may cause the generating the new information models in the memory without any external influence.

Information Objects and Processes

The entity, which has possibility for:

- *(primary) activity* for external interaction;
- *information reflection and information memory*, i.e. possibility for collecting the information;
- *information self-reflection*, i.e. possibility for generating "secondary information";
- *information expectation* i.e. the (secondary) information activity for internal or external contact;
- *information modeling and resolving the information expectation*

is called Information Subject or Infos [Markov et al, 2007].

An entity, in which one or more information models are reflected, is called ***"information object".***

The information objects are only tools for the information exchange in the space and time, i.e. for the realizing the information interaction.

The information objects can have different properties depending on:

- the kind of influence over the entities - by ordering in space and time, by modifying, etc.,
- the way of influence over the entities - by direct or by indirect influence of the Infos on the object,
- the way of development in time - static or dynamic,

etc.

It is clear, that the Infoses are information objects.

The information is kind of indirect reflection. The only way one to operate with information is to operate with the entity it contains. An action on the entity may cause any internal changes in it and this way may change the information already reflected. The influence over the information object, regarding the contained information, is called "*information operation*".

The information operations may be of two main types:

- the Infos internal operations with the sub-entities that contain information,
- external operations with the information objects that contain information.

The internal operations with the sub-entities closely depend of the Infos possibilities for self-reflection and internal interaction of its sub-entities. The self-reflection (self-change) of the Infos leads to the creating of new relationships (and corresponding entities) in it. These are subjectively defined relationships, or shortly – *subjective relationships*. When they are reflected in the memory of the Infos they initiate *subjective* information model. These subjective information models may have not real relationships and real entities that correspond to them. The possibility for creating the relationships of similarity is a basis for realizing such very high level operations as "comparing elements or substructures of the information models", "searching given substructure or element pattern in the part or in the whole structure of the information model", etc.

The external operations with information objects may be differed in two main subtypes – basic and service operations.

There are two "*basic information operations*" which are called I-operations:

- I-reflection (reflecting the information object by the Infos, i.e. the origination of a relevant information model in the memory of the Infos).
- I-realization (creating the information object by the Infos);

In the process of its activity, the Infos reflects (perceives) information from the environment by proper sub-entities (sensitive to video, acoustic, tactile, etc. influences) called "*receptors*". Consequently, the Infos may receive some information models. This subjective reflection is called "*I-reflection*".

When necessary, the Infos can realize in its environment some of the information models, which are in his memory, using some sub-entities called "*effectors*". Consequently, new or modified already existing entities reflect information, relevant to these information models. This subjective realization is called *"I-realization"*.

There are several operations, which can be realized with the information objects: transfer in space and time, destroying, copying, composition, decomposition, etc. Because of the activity of the Infoses, these operations are different from other events in reality. In this case, the Infos determined operations with information objects are called "*service information operations*".

Let t_1, t_2,..,t_n are information operations. The consequence of information operations P, created using the composition, i.e.

$$P = t_1 \circ t_2 \circ \ldots \circ t_n$$

is called "*information process*". In particularly an information process can include only one operation.

The Information Societies

If an information model from an Infos is reflected in another entity, there exist possibility, during the "a posterior" interactions of the given entity with another Infos, to transfer this reflection in it. This way an information model may be transferred from one Infos to another.

Let S_1 and S_2 are Infoses and O is an arbitrary entity. The composition of two contacts

$$S_1 \xrightarrow{\Theta_{S_1O}} O \xrightarrow{\Theta_{OS_2}} S_2 \qquad (1)$$

is called "*information contact*" between Infos S_1 and Infos S_2 iff during the contacts any information model from S_1 is reflected in the Infos S_2 true the entity O. The Infos S_1 is called "*information donor*", the Infos S_2 is called "*information recipient*", and the entity O is called "*information object*".

For the realization of one information contact at least one information object is necessary. This way the elementary communicative action will be provided. In general, every information process "k", having as a start domain the set S_d (of information models) and as a final domain the set S_r (again of information models), which may be coincidental, we call "information contact": k: $S_d \rightarrow S_r$. S_d is called "Infos-donor" and S_r - "Infos-recipient".

The set "R" of all information contacts between two Infoses S_a and S_b : R= $\{k_i \mid i=1,2..; k_i:S_a \rightarrow S_b\}$ is called "*information interaction*" or simply "*inforaction*".

When S_a and S_b are coincident, we call it Information interaction with itself (in space and time). The set "B" of all information objects, used in the information interaction between given Infoses is called "*information base*".

A set of Infoses is called "Society", iff there exists agreement for information interaction between them, by means of which they could communicate. An important element of this agreement is the availability of a common information base. In other words, every group of information subjects, people in particular, is a society if any agreement for information interaction between them exists.

This definition is in accordance with usual understanding of the concept "society". The sociologist Richard Jenkins remarked that the term addresses a number of important existential issues facing people [Jenkins, 2002]:

> 1. How humans think and exchange information – the sensory world makes up only a fraction of human experience. In order to understand the world, we have to conceive of human interaction in the abstract (i.e., society).

2. Many phenomena cannot be reduced to individual behavior – to explain certain conditions, a view of something "greater than the sum of its parts" is needed.

3. Collectives often endure beyond the lifespan of individual members.

4. The human condition has always meant going beyond the evidence of our senses; every aspect of our lives is tied to the collective.

We shouldn't picture the information base like a number of drives with a certain data recorded, although it's the way it's been since the beginning – it was recorded on clay plates, papyrus, paper. The ability for digital storage of the data lays the beginnings of the genesis of the "Information Societies".

It's obvious that, there are many societies with correspondent information bases, and a person could belong to more than one society. Thus we could talk about "information societies" which exist in a certain way with or without a particular correlation between them. And it's not very likely for the humanity to reach such state of integrity so we could use this term in singular when speaking about the population of the whole planet. Nevertheless the concept "global information society" is very popular. This is a general concept which means the hypotetic digitally based integrated humanity.

The Culture Environment

The concept "Culture" means "every aspect of life: know-how, technical knowledge, customs of food and dress, religion, mentality, values, language, symbols, socio-political and economic behavior, indigenous methods of taking decisions and exercising power, methods of production and economic relations, and so on" [Verhelst, 1990].

The culture permeates and influences every aspect of life, but it is not static however, rather it is a process in a constant state of flux and adaptation to new contexts, demands, and needs. Culture is not a deterministic force but rather a subtle and often subliminal pattern of thinking that describes the "organization of values, norms, and symbols which guide the choices made by actors, limit the types of interaction and may occur between individuals" [Parsons et al, 1990].

Culture is "learned, and shared. In addition, culture is adaptive. Human beings cope with their natural and social environment by means of their traditional knowledge". In other words, as something inherited, 'traditional' cultural knowledge developed within a particular spatial and temporal "context" or "environment". But as a dynamic process culture continues to change as people cope with new challenges and adapt to changing conditions. Underlying values and expectations are arbitrary conceptions "of what is desirable in human experience, ... (and) these concepts of what is desirable combine cognitive and affective meanings ... they provide security and contribute to a sense of personal and social identity. For this reason, individuals in every society cling tenaciously to the values they have acquired and feel threatened when confronted with others who live according to different conceptions of what is desirable". Thus culture is like a "security blanket" which "has great meaning to its owner" [Spradley, McCurdy, 1987].

"Culture is at once socially constituted (it is a product of present and past activity) and socially constitutive (it is part of the meaningful context in which activity takes place)" [Roseberry, 1989].

A diversity of specific culture concepts was grouped into different categories and shown in table 1 as follows.

Table 1: Different definitions of culture ([Cultural Capital, 2003])

Definitions	
Topical	: Culture consists of everything on a list of topics, or categories, such as social organization, religion, or economy
Historical	: Culture is social heritage, or tradition, that is passed on to future generations
Behavioral	: Culture is shared, learned human behavior, a way of life
Normative	: Culture is ideals, values, or rules for living
Functional	: Culture is the way humans solve problems of adapting to the environment or living together
Mental	: Culture is a complex of ideas, or learned habits, that inhibit impulses and distinguish people from animals
Structural	: Culture consists of patterned and interrelated ideas, symbols, or behaviors
Symbolic	: Culture is based on arbitrarily assigned meanings that are shared by a society

The anthropologist Leslie White (1900-1975) suggested that for analytical purposes, a culture could be viewed as a three-part structure composed of subsystems that he termed ideological, technological, and sociological. In a similar classification, the biologist Julian Huxley (1887-1975) identified three components of culture: mentifacts, artifacts, and sociofacts. Together, according to these interpretations, the subsystems comprise the system of culture as a whole. But they are integrated; each reacts on the others and is affected by them in turn [Fellmann et al, 2007].

- *Mentifacts*: The ideological subsystem consists of ideas, beliefs, and knowledge of a culture and of the ways in which these things are expressed in speech or other forms of communication. Mythologies and theologies, legend, literature, philosophy, and folk wisdom make up this category. Passed on from generation to generation, these abstract belief systems, or mentifacts, tell us what we ought to believe, what we should value, and how we ought to act. Beliefs form the basis of the socialization process. Often we know (or think we know) what the beliefs of a group are from their oral or written statements. Sometimes, however, we must depend on the actions or objectives of a group to tell us what its true ideas and values are. "Actions speak louder than words" and "Do as I say not as I do" are commonplace recognitions of the fact that actions, values, and words do not always coincide.
- *Artifacts*: The technological subsystem is composed of the material objects, together with the techniques of their use, by means of which people are able to live. Such objects are the tools and other instruments that enable us to feed, clothe, house, defend, transport, and amuse ourselves. We must have food, we must be protected from the elements, and we must be able to defend ourselves. Huxley termed the material objects we use to fill these basic needs artifacts.
- *Sociofacts*: The sociological subsystem of a culture is the sum of the expected and accepted patterns of interpersonal relations that find their outlet in economic, political, military, religious, kinship: and other associations. These sociofacts define the social organization of a culture. They regulate how the individual functions relative to the group, whether it be family, church, or state. There are no "givens" as far as the patterns of interaction in any of these associations are concerned, except that most cultures possess a variety of formal and informal ways of structuring behavior. Differing patterns of behavior are learned and transmitted from one generation to the next [Fellmann et al, 2007].

It is clear that the sociofacts are variety of information models whith different importance and actuality.

Let remark that the main and most important part of artifacts is formed by the techniques, i.e. the information models of using the material objects. Without this information the material objects are unusable. In addition, without knowledge, without the information models to build material objects they could not became reality. So, we may conclude, that the information models are in the base of artifacts.

The mentifacts, in particulary the esoteric and religious information objects, are important parts of the culture environment. Theirs main characteristic is that they explicitly or implicitly lead to any supernatural phenomena. The exoterics and religions correspond to thousands-years old concepts. Because of this, the discussion is more complicated and needs an example. We may ask ourselves “What is Santa Claus”. From the point of view of our paradigm we could answer: Santa Claus is an information model, which, if followed could achieve very delightful results. That’s why he doesn’t die, as long as there are people who follow the model. It’s not simple but rather a subject with a great variety of personifications – from the jolly old man, who the Coca-Cola Company dressed in red, and the Pepsi Company – in blue, to the vivid character of the Russian Ded Moroz who’s wearing a huge fur-coat, a boyar hat and has a down-to-the-waist beard. Believing in Santa Claus is actually accepting and following of one of the variations of his information model. Every religion is a totality of information models, which are assumed and followed. Many of them are very important for human been and for stability of the social systems.

At the end we need to ask "Where is the difference between the religion and the science, which is also a combination of important information models to be followed?" It is clear – at the first place the difference is the believing in the supernatural phenomena. This leads to the way we create and perceive the information models and the attitude to them. There are two main ways:

– *The first* is wonderfully described by the motto of the medieval theologian Anselm of Canterbury, lately canonized as St. Anselm (1033-1109): ***"Credo, ut intelligam!"*** (I believe in order to understand) [St.Anselm]. You have to believe in the information model, so you could understand and follow it. This is the non-scientific

approach – every subjective notion can turn into a commonly accepted model or dogma, as long as there's someone to believe in it and follow it implicitly.

– *The second* is described with the phrase *"Intelligo, ut credam !"* (I understand in order to believe), used by the German reformer Thomas Muentzer (~1490-1525) [Muentzer]. You have to understand the information model and only after then to trust it if possible. This is the scientific approach – every science builds information models – hypothesizes, which are repeatedly tested before assumed to be true. The scientific approach includes a permanent improvement and revolutions of the existing models [Kuhn, 1966].

The culture aspects of the inforaction

From the point of view of the Theory of Inforaction the cultural environment is the set of all information bases (in the sence given above) which are available in the society. These bases grow permanently because building and exchanging of information models are basic activities for every society. Whether they are perceived with the scientific or non-scientific approach is a question only of the circumstances, executors and users.

In the information contact (1) the Infos S_2 reflects only the information object O, but not the whole process of its genesis. This means that S_2 need to reconstruct in his mind the missing part of the sheme and to make decision what to do with the incoming information model – to accept or not. In this case the important role plays the culture environvent – it may obligate the S_2 to accept O as a dogma or to fill free to make his own decision.

In addition, the information models and objects generated by any artificial systems (Infortrons [Markov et al, 2007]), i.e. so called "*artificial information models and objects*" became one of the main tools for information interaction.

What is the purpose of artificial systems?

– to be a substitute of any of the Information Subjects (Infoses);

– to extent its possibilities to create the information models.

In both cases if an artificial information model is used in the process of information interaction, the perceiver need to decide what attitude he or she needs to assume. The artificially generated information objects may be of any kind and some times it is impossible to make diference between human and artificially generated information object. In addition, in the information processes any information operations may be provided by any artificial systems and the final result may be an information object with mixed genesis.

The receiver's "information immune system" needs to select what from incoming information objects to be verified and what not. Usualy, the scientific oriented subjects do not accept information models which lead to supernatural origins. For every adult person it is clear that Santa Claus does not exist. But the information objects created from other scientists usually are acceped as already verified. The result may be unpredictable. The main peril is the exchange of scientific approach for non-scientific. The scientific information models may be perceived in non-scientific maner. For instance we may point the myth about spinach.

The myth about spinach and its high iron content may have first been propagated by Dr. E. von Wolf in 1870, because a misplaced decimal point in his publication led to an iron-content figure that was ten times bigger than the real. In 1937, German chemists reinvestigated this "miracle vegetable" and corrected the mistake. It was described by T.J. Hamblin in British Medical Journal, December 1981.

The case with the spinach is an example of the unintentional error. But more dangerous are the aforethought actions which may cause damages in the global range. One very significant example in this area is the myth about the fluoride [EWG, 2006].

Fluoride exposure has created controversial health concerns in the United States. For years, doctors and dentists have alleged that fluoride was actually a benefit to health, promoting strong, cavity free teeth. However, studies have suggested that the health risks associated with fluoride exposure may in fact outweigh the benefits. Fluoride exposure has been linked to the development of bone cancer - including osteosarcoma in children - among other serious health complications.

Fluoride is commonly found in or added to numerous consumer products, including tap water, toothpaste, juices, teas, wines, beers, infant formula, sodas, seafood, processed chicken, cigarettes, cereal, anesthetics and Teflon pans. Doctors and dentists have long recommended fluoride exposure for the prevention of tooth caries such as cavities and decay. Accordingly, many municipalities artificially fluoridate their public water supply. Fluoridated water is the greatest source of exposure to fluoride for children.

The federal government first set limits on the amount of fluoride in tap water in 1945. The recommended or optimum level for artificial fluoridation of drinking water was then set at 1 ppm or 1mg/L and remains at that level today. In the 1980s, the United States Environmental Protection Agency revisited the recommendations and raised the maximum contaminant level (or maximum amount of fluoride allowed in water and still considered safe) to 4ppm. Municipalities can independently determine whether to fluoridate their water supplies but cannot exceed the levels set by the federal government. Approximately 60% of all public water is or has been fluoridated.

Recent studies suggest a strong correlation between childhood fluoride exposure and the development of osteosarcoma in young boys. Studies performed by the United States National Toxicology Program and Harvard University have determined that there is biological and physical evidence relating the development of osteosarcoma cancer to children experiencing fluoride exposure in the bone formative years.

Fluoride is a known mutagen, particularly where it is found in concentrated amounts. In the body, fluoride accumulation occurs primarily in the bones, particularly during the developmental years. There, fluoride artificially stimulates bone cell growth, generally in long bones such as the legs and arms, leading to cancerous growths. Osteosarcoma in children, particularly young boys exposed during the bone growth spurt years of five to ten, has been specifically associated with the effects of fluoride exposure.

Osteosarcoma cancer is characterized by the growth of a cancerous tumor in the bone. The cancer generally occurs in the legs or arms and may cause pain and swelling, broken bones, or a visible lump. Treatment of osteosarcoma, like other cancers, may include a course of chemotherapy and radiation but osteosarcoma is not particularly responsive to radiation. Surgery, and sometimes amputation, is frequently required to treat a patient with osteosarcoma.

Osteosarcoma is not the only serious side effect of fluoride. Bone cancer, bone pain and swelling, and fluorosis have all been associated with excessive fluoride exposure. The effects of fluoride can cause long term and irreversible health effects. Treatment for osteosarcoma and other fluoride induced health problems can be a long and expensive process resulting in physical, emotional and financial stress on the victim and the victim's family.

In spite of this very dangerous data how many persons, asked on the street, will ansver that the fluoride is not useful for the teeth?

The artificially generated information objects are assumed as scientifically generated and as result they are in the same category of "verified in advace" information models. Again, the resul may be unpredictable. Very important examples are the "e-government" information objects. The inaccuracies of the governvent administrators and of the information systems are assumed as it need to be and the result is a great chaos in the business and social activities. Now, in many of the East European countries and especially in Bulgaria this is an every day situation. The culture environment is very susceptible especially in this case and the cultural changes to the worst may be easily recognized in these countries.

Instead of supporting human acivities the e-systems are taken as control and supervising social elements. In the same time, the government officials are assumed as service attendants of the e-systems which are not responsible for theirs activities. The usual saying is not "the law demands …" but the "system demands …".

At the end, the S_2 may be an Infotron. What do we need to take in account in such case? For many years the Infotrons have simple formal reflection (input) and the cultural environment was undefined concept. But the importance of culture environment is obvious. The Infotrons' decisions closely depend on it especially in the cases when they will live in the same information societies with mankind.

Conclusion

The Artificial Intelligence (AI) needs to pay attention to all available information bases, i.e. the culture environment, during modeling the brain activities. We expect the investigations on the boundary of the individual and social intelligence to become in the focus of the AI scientists. The AI models and realizations will take in account the existence of the culture environment. At the first place, the same AI system may give different results in different culture environments.

In abstract theories it is simple to make classifications like – "natural-artificial", but in the real human activities it is important to clear who owns the responsibility. This closely depends on the culture environment. The role and the importance of a particular exoterics and religions in a certain society are determined by the influence of the people ready to doubt the information models, on the others who easily and “blindly” follow the dogmas.

Keeping in mind the limited abilities of the human mind, we can presume that the non-scientific approach would probably dominate. Just a small part of the humanity would be able to build and understand the difficult scientific information models.

The problem is that the artificial information objects may be considered as "dogmas" because the user will perceive it “blindly” without any additional information about its genesis.

That’s why it’s crucial to keep the harmony and dialectical unity of the scientific and non-scientific approaches, following the wisdom of St. Augustine: ***"Intelligo ut credam, credo ut intelligam!"*** [St. Agustine].

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USING A QUERY EXPANSION TECHNIQUE TO IMPROVE DOCUMENT RETRIEVAL

Abdelmgeid Amin Aly

Abstract: Query expansion (QE) is a potentially useful technique to help searchers formulate improved query statements, and ultimately retrieve better search results. The objective of our query expansion technique is to find a suitable additional term. Two query expansion methods are applied in sequence to reformulate the query. Experiments on test collections show that the retrieval effectiveness is considerably higher when the query expansion technique is applied.

1. Introduction

Since the 1940s the problem of Information Retrieval (IR) has attracted increasing attention, especially because of the dramatically growing availability of documents. IR is the process of determining relevant documents from a collection of documents, based on a query presented by the user.

There are many IR systems based on Boolean, vector, and probabilistic models. All of them use their model to describe documents, queries, and algorithms to compute relevance between user's query and documents. Each model contains some constraints, which cause disproportion between expected (relevant) documents and documents returned by IR system. One of the possibilities (how to solve the disproportion) is systems for automatic query expansion, and topic development observing systems. In this respect, query expansion aims to reduce this query/document mismatch by expanding the query using highly "correlated" to the query terms, words or phrases with a similar meaning or some other statistical relation. To detect such correlations between terms, different based-statistical-measures approaches, requiring the analysis of the entire document collection, have been introduced, e.g., term Co-occurrence measures or lexical co-occurrence measures [1, 2]. Query expansion (or term expansion) is the process of supplementing the original query with additional terms, and it can be considered as a method for improving retrieval performance. The method itself is applicable to any situation irrespective of the retrieval technique(s) used. The initial query (as provided by the user) may be an inadequate or incomplete representation of the user's information need, either in itself or in relation to the representation of ideas in documents.

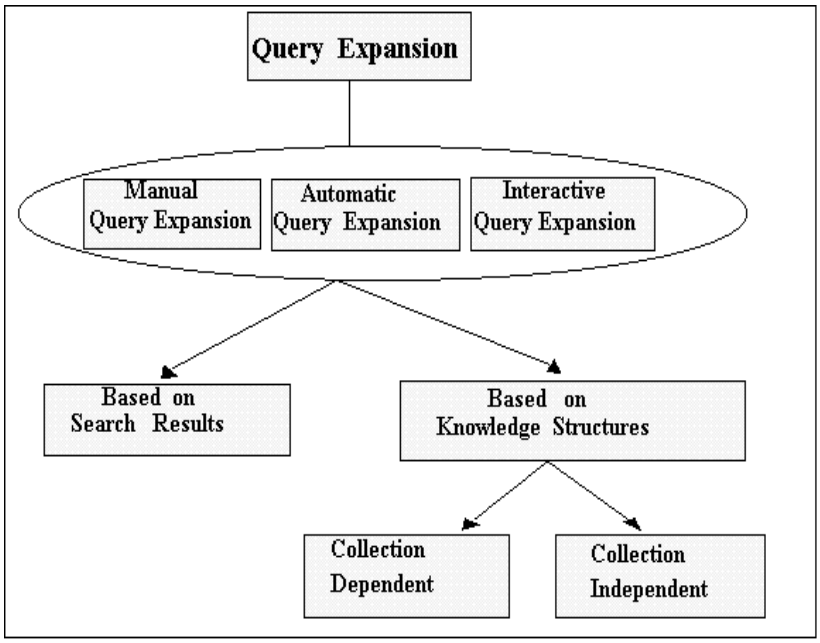

Figure 1: Query Expansion: Methods and Sources

There are three types of QE: manual, automatic, and interactive. Manual QE takes place when the user refines the query by adding or deleting search terms without the assistance of the IR system. New search terms may be identified by reviewing previous retrieval results, communication with librarians or colleagues; other related documents, or a general vocabulary tool are not specific to the IR system (e.g., a dictionary or standard thesaurus) [3]. Decisions about the association of terms are up to the users themselves and are dependent on the expertise of the users with the search system and features [4].

Query expansion involves adding new words and phrases to the existing search terms to generate an expanded query. However, previous query expansion methods have been limited in extracting expansion terms from a subset of documents, but have not exploited the accumulated information on user interactions. We believe that the latter is extremely useful for adapting a search method to the users. In particular, we will be able to find out what queries have been used to retrieve what documents, and from that, to extract strong relationships between query terms and document terms and to use them in query expansion.

Query expansion, as depicted in Figure 1, can be performed manually, automatically or interactively (also known as semi-automatic, user mediated, and user assisted).

2. Related Works

The existing state-of-the-art query expansion approaches can be classified mainly into two classes: global analysis and local analysis.

Global analysis is one of the first techniques to produce consistent and effective improvements through query expansion. One of the earliest global analysis techniques is term clustering [5], which groups document terms into clusters based on their co-occurrences. Queries are expanded by the terms in the same cluster. Other well-known global techniques include Latent Semantic Indexing [6], similarity thesauri [1], and Phrase Finder [7]. Global analysis requires corpus-wide statistics such as statistics of co-occurrences of pairs of terms, which results in a similarity matrix among terms. To expand a query, terms which are the most similar to the query terms are identified and added. The global analysis techniques are relatively robust; but corpus-wide statistical analysis consumes a considerable amount of computing resources. Moreover, since it only focuses on the document side and does not take into account the query side, global analysis cannot address the term mismatch problem well.

Different from global analysis, local analysis uses only some initially retrieved documents for further query expansion. The idea of local analysis can be traced back at least to a 1977 paper [8]. A well-known local analysis technique is relevance feedback [9,10], which modifies a query based on users' relevance judgments of the retrieved documents. Typically, expansion terms are extracted from the relevant documents. Relevance feedback can achieve very good performance if the users provide sufficient and correct relevance judgments. Unfortunately, in a real search context, users usually are reluctant to provide such relevance feedback information. Therefore, relevance feedback is seldom used by the commercial search engines.

