

Galina Setlak, Krassimir Markov
(editors)

**Artificial Intelligence
Applications to Business
and Engineering Domains**

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Galina Setlak, Krassimir Markov (ed.)

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It is represented that book articles will be interesting for experts in the field of information technologies as well as for practical users.

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PREFACE

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This issue contains a collection of papers that concern actual problems of research and application of information technologies, especially the new approaches, models, algorithms and methods of artificial intelligence to be used in business and engineering applications. Main topics which are included in the issue are:

- Natural Language Processing
- Automated Transformation of Algorithms
- Agent and Multi-agent Systems
- Image Processing
- Business Applications
- E-learning Systems
- Petri Nets' Models

We express our thanks to all authors of this collection as well as to all who support its publishing.

*Rzeszow – Sofia
September 2011*

G. Setlak, K. Markov

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Natural Language Processing

LEXISTERM – THE PROGRAM FOR TERM SELECTION BY THE CRITERION OF SPECIFICITY

Roque Lopez, Mikhail Alexandrov, Dennis Barreda, Javier Tejada

Abstract: *Term selection is one of the principal procedures in natural language processing. Existing advanced methods allow to construct multiword terms, to form hierarchy of related terms, etc. It provides a high quality of problem solutions where these terms are used. But almost always an expert needs a simple tool to glance a document corpus to reveal the most distinctive features. For this purpose we propose the simple program LexisTerm for one-word term selection based on a well-known criterion of term specificity. Speaking ‘specificity’ we mean the relation of term frequencies in a given document/corpus and in some gold standard as, for example, a National corpus of document. The program has two options, which give an opportunity. to select both specific terms in an individual document and specific terms for the whole corpus. In the paper we describe this program and demonstrate the results of its work on a real example. The program LexisTerm is free-share.*

Keywords: *Natural language processing, term selection, indexing*

ACM Classification Keywords: *1.2.7 Natural Language Processing*

Conference topic: *Natural Language Processing, Speech Understanding*

Introduction

Term selection has many applications in natural language processing (NLP). Its realization depends on the goal:

- whether we want to describe a contents of a domain or a document corpus (a)
- whether we want to classify or to cluster document set (b)

In case (a) selected terms should reflect some common properties of document set and in general each of such terms must have more or less equal relative frequency of its occurrence in documents (of course, each term has his own frequency distribution). In case (b) selected terms should have good distinctive properties and in general each of such terms must not have equal relative frequency of its occurrence in documents (of course, each term has his own frequency distribution).

The general approaches and algorithms for term selection are presented well in the well-known monographies [Baeza-Yates, 1999; Manning, 1999]. Researchers continue to consider special cases: key-phrases extraction for summarization [Schutz, 2008], indexing for clustering in narrow domains [Pinto, 2008], etc. Some authors propose to use a set of criteria related with cases (a) and (b) simultaneously. It allows to determine terms for description sub-topics in the framework of a topic reflected in a given document set [Makagonov, 2000]. It is a well-known that word collocations have a large informative and distinctive power. Just these collocations form

so-called multiword terms [Yagunova, 2010]. But all these techniques are not simple. They often need complimentary information about word distribution in a corpus, correlation between words, etc.

In this paper we consider the simplest case: one-word term selection based on the principal of word specificity. The specificity of word is determined on the basis of its frequency in a given document or in a given corpus and in some standard corpus, which is considered as a gold standard. Such a criterion of term selection is well-known. In particular, we could mention two works [Makagonov, 2000; Makagonov, 2004], where this criterion was used among the other ones for constructing domain-oriented vocabularies and for clustering super-short documents.

In section 2 we present the criterion of term selection in two forms of its realization. In section 3 we describe functions of the program. Section 4 contains the results of experiments. Section 5 includes conclusions.

Criterion of specificity

2.1 General lexis and word specificity

To simplify the further program description we give the following two local definitions:

Definition 1. *The general lexis is a frequency word list based on a given corpus of texts*

The given corpus means here any standard document set reflecting the lexical richness of a given language. Generally such a corpus contains in a certain proportion the documents taken from newspapers, scientific publications related with various domains, novels and stories. For example, it could be the British National corpus.

The general lexis can contain:

- unlemmatized or lemmatized word frequency list
- absolute and/or relative word frequencies

Unlemmatized word list contains all forms of words from a given standard corpus. Example: the words *move* and *moved* (English) are considered as the different ones with their own frequencies. When the general lexis is presented in unlemmatized form then user can use his document set without any transformation. Here words from a given document corpus are compared with words from the general lexis as they are.

Lemmatized word list contains lemmas of all words from a given standard corpus. In this case instead of words *move* and *moved* (English) the list contains one word *move*. Its frequency is the sum of frequencies for all forms of the verb *move*. User should take into account this circumstance by the following ways:

- To construct the word frequency list of a given document corpus and then to lemmatize all words from this list. The frequencies of words having the same lemma are summarized. But such a procedure needs special tools including morphological dictionaries for the language under consideration
- To substitute lemmatized word frequency list of a general lexis for stemmed word frequency list. For this all words from the lemmatized list are reduced to its stems, and the frequencies of words having the same stem are summarized. The same operation should be done with a given document corpus. Namely, it is necessary to construct the word frequency list of this corpus, then substitute all words for their stems, and then summarize frequencies of words having the same stem

Note. Stemming can be implemented by means of the well-known Porter's stemmers [Porter, 1980]

Let we have a word \mathbf{w} . Let its relative frequency in a document is equal $f_D(\mathbf{w})$, in a document corpus $f_C(\mathbf{w})$, and in the general lexis $f_L(\mathbf{w})$.

Definition 2. *The level of specificity of a given word \mathbf{w} in a given document corpus C is a number $K \geq 1$, which shows how much its frequency in the document corpus $f_C(\mathbf{w})$ exceeds its frequency in the general lexis $f_L(\mathbf{w})$:*

$$K = f_D(\mathbf{w}) / f_L(\mathbf{w})$$

Definition 3. The level of specificity of a given word \mathbf{w} in a given document D is a number $K \geq 1$, which shows how much its frequency in the document $f_D(\mathbf{w})$ exceeds its frequency in the general lexis $f_L(\mathbf{w})$:

$$K = f_D(\mathbf{w}) / f_L(\mathbf{w})$$

2.2 Preprocessing general lexis

LexisTerm having read the general lexis always completes two operations: search of duplicate words and normalization of word frequencies

1) Duplicate word analysis and 'black list'

Some words from the general lexis can have copies. Their frequencies can be equal or no. Such a situation reflects the cases when a word has several meanings. The total number of copies usually does not exceed ten or about. Lexis Term joins equal words and summarizes their frequencies.

This operation proves to be very useful for excluding undesirable words. Really, for this it is only necessary to add to the general lexis these words with large values of their frequencies. For example, these values can be done equal to maximum frequency in a given list (absolute or relative frequency). Therefore such words look like words from 'a black list'

2) Normalization

LexisTerm normalizes all frequencies from the general lexis on their total sum. It means that the program always deals with *relative frequencies*.

If the general lexis contains absolute frequencies then such normalization is justified. If the general lexis contains relative frequencies then this normalization is unnecessary, but the program does not know in advance about it.

Program description

3.1 Modes of document processing

Program LexisTerm has two modes for processing document set: corpus-based term selection and document-based term selection

1) Corpus-based term selection

In this mode the program determines word frequencies considering the entire corpus as one document. Therefore the output file contains all words whose total relative frequency (that is corpus relative frequency) exceeds their frequency in the general lexis in K times.

2) Document-based word selection

In this mode the program determines word frequency in each document separately. It collects all words in each document, whose document relative frequency exceeds their frequency in the general lexis in K times. Then all equal selected words are joined

3.2 Data format

1) Input data

- It is a document corpus where documents are presented in a textual form. All documents should be located in one directory.
- It is a general lexis, presented in a textual file. It should contains words with their frequencies. Each line should contain the word itself and its frequency. Other information in the line is ignored.