To overcome the difficulty due to the lack of sufficient relevance judgments, pseudo-relevance feedback (also known as blind feedback) is commonly used. Local feedback mimics relevance feedback by assuming the top-ranked documents to be relevant [11]. Expansion terms are extracted from the top-ranked documents to formulate a new query for a second cycle retrieval.

In recent years, many improvements have been obtained on the basis of local feedback, including re-ranking the retrieved documents using automatically constructed fuzzy Boolean filters [12], clustering the top-ranked documents and removing the singleton clusters [13], clustering the retrieved documents and using the terms that best match the original query for expansion. In addition, recent TREC results show that local feedback approaches are effective and, in some cases, outperform global analysis techniques [14]. Nevertheless, this method has an obvious drawback: if a large fraction of the top-ranked documents is actually irrelevant, then the words added to the query (drawn from these documents) are likely to be unrelated to the topic and as a result, the quality of the retrieval using the expanded query is likely to be worse. Thus the effects of pseudo-feedback strongly depend on the quality of the initial retrieval.

Recently, Xu and Croft [15] proposed a local context analysis method, which combines both local analysis and global analysis. First, noun groups are used as concepts, which are selected according to their co-occurrences with the query terms. Then concepts are chosen from the top-ranked documents, similarly to local feedback.

3. Traditional Document Retrieval

The task of traditional document retrieval is to retrieve documents which are relevant to a given query from a fixed set of documents, i.e. a document database. In a common way to deal with documents as well as queries, they are represented using a set of index terms (simply called terms) by ignoring their positions in documents and queries. Terms are determined based on words of documents in the database, usually during pre-processing phases where some normalization procedures are incorporated (e.g. stemming and stop-word elimination).

3.1 Vector Space Model

The vector-processing model of retrieval is used to transform both the available information requests as well as the stored documents into vectors of the form:

$$D_i = (w_{i1}, w_{i2}, ..., w_{it}) \quad (1)$$

where D_i represents a document (or query) text and w_{ik} is the weight of term T_k in document D_i. A weight of zero is used for terms that are absent from a particular document, and positive weights characterize terms actually assigned. The assumption is that t terms in all are available for the representation of the information.

In choosing a term weighting system, low weights should be assigned to high-frequency terms that occur in many documents of a collection, and high weights to terms that are important in particular documents but unimportant in the remainder of the collection. The weight of terms that occur rarely in a collection is relatively unimportant because such terms contribute little to the needed similarity computation between different texts.

A well-known term weighting system following that prescription assigns weight w_{ik} to term T_k in query Q_i in proportion to the frequency of occurrence of the term in Q_i, and in inverse proportion to the number of documents to which the term is assigned. [16, 17] Such a weighting system is known as a tf x idf (term frequency times inverse document frequency) weighting system. In practice the query lengths, and hence the number of of non-zero term weights assigned to a query, vary widely. To allow a meaningful final retrieval similarity, it is convenient to use a length normalization factor as part of the term weighting formula. A high- quality term weighting formula for w_{ik}, the weight of term T_k in query Q_i is

$$w_{ik} = \frac{(\log(f_{ik})+1.0)*\log(N/n_k)}{\sqrt{\sum_{j=1}^{t}[(\log(f_{ij})+1.0)*\log(N/n_j)]^2}} \quad (2)$$

where f_{ik} is the occurrence frequency of T_k in Q_i, N is the collection size, and n_k the number of documents with term T_k assigned. The factor $\log(N/n_k)$ is an inverse collection frequency ("idf") factor which decreases as terms are used widely in a collection, and the denominator in expression (2) is used for weight normalization.

The weight assigned to terms in *documents* are much the same. In practice, for both effectiveness and efficiency reasons the *idf* factor in the documents is dropped [18, 19]. The term T_k included in a given vector can in principle represent any entities assigned to a document for content identification. Such terms are derived by a text transformation of the following kind: [20]

1. recognize individual text words
2. use stop lists to eliminate unwanted function words
3. perform suffix removal to generate word stems
4. optionally use term grouping methods based on statistical word co-occurrence or word adjacency computations to form term phrases (alternatively syntactic analysis computations can be used)
5. assign term weights to all remaining word stems and /or phrase stems to form the term vector for all information items.

Once term vectors are available for all information items, all subsequent processing is based on term vector manipulations.

The fact that the indexing of both documents and queries is completely automatic means that the results obtained are reasonably collected independently and should be valid across a wide range of collections.

3.1.1 Text Similarity Computation

When the text of document D_i is represented by a vectors of the form (d_{i1}, d_{i2}, …, d_{it}) and query Q_j by the vector (q_{j1} , q_{j2}, …,q_{jt}), a similarity (S) computation between the two items can conveniently be obtained as the inner product between corresponding weighted term vector as follows:

$$S(D_i, Q_j) = \sum_{k=1}^{t} (d_{ik} * q_{jk}) \quad (3)$$

Thus, the similarity between two texts (whether query or document) depends on the weights of coinciding terms in the two vectors.

In the following section we discuss the query expansion technique that will be used for comparison.

4. Query expansion

Query expansion algorithms at first evaluate given query on collection of documents, and then select from relevant documents appropriate terms. The original query is expanded with such selected terms. The expanded query is used to retrieve new set of relevant documents. In this paper we apply two query expansion methods in sequence to reformulate the query so that it will suit to the user's needs more appropriately. One method we applied is similarity thesaurus based expansion [1], and the other is local feedback method. The similarity thesaurus we use, based on [1], calculates the relevance between terms and queries and is constructed by interchanging the role of documents and terms in retrieval model. The relevance of a term in the similarity thesaurus to the concept of the query is the sum of the weighted relevance of the term to each term in the query. The queries are expanded by adding top *n* relevant terms, which are most similar to the concept of the query, rather than selecting terms that are similar to the query terms.

The local feedback method is similar to traditional relevance feedback method [21], which modifies queries by using the result of the initial retrieval, except that the latter uses the judgment set for calculating re-weighting while the former assumes that the terms in the top ranked *n* documents are relevant to the user's request. Queries are expanded by adding the weight of terms in relevant documents and reducing the weight of terms in last *m* documents of the initial retrieval.

We modify the traditional Rocchio expansion equation to include the query expanded by the thesaurus method and to include negative evidence from the lowest ranked documents rather than non-relevant documents. The new query Q_{new}, including thesaurus expansion, can be defined as the following:

$$Q_{new} = \alpha_1 Q_{org} + \alpha_2 + Q_{te} + \beta \sum_{top} D_i - \gamma \sum_{last} D_j \quad (4)$$

Here, Q_{org} is a initial query, Q_{te} is a query expanded by the similarity thesaurus based method, $\sum_{top} D_i$ represents terms in top ranked documents retrieved in the initial run, and $\sum_{last} D_j$ is terms in low ranked documents. The parameters $\alpha_1, \alpha_2, \beta$ and γ represent the importance of each item. Currently, these parameters are given by human experience. For the initial retrieval, we used the queries expanded by thesaurus method. In this study, we set the parameters as following: $\alpha_1 = 1$, $\alpha_2 = 0.5$, $\beta = 0.6$, and $\gamma = 0.3$.

5. Experiments and their Results

In our experiments, we used the three standard test collections (CISI, NPL, and CACM). We evaluate the performance of the retrieval by average precision measure. Precision is the ratio of the number of relevant documents retrieved to the total number retrieved. The average precision of a query is the average of precisions calculated when a relevant document is found in the rank list. All the query's average precisions are averaged to evaluate an experiment.

Table (1) shows the retrieval quality difference between the original queries and the expanded queries. It seems that the improvement increases with the size of collection.

Table 1: Improvement using expanded queries

Collection	CISI	CACM	NPL
Documents	1035	3205	11430
Avg. precision of original query	0.5547	0.2819	0.1918
Number of additional terms	80	100	800

Avg. precision of expanded query	0.6445	0.3438	0.2448
Improvement	16.19%	21.96%	27.63%

The figure indicates that our query expansion technique yields a considerable improvement in the retrieval effectiveness. It seems that the improvement increases with the size of the collection. In addition, the improvement increases with the number of additional search terms that expand the original query as long as the collection is large enough. In Fig. 2, we show how the number of additional terms affects the retrieval effectiveness. It can be seen easily that the improvement by expanded queries increases when the number of additional terms increases. When the number of additional terms is between 100 and 200, the improvement of the retrieval effectiveness remains constant in the small collections CISI and CACM. Once the number of additional terms gets to be larger than 200, the improvement decreases in the small collections, but continues to increase in the relatively large collection NPL. This could be explained by the fact that more search terms are needed to distinguish relevant documents from non-relevant documents in large collections.

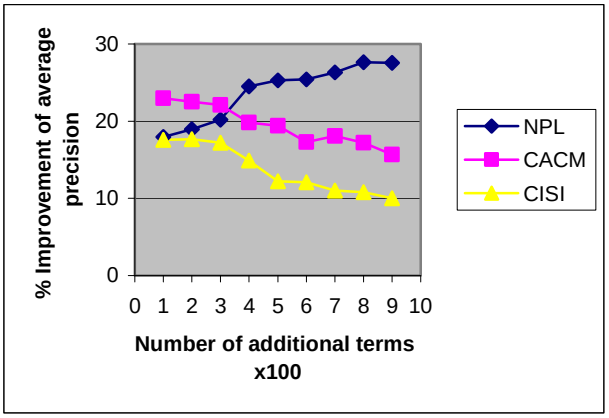

Fig.2: Improvement using expanded queries with various numbers of additional terms

6. Conclusion

We presented a two query expansion methods in sequence to reformulate the query. Our experiments made on three standard test collections with different sizes and different document types have shown considerable improvements vs. the original queries in the standard vector space model. Experiments on test collections showed that the improvement increases with the size of the collection. In addition, the improvement increases with the number of additional search terms that expand the original query as long as the collection is large enough. Also it has been pointed out how the number of additional terms affects the retrieval effectiveness.

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APLICATIONS OF NEURAL NETWORKS TO FIND THE IMPACT OF WATER IN DIFFERENT BERRY COMPONENTS IN GRAPES

Angel Castellanos, Marita Esteban, Ana Martinez, Valentin Palencia

Abstract: *Grape juice composition during the different stages of berry growth was compared. The analytical data collected were used to investigate the relationships between some of the different components studied in these berries during the ripening period.*

Our goal is to study, with neural networks, the impact of water availability on Vitis vinifera L. cv. Tempranillo grape yields and juice composition over a three-year period.

Keywords: Clustering, Grapes, Neural networks, Organic acids, Sugars, Vitis vinifera.

ACM Classification Keywords: C.1. Processor Architectures , I.5.2 Design Methodology

Introduction

The object of the present study is to ascertain whether irrigation, which has a quantitative effect on the values of the different components analysed in berries of the Tempranillo (Vitis vinífera L.) grape variety, though that effect is not always significant [Esteban MA, Villanueva MJ and Lissarrague JR, 1999], [Esteban MA, Villanueva MJ and Lissarrague JR, 2001] affects the relationships between the different components considered.

We use neural networks models with analysis of sensibility. This model predict more accurately the relationship existing.

The purpose of irrigation is to offset crop water deficits and thereby maximize yields and must quality, to increase profits [Rühl EH and Alleweldt G, 1985]. There are many regions with dry summers in Spain in which irrigation is an effective mean of regulating water availability to grape vines.

As has previously been noted by other workers [Williams LE and Matthews MA, Grapevine, 1990], irrigation of grape vines affects vine physiology, which may directly or indirectly affect yield and grape composition (°Brix, pH, total acidity, etc.) two aspects that also influence wine quality. There is considerable controversy in the literature concerning the positive and negative effects of vine irrigation on must and wine quality [Van Zyl JL, 1984].

Response to irrigation will depend upon such factors as harvest time, crop load, soil water availability and primarily summer rainfall.

Sugar concentration is used as an indicator of fruit maturity, being glucose and fructose the principal sugars in grape juices [Ough CS and Amerine MA, 1988]. Irrigation has a variable effect on sugar accumulation in the berries, and an increase, a decrease, or no change in sugar concentration have all been observed [Hardy P.J.,1968]. The sugar to acidity ratio parameter is ordinarily useful in evaluating the ripening period [Ribéreau-Gayon J, Peynaud E, Ribéreau-Gayon P and Sudraud P, 1975]. Both titratable acidity and pH are of great importance for grape juice stability and are parameters commonly used as an indicator of quality. This is because the concentration of organic acids does not only contributes to the acid taste of the must but also influences subsequent wine color and microbiological stability [Boulton RB, 1980]. According to Hrazdina et al. [Hrazdina G, Parsons GF and Mattick LR, 1984] changes in the pH of grape berries are caused by the metabolism of the major acids and the accumulation of cations, which transform free acids into their corresponding salts. Some authors [McCarthy MG, Cirami RM and McCloud P, 1983], [Romero EG, Muñoz GS and Ibañez MDC, 1993] have stated that decreases in titratable acidity are primarily due to losses in malic acid concentration and to the formation of potassium salts. Potassium is the main mineral cation in grapes [Peynaud E and Ribéreau-Gayon J, 1971], and is predominantly involved in neutralization of tartaric acid and malic acid in the berries, thereby affecting the acid characteristics of the grapes [Hale CR, 1977].

Neural networks can predict any continuous relationship between inputs and the target. Similar to linear or non-linear regression, artificial neural networks develop a gain term that allows prediction of target variables for a given set of input variables. Physical–chemical relationships between input variables and target variables may or may not built into the association of target and input variables.

Neural networks [Anderson, James A. and Edward Rosenfield., 1988] are non-linear systems whose structure is based on principles observed in biological neuronal systems [Hanson, Stephen J. and David J. Burr. 1990]. A neural network could be seen as a system that can be able to answer a query or give an output as answer to a specific input. The in/out combination, i.e. the transfer function of the network is not programmed, but obtained through a training process on empiric datasets. In practice the network learns the function that links input together with output by processing correct input/output couples. Actually, for each given input, within the learning process, the network gives a certain output that is not exactly the desired output, so the training algorithm modifies some parameters of the network in the desired direction. Hence, every time an example is input, the algorithm adjusts its network parameters to the optimal values for the given solution: in this way the algorithm tries to reach the best solution for all the examples. These parameters we are speaking about are essentially the weights or linking factors between each neuron that forms our network.

Neural Networks application fields are typically those where classic algorithms fail because of their inflexibility (they need precise input datasets). Usually problems with imprecise input datasets are those whose number of possible input datasets is so big that they cannot be classified. A field where classic algorithms are in troubles is the analysis of those phenomena whose mathematical rules are unknown. There are indeed rather complex algorithms which can analyses these phenomena but, from comparisons on the results, it comes out that neural networks result far more efficient: these algorithms use Fourier's transform to decompose phenomena in frequential components and for this reason they result highly complex and they can only extract a limited number of harmonics generating a big number of approximations. A neural network trained with complex phenomena's data is able to estimate also frequential components, this means that it realizes in its inside a Fourier's transform even if it was not trained for that.

With neural networks is possible to predict, analyzing historical series of datasets just as with these systems but there is no need to restrict the problem or use Fourier's transform. A defect common to all those methods it is to restrict the problem setting certain hypothesis that can turn out to be wrong. We just have to train the neural network with historical series of data given by the phenomenon we are studying [Anderson, James A. and Edward Rosenfield., 1988.].

Calibrating a neural network means to determinate the parameters of the connections (synapses) through the training process. Once calibrated there is needed to test the network efficiency with known datasets, which has not been used in the learning process. There is a great number of Neural Networks [Anderson, James A. 1995] which are substantially distinguished by: type of use, learning model (supervised/non-supervised), earning algorithm, architecture, etc. Multilayer perceptrons (MLPs) are layered feed forward networks typically trained with static backpropagation. These networks have found their way into countless applications requiring static

pattern classification. Their main advantage is that they are easy to use, and that they can approximate any input-output map. In principle, backpropagation provides a way to train networks with any number of hidden units arranged in any number of layers. In fact, the network does not have to be organized in layers any pattern of connectivity that permits a partial ordering of the nodes from input to output is allowed. In other words, there must be a way to order the units such that all connections go from earlier (closer to the input) to later ones (closer to the output). This is equivalent to stating that their connection pattern must not contain any cycles. Networks that respect this constraint are called feed forward networks; their connection pattern forms a directed acyclic graph or dag.

Materials And Methods

Plant material

This experiment was conducted during three consecutive years in a vineyard planted with Richter 110 rootstock and grafted to Vitis vinifera L., cv. Tempranillo. The vineyard was located at the experimental fields of the Polytechnic University of Madrid. Vine spacing was 2m between rows and 1.35m within the row (3700 vines per hectare). Row orientation was North-South. All vines were head trained and cane-pruned (Guyot), and shoots were positioned with a vertical shoot positioning trellis system.

Irrigation treatments

Two irrigation regimes were established: irrigated (I) and non-irrigated (NI) vines. The object was to replace weekly vineyard evapotranspiration (ETc) in the soil from the earliest stages of plant growth, which has depended of when the precipitation took place, as it has been described previously [Esteban MA, Villanueva MJ and Lissarrague JR, 1999]. The potential evapotranspiration (ET0) was calculated from a class A pan evaporation [Doorenbos J and Pruitt WO, 1977]. Daily trickle irrigation was applied at 0.6 x ET0 in the irrigated treatment (I), and no water was applied in the non-irrigated treatment (NI) over the entire growing season. Precipitation amounts less than 5 mm were ignored, and the irrigation application efficiency was considered to be 90%. The soil at this site had a water availability of 131 mm/m. Data on seasonal and annual rainfall, effective rainfall, total water applied, irrigation period, and accumulated growing degree days (10ºC basis) from budbreak to harvest have been described in an earlier paper [Esteban MA, Villanueva MJ and Lissarrague JR, 1999].

Four replications of each of the two treatments were randomly distributed in the vineyard, each replication consisting of three rows with nine vine plots. Measurements were made on the central seven vines of the middle row.

Analytical determinations

General variables: Total soluble solids (ºBrix) was measured using an Abbé type refractometer (Zeiss, mod.B) equipped with a temperature control system (20ºC). Must pH was measured with a pH meter (Crison mod. MicropH 2001), using a glass electrode. Finally, titratable acidity was measured by titration with a base to an end point of pH=8.2 (20ºC), and the results were expressed in g/L tartaric acid.

Glucose and fructose: Analysis of these two sugars was performed by HPLC according to the procedure described by Esteban et al. [Esteban MA, Villanueva MJ and Lissarrague JR, 1999].

The chromatograph employed was equipped with a refractive index detector (Waters 410 differential refractometer), and the sample and reference cells were held at 40 ºC. An Aminex HPX-87P column (300 mm x 7.8 mm i.d., 9-μm particle size) with a guard column cartridge (Bio-Rad Laboratories, Richmond, CA, U.S.A.) was used. Data were processed using the Waters Millennium 2.0 chromatographic data system.

Tartaric acid and malic acid: Individual acids were determined by HPLC as previously described by Esteban et al. [Esteban MA, Villanueva MJ and Lissarrague JR, 1999] The chromatograph employed was a Waters liquid chromatograph equipped with a Waters model 996 PDA detector. An Aminex HPX-87C cation exchange column (300 mm x 7.8 mm i.d., 9-μm particle size) was used, with a guard column cartridge (Bio-Rad Laboratories, Richmond, CA, U.S.A.). Data were processed using the Waters Millennium 2.0 chromatographic data system.

Relationships between different berry components.

Multilayer feedforward networks are often used for modeling complex relationships between the data sets. Deleting unimportant data components in the training sets could lead to smaller networks and reduced-size data vectors. The process of finding relevant data components is based on the concept of sensitivity analysis applied

to a trained neural network. ANN models predict changes for certain combinations of input variables, detecting the most important influence in the output variables.

We have studied different analysis for detecting relathionships between berry weight or ºBrix and other grape components in the two irrigation treatments (T1=Irrigated and T2=non irrigated) during the ripening period.

In order to study the relationships between different variables it has been used neural networks models with a single hidden layer with 6 axons and a Tanhaxon transfer function and based on the momentum learning rule.

Study of the relationships between different variables and ºBrix in I y NI treatments

Analysis of the results

I	*Berry weight*	*Ph*	*Total acidity*	*ºBrix*	NI	*Berry weight*	*Ph*	*Total acidity*	*ºBrix*
	11.342	17.709	70.949	100.000		33.765	25.123	41.111	100.000
		22.712	77.288	100.000			41.958	58.042	100.000
	17.930	82.070		100.000		55.994	44.006		100.000
	14.877		85.123	100.000		37.859		62.141	100.000

Active performance of the analysis

I	*MSE*	*NMSE*	*r*	*%Error*	NI	*MSE*	*NMSE*	*r*	*%Error*
	0.03	0.01	0.99	5.76		0.004	0.01	0.99	6.66
	0.004	0.01	0.99	6.43		0.008	0.02	0.98	9.61
	0.008	0.03	0.98	8.67		0.005	0.01	0.99	6.72
	0.003	0.01	0.99	5.86		0.004	0.01	0.99	6.64

During the ripening period in berries of the cv. Tempranillo grape variety along a period of three years, it has been studied that the values of ºBrix in the two irrigated treatments are different. It has been analysed the importance that has the impact of some components (total acidity, pH and berry weight) on the ºBrix. Thus we observed that total acidity is the variable that influences most in the irrigated treatment with 70.9%, followed of pH with 17,7% and finally the berry weight with 11.3%. In the non-irrigated treatment occurs the same, reaching total acidity a value of 41,1%, however, the berry weight (33.7%) influences more than pH (25.1%). Analyzing variables two to two we verified that those models are the same in both treatments. Thus, the impact of the berry weight in the ºBrix in the irrigated treatment is less than in the non- irrigated treatment, this could be because of the concentration effect that takes place since the absolute values in both treatments are the same.

We have also analyzed Tartaric and Malic

I	*Berry weight*	*Tartaric*	*Malic*	*ºBrix*	NI	*Berry weight*	*Tartaric*	*Malic*	*ºBrix*
	8.556	31.008	60.436	100.000		40.110	14.112	45.778	100.000

Active performance of the analysis

I	*MSE*	*NMSE*	*r*	*%Error*	NI	*MSE*	*NMSE*	*r*	*%Error*
	0.003	0.001	0.99	5.22		0.003	0.01	0.99	6.04

We have analyzed the two most important acids in the grape because they determine the value of the total acidity. As it happens with the total acidity, both acids influence in the ºBrix value more than the berry weight in the irrigated treatment, whereas in the non- irrigated treatment this only happens with the malic acid and nor with the tartaric acid.

Study of the relationships between different variables and berry weight in I y NI treatments

Analysis of the results

I	*ºBrix*	*Ph*	*Total acidity*	*Berry weight*	NI	*ºBrix*	*Ph*	*Total acidity*	*Berry weight*
	29.960	15.411	54.629	100.000		60.653	28.628	10.719	100.000
	29.211	70.789		100.000		67.386	32.614		100.000
	37.080		62.920	100.000		76.970		23.030	100.000
		38.506	61.494	100.000			47.754	52.246	100.000

Active performance of the analysis

I	*MSE*	*NMSE*	*r*	*%Error*	NI	*MSE*	*NMSE*	*r*	*%Error*
	0.01	0.07	0.96	8.99		0.005	0.02	0.98	5.77
	0.02	0.08	0.94	10.4		0.005	0.02	0.98	5.88
	0.02	0.09	0.95	10.3		0.005	0.02	0.98	5.83
	0.03	0.12	0.93	10.9		0.02	0.11	0.93	11.08

It has been studied the importance of the impact of some variables (total acidity, pH and ºBrix) on the berry weight. Thus we observed that total acidity is the variable that influences most in the irrigated treatment with 54.6%, followed by ºBrix with 29.9% and finally pH with 15,4%. In the non-irrigated treatment ºBrix is the variable that influence the most in the berry weight with a value of 60.6%, then the pH (28.6%) and the total acidity (10.7%).

We have also analyzed Glucose, Fructose, Tartaric and Malic.

I	*Ph*	*Glucose*	*Fructose*	*Tartaric*	*Malic*	*Berry weight*
	22.645	18.624	33.515	10.830	14.387	100.000
		20.461	34.891	11.707	32.942	100.000
NI	*Ph*	*Glucosa*	*Fructosa*	*Tartárico*	*Málico*	*Berry weight*
	18.590	36.107	25.640	8.388	11.275	100.000
		41.808	24.284	14.115	19.793	100.000

Active performance of the analysis

I	*MSE*	*NMSE*	*r*	*%Error*
	0.01	0.05	0.97	7.93
NI	*MSE*	*NMSE*	*r*	*%Error*
	0.004	0.02	0.98	5.3

Glucose and fructose are the most important sugars in the grapes and they are the ones that determine mainly the ºBrix value. In the irrigated treatment pH is the variable that influences most in berry weight followed by fructose and glucose, although the amounts of the two sugars influence more than any other variable. However, in the non- irrigated treatment the impact of these two sugars is the highest.