Note. One should use *dot* instead of *comma* to separate a fractional part of numbers.

2) Output data, results

It is a textual file, which contains the list of selected words with their relative frequencies and the number of documents where this word occurred.

There is a difference in the content of values calculated by the program:

- In case of corpus-based term selection the frequency of word means the relative frequency of this word in the entire corpus, which is considered as one document. The number of documents shows the number of documents, where this word occurs at least one time
- In case of document based term selection the frequency of word means the average relative frequency of this word in the documents where this word satisfies the criterion of word selection. This value does not take into account the document sizes, so it is not the weighted averaged value. The number of documents shows the number of documents, where the word satisfies the criterion of word selection. So, this value does not take into account other documents even they can contain this word.

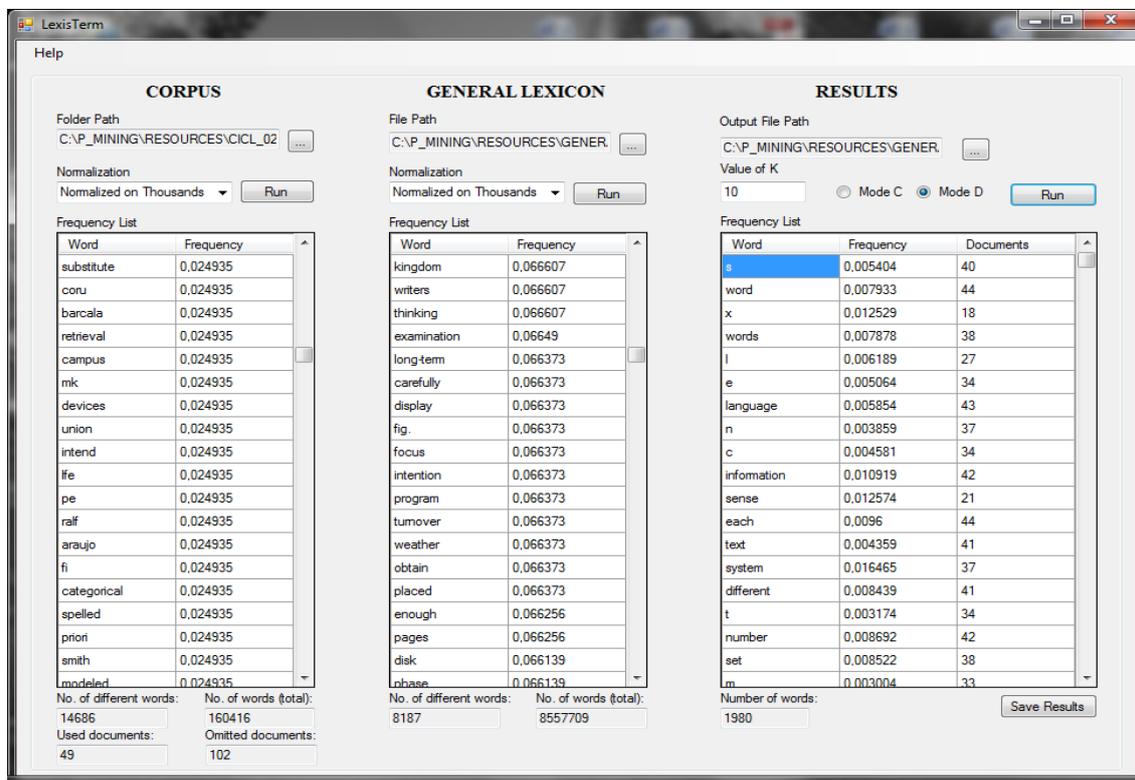


Fig.1 Dialog box of the program

3.3 Interface

The following controls are used to manage the program functionality

- The name of directory with document corpus, the name of file with the general lexis, and the name of file with results are indicated in text boxes located at the top part of the main dialog box.
- Parameter K is assigned in the corresponding text box located at the right top of the dialog box.
- The mode of term selection is assigned by radio buttons at the right top of the dialog box.

Information about number of documents, words and selected words are shown at the bottom part of the dialog box. If file with the general lexis has incorrect format then the corresponding message appears.

A user has possibility to see the following information in three windows:

- words from document set with their frequencies (absolute, relative, and scaled values)
- general lexis, that is words with their frequencies (absolute, relative, and scaled values)
- selected words with their relative frequencies and the number of documents, where these words occurred (output data are described in p.3 above)

The view of program dialog box is presented on Figure 1

Experiments

4.1 Document set

We tested the program LexisTerm in our project related with Peruvian blogosphere. The purpose of the project was to reveal the relation of active part of the blogosphere to the notion 'terrorism'. The document set included 100 documents downloaded from the Internet. Table 1 shows the general characteristics of this document corpus.

The typical solution consisted in clustering users, events, etc. Naturally, such a procedure needed an attribute space, and LexisTerm prepared this space on the basis of selected terms.

Table 1. Lexical resources of corpus

Number of documents	100
Number of words	45294
Number of different words	12392

In our experiments we studied

- how parameter K (level of specificity) affects on term list
- difference between options C and D
- influence of stemming

We expected that:

- the number of selected terms would be reduced approximately according the logarithmic law with respect to K (it could be a consequence of Zipf law) in mode C
- option D always would give essentially longer term list than option C
- stemming would increase term list

Our experiments confirmed all these suppositions.

4.2. Experiment with different values of K and different options C/D

In this experiment we varied the threshold K and options C and D. Table 1 contains the description of document set, Table 2 shows the results of experiment, and Figure 2 demonstrates these results in graphic form. The table cells contain the number of selected terms

Table 2. Number of words for different options and K-values

<i>k</i>	Mode C	Mode D
2	7112	9973
5	4767	9936
10	3395	9851
20	2492	9510
50	1250	8367
100	1139	7014

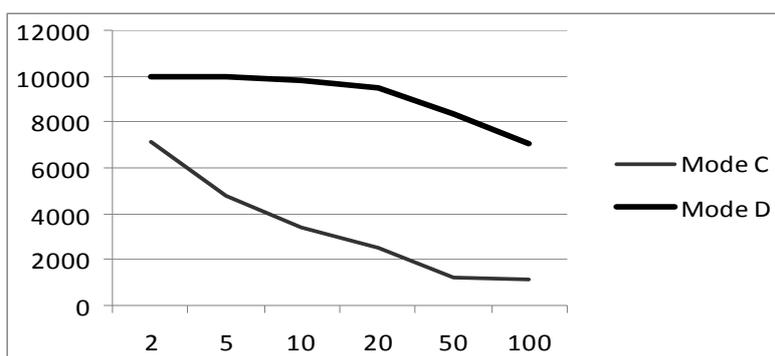


Fig.2 Number of words for different options and K-values (graphical illustration)

It is easy to see, that for mode C the central part of graphics is almost a straight line. It means we have here the logarithmic law having in view the logarithmic scale on axis X. Besides, one can see that mode D gives essentially longer list of terms than mode C.

2.3. Experiment with stemming and hybrid scheme

In this experiment we used only the mode C. First of all we completed stemming both for a given corpus and for the general lexis. The results are presented in Table 3.

Table 3. Data about corpus and general lexis before and after stemming

	Corpus without stemming	General lexis without stemming	Corpus with stemming	General lexis with stemming
Total number of words	45294	152558294	45294	152558294
Number of different words	12392	737799	8047	404659

Then we did two experiments: a) a pure experiment, when both a given corpus and a general lexis were taken after stemming and b) a mixed experiment, when terms were selected without stemming and then we applied stemming to the selected list of terms. The results are presented in Table 4, its graphical illustration is given on Figure 3

Table 4. Number of words for different schemes

<i>k</i>	<i>Without stemming</i>	<i>Hybrid scheme</i>	<i>With stemming</i>
2	7112	4490	3216
5	4767	3376	2049
10	3395	2593	1515
20	2492	2016	1183
50	1250	1111	834
100	1139	1030	782