Conclusion

The results with neural networks show that total acidity is the variable that influence most in ºBrix value in both treatments when the analysis has been total or with tartaric and malic acids, except in the case of tartaric acid in the non irrigated treatment. It is also shown that ºBrix value is the variable that influences most in the berry weight non irrigated treatment while total acidity is in the irrigated one.

These results provide that in both treatments, irrigated and non-irrigated vines, and during the different stages of the berry growth it is possible to establish significative relationships between the parameters studied. Glucose and fructose influence more in the berry weight than tartaric and malic acids.

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SELF-ORGANIZING MAP AND CELLULAR AUTOMATA COMBINED TECHNIQUE FOR ADVANCED MESH GENERATION IN URBAN AND ARCHITECTURAL DESIGN

Álvaro Castro Castilla, Nuria Gómez Blas

Abstract: This paper presents a technique for building complex and adaptive meshes for urban and architectural design. The combination of a self-organizing map and cellular automata algorithms stands as a method for generating meshes otherwise static. This intends to be an auxiliary tool for the architect or the urban planner, improving control over large amounts of spatial information. The traditional grid employed as design aid is improved to become more general and flexible.

Keywords: self-organizing map, cellular automata, CAD, CAAD, architectural computation.

ACM Classification Keywords: J.6. Computer Applications - Computer-aided design

Introduction

Architectural and urban design brings up a kind of problems inherently different from those found in engineering or science. In contrast with generalized belief, specially from the engineering and scientific domains, the main difficulties in the development of consistent CAD tools are more related to simultaneity of constrains and complexity of their parametrization, rather than in the topics of creativity and inspiration. Currently these tools are aimed to do little more than mimic the abilities of pen and paper, with the addition of basic copy-related commands.

Different methods for coping with that complexity are to be investigated from artificial intelligence and other research areas such as L-systems or fractals. In this paper a technique for supporting the designer's work in the early stages of the process is proposed through the combination of two models: self-organizing maps and cellular automata .

A self-organizing map (SOM) is a new, effective software tool for the visualization of high-dimensional data. In its basic form it produces a similarity graph of input data. It converts the nonlinear statistical relationships between high-dimensional data into simple geometric relationships of their image points on a low-dimensional display, usually a regular two-dimensional grid of nodes [Kohonen, 2001].

Cellular automata (CA) are mathematical and computational models for systems in which the global behavior is reached through the collaboration of multiple simple parts.

Motivations for cellular automata study can be found in different fields as vehicles for studying pattern formation and complexity. CA can be treated as abstract discrete dynamical systems embodying intrinsically interesting and potentially novel behavioral features [Ilachinski, 2001].

Problem description

Urban planning deals mainly with land units and classification, taking decisions at the large scale that affect each one smaller portion. The basic atom for urban design are those pieces of ground that introduce an extensive list of parameters, such as area, use, cost per measuring unit, etc [Colonna, Di Stefano, Lombardo, Papini, Rabino, 1998]. A variable amount of them, acting together and usually seen statistically, are used by the designer to constrain and design others. In fact, those layers of information usually come one after the other but depending on upcoming ones. That implies cyclic processes and introduces the need for induction thinking.

Land units manifest their geometrical phenotype: the land divisions map and the set of rules that should govern its physical execution. The former is commonly worked out using a mesh for spatial structuration. Of course, there several other techniques, even unique ones depending on the project. This is a matter of process decision, however we can't -and should not- avoid some sort of deviation at most stages of the urban project. We will aim for the most general approach, in this case, mesh-based design.

Meshes introduce two issues; these are the limitations we want to solve with this proposal:

Fixed topology: basic design meshes have fixed topology, as they aim for simplicity and ease of use for the designer. In contrast with the usability, the information this meshes use to be built from is inherently

dynamical in its topology, as one consequence of complexity in real-life originated data. In other words, spatial relationships are not kept over time in urban reality. So our tool should be able to assume that feature and develop the framework to process such variations.

Shape constrains: refers to the land division methods and geometrical structures that conform the actual plan. Historical and cultural diversity show us several different ways to accomplish this goal. However, any taken decision at this aspect would limit the method's generality. This suggests that building a mesh where basic units are not limited by enclosures, thus conforming shapes, but turning its basic units into something shapeless would be desirable. This is quite obvious but not a common design approach, as it implies a higher level of abstraction and a bigger leap towards materialization of a design idea.

The objective is to build a new mesh that improves on the basis of these two limitations for the specific task of helping the urban planner. After that we should be able to use it in order to evaluate its first results.

Orthogonal grid approaches

Urban behavior modeling based on cellular automata has been widely studied in recent years. Many of those models are based on the typical orthogonal mesh, the archetypical grid. The CA orthogonal lattice is commonly used as the most neutral -thus general- geometrical base. It turns variables which are spatially extensive into their density-intensity equivalents and this immediately means that comparisons can be made [Batty, Xie, Sun, 1999]. The geometric configuration of the spatial units used to represent the spatial data can have a profound effect, explaining why using spatial systems which neutralize the effect of configuration remove any bias caused by convoluted or distorting geometries.

The regular grid has other advantages, as the additional ability to work in layers without additional efforts to make different ones fit into the same system, and the significant work which proves its success even with highly refined CA rules involving cultural and human factors [Portugali, Benenson, 1997].

For such reasons current models are centering their interest in *orthogonal isotropic shape-constrained meshes* (the regular grid); they are essentially analytic. Nevertheless, most of them function with a certain degree of deviation from classic CA [Zhongwei, 2003], redefining cell space, neighborhood, lattice and time concepts, which is necessary for some degree of flexibility.

Proposed technique

We are going to describe a technique for building meshes as a generalization of these grids, more flexible and adaptable entities where orthogonality, isotropy, and constant topology are specific cases. Fur such purpose, a combination of Kohonen's self-organizing map and a general CA algorithms set lead us to satisfactory results.

1. Motivations for SOM and CA combined approach

We detected interesting properties in both models that acting indepently solve different aspects of the grid (see Table 1). Basic SOM algorithms work reconfiguring their neurons' weight in a competitive basis, resulting in a problem-specific distribution while preserving topology of the map. However, CA algorithms work efficiently calculating relationships among cells, with just an initial configuration and no needed input data. On the other hand, classic CA rely on fixed-topology lattices, being highly suitable for massively parallel calculations, although they are not limited to be rectangular and uniform [Abdalla, Setoodeh, Gürdal, 2006].

Self-Organizing Maps	Cellular Automata
preserves topology of the map	relies on topologically static lattice
works on input data	works from seed and sets of rules
problem-specific adaptation (outer generation)	cell relationships (inner generation)

Table 1. SOM and CA for design.

These features suggest the possibility of dividing the design problem into two conceptually complementary parts:

- *Outer generation*: refers to the ability of the design system to assimilate external information and reconfigure itself depending on the input.

- *Inner generation*: concerning the inner properties of the system, not directly depending on the external constrains of the design problem. Although it can introduce external variables to the system, the only potential effect on the global qualities could be emergent, thus unpredictable.

2. Kohonen's self-organizing map

SOM are Artificial Neural Networks that carry out their adjustment process through the unsupervised learning paradigm, and the input data are called unlabeled data. As a simplified definition, we can say that, in a topology-preserving map, units located physically next to each other will respond to classes of input vectors that are likewise next to each other. Although it is easy to visualize this in two-dimensional array, it is not so easy in a high-dimensional space. N-dimensional input vectors are projected down on the two-dimensional map in a way that maintains the natural order of the input vectors. This dimensional reduction could allow us to visualize easily relationships among the data that otherwise might go unnoticed [Freeman, Skapura, 1991].

A basic SOM is able to reconfigure its weights distribution depending on the training data. Weight vectors correspond to the classes the algorithm is finding in the training set. If we graph the weights vectors together with the input vectors we get a similarities diagram where the neuron units are shown as representatives of a data class from that input. We can describe the learning process by the equation

$$w_i = \langle(t)(x – w_i) U (y_i)$$

Where w_i is the weight vector of the *i* unit and *x* is the input vector. The function $U(y_i)$ is zero unless $y_i > 0$ in which case $U(y_i) = 1$ so only active units will learn. The factor α(t) is a function of time to allow its modification as the learning process progresses.

As a competitive structure a winning unit is determined for each input vector based on the similarity between the input and the weight vectors. The winning unit is evaluated by

$$|| x - w_c || = \min_i \{ || x – w_i || \}$$

Finally the updated weights are those of the winning unit plus a defined neighborhood with certain decay. The cycle is repeated, adjusting the neurons' weight until a number of iterations is reached or a fixed condition is satisfied. The neurons are gradually learning as they win for a specific class of input sample. New sample vectors will fall into a previous class or excite a neuron that wasn't previously excited, tending to be a representative of a new class. Hence, the algorithm -in its simple form- is often used as a generic classifier.

The output, seen as a *weights map*, is generally used as a representation of the classes. If you graph the input vectors on top of it, you would see the relationships easily.

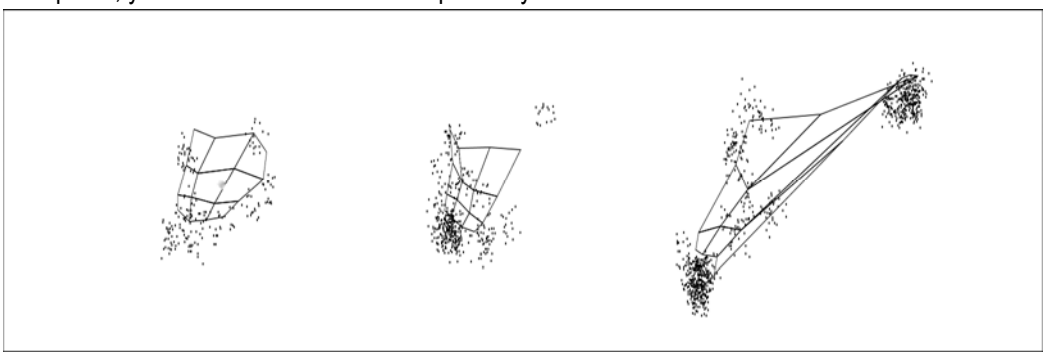

Figure 1. Graphing input vectors (point clouds) and weights (nodes of the mesh).

Nevertheless, our interest is mainly focused on that output graph. The principle we are going to follow is very simple: If we use spatial data as input, we will get spatial data output. Thus *the output graph of spatial information is spatial information itself*; and so the graph turns into a visualized mesh of points.

As information required by the designer is visual, the evaluation of the results could be done entirely with this mesh, until the next step (CA) is applied. Moreover, the mesh is adaptable to the new samples, which means that the designer could learn how to introduce new inputs an re-evaluate the results on the fly.

The SOM was built according to the following features:

- 2-dimensional input vectors
- Variable map resolution

- A Gaussian neighborhood.
- 2 learning phases: At the beginning the learning factor is tuned for exploration of the space and after 100 cycles it optimizes weights. The second phase stops after 10000 iterations or the variation is small enough.
- The weights are graphed in a 2-dimensional map of points, connected by lines representing the immediate neighborhood

It was implemented in Java and ran as an independent application, isolated from the rest of the experiment. Networks of 50x50, 100x100, 150x50 neurons were used, all of them running at a reasonable speed for its manipulation. The option of exporting the neurons' weights as a list of point coordinates was implemented in order to extract the desired configurations out of the program.

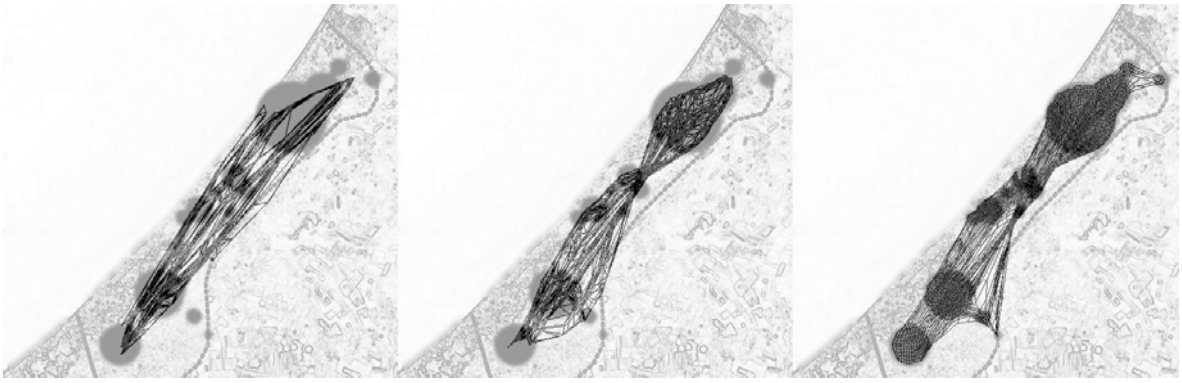

Figure 2. Evolution of the SOM algorithm applied on spatial data, in a vast land region.

3. Cellular Automata: topology reconfiguration

Cellular Automata are a very widespread method for modeling complex systems, such as urban growth. There have already been much work using this models in architecture and urbanism and even specialized ones have been developed [Torrens, 2000]. The discussion of these goes beyond the scope of this paper.

We have seen an algorithm that yields and adaptive mesh, continuously changing over time until we decide to halt it and extract the output. This mesh is an ordered set of points, which interpretation depends on the supplied data.

On the other hand, CA use a lattice of regularly spaced cells with no other geometrical information than the relationship among them. They are built from individual cells that contain all the information needed to update the state. Furthermore, the only external information to the cell comes directly from the adjacent cells, which along with it forms this neighborhood.

The proposal is to run a CA algorithm on top of the previously generated mesh, matching each neuron to a CA cell. The only prerequisite is that the CA dimension and the lattice resolution match exactly to the mesh.

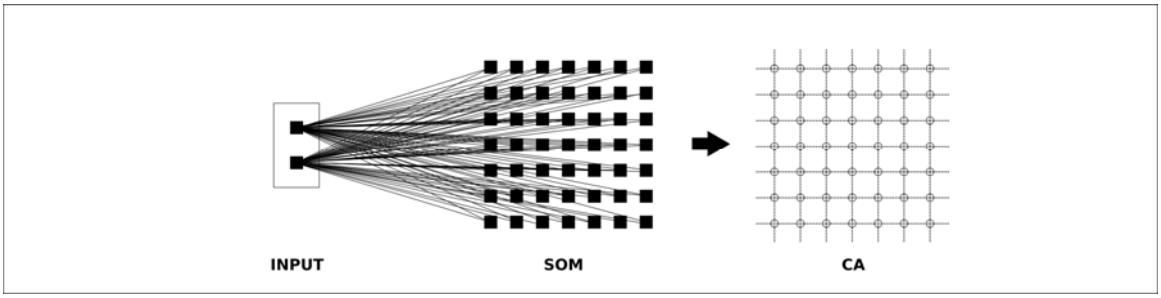

Figure 3. SOM-CA mapping

The CA task is to activate or deactivate a neuron for the next weights adjustment (modifying the neighborhood) or just for the output. By this way we obtain two different possibilities:

- *Filtered flow:* selecting the output units, a linear approach.
- *Feedback flow:* reconfiguring the neighborhood through the suppression of some units, a cyclic approach.

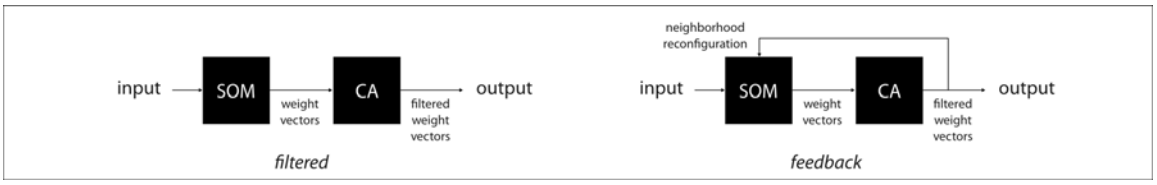

Figure 4. SOM-CA data flow methods.

Both of them result in the *topology reconfiguration* of the mesh, modifying the neurons space. This neurons space acts as the lattice of the CA, which itself has a constant cartesian topology (coming out from the SOM). That is necessary for a regular study of patterns formation [Marr, Hütt, 2005]. These patterns are then used for the reconfiguration of the SOM. It implies that there is always a virtual topology where the CA lives, and an actual topology that is being constantly regenerated by the cellular automata. The use of the CA paradigm for addressing the topology design has recently been demonstrated successful with several approaches [Abdalla, Setoodeh, Gürdal, 2006]. This activate/deactivate behavior could also be extended with other parameters from more complex, even n-dimensional models [Castro, Cabañero, 2007].

The tests were made using the simplest option (filtering), so the separated programs approach was reasonable. A more detailed study should be dedicated exclusively to the feedback configuration.

This second program was also implemented in Java providing the following features:

- Time control: start/stop
- Direct interaction with the CA cells: manually add/erase
- A set of implemented Classic CA, plus traffic-pedestrian simulation and other interesting rules to test
- The ability of changing rules on the fly
- A stack of rule processes, allowing to apply more than one rule in the same run, in a linear and ordered manner

As the previous program, the mesh generator, it is able to export the data at a specific time and extract it from the program.

Merging the two algorithms: results

Both programs were implemented with the ability to export their results, so we can use the frozen data externally. In this last section it is described briefly how this information has been introduced into the designer's workflow, the last step of the technique. The most important thing that has to be performed is to process that information into a 3-dimensional geometry inside a design tool. The chosen platform was the open-source 3d modeling software called Blender, running an embedded Python interpreter.

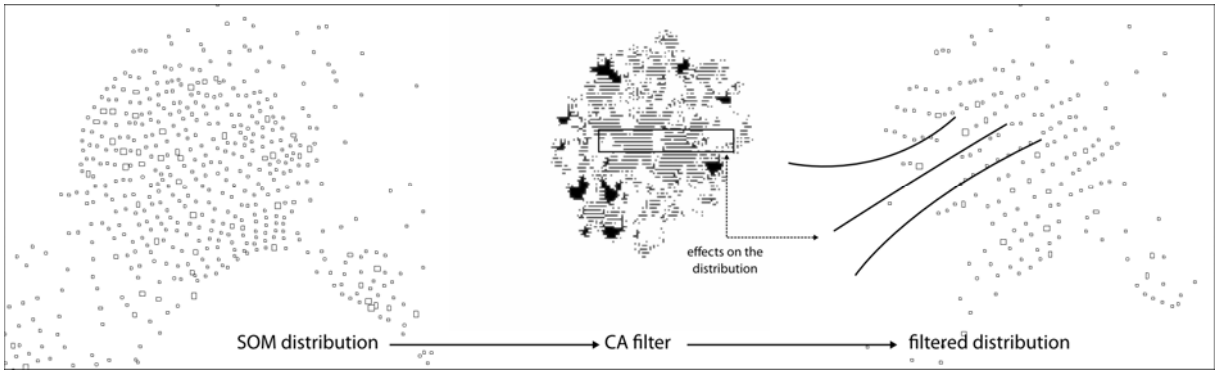

Figure 5. Example application: effects CA-filtered SOM.

The python algorithm is straightforward. These steps are to be followed:

1. Read the SOM mesh data points
2. Read the CA cells status
3. Match the SOM neurons with the CA cells, activating or deactivating the neurons

4. Project the SOM in the 3d space, on the XY plane
5. Optional use of an interpretative/generative algorithm to create volumes or additional point properties. It is an interesting step, in which relies the final aspect of the urban plan as it introduces the actual phenotype directly. It is important to notice that although it will introduce great differences in the system, the underlying structure will remain dependent on the previous steps. If this step is avoided, the designer will work directly with the imported 2-dimensional mesh.

Conclusion

The degree of success this technique could have in the design process is a matter of discussion both in the practical and the theoretical domains. However, different applications have already shown that it can be used as an aid tool with more general ambit than the regular grid. Becoming more than an aid tool, capable of synthesizing part of a design is a promising but ambitious objective.

Future work will develop this issues:

- Input data preprocessing
- Feedback flow as a more powerful and complex mechanism
- Multidimensionality of the input data
- Creation of layered or 3-dimensional meshes

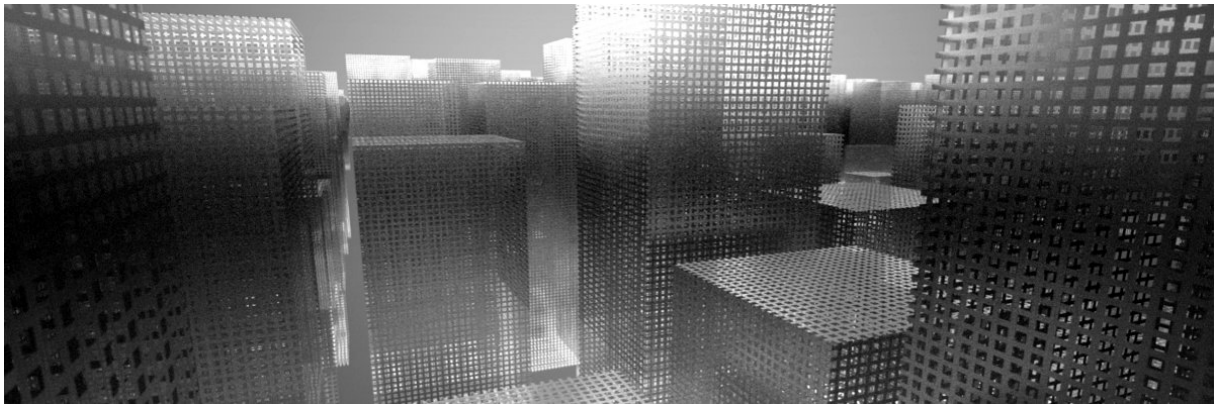

Figure 6. View of a prototype of synthesized city generated with this system.

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LACK OF ANSWER ESTIMATION BY FUZZY CONTROL

Jesús Cardeñosa, Pilar Rey

Abstract: The problem of the lack of answer in questions of survey is usually dealt with different estimation and classification procedures from the answers to other questions. In this document, the results of applying fuzzy control methods for the vote -one of the variables with bigger lack of answer in opinion polls- are presented.

Keywords: Fuzzy systems, voting systems

ACM Classification Keywords: J4 Social and Behavioral Sciences; I.2.3. Deduction and Theorem Proving

Introduction

The opinion polls show in general a big problem of lack of answer because of the special sensitivity of the persons to some kind of questions. Usually it is treated by different statistical procedures of estimation and classification: in this document we show the results of applying fuzzy control methods for the vote variable in the opinion polls carried out by the Sociological Research Centre (SRC).

The interest of this procedure is in the fact that we use only four simple rules produced in a direct and easy way from the answer to four other questions of the same survey and that the results are similar or better to the ones obtained with other sophisticated and traditional methods.

In the first section the data used are described, emphasizing some problems which could be solved by means of classification methods. The second section shows the designed fuzzy control system for classification, describing the procedures to generate the fuzzy rules and sets and their operation. Finally, we present the results and some conclusions and possible ways of improvement.

The Data

One of the missions assigned to the SRC by the law regulating its activity is to carry out surveys and opinion polls to know the Spanish social reality; in particular, to learn about the Spaniards' vote intention for the general elections. In the opinion poll periodically carried out the first month of every trimester (known as "Opinion Barometer"), a direct question is posed about this vote intention. In addition, the survey includes other questions about the socio-demographic variables (sex, age, study level, labour situation, profession,…), and about other subjects that can contribute to improve knowledge about the reasons a person may have to vote for a specific political party.

In the surveys carried out by public institutions, the opinion polls are especially easy due to the simplification of some of the most technical phases of the survey processing. One of the reasons is the use of variables of qualitative type with a limited number of answering categories. In addition, only proportion estimates are almost exclusively used, and they originate smaller sampling errors than other kind of estimates. Another peculiarity of these surveys is the treatment given to the partial lack of answer (when the interviewed answers one or some of

the questions, but not all of them): the category "*Don't know / Don't answer"* is added, and it is considered as any other one. By this procedure, the proportion estimated for the rest of the categories are skewed downwards, but the precision level demanded does not seem to be really great. In the case of the variable measuring the proportion of vote intention for every party ("*vote*", from now on), the highest precision is demanded and it is precisely in this question where the partial lack of answer is usually bigger. To deal with this problem, the SRC usually make some *a posteriori* treatment (incorporation of expert's opinion, econometric modelling…). In any case, after elections are held, the media frequently points out critics and comments about the poor results obtained by these procedures regarding vote forecasting. Thus, when testing fuzzy systems, we will use "*vote"* as classification variable, with the purpose of using the classification results as an alternative procedure for the proportion estimates. The lack of answer would be replaced by classified values and the new proportions would be calculated. Since this work is only a first approach to the use of fuzzy controllers for this type of data and we tried to build a simple system with few rules, the answers will be grouped in four categories: "*IU*", "*PP*", "*PSOE*" and "*OTHER*" (being IU, PP, and PSOE acronyms of the main Spanish Political parties).

As input variables we will use the answer to four questions related to the vote: the assessment of the government management, the assessment of the first opposition party performance, the memory of the party voted for in the last national elections, and the ideological position (this latter resulting from asking the interviewed about his/her ideological position ranging from 1 to 10: 1 being the extreme left, and 10 the extreme right). The answer categories for the questions about the assessment of government management and the first opposition party performance are "*Very good*", "*Good*", "*Regular*", "*Bad"* and "*Very bad*". For memory of party voted for, they are also grouped in "*PP*", "*PSOE*", "*IU*" and "*OTHER*". This may lead to an excessive simplification, because besides grouping very different political parties (as in the case of vote intention variable), it also groups other categories that may show very different behaviours as "Did not have age", "Does not remember", "Vote in white" and "Did not vote". We have selected the data from the study number 2640 of the SRC Data Bank Catalogue (April 2006 Barometer), with a sample size of 2.500 interviews. The microdata corresponding to people residing in Autonomous Communities with other great parties (Catalonia, Galicia, and Basque Country) have been eliminated, and also those having partial lack of answer in some of the four input variables or in the output variable, resulting in 1.216 microdata to test the procedure.

Fuzzy Controller Design

An attractive point of the fuzzy control systems is the option of using simple rules that do not require special efforts for its design. As we have not experts in vote motivation, the classification rules are built by supposing that the interviewed answered the survey questions with some consistency. On the other hand, we are going to apply fuzzy rules in which each one will describe one of the possible classification categories. The antecedent part of the rules will be expressed by means of defined fuzzy sets in the answer categories sets of the four input variables, whereas the consequent part will be a crisp class label in the set of the classification categories. The general expression of these rules is:

R_i : If x_1 is A_{i1} and x_2 is A_{i2} and x_3 is A_{i3} and x_4 is A_{i4} then $y = y_i$, $i=1, 2, 3, 4$

where: x_1 = *assessment of government management*

x_2 = *assessment of first opposition party performance*

x_3 = *ideological position*

x_4 = *memory of the party voted for*

y_1= *IU*

y_2 = *OTHER*

y_3 = *PP*

y_4 = *PSOE*

In a detailed form, the rules are:

- R_1: If the assessment of government management is negative, the assessment of first opposition party is negative, the ideological position is low and the memory of the party voted for is "*IU*", then the vote is "*IU*".
- R_2: If the assessment of government management is negative, the assessment of first opposition party is negative, the ideological position is average and the memory of the party voted for is "*OTHER"*, then the vote is "*OTHER*".

– R_3: If the assessment of government management is **negative**, the assessment of first opposition party is **positive**, the ideological position is **high** and the memory of the party voted for is "*PP*", then the vote is "*PP*".

– R_4: If the assessment of government management is **positive**, the assessment of first opposition party is **negative**, the ideological position is **low average** and the memory of the party voted for is "*PSOE*", then the vote is "*PSOE*".

It is important to point out that, although we have defined for "*memory of the party voted for"* the same answer categories than those for the "*vote"*, in the rules the meaning is very different, since for the "*memory of the party voted for"* variable we will define a fuzzy set for each party, whereas for the "*vote"* variable it regards to crisp class labels. After that, we move on to build the A_{jj} fuzzy sets of the antecedent part of the rules. In the first place, we built the "*Positive Assessment*" (*PA*) and "*Negative Assessment*" (*NA*) sets for the variables x_1 and x_2, which will be identical for both. As of the answer categories, their membership functions will respectively be in a natural way:

$$\mu_{PA}(x)=\begin{cases}0.00 & if\ x=very\quad bad\\ 0.25 & if\ x=bad\\ 0.50 & if\ x=regular\\ 0.75 & if\ x=good\\ 1.00 & if\ x=very\quad good\end{cases}\qquad and\quad \mu_{NA}(x)=1-\mu_{PA}(x)$$

where a set is the complementary of the other, taking for the complementary the strong standard negation (Figure 1).

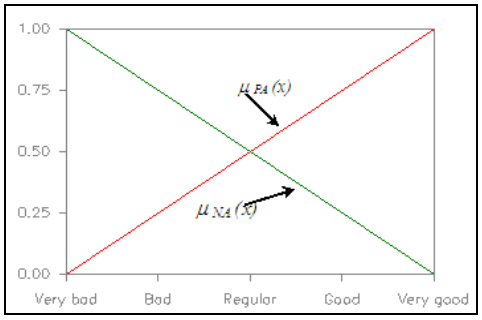

Figure 1

Now, in order to build the "*Low*" (*L*), "*Low Average*" (*LA*), "*Average*" (*A*) and "*High*" (*H*) fuzzy sets for the universal set of answers to the question about the ideological position, we will base on the average and the standard deviation for each classification category obtained from the sample. For later evaluation of the behaviour of the fuzzy classifier, we took into consideration the first 916 observations to estimate, being left the other 300 for the classification test. Table 1 shows the obtained values:

Party	Average	Standard deviation
IU	*3.00*	*1.06*
OTHER	*4.53*	*1.40*
PP	*6.67*	*1.31*
PSOE	*3.71*	*1.25*

Table 1

From this one, we built the Gaussian membership functions, in the form:

$$\mu_L(x)=e^{-\frac{(x-3{,}00)^2}{2.1{,}06^2}},\ x=1,2,\ldots,10\quad ,,\ \mu_{LA}(x)=e^{-\frac{(x-3{,}71)^2}{2.1{,}25^2}},\ x=1,2,\ldots,10$$

$$\mu_A(x)=e^{-\frac{(x-4{,}53)^2}{2.1{,}40^2}},\ x=1,2,\ldots,10\quad ,,\ \mu_H(x)=e^{-\frac{(x-6{,}67)^2}{2.1{,}31^2}},\ x=1,2,\ldots,10$$

that appears in Figure 2. They are taken as symmetrical functions around the average because that is how the studied frequencies in the micro data sample seem to behave.

Finally, we built the fuzzy sets for the results of the "*memory of the party voted for"* variable also from the information provided by the sample of the first 916 micro data, as the vote frequency (distribution by categories of the classification variable) for each group of "memory of the party voted for", as it appears in Table 2:

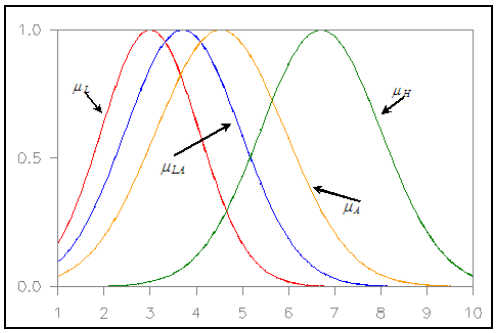

Figure 2

	Vote				
Memory of the party voted for	*IU*	*OTHER*	*PP*	*PSOE*	*Total*
IU	66.1	6.8	3.4	23.7	100.0
OTHER	2.9	37.5	23.0	36.6	100.0
PP	0.7	7.2	75.9	16.2	100.0
PSOE	1.0	7.0	6.1	85.9	100.0

Table 2

This gives rise to the membership functions in Figures 3 to 6:

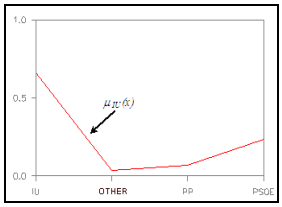

Figure 3

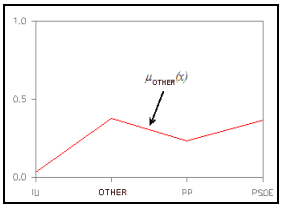

Figure 4

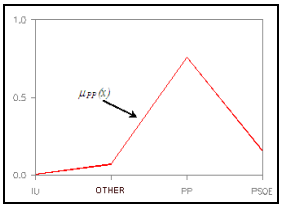

Figure 5

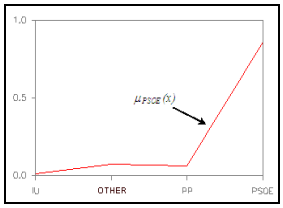

Figure 6

Once the fuzzy sets for the input variables were built, the next action was to follow the steps to design the system of fuzzy control.

Working of the System

In order to allow the development of the system output once an input takes place, it will be necessary to choose the implication functions, t-norms, t-conorms and the way of combining the rules. It has already been pointed out that the standard negation is used for the complementary. As implication function we choose the Mamdani implication, based on the t-norm of the minimum. For the t-norms (connective *and*) we used the product, and as t-conorm the standard fuzzy union (maximum operator). It has also been studied the use of the t-norm of the minimum instead of the product one: the first one showed the problem that frequently the maximum value to select the class was the same for different parties. The use of the t-norm of the product allows avoiding it, making possible the interaction among the antecedent proposals of each rule. On the other hand, we applied the Zadeh's compositional rule of inference locally to each fuzzy relation generated by the rules, coming later to combine the resulting sets in a disjunctive way.

If we suppose now that a numerical input to the system takes place, that is to say, the fact $x = x_0$ takes place or $x \in P^* = \{x_0\}$, where $x = [x_1, x_2, x_3, x_4]^T$ is the vector of input of the four variables, it will be:

$$\mu_{P^*}(x)=\begin{cases}1, & si\ x=x_0\\ 0, & si\ x\neq x_0\end{cases}$$

We will then have, to make the inference, the four rules and the previous fact. In the first place, we will combine the fuzzy sets of the inputs of each rule applied to $P^*=\{x_0\}$ in a multiplicative way according to the selected t-norm, getting the activation rank of each rule as:

$$\beta_i(x_0)=\prod_{j=1}^{4}\mu_{ij}(x_{j0}),\ i=1,2,3,4$$

where $x_0=[x_{10},x_{20},x_{30},x_{40}]^T$ and μ_{ij} are the corresponding membership functions. As the output of each rule is a crisp set (the class label of the corresponding party), it will have a membership function that will be, in fact, a characteristic function, properly:

$$\mu_{y_i}(y)=\begin{cases}1, & si\ y=y_i\\ 0, & si\ y\neq y_i\end{cases},\quad i=1,2,3,4$$

In order to apply Zadeh's compositional rule to each rule, it would be necessary to make:

$$\mu_{Q_i^*}(y)=\mathcal{J}\left(\beta_i(x_o),\mu_{y_i}(y)\right)=\min\left[\beta_i(x_o),\mu_{y_i}(y)\right]=\begin{cases}\beta_i(x_o), & si\quad y=y_i\\ 0, & si\quad y\neq y_i\end{cases},\quad i=1,2,3,4$$

where J is the Mamdani implication. Applying now the disjunctive combination of each rule outputs, the output of the classifier will be determined by the rule with the highest activation degree, that is to say,

$$y=y_{i^*},\ i^*=\arg\max_{1\le i\le 4}\beta_i(x_0)$$

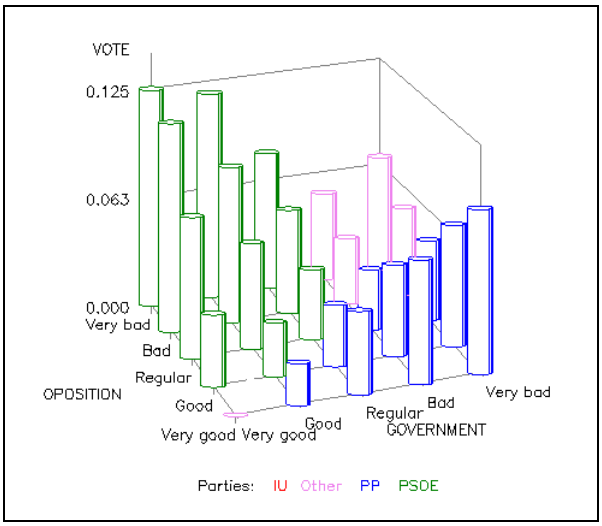

Figure 7

It is difficult to see as a function of four variables: as an example, we show it in Figure 7 as a function of x_1 and x_2 -the "assessment of government management" and the "assessment of first opposition party performance"-, given the "ideological position" (x_3) is 4 and the "memory of the party voted for" (x_4) is PP.

Results

In order to test the classifier, we applied it to obtain the value of the *vote* for the 300 observations that have been left in the sample with this aim. If we compare the vote thus obtained with the real value provided by the interviewed person, we found that there was coincidence in 240 observations (80%). We made a cross validation leaving 300 different observations every time for verification with the model developed with the rest of the observations. Although the test number is not enough to extract significant consequences, it is observed that all

the parameters taken into account stayed quite stable from a repetition to another one, which provides confidence in the reliability of the procedure. The results of the four iterations are shown in Table 3.

Iteration	*% of coincidence*
1	80.00
2	80.76
3	80.76
4	80.70
Average	80.56

Table 3

On the other hand, tests have also been made changing the membership functions obtained for other simpler ones, of trapezoidal and triangular type. It has been found that it is very simple to refine the parameters of those functions to significantly improve the results, but those refined parameters do not continue giving good results in other segments of sample. Although results may seem a little unexciting, if we compared them with 51%, at the most, that has been obtained with data of a similar survey, using classifiers based on Bayesian networks, it is rather positive. (These results are not totally comparable since the other survey used different input variables).

Conclusions

The experiment made here is only a first approach to obtain classifiers for the vote in opinion polls based on fuzzy controllers; therefore, instead of conclusions we are making some comments. The final mission has been to improve the imputations of the "vote" lack of answer in the barometers of the SRC. It is necessary to point out that this experiment is rather more modest than to improve the estimations of the vote for the following elections. Also, it is necessary to remember that the interviewed people can be incongruous when they are asked about the vote and when they go to vote.

The shown results are quite encouraging, mainly considering that the design of the control system has not required of exhaustive previous analysis, but it has been obtained with a few rules based on common sense. The system is simple and with very few rules to group the parties in only four groups, but it would necessarily become more complicated if it were tried out with all the political parties.

In the barometers there also are other questions included that can be used like input variables in the system: for example, questions about the assessment of the main leaders of the political parties, the confidence in the President of the government, etc. It is quite possible that its inclusion could allow improving results. The tests made with other simpler functions of property indicate that it is also possible to improve the results using that route.

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INTEGRATION PRINCIPLES OF RUSSIAN AND JAPANESE DATABASES ON INORGANIC MATERIALS

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Abstract: The methods and software for integration of databases (DBs) on inorganic material and substance properties have been developed. The information systems integration is based on known approaches combination: EII (Enterprise Information Integration) and EAI (Enterprise Application Integration). The metabase - special database that stores data on integrated DBs contents is an integrated system kernel. Proposed methods have been applied for DBs integrated system creation in the field of inorganic chemistry and materials science. Important developed integrated system feature is ability to include DBs that have been created by means of different DBMS using essentially various computer platforms: Sun (DB "Diagram") and Intel (other DBs) and diverse operating systems: Sun Solaris (DB "Diagram") and Microsoft Windows Server (other DBs).

Keywords: Databases integration, metabase, distributed information system, inorganic substances and materials, EII, EAI.

ACM Classification Keywords: H.2.4 Distributed databases, H.2.8 Scientific databases, J.2 Chemistry.

Introduction

At present rich variety of databases on properties of inorganic substances and materials were developed and maintained in the world [Bale and Eriksson, 1990; Dudarev et al., 2006; Eriguchi and Shimura, 1990; Khristoforov et al., 2001; Kiselyova, 2005; Kiselyova et al., 2004, 2005, 2006; Villars et al., 2004; Xu et al., 2006; Zemskov et al., 1998]. Traditional areas, that DBs cover, are thermodynamic, thermo-chemical, crystallographic and crystal chemical properties. The majority of large industrial corporations support DBs developments that contain the information on physical, technical and technological parameters of materials and substances. The development tendencies of modern DBs on inorganic substances and materials properties are following:

1. Internet-access to the information.

2. Powerful DBMS usage: Microsoft SQL Server, Oracle, IBM DB2, etc.

3. Great attention has been concentrated on stored information quality (reliability). Highly skilled specialists are engaged in development process of the most "advanced" commercial information systems for data capture and data reliability expert estimation. So users receive not simply "row" information but recommended values passed filtration for misprints elimination.

4. Often DBs are supplemented with information analysis tools: from traditional thermodynamic calculations and statistical procedures up to modern means for regularities search in the data allowing predicting objects behavior and making decisions. In the last case usual DBs, oriented to transaction processing, are often supplemented, for example, with special integrated information systems, that are known in English literature as *Data Warehouse* [Kimball and Caserta, 2004]. They are intended for data coordination and integration from various information sources and its preparation for subsequent computer analysis.

5. DBs on substances and materials properties integration. In this case user can find the most complete cumulative information on certain substance properties.

The last problem, resources on inorganic substance and material properties information integration is the most important today. The data on various properties of a certain substance or material are distributed among different heterogeneous DBs. The chemist or material scientist has to look through a great number of DBs in order to find necessary information. Therefore some superstructure above DBs, that will allow to output some cumulative – the integrated information on all properties set of a substance stored in different information systems, is required. That is, DBs integration is necessary. This problem solution is concerned with several difficulties. Databases on inorganic substance and material properties have been developed in various organizations and countries and thus they use different database management and operating systems. Taking into consideration differences in data quality, data expertise procedures, data formats, languages and many other troubles it should be stated that

full and smooth information resources integration is practically impossible problem. We have developed an approach to DBs integration taking into consideration DBs on inorganic substance and material properties peculiarities. The approach can be used for Russian and Japanese DBs integration in this knowledge domain.

Known Approaches to Database Integration

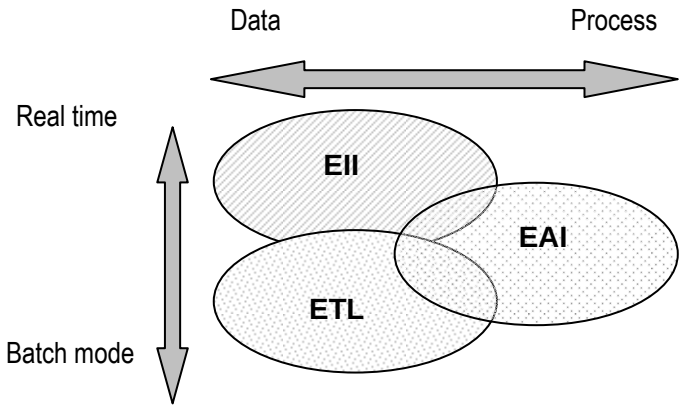

Fig. 1. Modern approaches for information systems integration.

Principally there are three approaches to database integration [Imhoff, 2005]:

1) Data Warehouse based on ETL (Extract, Transform, Load) paradigm [Kimball and Caserta, 2004].

2) EII (Enterprise Information Integration) [Morgenthal, 2005].

3) EAI (Enterprise Application Integration) [Morgenthal, 2000].

These approaches can be used to solve wide set of problems: from real-time integration to batch integration and from data integration to applications integration. Fig. 1 illustrates these approaches application area in relation to different task types [Imhoff, 2005]. The EII technology is the best approach for real-time data integration. The ETL technology allows the best batch data integration. The EAI technology gives the best results at applications integration in real-time or batch modes.

The ETL-technology implies existing resources full merging (fig. 2). That is the case when database complex is a single information system (*megabase*) for end users, operators and administrators. This approach is also known as Data Warehouse [Imhoff, 2005; Kimball and Caserta, 2004]. So at first information is extracted from DBs to be integrated. Then these data are somehow processed for clearing (that is, check for discrepancies and obviously false data elimination) and transformations – series of special procedures that allow to get a common unified format and scale. Only after these stages cleared and unified data are input into data warehouse or megabase. Database exploitation costs reduction and information duplication reduction can be mentioned among this integration approach advantages.

The second integration approach is based on EII-technology (fig. 3). It is not going to integrate databases themselves [Imhoff, 2005; Morgenthal, 2005]. Integrated data are not transferred into a central megabase but remain in the same information systems, as before. Instead the program interface for data access is developed that allows retrieving required data. EII is data integration means from multiple systems into a unified, consistent and accurate representation format geared toward the data manipulation and browsing. So the data are aggregated, restructured and relabeled (if it is necessary) and presented to a user. Usually the result of this approach is a virtually integrated heterogeneous distributed information system.

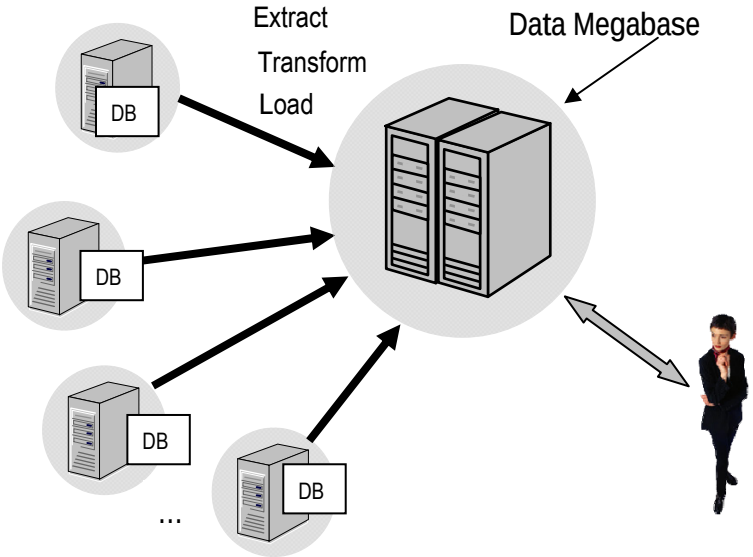

Fig. 2. ETL-approach – existing DBs full merging.

The third approach – EAI – (fig. 4) is aimed for applications integration [Imhoff, 2005; Morgenthal, 2000]. Integration can be carried out in batch or real-time mode. Combined work of two and more applications can be achieved using this approach. This approach is based on message exchange between several applications. Frequently such information exchange is carried out through some common message exchange infrastructure known as message bus. Applications are connected to this common message bus by means of special program adapters.

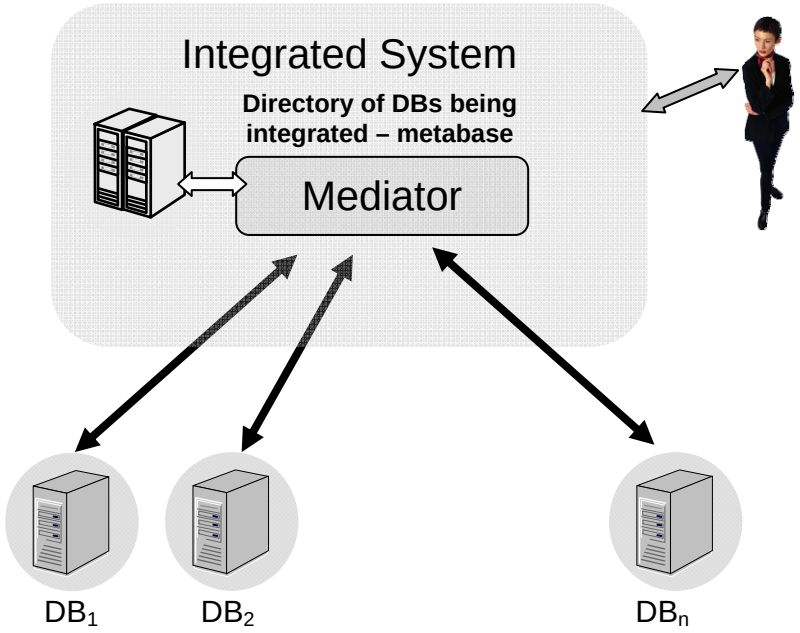

Fig. 3. EII-approach – real time data integration.

The EII and EAI technologies allow not to change every integrated database structure dramatically (and thus established database administration technology). So called "virtual" database integration and heterogeneous distributed information system creation implies independence in evolution of separate subsystems and at the same time allows to end user to get access to the whole "live" data array on a certain chemical substance or material that is stored in databases of virtually united system.