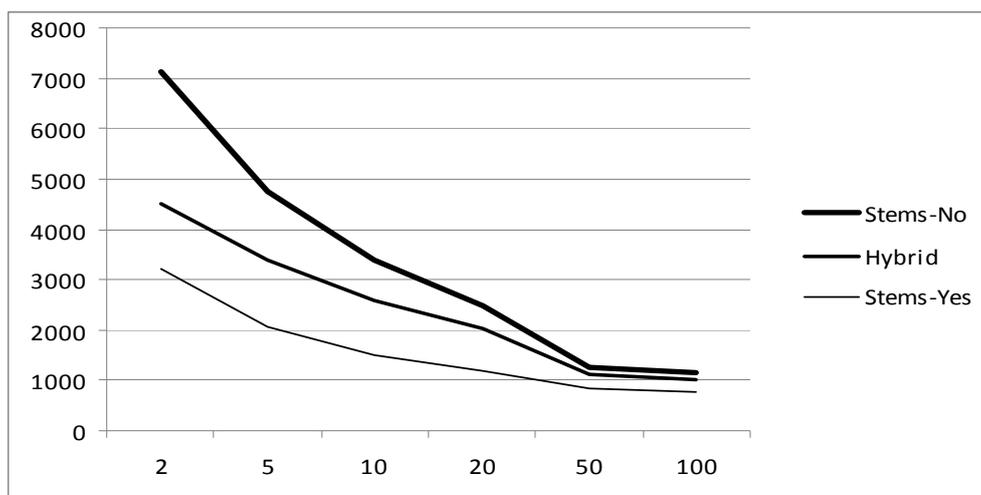


Fig. 3. Number of words for different schemes (graphical illustration)

One can see that stemming increases the list of selected terms. But given a large value of *K* the results become close from the point of view of the quantity of selected terms. Hybrid scheme is between both options.

Conclusion

In the paper we introduced the notion 'term specificity' with respect to corpus and to individual documents. We developed the program LexisTerm, which implements term selection based on the introduced definitions. We demonstrated the program functionality on the real example. The results of experiments can be useful to evaluate how criterion parameters affect the list of selected terms.

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METHODS AND TOOLS OF COMPUTATIONAL LINGUISTICS FOR THE CLASSIFICATION OF NATURAL NON-REFERENTIAL ELLIPSIS IN SPANISH (REVIEW)

Vera Danilova

Abstract: *This article represents a brief survey of the few works, dedicated to the modern approaches of natural language processing (NLP) to the analysis of impersonal sentences in Spanish. Such an analysis consists in classification of non-referential ellipsis that can be used in machine translation systems. The NLP approaches related with Spanish are mainly based on the work of Rello published in 2010. These approaches do not make use of a proper classification of impersonal models, but of a relative descriptive distribution without strict criteria. The structured classification presented in this article, based on historical and semantic data of interlingual nature, can be also applied for creation of linguistically-motivated classes for machine learning methods. The automatic classification method, employed in the work of Rello, is based on the use of the well-known WEKA package instance-based learner.*

Keywords: impersonal construction, non-referential ellipsis, machine translation

ACM Classification Keywords: I.2.7 Natural Language Processing - Language models

Introduction

The analysis of impersonal constructions in modern linguistics implies creation of appropriate classification of models which can be applied to the further detection and extraction of this kind of models in NLP. This can be an important and necessary task for improving the accuracy of machine translation.

The identification of impersonal sentences is closely related to the extraction of different types of subject ellipsis in case of zero anaphora resolution. There are few recently published works which describe the tools created for this kind of extraction in Spanish.

Certain aspects of the machine learning method for detection of non-referential subject in Spanish, described below, are based on the approaches, dedicated to the classification and extraction of pleonastic *it* in English [Evans, 2001; Mitkov et al., 2002; Boyd et al., 2005].