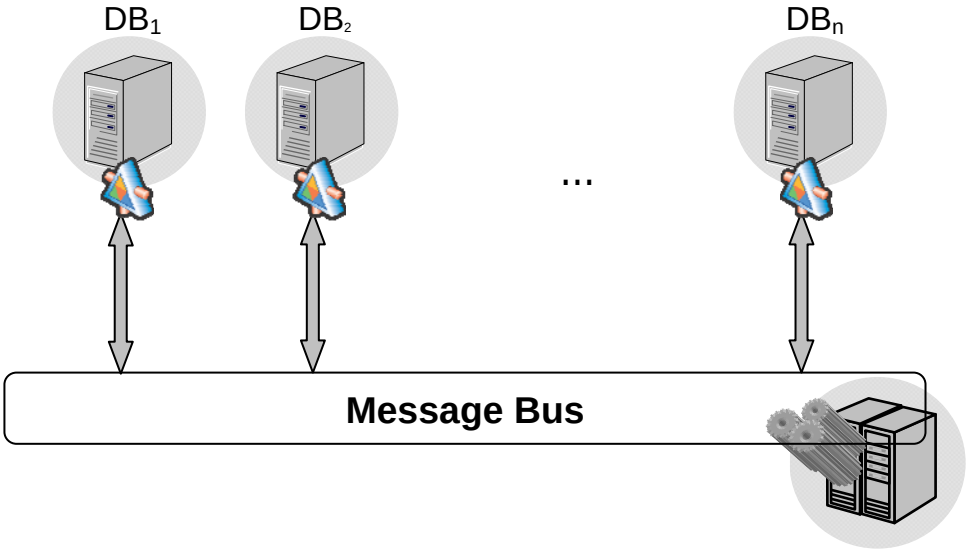

Fig.4. EAI-approach – applications integration.

So EAI technology integrates transactions of two or more applications, ETL technology merges the data of several information sources into a single one, and EII technology carries out virtual data integration of various information sources. It should be mentioned that no approach can solve all tasks arising when integrating information systems on material and substance properties.

It is necessary to take into consideration that every data center on materials properties is a point of information concentration and data analytical processing based on different software and hardware. The technology of

information accumulation and data processing has been settled down in each organization. So, great investments that have been made in hardware and software do not allow mechanically transporting all the data into some centralized database. Moreover many DBs on material and substance properties are equipped with ancillary programs for substance parameters calculation. Therefore taking into consideration current development conditions of databases on inorganic substance and material properties the integrated system based on both EAI- and EII-technologies has been developed in Baikov Institute [Dudarev et al., 2006; Kornuyshko and Dudarev, 2006] (fig. 5). It allows dynamically integrate a plenty of heterogeneous databases that are supplied with any computational subsystems.

Integration of Russian Databases on Inorganic Material and Substance Properties

From the beginning the proposed approach has been used for integration of Russian DBs on inorganic material and substance properties. For successful integration solution it is needed some coordinating center, which "knows" what information is stored in every integrated DB. Such function can be carried out by *metabase* – a special metadata database that stores information on integrated DBs contents, namely, about chemical systems, substances and its modifications. Every chemical system is identified by a set of chemical elements, which are included into its composition. Each chemical substance is determined by a set of chemical elements (as a system) and their quantitative composition in the substance. Every chemical modification is defined as chemical substance having special crystal structure of phases. Metabase contains also information on properties, which data are stored in different DBs, and other data. This information is enough to make search for relevant chemical systems and data on substances and materials properties.

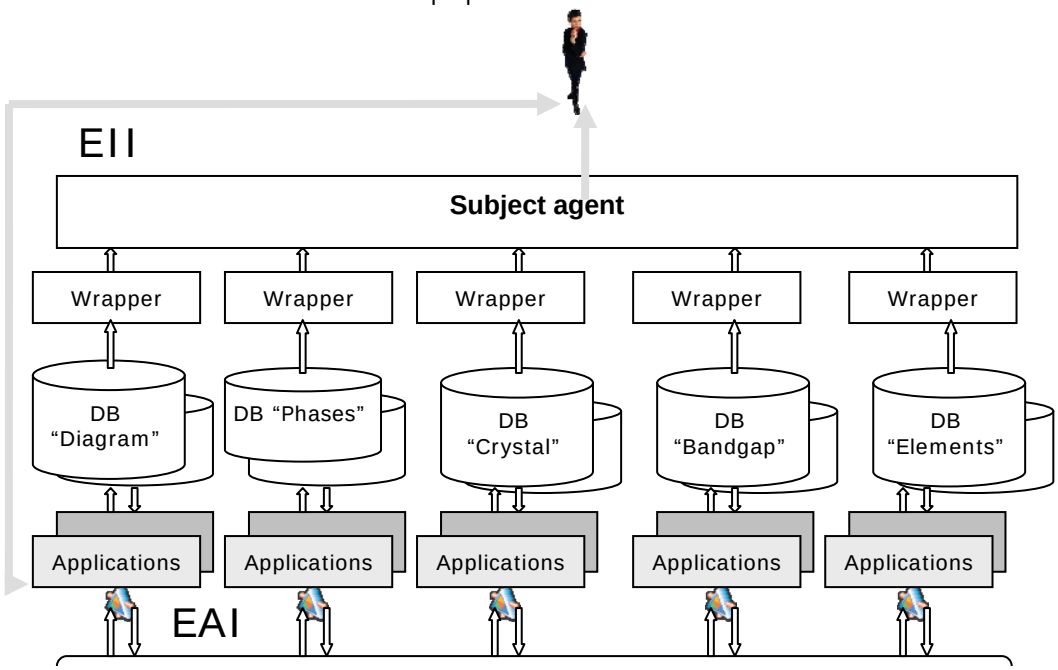

Fig. 5. Structure of integrated DBs system of Baikov Institute.

Currently the integrated information system includes five DBs that have been developed by Baikov Institute: DB on inorganic compounds properties "Phases" [Kiselyova et al., 2006], DB on semiconducting systems phase diagrams "Diagram" [Khristoforov et al., 2001], DB on substances with significant acousto-optical, electro-optical and nonlinear-optical properties "Crystal" [Kiselyova et al., 2004], DB on inorganic substances forbidden zone width "Bandgap" [Dudarev et al., 2006] and DB on chemical elements properties "Elements" (fig. 5). One of the most important developed integrated system features is that DBs which have been included into integrated system have been created with various DBMS using essentially different computer platforms: Sun (DB "Diagram") and Intel (other DBs) and different operational systems: Sun Solaris (DB "Diagram") and Microsoft Windows 2003 Server (other DBs). However the way, offered by us, has appeared successful even in such a difficult case for program realization.

Integration of Russian and Japanese Databases on Inorganic Material and Substance Properties

Next stage is an integrated system expansion. Baikov Institute information system will be integrated with other Russian [Zemskov et al., 1998] and foreign DBs [Villars et al., 2004; Xu et al., 2006] on inorganic materials and substances. Integration principles are based on the application of metabase and combined approach that has been developed in Baikov Institute [Dudarev et al., 2006; Kornuyshko and Dudarev, 2006]. Sometimes small additional tables, that contain information about elements sets and their contents in substance and crystal structure, should be included into these DBs.

The following metabase structure can be used for Web-applications integration of DBs on inorganic substances and materials properties (fig. 6).

Tables designation (fig. 6): DBInfo – main table containing information on DBs Web-applications to be integrated; UsersInfo, UsersAccess - tables containing information on integrated system users and their access permissions to information; SystemInfo, PropertiesInfo, DBContent – tables that describe integrated resources contents (what information on chemical systems and their properties is stored in what DB); CompatibilityClasses, Compatibility, Systems2ConsiderInCompatibility – tables that contain information on relevance classes and determine relevant chemical systems.

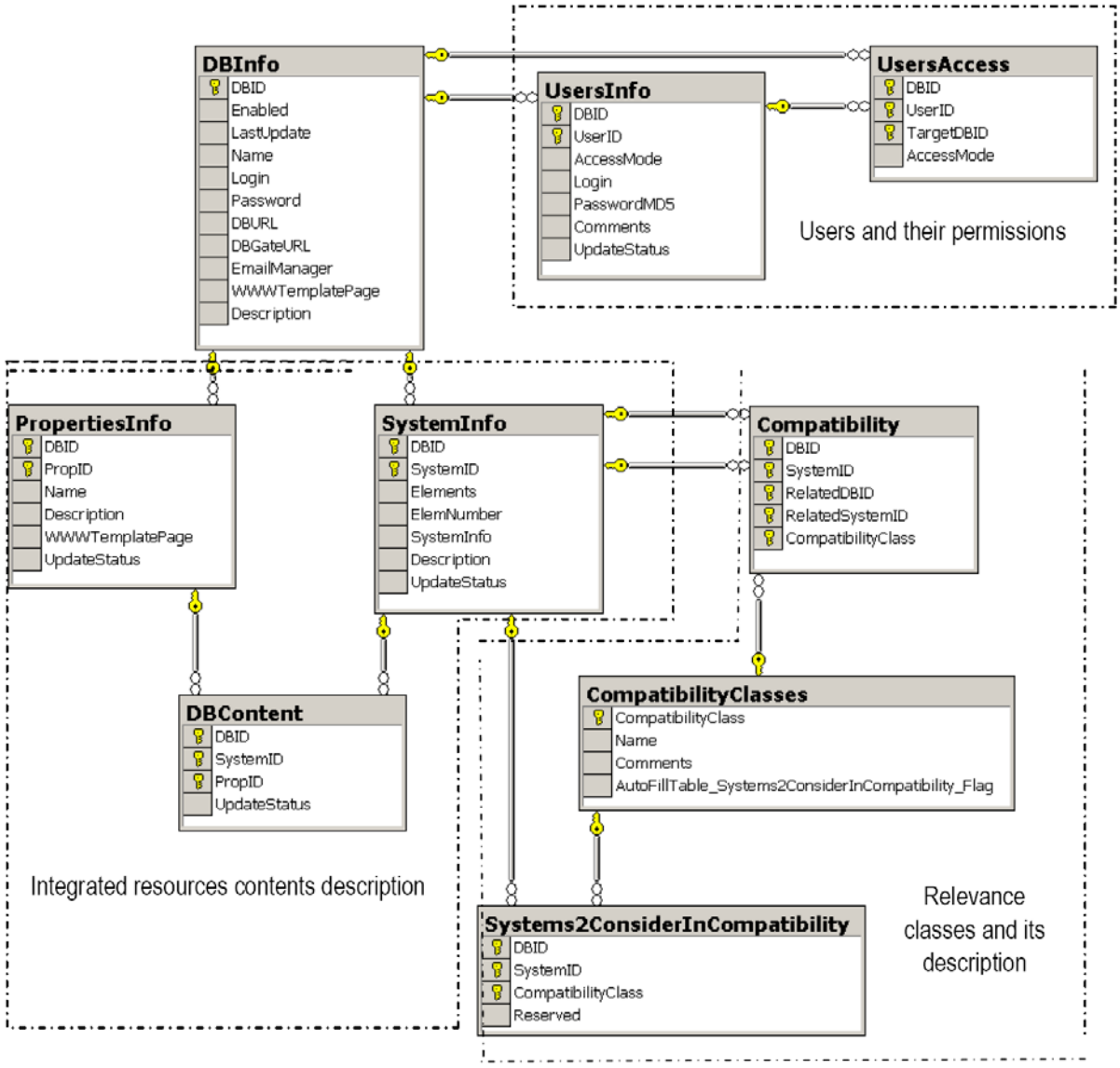

Fig. 6. Metabase structure for DBs Web-applications integration.

Conclusion

The complex approach to information integration combining integration at data level and at user interfaces level (EII+EAI) is offered. Within proposed approach access means have been implemented to all current user interfaces of virtually united information system. Moreover the system allows users to move transparently between different applications (EAI). According to the common developed information schema subject mediator has been implemented. It provides rich opportunities for information extraction and aggregation from diverse distributed data sources on material and substance properties (EII).

Search for relevant data in integrated information system tasks and transparent user transition between DBs Web-applications implementation (taking into account the security issues) have been solved during DBs Web-applications integration. Metadata database (metabase) has been used for relevant information search mechanisms implementation. Matabase is a special reference database containing metadata only. Metadata are information on information systems to be integrated. Diverse data sources integration is based on conceptual knowledge domain structure (inorganic chemistry) and heterogeneity conflicts resolution ways development.

Databases on inorganic material and substance properties system is accessible for registered users via Internet: http://www.imet-db.ru.

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IMAGE QUOTIENT SET TRANSFORMS IN SEGMENTATION PROBLEMS

Dmitry Kinoshenko, Sergey Mashtalir, Konstantin Shcherbinin, Elena Yegorova

Abstract: Image content interpretation is much dependent on segmentations efficiency. Requirements for the image recognition applications lead to a nessesity to create models of new type, which will provide some adaptation between law-level image processing, when images are segmented into disjoint regions and features are extracted from each region, and high-level analysis, using obtained set of all features for making decisions. Such analysis requires some a priori information, measurable region properties, heuristics, and plausibility of computational inference. Sometimes to produce reliable true conclusion simultaneous processing of several partitions is desired. In this paper a set of operations with obtained image segmentation and a nested partitions metric are introduced.

Keywords: image, spatial reasoning, partitions, covers, interpretation.

ACM Classification Keywords: I.4.6 Segmentation: region growing, partitioning

Introduction

Modern phase of developing intellectual systems for information processing in correlation-extremal tracking, industry robotics vision, graphical and graphological information processing, medical diagnostic complexes, etc. requires ability to process different visual data for its unsupervised context interpretation. Increasing of arbitrary image identification reliability in real time necessitates refinement of complex images recognition under uncertainty factors.

Efficiency of image structuring and understanding strongly depends on a segmentation as a process of separating an image into several disjoint (or weakly intersecting) regions whose characteristics such as intensity, color, texture, shape, etc. are similar [see e.g. 1-4]. Segmentation is a key step in early vision and it has been widely investigated in image processing. Generally this process is rather laborious and not completely algorithmized for arbitrary images. Different data registration conditions, by-product facts, lack of robustness for the disturbing effects – this is a far not complete list of the reasons, which refers the process of image recognition to the class of not ordinary tasks. In practical applications the choice of methods which are able to form the most accurate regions of interest is of the prior importance. Unfortunately most of existing methods produce only the primary partitions which can not guarantee adequate image interpretation as image content formal descriptions obtained by using only low-level features are not necessarily the case for true conclusions. We may get totally correct segmentation, but in most cases we obtain under-segmentation, over-segmentation, missed regions, and

noise regions. It should be emphasized that a fair segmentation can be provided if and only if we know exactly what we are looking for in an image.

To obtain a reliable image interpretation we have to transform a row image into an image data structure, then into an image knowledge structure and finally into a user-specific knowledge structure. Spatial reasoning plays a most important part in decision making. In this respect partition transforms (e.g. set theoretic) are serviceable in order to find regions that are heavily correlated with significant objects in the scene and it is essential to have tools in order to compare segmented image accurately.

The three classes of distance function (point to point, point to set, and set to set) are usually discussed as measures of proximity or dissimilarity in image processing [5-8]. It is desirable to define an image metric that can be efficiently embedded in segmentations methods. A partition metric is consequently a candidate because it represents images as a finite subsets assemblage that takes into account mutual dependences of equivalence class corresponding to separate regions of interest. Metrics on nested partitions take on special significance since they give possibilities to define hierarchical content descriptions. We propose spatial relations operations for segmented images and a metric on nested partitions useful for such applications as object tracking and pattern matching.

Operations with segmented images

Let $\mathrm{B}(x)$ be an image and $x \in \mathrm{D} = \mathbb{Z}_{\mathrm{n}}^{+} \times \mathbb{Z}_{\mathrm{m}}^{+}$ (here D is a viewing field). It should be noted that any faithful segmentation (a crisp clustering) generates a partition of the viewing field, i.e. $\mathrm{X} = \{[x]_1, \ldots, [x]_\alpha, \ldots, [x]_{\mathrm{s}}\}$ where $[x]_\alpha \neq \varnothing$, $\mathrm{X} = \bigcup_{\alpha=1}^{s} [x]_\alpha$, $\forall \alpha \neq \beta \Rightarrow [x]_\alpha \cap [x]_\beta = \varnothing$ (hereafter α, β, γ denote all allowable indices). Suppose that a region labeling $\mathrm{F} : \mathrm{B}(x) \to \mathbb{Z}_{\mathrm{r}}^{+}$ corresponds to obtained segmentation then arbitrary two points $x', x'' \in \mathrm{D}$ belong to the same equivalence class $x', x'' \in [x]_\alpha$ if the binary relation $\langle \mathrm{B}(x'), \mathrm{B}(x'') \rangle \in \tau \Leftrightarrow$ $\Leftrightarrow \mathrm{F}(\mathrm{B}(x')) = \mathrm{F}(\mathrm{B}(x'')) = \alpha$ is fulfilled.

In practice it is not always possible to obtain crisp segmentation, in this case it is necessary to work with fuzzy elements, i.e. covers.

A system of sets $[x]_{\mathrm{i}}$ is a cover Ξ of set D if for $\exists x \in D$ it holds true that $[x]_\alpha \cap [x]_\beta \neq \varnothing$ for any α and β. Cover generating sets $[x]_\alpha$ intended not to necessarily be singly connected.

If two sets of the cover have a non-empty intersection, i.e. $[x]_\alpha \cap [x]_\beta = \varnothing$, we shall concider them to be tolerant: $[x]_\alpha \, \tau \, [x]_\beta$.

For fixed $[x]_{\mathrm{o}} \in \Xi$, union of all intersections $[x]_{\mathrm{o}} \cap [x]_\alpha = \varnothing$, $\left([x]_\alpha \neq [x]_{\mathrm{o}}, [x]_\alpha \in \Xi\right)$ forms so-called boundary set d_{o}, which we shall conditionally call a 'boundary' of set $[x]_{\mathrm{o}}$. Joint border of two tolerant sets $[x]_\alpha \, \tau \, [x]_\beta$, which belong to Ξ, we shall call a union of all intersections:

$$\left([x]_\alpha \cup [x]_\beta\right) \cap [x]_\gamma,$$

where $[x]_\gamma \neq [x]_\alpha; [x]_\gamma \neq [x]_\beta; [x]_\gamma \in \Xi$.

A total boundary of the tolerant sets chain is defined by induction

$$[x]_\alpha \, \tau \, [x]_\beta \, \tau \ldots \tau \, [x]_{\mathrm{s}}.$$

It is presumed that each element of cover $[x]_{\mathrm{o}} \in \Xi$ includes a set $[a]_{\mathrm{o}} : [a]_{\mathrm{o}} = [x]_{\mathrm{o}} \setminus d_{\mathrm{o}}$, which we shall call as an equivalence set held in $[x]_{\mathrm{o}}$.

Further we shall introduce the following designation: $[x]_{\mathrm{o}} = [\tilde{a}]_{\mathrm{o}}$, $[\tilde{a}]_{\mathrm{o}} = [a]_{\mathrm{o}} \cup d_{\mathrm{o}}$. If $[\tilde{a}]_\alpha \, \tau \, [\tilde{a}]_\beta$, then sets $[a]_\alpha$ and $[a]_\beta$ we shall also call tolerant: $[a]_\alpha \, \tau \, [a]_\beta$.

Let us concider a set of points $\mathfrak{M} \in D$ as an observed object. It is expected that some cover Ξ_{temp} is extracted, and we shall call it as object's template cover.

Thus, instead of a given object $\mathfrak{M}$ we concider its cover $\mathfrak{M}_{\mathrm{temp}}$. On sets $[x]_{\mathrm{temp}}^{\mathrm{i}} \in \mathfrak{M}_{\mathrm{temp}}$ (which obviously

are the elements of cover Ξ_{temp}) K binary relations $b_1, b_2, ..b_k$ are introduced. Given relations induced on subsets Ξ^{i}_{temp} , define template features of the object.

Let Ξ_n now be some cover, different from the template one (another observation of the object), for elements of which same K relations $b_1, b_2, ..b_k$ are defined. We shall extract from the cover Ξ_n features $\Xi^1_n, ..., \Xi^n_n$ as sunsets of elements Ξ_n with given relations.

Commbination (union) of features $\mathfrak{M}_n = \cup \Xi^i_n$ forms the observed cover of the object which we shall call as objects observation. Besides «inner» relations for each feature on $\mathfrak{M}_n$ elements, there are some relations which establish connection between features themselves.

If there is a mapping of elements from $\mathfrak{M}_n$ on elements from $\mathfrak{M}_{\text{temp}}$, which is a homomorphism of each binary relation b_j, $j = 1, ..., k$, than we say that the object observation is consistent.

If under mapping there is a homomorphism between some observed and template features at least for some binary relations, then we shall call the observation of $\mathfrak{M}_n$ as partially consistent, and will define it concretely for every certain case.

Thus, the object feature will be a family (collection) of cover elements with given binary relations. The object itself we shall interprete as a finite system of such features. At that except the scleronomous for each feature binary relations, there can be some relations between elements of different features.

When extracting the object features we shall use the topology of cover sets. As it was mentioned above, set $[x]_o \in \Xi$ is not neceserily simply connected.

It is necessary to define k_1, k_2 , where k_1 is a total number of closed (connected) boundaries of set $[x]_o$, k_2 is number of closed boundaries of set $[x]_o$, which are situated inside some region, bounded by some outer boundaries of the given set. The border of 'frame' can be included into the own border of the set.

If $k_1 - k_2 = 2$, then «outer» border consist of two closed contours, if $k_1 - k_2 = 1$ the border consist of one closed contour solely (fig. 1).

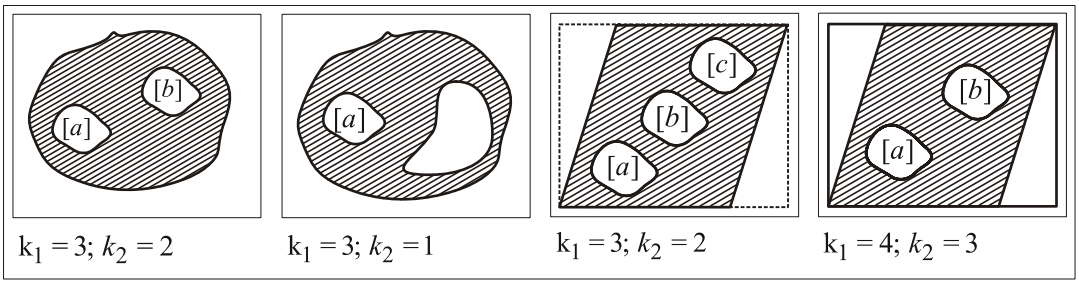

Figure 1. Example of total numbers of inner and outer borders of sets

«Inner» sets can be tolerant (have mutual border), and also it is possible for them to have mutual outer border with the outer set.

Let us assume that the border of set A is situated inside of the outer border if $[a]\tau[b]$, but $[a]$ is not tolerant to any set $[c]$ situated outside of outer border of set $[b]$. But if $[a]\tau[b]$ and $[a]\tau[c]$, then we assume that set $[a]$ is situated outside of set $[b]$, as it is shown in fig. 2.

As a matter of fact, one should differ three types of connectivity: connectivity of tree components υ_s ; connectivity into simply connected domain υ_1 : $[a]_1 \upsilon_1 [a]_3$; $[a]_2 \upsilon_1 [a]_3$; and including into doubly-connected domain υ_2 : $[a]_1 \upsilon_2 [a]_2$. A simply-connected domain case is not a case of multiple connection $[a]_1 \subset [a]_3$, as in fig. 2 $[a]_3$ is a set with two holes.

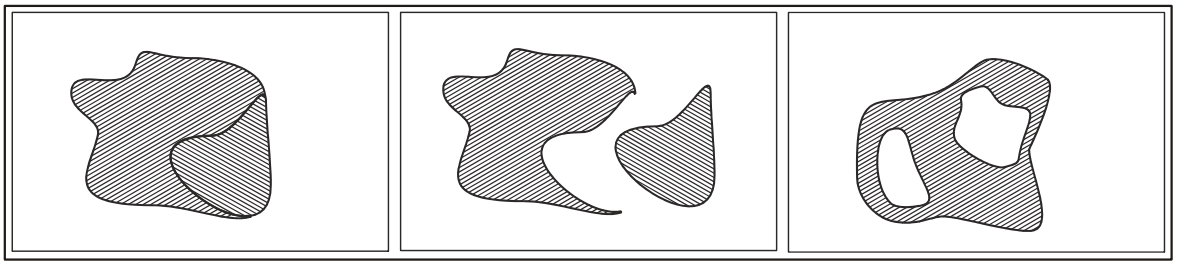

Figure 2. Example of sets connections:
a – sets have a joint boundary, b – sets do not intersect, c – a set with two holes

On cover of Ξ elements we shall introduce a relation S, and in addition to relation $\subset$ for components we shall also introduce a components tolerance τ_S. Let $S_{[a]}$ and $S_{[b]}$ be two arbitrary components. We shall state that $S_{[a]} \tau_S S_{[b]}$, if at least two sets $[a] \in S_{[a]}$ and $[b] \in S_{[b]}$ are tolerant.

Let $S_{[a]}$ be a connecting set of cover elements. We shall consider a set of this component boundary sets, i.e. a family of Ξ elements intersections (without sets included in $S_{[a]}$) with sets belonging to $S_{[a]}$. The boundary set which contains all the rest of the boundaries inside we shall call as outer boundary. Any arbitrary set $[c]$ situated inside ther region limited by outer boundary we shall concider to be connected to component $S_{[a]}$ by relation $[c] \upsilon_S S_{[a]}$. If all sets of component $S_{[b]}$ are connected by this relation with $S_{[a]}$, then $S_{[b]} \upsilon_S S_{[a]}$, i.e. $S_{[b]}$ "enters" $S_{[a]}$. It is obvious, that $S_{[b]}$ is connected, i.e. it either is completely situated in $S_{[a]}$, or none of S_B the sets "enters" $S_{[a]}$ (fig. 3).

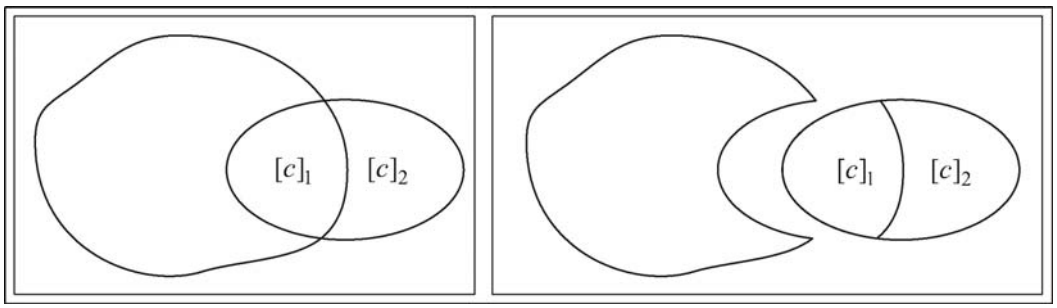

Figure 3. Intersecting and connected sets

Another important part in describing image/object structure is a spatial layout.
Let us introduce a characteristic function on equivalence classes

$$\lambda_{[x]_\alpha}(x) = \begin{cases} 0, & x \in [x]_\alpha, \\ 1, & x \in \mathrm{D} \setminus [x]_\alpha. \end{cases} \quad (1)$$

It follows immediately that boundary conditions for spatial reasoning are

$$\lambda_{\mathrm{D}}(x) = 0, \ \lambda_{\varnothing}(x) = 1.$$

In addition it is reasonable to indicate the expression providing certain duality in order to analyze image contents

$$\lambda_{\mathrm{D}\setminus[x]_\alpha}(x) = 1 - \lambda_{[x]_\alpha}(x).$$

The direct check-up allows to introduce explicitly definable formulae of spatial interdependence between characteristic functions of two elements of arbitrary partitions X and Y

$$\lambda_{[x]_\alpha \cup [y]_\beta}(x) = \lambda_{[x]_\alpha}(x) \lambda_{[y]_\beta}(x), \quad (2)$$

$$\lambda_{[x]_\alpha \cap [y]_\beta}(x) = \lambda_{[x]_\alpha}(x) + \lambda_{[y]_\beta}(x) - \lambda_{[x]_\alpha}(x) \lambda_{[y]_\beta}(x), \quad (3)$$

$$\lambda_{[x]_\alpha \setminus [y]_\beta}(x) = 1 - \lambda_{[x]_\alpha}(x) + \lambda_{[y]_\beta}(x). \quad (4)$$

Appreciably intense interest consists in simultaneous transformations of equivalence class families since namely splitting and merging of partitions can get totally correct and complete segmentation of complex scenes. It easily seen that for any unions and intersections we get

$$\Xi = \bigcup_{\gamma\in\Gamma}[x]_\gamma \Rightarrow \lambda_\Xi(x) = \min_{\gamma\in\Gamma} \lambda_{[x]_\gamma}(x), \quad (5)$$

$$\Xi = \bigcap_{\gamma\in\Gamma}[x]_\gamma \Rightarrow \lambda_\Xi(x) = \max_{\gamma\in\Gamma} \lambda_{[x]_\gamma}(x). \quad (6)$$

The 169 types of spatial relations between two rectangles in 2-D space had been proposed in [9]. However, if we introduce a representation of each equivalence class as union of sets (rather points of boundaries and interior) it suffices to use combinations only of four relations in general case. Indeed, suppose that

$$\lambda_{[x]_\alpha}(x) = \partial\lambda_{[x]_\alpha} \cup \lambda^{\circ}_{[x]_\alpha}$$

where $\partial\lambda_{[x]_\alpha}$ denotes the boundary of the partition element describing by the characteristic function (1) and $\lambda^{\circ}_{[x]_\alpha}$ corresponds to interior points of this partition element. Let us introduce relations defining spatial relationships between any two objects $[x]_\alpha$ and $[x]_\beta$, $\alpha \neq \beta$

$$\begin{cases} \langle [x]_\alpha, [x]_\beta \rangle \in \varsigma_{11} \Leftrightarrow \partial\lambda_{[x]_\alpha} \cap \partial\lambda_{[x]_\beta} \neq \varnothing, \\ \langle [x]_\alpha, [x]_\beta \rangle \in \varsigma_{12} \Leftrightarrow \partial\lambda_{[x]_\alpha} \cap \lambda^{\circ}_{[x]_\beta} \neq \varnothing, \\ \langle [x]_\alpha, [x]_\beta \rangle \in \varsigma_{21} \Leftrightarrow \lambda^{\circ}_{[x]_\alpha} \cap \partial\lambda_{[x]_\beta} \neq \varnothing, \\ \langle [x]_\alpha, [x]_\beta \rangle \in \varsigma_{22} \Leftrightarrow \lambda^{\circ}_{[x]_\alpha} \cap \lambda^{\circ}_{[x]_\beta} \neq \varnothing. \end{cases} \quad (7)$$

Consequently, the (2×2) matrix (ς_{ij}) entirely determines all eight possible mutual locations of regions, viz:

i) $[x]_\alpha$ disjoins $[x]_\beta$, i.e. all parts of $[x]_\alpha$ are separated from all parts of $[x]_\beta$ iff $\langle [x]_\alpha, [x]_\beta \rangle \notin \varsigma_{ij}$ $\forall i, j$;

ii) $[x]_\alpha$ contains $[x]_\beta$, i.e. all parts of $[x]_\beta$ are completely overlapping with any part of $[x]_\alpha$ iff $\varsigma_{21}, \varsigma_{22}$, are valid and the relations are not true;

iii) similarly, $[x]_\alpha$ belongs $[x]_\beta$ iff $\langle [x]_\alpha, [x]_\beta \rangle \in \varsigma_{12}, \varsigma_{22}$ and $\langle [x]_\alpha, [x]_\beta \rangle \notin \varsigma_{11}, \varsigma_{21}$;

vi) $[x]_\alpha$ equals to $[x]_\beta$ iff $\langle [x]_\alpha, [x]_\beta \rangle \in \varsigma_{11}, \varsigma_{22}$ and $\langle [x]_\alpha, [x]_\beta \rangle \notin \varsigma_{12}, \varsigma_{21}$;

v) $[x]_\alpha$ is partly overlapping $[x]_\beta$ iff all relations ς_{ij} hold;

vi) $[x]_\alpha$ is externally bound to bound with $[x]_\beta$, i.e. there exist common points of boundaries and no part of $[x]_\alpha$ is overlapping with any part of $[x]_\beta$ iff $\langle [x]_\alpha, [x]_\beta \rangle \in \varsigma_{11}, \varsigma_{22}$ and $\langle [x]_\alpha, [x]_\beta \rangle \notin \varsigma_{12}, \varsigma_{21}$;

vii) $[x]_\alpha$ is internally bound to bound with $[x]_\beta$, i.e. there exist common points of boundaries and $[x]_\alpha$ belongs $[x]_\beta$ iff only the relation ς_{21} is not true;

viii) $[x]_\beta$ is internally bound to bound with $[x]_\alpha$, i.e. there exist common points of boundaries and $[x]_\alpha$ contains $[x]_\beta$ iff only the relation ς_{12} is not true.

Now we can formalize intersection and conditional union operations with partitions. For simplicity of notations we write μ instead of a matrix (ς_{ij}) elements sum then introducing an indicator function

$$\varphi(\alpha,\beta) = \begin{cases} -1, s = 1; \\ 0, s = 0; \\ 1, s > 1. \end{cases}$$

we get for $\mathrm{X} = \{[x]_\alpha\}$, $\mathrm{Y} = \{[y]_\beta\}$

$$Z = X \otimes Y,\ Z = \{[z]_\gamma : \lambda_{[z]_\gamma}(x) = \lambda_{[x]_\alpha}(x) + \lambda_{[y]_\beta}(x) - \lambda_{[x]_\alpha}(x)\lambda_{[y]_\beta}(x)\} \quad (8)$$

and

$$Z = X \oplus Y,\ Z = \{[z]_\gamma\},\ [z]_\gamma = \begin{cases} \{[x]_\alpha, [y]_\beta\}, \text{if } \varphi(\alpha,\beta) = 0; \\ [x]_\alpha \cup [y]_\beta, \text{if } \varphi(\alpha,\beta) = 1. \end{cases} \quad (9)$$

It is obvious evident that under $\varphi(\alpha,\beta) = -1$ a complementary analysis is required since merging of adjoining region is admissible action if features of $[z]_\gamma$ with the characteristic function $\lambda_{[z]_\gamma}(x) = \lambda_{[x]_\alpha}(x)\lambda_{[y]_\beta}(x)$ satisfy, for instance, requirements to the sought-for shape.

Thereby, expressions (2)–(4) determine operations with separate equivalence classes, relationships (5), (6) predetermine transformations of equivalence class families and (8), (9) on the base of relations (7) provide partition manipulations. The main goal of such segmented image reforming is a guaranteeing trade-off decision about regions of interest.

We shall concider that for equivalence sets $[a]_i$ from Ξ (these sets do not mutually intersect) a brightness function $\Upsilon_i = S([a]_\alpha)$ is defined, such that brightness of all points of one set $[a]_o$ is the same and the brightness degree of each set $[a]_\alpha$ can be ordered on increase. Given function defines quasi-order S : $[a]_1 S [a]_2$, and therefore $\Upsilon_1 \le \Upsilon_2$ for sets $[a]_\alpha$.

Results and outlook

Significant efforts are continuously being made in development of segmentation techniques. Cognitive-like approaches require obtaining of regions strongly correlated with meaningful objects in the scene. Mentioned operations create the necessary prerequisites for partitions transformations. However, efficiency of image structuring and understanding depends on the objectivity of partitions matching. Previously for finite sets we proved [10, 11] that the functional

$$\rho(X,Y) = \sum_\alpha \sum_\beta card([x]_\alpha \Delta [y]_\beta) card([x]_\alpha \cap [y]_\beta) \quad (10)$$

(here the notation $X_i \Delta Y_j$ defines a symmetric difference) is a metric. Later for arbitrary measurable set with given measure $\mu(\circ)$, which can be interpreted as length, area, volume, mass distribution, probability distribution, and in special case cardinality, we had proved [6] that the functional

$$\rho(X,Y) = \sum_\alpha \sum_\beta \mu([x]_\alpha \Delta [y]_\beta) \mu([x]_\alpha \cap [y]_\beta) \quad (11)$$

is a metric also. Taking into consideration properties of nested partitions one can give concrete expression to metrics (10) and (11) for $X \subseteq Y$

$$\rho(X,Y) = \sum_\beta \mu([y]_\beta)^2 - \sum_\alpha \mu([x]_\alpha)^2 \quad (12)$$

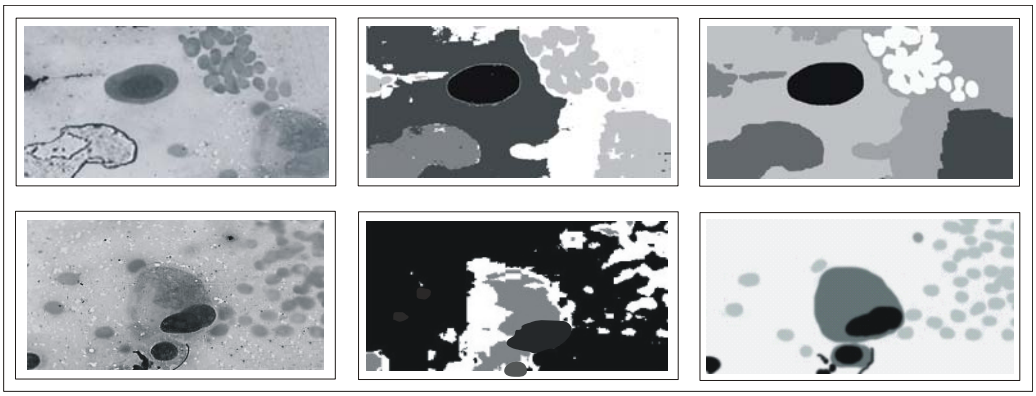

Figure 4. Example of nested partitions

Substantially metric (12) intends for combination of visual features and metadata analysis to solve a semantic gap between low-level visual features and high-level human concept. Figure 2 illustrates nested partitions that are

generated by algorithms based on adaptive thresholding, multithresholding and band-thresholding [6]. Simple geometrical shape parameters (the area and the perimeter of region, the diameters of circles with fixed area and perimeter, orthogonal projections of the figure on axes of abscissae and ordinates, the minimal and the maximal orthogonal projections of the figure on a line, the distance between opposite sides of the figure, the distance from an origin point in the figure to its boundary point for a given direction, the same average distance for all possible directions for a given point, the lengths of the long and short semi-axes of the ellipse with given area and perimeter, drainage-basin circularity, coefficient convexity ratio, etc.) were used for split and merging procedures along with relations (7) under operations (8) and (9).

The analysis of experimental results has shown that partition transforms and unbiased partitions matching substantially meant for the use at conceptual segmentation which not only builds partitions but can also explain why a set of regions confirms a desired pixel family.

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VLSI WATERMARK IMPLEMENTATIONS AND APPLICATIONS

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Abstract: This paper presents an up to date review of digital watermarking (WM) from a VLSI designer point of view. The reader is introduced to basic principles and terms in the field of image watermarking. It goes through a brief survey on WM theory, laying out common classification criterions and discussing important design considerations and trade-offs. Elementary WM properties such as robustness, computational complexity and their influence on image quality are discussed. Common attacks and testing benchmarks are also briefly mentioned. It is shown that WM design must take the intended application into account. The difference between software and hardware implementations is explained through the introduction of a general scheme of a WM system and two examples from previous works. A versatile methodology to aid in a reliable and modular design process is suggested. Relating to mixed-signal VLSI design and testing, the proposed methodology allows an efficient development of a CMOS image sensor with WM capabilities.

Keywords: Watermark, CMOS sensors, image sensors, VLSI, mixed-signal circuits, fast prototyping.

ACM Classification Keywords:

1. Introduction

The field of digital imaging and its subsidiaries has been going through a continuous and rapid growth during the last decade. Research activity has been extensive in both the academic and commercial communities, and significant advances and breakthroughs are being constantly published [1]. Cost reductions and miniaturization enabled by major developments in VLSI fabrication technologies, CMOS in particular, are making high quality digital imaging products widely accessible, thus effectively taking traditional analog imaging out of the picture. Digital imaging has become a standard in almost all imaging applications, from professional photography and broadcasting to the everyday consumer digital camera. The ease of integrating CMOS imagers with supporting peripheral elements together with a significant reduction in power consumption introduced a variety of new portable products such as imagers on cell phones and narrow-band web cameras [2].

Since digital images are very susceptible to manipulations and alterations, a variety of security problems are introduced. For example, a security centre may wish to authenticate the data received from sensors spread across a facility it is supposed to protect. Another common application is resolving ownership disputes when copyrighted material is distributed illegally. Those problems and needs can be treated by embedding a secret, invisible watermark (WM) in images. A WM is an additional, identifying message, covered under the more significant image raw data, without perceptually changing it. By adding a transparent WM to the image, it can be made possible to detect alterations inflicted upon the image, such as cropping, scaling, covering, blurring and many more.

The WM can be added on either a software platform or a hardware platform, each having some benefits and some drawbacks. Although WM implementation on a hardware platform suffers from limited processing power, compared to the software implementation, it features real time capabilities and compact implementations. The advantages of hardware WM implementations are especially enhanced in CMOS imagers, where it is possible to integrate the WM embedder monolithically with the sensor array on the same die.

Many WM implementations both in software and in hardware have been proposed in the literature [3]-[11]. In 1990 the modern study of steganography and digital WM was started by Tanaka et al. [10]. They suggested hiding information in multi-level dithered images as a form of secured military communications. Following that work, digital WM arose, and the development of WM algorithms became a growing field of research. Some of the proposed algorithms were relatively simple and weak, merely substituting image least significant bits with WM data [12],[13]. Others had a similar approach but selectively chose the pixels that were to be modulated – either by a random choice to enhance security or according to image quality considerations such as the variance of luminosity. In [14], the WM was embedded in the coefficients of the discrete cosine transform (DCT) of the image to allow better robustness against JPEG lossy compression. Later algorithms modulated only middle-band DCT coefficients [15] to avoid image quality degradation while maintaining a high level of robustness. During the

second decade of digital WM research, much thought has been given to the methods in which the WM is implemented and some hardware specific algorithms have been presented [16],[17]. These implementations are usually optimized versions of the former software implementations as will be shown in later sections.

This paper aims to achieve two main objectives. First, the reader is introduced to basic principles and terms in the field of image WM. The paper presents different classification criterions and elementary WM properties such as robustness, computational complexity and influence on image quality. The second goal is to discuss a versatile methodology to design and test hardware implemented WM algorithms, integrated with an image sensor. The proposed methodology speeds up the development process while enhancing reliability.

Section 2 reviews the theory of WM algorithms. Watermark implementations in software and hardware are presented in Section 3. Hardware implementation development methodologies are discussed in Section 4. Section 5 concludes the paper.

2. Theory and implementation of watermark algorithms

2.1 Watermarks Classification

Different applications require utilization of WM with different properties, and no universal WM algorithm that can satisfy the requirements for all kinds of applications has been presented in the literature. WM can be classified into different categories according to various criterions. Figure 1 shows general classification of existing WM algorithms. First of all, all WM can be divided into two main categories: *visible* and *invisible*. The invisibility of a WM is determined by how it affects the image perceptually. Sometimes a WM is intentionally visible, in which case, the identifying image is embedded into the original one and both are visually noticeable. Figure 2 shows examples of the original image and the image with embedded visible WM. Generally, most WM algorithms aim for the WM to be as invisible as possible. Invisible WM has the considerable advantage of not degrading the host data and not reducing its commercial value. For that reason a lot of research has been carried out in this field, while visible WM has received substantially less attention.

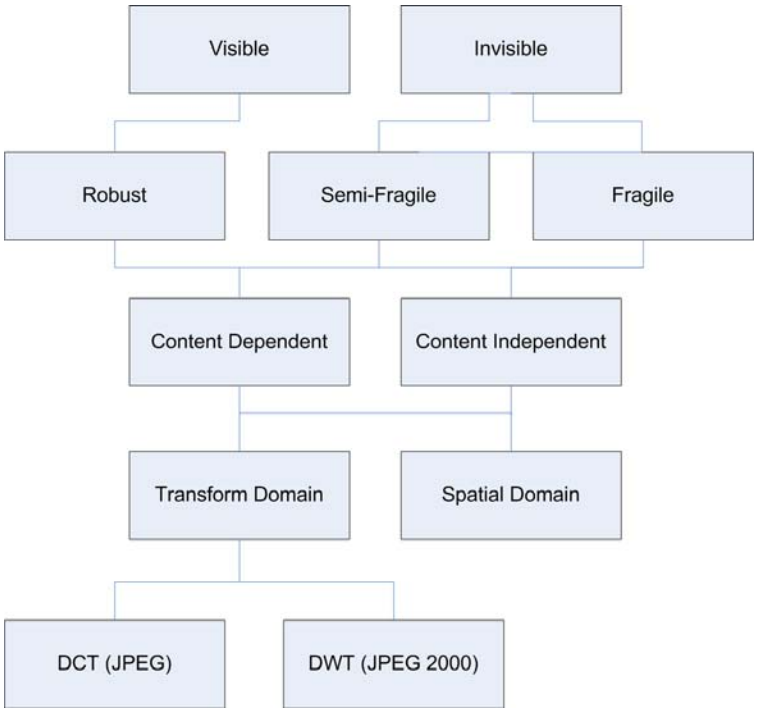

Figure 1. General classification of existing watermark algorithms

WM can also be classified according to the level of robustness to image changes and alterations. Three main categories of WM can be identified: *Fragile*, Semi-fragile and *Robust*, though no standard definition exists to explicitly determine which is which. Different applications will have different requirements, while one would need the algorithm to be robust as possible the other may be designed to detect even the slightest modification made to an image - such a WM is called fragile. A fragile WM is practical when a user wishes to directly authenticate that the image he is observing is exactly the same as it was when the WM was first embedded. This might be the case in applications where raw data is used. However, in most existing applications such modifications as lossy compression and mild geometric changes are inherently performed to the image. For those applications it is most efficient to use a semi-fragile algorithm which is designed to withstand certain legitimate modifications, but to detect malicious ones. Finally, some applications, such as copyright protection, require that the WM would be detectable even after an image goes through severe modifications and degradation, including digital-to-analog

and analog-to-digital conversions, cropping, scaling, segment removal and all sorts of attacks. A WM that answers these requirements would be called robust.

(a) (b)

Figure 2. Examples of (a) the original image and (b) the image with embedded visible watermark

Whether or not the algorithm is content dependent is another important distinction. Making the algorithm depend upon the content of the image, is good against counterfeiting attacks, however it complicates the algorithm implementation and therefore the embedding and extracting processes.

An additional classification relates to the domain in which the WM is performed. The most straight forward and simple approach is a WM implementation in the spatial domain that relates to applying the WM to the original image, for example by replacing the least significant bit (LSB) plane with an encoded one [12],[13]. Two other common representations are the discrete cosine (DCT) and the discrete wavelet transforms (DWT) [18],[19] in which the image first goes through a certain transformation, the WM is embedded in the transform domain and then it is inversely transformed to receive the watermarked image.

2.2 Watermark Design Considerations

In order to discuss WM design considerations a number of WM properties should be introduced: (1) *Capacity* (the term is adopted from the communications systems field [21]): in a watermarking system the cover image can be thought of as a channel used to deliver the identifying data (the watermark). The capacity of the system is defined as the amount of identifying data contained in the cover image, (2) *False detection ratio:* this ratio is characterized according to the probability of issuing the wrong decision. It is comprised of the probability to falsely detect an unauthentic WM (false positive), and the probability to miss a legitimate one (false negative). It is possible to manipulate the detection algorithm in order to minimize one or the other, according to the application. The value of this ratio is usually determined experimentally, (3) *Image quality degradation*: the embedding of foreign contents in the image has a degrading effect on image quality. That parameter is relatively hard to quantize and different measures such as peak signal-to-noise ratio (PSNR) or a subjective human perception measure may be applied.

These properties are elementary in every WM system and need to be carefully appreciated. The following subsections show how they are considered from different design point of views and indicate several trade-offs between them.

2.2.1 Robustness to Attacks

A good attack on fragile and semi-fragile WM will attempt to modify the perceptual content of the image, without affecting the WM data embedded in it. Knowledge of the embedding and extracting methods is assumed. There are two approaches for an attack; while the first approach requires the decryption of the encoded mark in order to produce a suitable WM on an unauthentic image, the second one aims to maintain the original mark on a modified image without knowing the mark itself. Decrypting the original WM is a cryptographic computational problem and is directly related to the capacity of the WM system. In WM however, the potential for such an attack is even greater (compared with the cryptographic case) as the attacker does not have to find the exact key, but

only one that would be close enough to pass over the detector's threshold. And still, if the capacity of the WM is large enough - using a key of several hundred bits, this attack may not be computationally tractable.

There are numerous attacks that take advantage of the existing image to create a forged one. The most intuitive one is the cover up attack [17]. This attack can be used when the mark is embedded independently to a block divided image. If the image contains homogeneous areas such as a wall, or a floor and the attacker wishes to hide a smaller object, he may do so by copying other blocks in such a way that the change would be perceptually un-noticeable, but the detector would still recognize a valid WM on the copied block. A possible counter measure for such an attack is to complicate the scheme, while increasing system complexity, and create dependencies between the marks of neighboring blocks – if a block is placed in the wrong place, detection would be false.

Attacks on copyright protection WM are designed to cause defects to the embedded WM so that it will be undetectable, while still maintaining reasonable image quality. Such attacks may include one or more of the following: (1) A geometric attack such as cropping, rotation, scaling etc, (2) A Digital-to-Analog conversion, such as printing and then Analog-to-Digital conversion by scanning (can also be done by re-sampling), (3) Lossy compression and (4) Duplicating small segments of the picture and deleting others (jitter attack) [9].

It is shown then, that several parameters must be considered for each application, in order to optimize the use of counter-measures. The goal is to maintain the required image quality desired for each application and still be robust to potential attacks. That trade-off is discussed in the next two subsections.

2.2.2 Image quality

As mentioned, an important objective of a good WM is minimizing image quality degradation. Recently we have shown [20], that for a blind content-independent algorithm, the trade-off between the security (capacity) of the mark and the negative affect on image quality is straight-forward. There, the WM is embedded by adding a pseudo-random noise to each pixel. Increasing the bit size of the mark is equivalent to increasing the variance of the noise, which is the measure for the capacity of that algorithm. It relates directly to better false detection ratio. However, it also adds significant high frequency values to the original image, affectively degrading its quality, especially in homogeneous parts of the picture.