Elliphant and other NLP methods for classification of subject ellipsis in Spanish

The machine learning method Elliphant which is considered to be the first attempt of non-referential ellipsis classification in Spanish was created and described in 2010 by Luz Rello [Rello 2010].

With respect to previous approaches, this one has a number of serious advantages. In the first place, it uses a ternary classification of subjects: explicit, zero pronouns and impersonal constructions. In the previous work by the same author [Rello and Illisei, 2009] a binary classification was used, which included elliptic and non-elliptic variants of subjects, so that it couldn't permit the further identification of impersonal constructions. Also, the rule-based method was used, which can be applied only to zero pronouns.

Another previous work by Ferrández and Peral [Ferrández and Peral, 2000] represents an algorithm for zero pronoun resolution. By means of their system, the Slot Unification Parser for Anaphora Resolution, anaphoric (the referent of zero pronoun appear in the previous explanation), exophoric (the referent can be found outside the text) and cataphoric (the explanation lies after the verb) zero pronouns' references can be classified. These

authors also used a rule based approach and a binary classification, which implied no identification of non-referential zero pronouns.

According to the Elliphant method, subjects located within the clause, before and after the verb or irrespective ones are included in the explicit class. One of the main advantages of the present system is also the use of an instance-based learner for classification (K^* instance-based learner of the WEKA package). All the previous methods, as it has been already mentioned, are rule-based and exclude the possibility of non-referential zero anaphora classification.

Thus, the Elliphant system identifies non-elliptic (explicit) and elliptic (omitted) subjects. The elliptic ones are divided into referential/argumental (zero pronouns) and non-referential/non-argumental (impersonal constructions). Explicit subjects represent the first class in the present study. Zero pronouns (the second class) are defined in this context as subjects that are omitted, but nevertheless understood (e.g. those, which are not phonetically realised in a pro-drop language like Spanish). This referential type is in turn subdivided into specific (*No vendrán* "They won't come"), unspecific (*Dicen que vendrá* "They say he will come"). In some cases both interpretations are possible, therefore, they were included in the same class. Impersonals sentences (the third class) are classified according to the distribution given in the Grammar of Real Academy of the Spanish language [RAE, 2009]. The omitted subject of an impersonal construction can't be lexically retrieved. The construction itself can be formed with so-called "impersonal verbs" or it can be a reflexive impersonal clause with the element "se". According to the used classification, there are non-reflexive impersonal clauses (IC), which may contain verbs of meteorological phenomena, *haber* (to be), *hacer* (to do), *ser* (to be), *estar* (to be), *ir* (to go) and *dar* (to give), other verbs, such as *sobrar con* (to be too much), *bastar con* (to be enough), *faltar con* (to have lack of) and pronominal unipersonal verb with subject zero *tratarse de* (to be about). In regard to the reflexive IC, they are considered to have non-specific referents which cannot be retrieved.

Thus, in order to perform the classification, a linguistically motivated classification system was developed for all instances of subject ellipsis. The training data (**ESZIC** (explicit subjects, zero-pronouns and impersonal constructions corpus)) was composed of seventeen legal and health texts written in Peninsular Spanish. It was compiled and an annotation tool was created.

The corpus included 6,825 finite verbs, 71% with an explicit subject, 26% with a zero pronoun and 3% of those verbs forming the impersonal constructions. The parser was based on the Functional Dependency Grammar [Järvinen and Tapanainen, 1998] and it was able to return the POS, the lemma of words in a text and their dependence relations. Every finite verb received a feature and thereupon it was classified by a human annotator. The training file was then provided with vectors, along with the manual classification.

The appropriate fourteen features were selected from the corpus by means of the corresponding tool, developed *ad hoc*, as the parsers used do not provide the information concerning the limits of the clauses within sentences. The extracted features were subsequently used for classification by machine learning method (WEKA package tool). The features belonging to nine classes, defined broadly by the author, are described in detail below. The feature description is taken from [Rello, Suarez, Mitkov, 2010: 283-284]

Table 1: The description of features.