To avoid such a significant degradation, it is possible to increase the security of the mark by making it content dependent [16],[18]. In a content dependent WM system, the embedded data is also some function of the cover image. The decoder would need the cover image data in order to extract the correct WM, making it more difficult, and sometimes even impossible to use for marking unoriginal content. This introduces higher computational complexity, but features a more secured mark without influencing the cover data severely.

2.2.3. Computational complexity

Intuitively, it is obvious that in order to apply a more complicated algorithm, more complex embedding and detecting blocks would be required. The motivation to keep the computational complexity low depends on the application and on the method of implementation. In real time applications, computations must be done in a very short time period. The speed and processing power of the computational platform at hand, limit the algorithm level of complexity that can be computed in a given time frame. When implementing in hardware, higher complexity requires additional hardware which means more area and additional costs.

In [20] we have introduced a scheme that is very easily implemented in hardware. In this implementation, computation time and hardware requirements are almost negligible, however compromising the performance achieved. As previously mentioned, in order to provide high detection rates perceptual effects are inevitable. In addition, this scheme is not able to detect local modifications. A potential attacker may take advantage of this inability, to cover parts of the picture he is trying to hide.

Depending on the intended application, more complicated schemes can be implemented to withstand expected attacks. If, for instance, localization of the changes made is important, a partition of the image into blocks may be of use. If the marked image is expected to go through lossy compression, one may consider embedding the WM in the frequency domain, as will be described in the next section. Other algorithms employ global and local mean values, temporal dependencies (in video WM) and variety of extra features to enhance their performance. However, each additional feature, added to the algorithm, increases the computational effort and hardware resources (such as memory and adders\multipliers) used. Therefore, an optimized scheme will be comprised of the minimum number of features needed to satisfy the needs of the application it is designed for.

2.3 Discussion

It has been shown that during the design of a WM system, many trade-offs are taken into account. How can one evaluate the overall quality of the final outcome? Although there is no accepted standard to uniformly asses the quality of WM [21], there are a few popular benchmarks available. A designer can use the evaluated system to embed a WM in a series of test images, and then run them through the benchmark and asses the performance by observing the quality of detection. The *StirMark* code, which is used for evaluating the robustness of WM algorithms designed for copyright protection applications, applies a series of attacks on a marked image [22]. In addition, it is possible to evaluate robustness to specific attacks by manually adding them to this benchmark. The *Checkmark* benchmark provides a framework for application-oriented evaluation of WM schemes, applicable to all sorts of WM algorithms including fragile and semi-fragile [21]. The use of such independent, third party, evaluation tools provides a good perspective on how well a WM system performs.

3. Watermark implementations – Software vs. Hardware

Figure 3 shows a scheme of a general WM system. The system consists of a WM generation, embedding and detection algorithms.

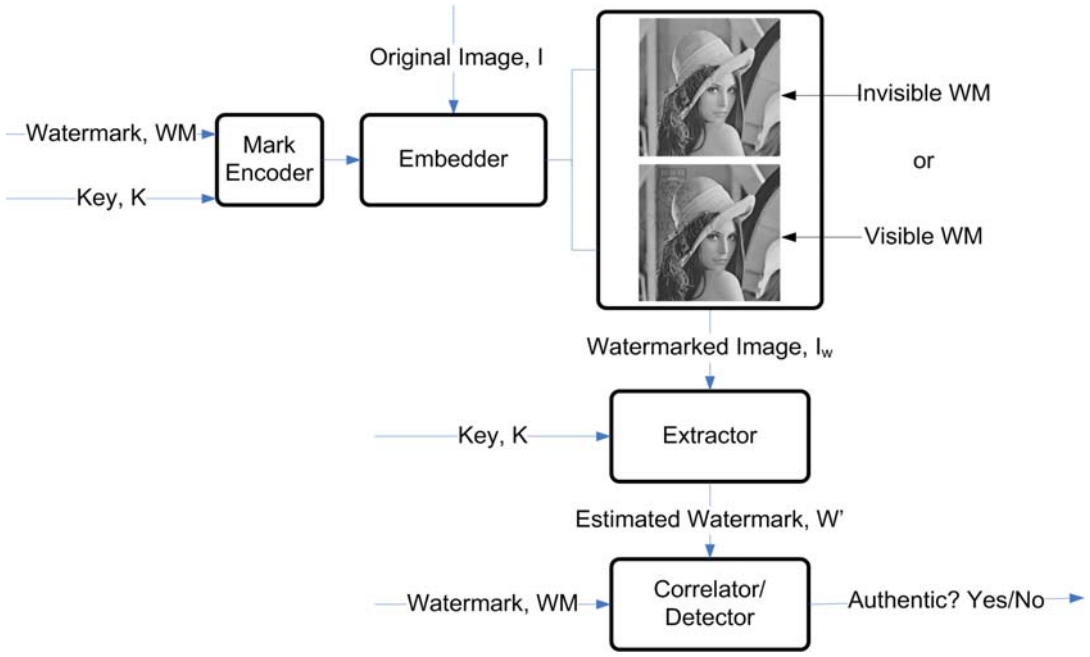

Figure 3. Scheme of general watermark system.

The identifying data (W in Figure 3) can be meaningful, like a logo, or it can just be a known stream of bits. First the identifying data is encoded using a secret key, K. Then the encoded identifying data is embedded into the original image (I in Figure 3). The result is the WM image. As previously mentioned, the WM can be visible or invisible, as shown in Figure 3. The detector part is at the receiving end. The objective is to extract the identifying data embedded in the received image, using the secret key and an inverse algorithm. Finally, a decision is made by correlating the extracted mark with the original and applying a chosen threshold.

The system can be implemented on either software or hardware platforms, or some combination of the two. A pure software WM scheme can simply be implemented in a PC environment. Such an implementation is relatively slow, as it shares computational resources and its performance is limited by the operating system. It is unsuitable for real-time applications, for it would be too slow, and it cannot be implemented on portable imaging devices that have limited processing power. On the other hand it can be easily programmed to realize any algorithm of any level of complexity, and can be used on everyday consumer PC's.

A good example of software WM solution was presented by Li [18]. In this work he proposes software implemented fragile WM, embedded in the coefficients of the block DCT. This algorithm is designed for authentication and content integrity verification of JPEG images. The algorithm embeds the WM only in a few selected DCT coefficients of every block in order to minimize the effect on the image. The author directly

addresses known issues in similar previous works, inserting additional complexity to overcome security gaps. The system utilizes the advantages of software implementation by using resources needed to store image data, transform coefficients and WM mappings. Using a combination of different security resources, including a non-deterministic mapping of the location of coefficient modulation and block dependencies, the system succeeds in facing several attacks without changing the affect on image quality – when compared to similar works. Moreover, the computations involved in the embedding process are kept relatively basic, suggesting suitability for future hardware implementation as well.

In opposite to software solutions, hardware implementations offer an optimized specific design to incorporate a small, fast and potentially cheap WM embedder. It is most suitable for real time applications, where computation time has to be deterministic (unlike software running on a windows system for example) and short. Optimizing the marking system hardware enables it to be added into various portable imaging devices. In a full imaging system that includes both the imager and WM embedder, the system security is improved as it is certain that the data entering the system is untouched by any external party. However, hardware implementations usually limit the algorithm complexity and are harder to upgrade. The algorithm must be carefully designed, minimizing any unexpected deficiencies. For example, in [16], Mohanty et al. present an implementation of both fragile and robust invisible WM algorithms in hardware. Which WM is used will be defined by the user. The WM are embedded in the spatial domain but are designed to be robust for JPEG compression. The motivation for hardware implementation is to enable the integration of a WM module within a secure digital camera system. As JPEG is the standard data format for digital cameras it is imperative that the algorithm will not be harmed by compression. The availability of two kinds of WM algorithms corresponds to applications such as image authentication for the fragile algorithm and copyright protection for the robust. The hardware employed in this implementation is comprised of image and WM RAM memories, adders/subtractors, registers and multipliers. This is a relatively large implementation and accordingly, the algorithm is rather complex.

4. WM Hardware Implementation - A Development Methodology

In this section a development methodology to a fast mixed signal hardware design is presented. This methodology can be used for the development of an image sensor with integrated WM capabilities. Figure 3 shows different elements required for such a system. The design of this complete system is a very demanding task requiring time and financial resources. It involves hardcore analog and mixed signal design as well as complex digital architecture. Although the end goal is to implement the whole system monolithically on a single chip, it is expected, as in every development process, that more than one prototype will be designed before a final version is issued. Therefore it is worthwhile, to first focus on determining the core elements of the system which are the imager, the WM digital architecture and the interface between the two. To do so without significantly compromising the quality and performance of the peripheral elements such as the A/D converter, analog voltage biasing and memory, the design is first tested on a board utilizing commercial devices.

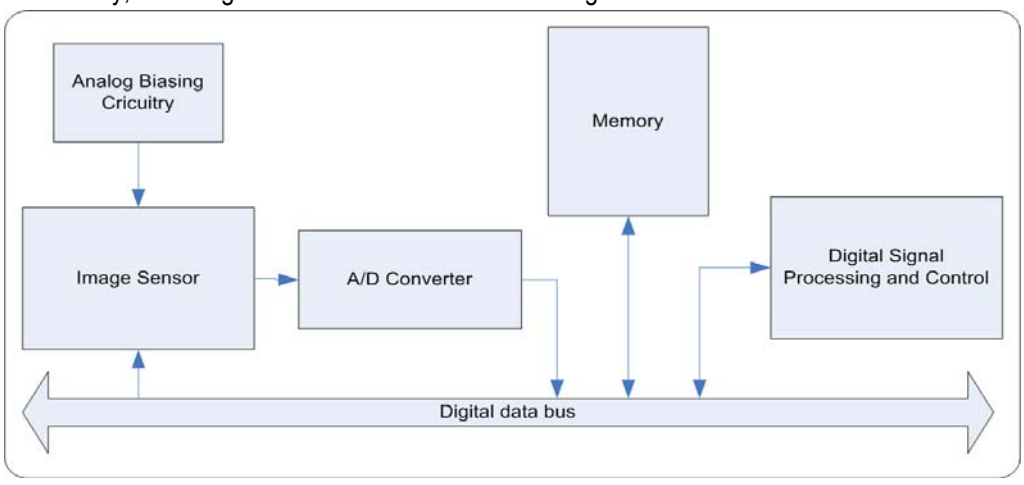

Figure 4. A general scheme of the complete image system in conjunction with digital processing.

This specifically designed board, shown in Figure 5, emulates a System-On-a-Chip (SoC) platform, allowing the incorporation of custom VLSI designs (the imager) with peripheral elements and digital logic implemented on an FPGA. It features low-noise, separated digital and analog power supplies, 12 bit analog voltage and current biasing, 12 and 18 bit A/D converters, an SRAM memory and several I/O ports including LVDS, RS-232 and direct test points for maximum testing flexibility. The designer can choose what part of the system he wants to implement in VLSI and what elements he would use of those available on board. For the discussed WM implementation a basic imager is first designed, and then the WM logic is implemented on the FPGA, together with all other required control logic, making use of the A/D converter and SRAM memory to aid the implementation of more complex algorithms. Finally the data is read out either as a WM video stream through the LVDS interface or stored in memory and read as a WM still image.

Note the presented methodology is modular and can host various kinds of SoC designs.

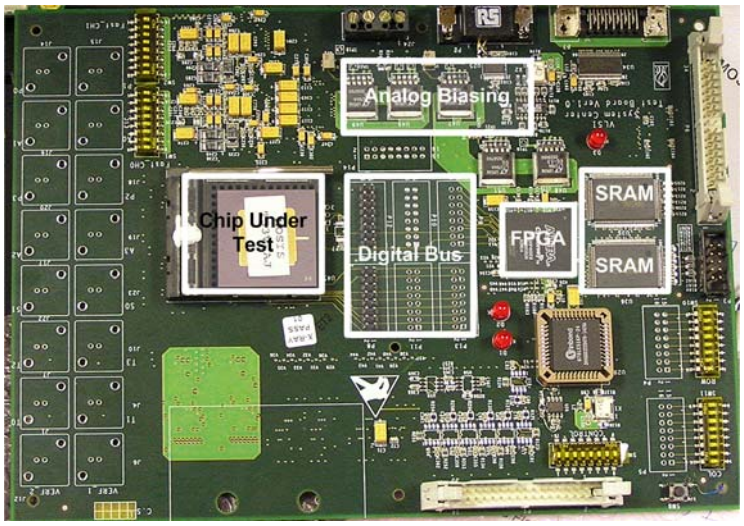

Figure 5. Mixed signal SoC fast prototyping custom development board.

5. Conclusions

Basic terms and principles in WM design and evaluation were presented. The main trade-offs and design considerations were discussed pointing out the importance of designing in light of the intended application and expected attacks. Several common attacks were also described, as well as a couple of evaluation benchmarks that facilitate the testing of different WM schemes robustness to a very large scale of attacks. The general scheme of a WM system was shown and the major benefits and shortcomings to implementations in hardware or software described. Two examples of previous works done, featuring fragile and robust WM, spatial and DCT domains, hardware and software implementations were given. In addition, a development methodology, employing custom development board for mixed signal SoC fast prototyping was shown.

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SYSTEMOLOGICAL BASES OF MANAGEMENT CONSULTING

Mikhail Bondarenko, Ekaterina Solovyova, Dmitriy Elchaninov

Abstract: The problem of management consulting for sustainable development organization support is discussed. The problem is formally described by means of systemological terms. The mathematical problem solving is considered. Practical use of the obtained results is outlined.

Keywords: systemology, competitive intelligence, management consulting, sustainable development.

ACM Classification Keywords: H. Information Systems - H.1 Models and Principles - H.1.1 Systems and Information Theory - General systems theory

Introduction

At the beginning we will discuss the sustainable development firm problem. Then the problem will formally described by means of systemological terms. The end of the paper will be devoted to mathematical problem solving. In conclusion we will outline practical use of the obtained results.

Management Consulting for Sustainable Development

According to [Greiner and Metzger, 1983]: management consulting is an advisory service contracted for and provided to organizations by specially trained and qualified persons who assist, in an objective and independent manner, the client organization to identify management problems, analyze such problems, recommend solutions to these problems, and help, when requested, in the implementation of solutions.

Staffan Canback defines management consultants as those who provide general management advice within a strategic, organizational or operational context [Canback, 1998].

The contexts correspond with three management levels: strategic, tactical and operational. Strategic managers focus on long-term issues and emphasize the survival, growth and overall effectiveness of the organization. Tactical managers are responsible for translating the general goals and plans developed by strategic managers into more specific objectives and activities. Operational managers are directly involved with nonmanagement employees, implementing the specific plans developed with tactical managers. [Bateman and Snell, 1996].

Management is about helping a firm survive and win in competition with other companies. The firm gains competitive advantage by adopting management approaches that satisfy people (both inside and outside the firm) through cost competitiveness, high-quality products, speed and innovation [Lawler, 1992].

The aim of many companies is to jointly achieve the goals of economic growth and environmental quality in the long run by striving for sustainable growth. Sustainable growth is economic growth and development that meets the organization present needs without harming the ability of future generations to meet their needs [Rice, 1993].

The first thing managers can do to better understand environmental issues in their companies is to engage in systems thinking. Managers operate in organizations. An organization is a managed system designed and operated to achieve a specific set of objectives. Management scholars during the 1950s stepped back from the details of the organization to attempt to understand it as a whole system. These efforts were based on a general scientific approach called systems theory [Bertalanffy, 1972]. Business research is largely supported by business organizations that hope to achieve a competitive advantage [Cooper and Schindler, 2001].

In [Bossel, 1999] systems theory is used to identify the vital aspects of sustainable development and relevant indicators. Much work has been devoted to developing quantitative indicators of sustainable development [Parris and Kates, 2003], [Segnestam, 2002], [Harris, 2000]. A great deal of literature concerned with understanding the core principles of sustainable development [Scottish Executive, 2006].

The aim of this paper is to show the efficiency of systemology [Melnikov, 1988] as a new concept for a system approach to solving sustainable development problems. The systemology was successfully used to solve a natural classification problem [Bondarenko et al, 2001] and business-systems modeling [Matorin and El'chaninov, 2002]. We hope that our results will useful for sustainable business-systems modeling in management consulting process.

Properties of a System

In connection with the fact that the terminology of the suggested systemological approach is not widely known, we will give a list of terms needed to understand the essentials of the present investigation [Melnikov, 1988], [Bondarenko et al, 1996].

System - an object the properties of which are determined by a function, which amounts to maintaining certain properties of an object at a higher level. This object is a supersystem in relation to the object (system) under consideration. Substance of a system - elements or components of the system, usually considered as subsystems. Structure of a system - the scheme of relations and interactions of a system's substance. Property of a system (valence) - the ability to maintain (in certain conditions) relations of one type and to prevent realization of relations of other types. Functional property of a system - a property that a system must possess in order to perform its functions; the ability to maintain relations (flows) on the basis of which interactions that are important for the supersystem occur between the system and surrounding systems. Extensional valence - a property realized in the form of a relation of the corresponding quality and constituting one of the varieties of reality. Free valence - a property only as an ability, not manifested in an existing relation and constituting one of the varieties of possibility (weak: potential, strong: intentional). External determinant of a system - the main reason for formation of a system: the supersystem's functional need for certain interactions of the system under consideration with other (surrounding) systems of this supersystem, which dictates the choice of the system's determinant.

Ports of a System

A port of a system S is an input or an output of the system S. By means of ports the system S maintains relations with another systems. In other words system's ports correspond to system's properties. Extensional, intentional and potential ports of the system S are represented as figure 1 shows.

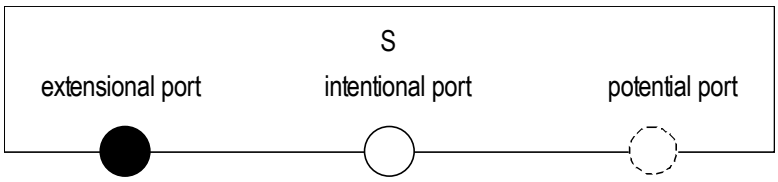

Fig. 1

An input port In is equal to an output port Out if the type of the port In is equal to the type of the port Out and vice versa. It means that if a system S_i has an output port $Out_{i,x}$, which is equal to an input port $In_{j,y}$ of a system S_j, then systems S_i and S_j can be connected with each other as figure 2 shows.

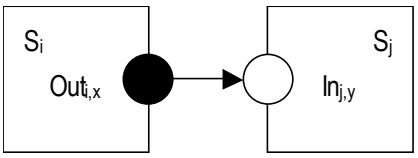

Fig. 2

Let In(S) is a set of the input ports of a system S and Out(S) is a set of the output ports of a system S.

An input port In_i of a system S is connected with an output port Out_j of the system S by means of component sequence $\{S_q\}$ (see fig. 3) if:

1. $In_i \in In(S_1)$;
2. $Out(S_q) \cap In(S_{q+1}) \neq \varnothing$, (q=1,…,Q-1);
3. $Out_j \in Out(S_Q)$.

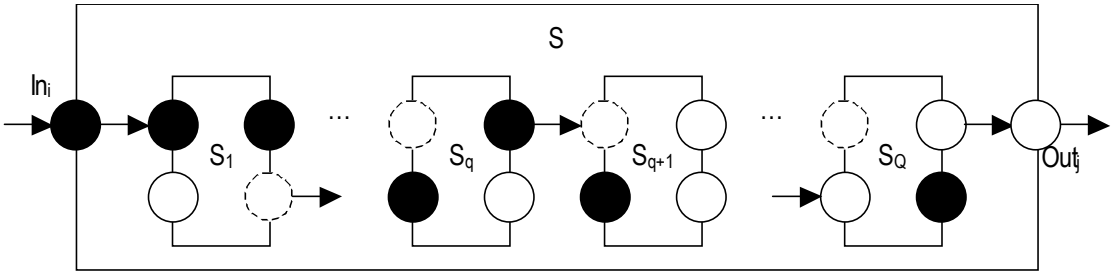

Fig. 3

Let this connection is denoted as follows: $\langle In_i, S_1,\ldots, S_q, S_{q+1},\ldots, S_Q, Out_j\rangle$.

A subset $B=\{B_u\}$ of the set of components $C=\{C_k\}$ is satisfied to a system S if each ports from the set In(S) is connected with some port from the set Out(S) by means of some subset of the subset B and vice versa, i.e.:

1. $\forall In_i \in In(S)\ \exists Out_j \in Out(S)\ \exists D_i=\{D_{i,v}\}\subset B$: $\langle In_i, D_{i,1},\ldots, D_{i,v}, D_{i,v+1},\ldots, D_{i,V(i)}, Out_j\rangle$;
2. $\forall Out_j \in Out(S)\ \exists In_i \in In(S)\ \exists E_j=\{E_{j,w}\}\subset B$: $\langle In_i, E_{j,1},\ldots, E_{j,w}, E_{j,w+1},\ldots, E_{j,W(j)}, Out_j\rangle$.

Formal Statement of Problem

It is given:

1. External determinant of a system S - a set $\{T_m\}$ of systems with free ports $Out(T_m)$ and a set $\{P_n\}$ of systems with free ports $In(P_n)$.
2. A set (library, package) of components $C=\{S_k\}$.

It is required to find a substance $B\subset C$ of a system S and a structure of a system S such that $\cup Out(T_m)\subset In(B)$ and $\cup In(P_n)\subset Out(B)$ (see fig. 4).

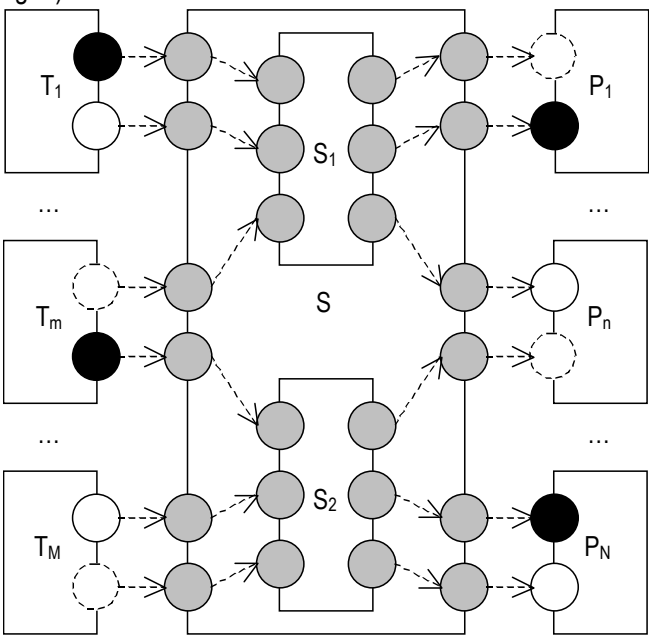

Fig. 4

Problem Solving

Lemma 1. The necessary conditions of being a set of components, which is satisfied to a system.

If a set of components $\{S_u\}$ is satisfied to a system S then $In(S)\subseteq\cup In(S_u)$ and $Out(S)\subseteq\cup Out(S_u)$.

The proof is illustrated by fig. 5.

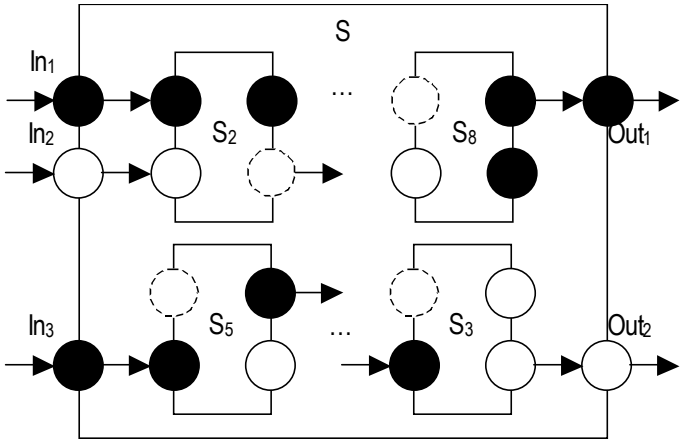

Fig. 5

Lemma 2. The sufficient conditions of excluding a component from a set of components, which is satisfied to a system.

If $Out(S_k) \cap Out(S) = \varnothing$ and $Out(S_k) \cap (\cup In(S_u)) = \varnothing$ or $In(S_k) \cap In(S) = \varnothing$ and $In(S_k) \cap (\cup Out(S_u)) = \varnothing$ then $S_k \notin \{S_u\}$, where the set of components $\{S_u\}$ is satisfied to the system S.

The proof is illustrated by fig. 6.

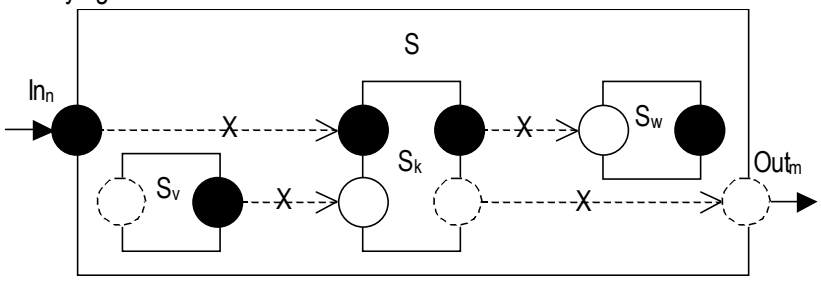

Fig. 6

Lemma 3. It is the consequence of lemma 2.

If C* is a set of components, which is satisfied to the conditions of lemma 2, then any component S_u from a set $C \backslash C^* = \{S_u\}$ is such that:

1. $In(S) \cap In(S_u) \neq \varnothing$ or $\exists S_v \in \{S_u\}$: $Out(S_u) \cap In(S_u) \neq \varnothing$;

2. $Out(S) \cap Out(S_u) \neq \varnothing$ or $\exists S_w \in \{S_u\}$: $Out(S_u) \cap In(S_w) \neq \varnothing$.

The proof is trivial.

Theorem. The sufficient conditions of being a set of components, which is satisfied to a system.

If $\exists \{S^r\}$: $\cup S^r \subseteq C$, where $S^r = \{S_{r,u}\}$, are such that:

1. $\forall S_{1,v} \in S^1 \Rightarrow (In(S) \cap In(S_{1,v}) \neq \varnothing) \wedge (In(S) \subseteq \cup In(S_{1,v}))$;

2. $\forall S_{r,v} \in S^r \Rightarrow (\exists S_{r-1,v} \in S^r$: $Out(S_{r-1,v}) \cap In(S_{r,u}) \neq \varnothing) \wedge (\exists S_{r+1,w} \in S^{r+1}$: $Out(S_{r,u}) \cap In(S_{r+1,w}) \neq \varnothing)$, r=2,…,R-1;

3. $\forall S_{R,u} \in S^R \Rightarrow (Out(S) \cap Out(S_{R,w}) \neq \varnothing) \wedge (Out(S) \subseteq \cup Out(S_{R,w}))$,

then the set of components $\cup S^r$ is satisfied to the system S.

The proof is left to the reader.

Conclusion

Using the obtained results, one can make sustainable organization modeling. Lemma 1 can be used for selection of component libraries. Lemma 2 is useful for exclusion of components, which are unfit for system modeling. Lemma 3 describes all possible connections of components, which can be used for sustainable system modeling. Finally, the theorem is useful for assembling of complex multi-tier system configuration. The results can be applied in powerful modeling tool for analyzing, documenting and understanding complex business processes.

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AUTOMATED SYSTEM FOR EFFECTIVE INTERNET MARKETING CAMPAIGN (ASEIMC)

Todorka Kovacheva

Abstract: The purpose of the paper is to present an automated system for realization of effective internet marketing campaign (ASEIMC). The constantly growing number of websites available online brings more problems for the contemporary enterprises to reach their potential customers. Therefore the companies have to discover novel approaches to increase their online sales. The presented ASEIMC system gives such an approach and helps small and medium enterprises to compete for customers with big corporations in the Internet space.

Keywords: internet marketing, internet strategy, marketing strategy, search engine optimization, web promotion

ACM Classification Keywords: H.4.3 Communications Applications, H.3.4 Systems and Software, H.3.1 Content Analysis and Indexing

Introduction

Internet is constantly and rapidly growing network. Everyday thousands of new websites become available online. Many businesses try to sell their products and services through Internet. The result: millions of website promoting and selling the same products and services. The competition is at high level. The companies from one business branch compete for visitors and customers online with other companies from the same business branch.

The constantly growing number of websites available online brings more problems for the contemporary enterprises to reach their potential customers. Therefore the companies have to discover novel approaches to increase their online sales.

The scope of the Internet Marketing

Internet marketing is a combination of activities directed to increasing of the rating of the site of the campaign in Internet, increasing of its traffic and as a result attracting of new clients and growing of the campaign One of the major activity of the Internet marketing is the search engine positioning. The major practices for this goal realization are:

- Code optimization
- Content optimization
- Technical processing
- Link popularity

The Internet marketing is realized profound analysis and market situation research (competitor activity, position of the branch, trends in the demand and supply), evaluation of the possibilities for using Internet for realization of competitive goods and services etc. It includes all activities related to the advertising activity of the company in Internet space: from design of the company's site to the sales realization.

Internet Marketing combines methods of using the Internet to promote and sell products and services. It includes:

- Information management – the management of information from various sources to one or more audiences, control over the structure, processing and delivery of information.
- Public relations – building sustainable relations with all publics in order to create a positive brand image.
- Customer service – the provision of service to customers before, during and after a purchase.
- Sales – the act of meeting buyers and providing them with a service for a negotiated compensation. Selling is a practical implementation of marketing.

Internet Marketing is important for all companies selling their products and services online. More than 2/3rds of all customers visit the web on regular basis and search for different types of products or services. Many companies compete for that customers and pay a high amount of money for developing of the effective internet marketing campaign.

Therefore to overcome the competition we need a competitive solution. The ASEIMC is designed as such solution.

Description of ASEIMC

The main purpose of the Automated System for Effective Internet Marketing Campaign is to increase the amount of sales of the company. At the end of the campaign we want to have more income than costs. The sales amount must be higher than the costs for the campaign. As bigger the positive difference between the profit and the invested costs as more effective is the internet marketing campaign.

Because of the big number of sites published in World Wide Web and big amount of repeating information it is very difficult for the modern enterprises to develop effective adverting strategy and which to be conformed to the limited budget of small and medium enterprises. The purpose of the automated system developed by us is to provide considerable competitive advantages of small and medium enterprises in the Internet space doing small investments.

The system works by doing preliminary survey (gathering of information) for the behavior and the specifics of the competing companies and branches and the data are gathered in a database which specially designed for this purpose. On the basis of these data an analysis of the strong and weak assets of the target company, whose adverting strategy is developed, is made. The information gathered in the database is used for analysis of the trends in the developing of close branches and working out forecast for probable innovations which will be made and which will affect the company activity directly or indirectly.

The system for gathering of information is a Web spider, which is developed by the author and which similarly to the traditional web robots travels over the Internet space and collects diverse data from the information published in World Wide Web.

The Architecture of ASEIMC

To realize its goals the AISEIMC is divided in the following modules:

1. Module for gathering of information from the global net. It is a web robot, designed for the purpose.
2. Database, in which the information gathered from module 1 is stored.
3. Module for analysis of the data from the database and working out of forecast of trends in the behavior of the competitors and competing branches.
4. Goal definition module. Before continuing with the planning of the company's advertising campaign in Internet it is necessary to define goals, which we wish to achieve through this advertising campaign. These goals may be:
   a. To impose trade mark of the company;
   b. To increase the number of the sales;
   c. To enter new markets;
   d. To promote a new product of service of the company;
   e. To inform the society for changes in the company's policy etc.

   This feature is realized through set of questions q which are logically ordered one after another. As a result the proper target zone is defined. These goals have not to contradict to the strategic company management.
5. Analysis of current state. Before continuing with planning and realization of the advertising campaign it is necessary to specify the position from which the company starts. This is necessary not only to be able to develop effective advertising strategy but also to evaluate the achieved results at the end of the advertising campaign.
6. Budget validation. A significant point in developing the company's advertising campaign is specifying of the financial funds which we have. Their amount is a limit, which defines the boundaries of carrying out our advertising campaign.
7. Keyword selection module. Next stage is to choose the key words and expressions which will help for advertising campaign realization. These words have to be the ones used by the users. This module provides information about which key words we have to use taking into consideration the searching for them by the users and the content of the site.
8. Competition analysis module. After the key words of campaign are specified, it is important to evaluate the chances of the company to become a leader in the most popular search engines by key words used by users. Therefore the competitors' web sites are analyzed according to these keywords. Their advantages and disadvantages are evaluated. Their behavior is forecasted. As a result the module prints a report containing instructions for the developing search engine optimization strategy.
9. Developing search engines optimization strategies module. It takes the report from the previous and builds the optimization strategy, which the company has to follow.
10. Website optimization and promotion module. The ability to realize the actual optimization of the web site based on the strategy developed in item 6. The promotion of the site in the search engines and Internet space is carried out.
11. Result evaluation module. At the end of each advertising campaign it is important the achieved results to be evaluated and effectiveness of the campaign to be specified.
12. Improving of the company's advertising strategy. This is a continuous activity directed to increasing the results.

Conclusion

The system designed by the author helps for incresing of the popularity of the company's web site and as a result of this it leads to increasing of the number of sales and the amount of the realized profit from the company activity. It can be used effectively not only by small and medium enterprises but also by transnational corporations. It contributes to achieving signifficant competative advantages in Internet space at comparatively small investments.

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THE MODEL OF UNRELIABLE ELEMENTS (HUMAN RESOURCES) INTELLECTUAL MANAGEMENT SYSTEM ON THE BASIS OF THEIR PSYCHOLOGICAL AND PERSONAL CHARACTERISTICS

Timofey Ryabtsev, Elena Antonova

Abstract: The Article suggests a possible approach to creation of the Intellectual Management System for human resources and personnel (during their professional tasks solving), and that could consider personal characteristics and psychological condition of the human resources as an “unreliable” element. The Article describes some elements of the Intellectual Management System: professional activity model and “unreliable” element (human resources) model.

Keywords: The theory of unreliable elements, The knowledge system, The intelligent control.

Introduction

Management in broad sense of word is the permanent process of influencing the object of management (person, collective, technological process, company, state) in order to achieve the optimal result within the minimal expenditures of time and resources.

Management exists for more than 7 thousands of years, it is social as it started since the appearance of the human relations. The trends of management development - methods, the attitude towards the object of management – during all the time were directed on improvement of the workers’ social environment and more subtle coordination with every person in order to consider his individual characteristics and demands. This is quite natural, because, without people, there is no organization. Without the specific people, no organization can achieve its goals and survive. And this is extremely difficult to do this without effective human resources management – one of the most crucial aspects of the Theory and Practice of Management. To make the organization function effectively, it is necessary to properly organize the staff’s working process, permanently controlling the workers’ activity, using the different methods of management.

Specific type of management activity, which object is the workers collective – personnel, was called Personnel Management (Staff Management). It is specific because in the management of people it is necessary to consider such an indefinite, unreliable thing as “human factor”.

Unreliable elements, within the context of management, are those elements that are not provided with reliable information on their real condition, their behavior can not be forecasted with the high level of probability. Unreliable elements in the Management theory are, first of all, human resources.

The achievements of new informational technologies today allow us to examine the possibility of automation of the management processes of human resources and personnel (during their professional tasks solving), which is one of the main reserves for increase the management effectiveness. Tens of years of local networks and Internet development suggested many types of technologies for organizing the communication between people and between the whole enterprises and program complexes, which could also be used in the management

context. The analysis of the existing program systems allows to conclude that the automation of the management process is seen, first of all, as the information provision of the persons who make the decisions.

In order to solve the abovementioned problems, it is proposed to work out the Collectives' Activity Management System. The basis of the system would consist of the human resources intellectual management model. The main feature of the system is that it considers the psychological characteristics of the people (human factor) in the collective, which allows to consider many situations in the work with people. Knowing the human psychology and the particular worker characteristics, you can influence the motivation of his activity, i.e. manage him in order to achieve the specified result.

On the conceptual level of designing the Unreliable Elements Management System, it is necessary to clearly define the general axiomatics of management processes description, i.e. fixation of basic theses of further research, Management System Model description.

Management System Model is the complex of conceptions of the system. It is necessary to define the basic structure elements of the Management Model. All these elements in complex should constitute a whole and non-contradictory set of models, characterizing all the basic components of the Unreliable Elements Management System.

Applying to the task of Unreliable Elements (human resources) management (during their professional tasks solving), the set of elements of the Management System Model includes:

1) the model of professional activity, defining the purposes and tasks of the activity, decisions plan, the limits and interrelation of the resources flows;
2) the model of "unreliable element" (human resources) as an object and subject of management, defining the role-based interrelations within the collective and the characteristics of Unreliable Elements;
3) Management Process model.

In the present Article we shall examine the Model of Professional Activity and the Model of "Unreliable Element" (human resources).

The Model of Professional Activity (MPA)

The purpose of working out the model of professional activity: formalizing the method of description and activity planning, describing the variety of states of current activity and its elements interrelations, formalizing the algorithm of estimating the activity effectiveness at all the stages according to determined criteria. On the basis of MPA, the System of Aggregative Representation of the Planned Business Processes is formed, as well as the description of the resources flows parameters interrelation, and the representation of the traceable parameters of the activity carrying-out, to make possible the interference of the System in order to provide the fulfillment of the decision plan by the "Unreliable Elements".

Professional Activity is the sequence of activities, starting and coming to the end, aimed at solving the tasks, pursuing definite purposes and using the corresponding resources.

The process of constructing the model of particular Professional Activity can be divided into the next procedures:

Procedure 1: Formulating the Professional Activity (PA).
Procedure 2: Planning of PA.
Procedure 3: Execution of PA.

In defining the Model of Professional Activity, it is necessary to consider the following determinative elements of this PA:

1. The purpose of the Professional Activity – the final result, outcome, production, defined in terms of inputs, quality and execution time.
2. Complexity. In order to achieve the purposes of the Professional Activity, it is necessary to solve a variety of sub-tasks. The correlations between the sub-tasks can be very complex.
3. Time limitation. The sub-tasks are starting and coming to the end. The time-based concentration of resources is needed to the realization of the sub-tasks. If it is necessary, the resources are used for the other purposes.
4. The life cycle. As new sub-tasks are realized, the need in particular resources is also subject to change. This change occurs according to definite predictable consequence.

MPA of the Management System must provide the project purposes achievement through realization of the following activities:

1) At the stage of formulating the PA:

1.1. Professional Activity planning and sub-tasks defining.
1.2. Defining the necessary resources.
2) At the stage of planning the PA:
2.1. Regulation of complexity level between the sub-tasks.
2.2. Resource distribution between the sub-tasks.
3) At the stage of realization the PA:
3.1. Selecting the control parameters for each stage realization.

The examples of the Professional Activity Model are given below:

Object: *Professional Activity*

Description: formal general representation of the current activity environment, in its framework the Management Process would be carried out.

Attributes: (critical points: *results, resources, terms*)

Object: *Sub-tasks*

Description: minimal activity unit, defined by the subject of management, which is the part of the whole Professional Activity.

Attributes: (critical points: *results, resources, terms; additional characteristics*)

Connection Function: *Strategy*

Description: represents the Professional Activity as the hierarchy of the minimal units (sub-tasks); the result of function effect is the sub-tasks hierarchy in the system, representing the relations between them. (It is recursive: fractures the sub-tasks until the lowest possible level of the hierarchy).

Definition: *Strategy (Professional Activity) → {Sub-tasks} U {Relations}*

Agreement: Professional Activity = = Σ {Sub-tasks}

Connection Function: *Purpose*

Description: defines the results of all the Professional Activity, and the results of each sub-task. The result of function effect is the variety of the output activity results, confirmed by definite document.

Definition: *Purpose (Professional Activity) → {Results}*

Agreement: {Professional Activity. Results} = = Σ {Sub-tasks. Results}

Attribute: Results

Description: definite expression of the results (of definite quality), achieved in the result of activity.

Admitted Region: *(documents, confirming the activity results availability)*

The Model of Professional Activity is closely related with the Model of Human Resources and its peculiarities.

The Model of Human Resources – the "Unreliable Element" (MOH)

The existing programmed management systems, which elements are people, have a number of peculiarities that complicate the management process. This is directly related to biological, emotional peculiarity of people (human resources), which makes them the "unreliable elements". Unreliability of human resources as the object/subject of management negatively effects the process of professional activity.

The Intellectual System should possess the knowledge about the personnel, including:

1) Information about each employee: type of behavior, professional responsibilities – for defining the methods of motivational influence and defining the types of entrusted tasks.;
2) Knowledge about the general types of human resources unreliability during the professional tasks solving – in order to implement the knowledge about justified (in this case) methods of motivational influence stored in the "Bank of Knowledge of the System of Unreliability and Motivation";
3) Responsibility, defined for each employee regarding to his sub-tasks – in order to assign human resources to the PA sub-tasks;
4) Behavior history: information about the activity and reactions of each employee on the types of motivation – in order to maintain the publicly available statistics, as the motivation instrument increasing the employee's

activity level, to provide the accounts to the administration and to define the most successful motivation methods.

The following definitions can be outlined in the Model of Human Resources:

1) Subject of Management, which provides the managing and organizational activity, makes decisions and provides the achievement of the set tasks. Subject of management is called the Managing System.
2) Object of Management, at which the management influence is directed, in order to provide system functioning and development. The Object of Management is sometimes called the Managed System.

The Management is provided by some Subject in respect to some Object (or Objects). It is accepted to consider the subjects and objects of management within the management hierarchy, because on the different levels of hierarchy the same object of management can appear to be the subject as well as the object. The Management process should always be preceded by defining the subject and object of management within the given hierarchy of their relations, and also by defining the features and peculiarities, negatively influencing the professional activity of human resources.

To work out the model, it is necessary to formalize the Managing System and the Managed System (subject and object of management) peculiarities, to define the probable "blocking" influences of the given "unreliable element" [Ryabtsev, 2006].

During the solving the tasks of management the collective, it is needed to achieve the realization of the tasks set before the employees within the proper time limits, decreasing the "unreliability". "Unreliability" should be understood as the psychological and the physical peculiarities of people, which can negatively effect the carrying out of the decisions plan.

For different types of unreliability, there are corresponding types of motivation defined in the literature on management. Table 1 shows as an example the proper motivation methods for particular events.

Unreliability	Motivation corresponding to the unreliability type
laziness	reprimand, encouragement, promotion, possibility of self-realization, possibility of participating in administration
unwillingness	reprimand, notice, compulsion, promotion, possibility of self-realization
forgetfulness	reminding
tiredness	trips to gather material for creative work
lack of knowledge	indispensable informing

Table 1. Motivation types corresponding to the unreliability types

Let us examine the Model of Human Resources as the object of management in the Intellectual Management System. This model includes:

- defining the role of each employee in the collective;
- defining the working characteristics of each person;
- defining the personal and psychological peculiarities of each person;
- defining the possible manifestation of unreliability;
- defining the proper motivation method for particular person and particular unreliability type.

The examples of the Model of Human Resources are given below:

Object: *Collective*

Description: a group of people working together at solving the professional tasks, who co-relate with each other so that each one can influence (provide managing influence to) the other one, and everyone is depending on the other one; i.e. the hierarchy of the subjects and objects of management is represented.

Attributes: *(Resources, Human Resources)*

Object: *Object (Managed System)*

Description: the Object, at which the management influence is directed, in order to provide management system functioning; it provides the tasks fulfillment and achievement of the set purposes.

Elements: *(Behavior History, Unreliability, Behavior Type, Job Description)*

Object: *Subject (Managing System)*

Description: provides the tasks planning, resources distribution, decision-making and control over the achievement of the set purposes.

Elements: *(Unreliability, Behavior History, Behavior Type, Job Description)*

Element: *Role-based Relations*

Description: relations between the subjects and objects of management model.

Admitted Region: *(manages, managed)*

Connection Function: *Responsibility*

Description: indication of the relations between the objects and the tasks carried out.

Admitted Region: (yes, no)

Definition: *Responsibility: ({task}, {object}) → {(yes, no)}*

Element: *Behavior Type*

Description: the number of individual psychological peculiarities of the object, representing it as the personality.

Admitted Region: *(high responsibility, normal responsibility, low responsibility)*

Element: *Behavior History*

Description: accumulated characteristics of the object during the life cycle of the collective activity: the successfulness of tasks fulfillment and reactions to motivation.

Admitted Region: *{(successfully, non-successfully)} U {(successfully*, non-successfully*)}*

Connection Function: *Job Responsibilities**

Description: definition of job description requirements for the object/subject, necessary for the professional activity carrying-out, by sub-tasks.

Definition:

Job Responsibilities (object) → {Job Characteristics*}*

Job Responsibilities (subject) → {Job Characteristics*}*

On the basis of MOH, the System of representing the "unreliable element" (human resources) as the subject and object of management is formed.

The knowledge about the "unreliable element" management, which is put into system, is represented as the enlargeable knowledge base. Using this knowledge, the System will make intellectual management decisions. Since the resources in the examined Intellectual System are human resources, it is necessary to take into account the human "unreliability" in the System: to formalize the human peculiarities that hamper or block the activity upon the prescribed decisions plan, to define the possible and justified motivation methods to prevent these "blocking' impacts. At the same time it is necessary to consider the peculiarities of each particular "unreliable element". Creation of the Knowledge Bases and data base, shown in Figure 1, will provide for fulfillment of these management purposes.

It is also necessary to define the algorithm, which allows to track the process of the professional activity tasks fulfillment, interfere in the process of the activity and implement the managing procedures necessary for particular case and particular "unreliable element", in order to provide the fulfillment of the decisions plan for professional activity (Subsystem B).

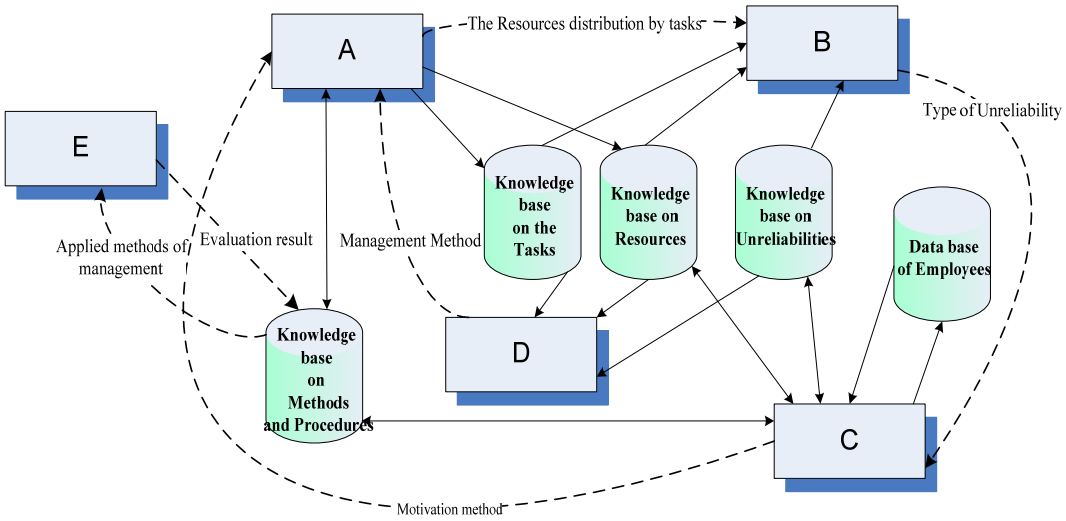
The suggested approach to the Management System designing allows to track the effectiveness of the managing procedures implementation and corresponding human resources reaction to the implemented impacts. Knowledge on effectiveness and human reactions will allow the system to provide self-training in future, thereby improving the possibilities of the System implementation during its further operation (Subsystem E).

Implementing all of the Intellectual Management System components will allow to achieve such system operating, when the human resources "unreliability" decreases during the professional tasks solving.

Thus, the conclusion could be made, that the functionality, put into the Intellectual Management System, is characterized by the influence (by implementation of particular management event – the number of management

procedures) on the “unreliable element” functioning. Such influences may cause the need of the decisions plan revising.

The main peculiarity of the Management System is that the System itself considers the psychological peculiarities of human resources (human factor) in the collective, which allows to take into account many situations in working with people.



A – Subsystem of procedures implementation on the basis of the chosen methods
B – Subsystem of plan execution and unreliabilities definition monitoring
C – Subsystem of motivation method defining
D – Subsystem of managing method defining
E – Subsystem of implemented managing methods effectiveness evaluation

Figure 1. Management System Architecture

Conclusion

The Article suggests a possible approach to creation of the Intellectual Management System that could consider personal characteristics and psychological condition of the human resources as an “unreliable” element. The Article describes the elements of the Intellectual Management System model: The Model of Professional Activity and the Model of “Unreliable” Element - Human Resources.

The programmed management systems, existing now, do not fully cover all the characteristics and peculiarities of the human resources as the object or subject of management. Thus, the problem of creating such Intellectual System, which could consider psychological peculiarities of the people as personalities during their management decision making, is urgent and practically important.

It should be noted that approach, suggested in the Article, to solving the tasks of intellectualization of people management considering their psychological peculiarities and personal characteristics, can be implemented in the problem domains, where the management system dependence on human characteristics is significant.

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