F1 Presence or absence of subject, as identified by the parser
F2 Clause type
F3-5 Morphological information features of the verb (number and person) and lexical information extracted from the parser (the lemma of the finite verb)

F6 Features which take into account the tense of the clause verb and its agreement in person, number and tense with the previous main clause verb and the previous clause verb
F7-9 Candidates for the subject of the clause: number of noun phrases in the clause before the verb, total number of noun phrases in the clause, and the number of infinitival forms.
F10 The appearance of the particle <i>se</i> close to the verb (when <i>se</i> occurs immediately before after the verb or with a maximum of one token lying between the verb and itself)
F11 The appearance of a prepositional phrase with an a preposition
F12-13 The parts of speech of eight tokens: four words prior to and four words after the verb
F14 Type of verb: a copulative verb, a verb with an impersonal use, a pronominal verb and its transitivity

Connexor's Machine syntax parser was exploited to perform the comparative evaluation of the system. Its results provided an accuracy of 74.9%. The corresponding table is presented below.

Table 2: The results of Connexor's parser.

Class	Precision	Recall	F-feature
Explicit subject (non-elliptic and referential)	0.991	0.716	0.802
Zero Pronoun and Impersonal Construction (elliptic, referential or non-referential)	0.543	0.829	0.656

The results of the evaluation, performed with K* instance-based learner algorithm [Cleary and Trigg, 1995], are presented below. The estimated accuracy of the method is 86.9%.

Table 3: The results of K* instance-based learner algorithm.

Class	Precision	Recall	F-feature
Subject (non-elliptic and referential)	0.901	0.924	0.913
Zero pronoun (elliptic and referential)	0.774	0.743	0.758
Impersonal Construction (elliptic and non-referential)	0.889	0.626	0.734

Hereby, the K* instance-based learner algorithm outperforms Connexor's Machine syntax parser in the total accuracy and therewith the latest algorithm doesn't distinguish between referential and non-referential constructions.

It should be mentioned, that the author [Rello, 2010: 284] acknowledges the difficulty of automatic non-referential identification and the necessity of the system improvement by, *inter alia*, parameter optimisation related to feature selection.

Linguistic approaches to the classification of impersonal constructions

Linguistic theory is the basis for deriving linguistically motivated classes and the criteria for annotation. In modern linguistics there is no unified approach developed for the classification of impersonal constructions, as the semantic aspect of this issue has many interpretations. The scale, presented in the work of J.C.Moreno [Moreno 1987: 250-280], seems to demonstrate the most adequate criteria of impersonal semantics.

Table 4: The scale of impersonality by J.C.Moreno.

Scale of Impersonality		
External (-animate): <i>Llueve; Nieva</i>	Internal (+animate) (-controller): <i>Me pesa de mis culpas; Me da miedo de confesártelo</i>	Generic/ non-specific (+animate) (+controller) (-specific): <i>Se vende pisos; Aquí se trabaja bien</i>
Agentless		Agentive

The main problem of the classification of impersonal models used in the previously examined Elliphant method is that the term “impersonal” aims to be applied for the constructions containing non-referential omitted subjects only, meanwhile the approaches of descriptive and Real Academy Spanish grammars (RAE’s distribution is the basis of the linguistically motivated classes in [Rello 2010]), as those of most European linguists, include in the notion of this term the constructions with animate active unspecific participants (represented by omitted 2Sg, 3Pl and the most part of constructions with “se”-element, depending on the semantics of the verb), which are considered to be referential [Soriano, 1999; Mendikoetxea, 1999; RAE, 2009]. The use of the verb “dar” (to give) and other verbs should be more specified, as there are cases with agreement, which are parallel to those with prepositions, however, they cannot be classified as impersonal due to the presence of the explicit cataphoric subject.

Hereby, the impersonal constructions can be split into agentive (non-specific interpretation, the referent subject is animate) and agentless (no reference, the null element is inanimate and the construction has no controller). Agentless models are considered to be authentic impersonals and can be broadly divided into proper IC (external class in Moreno’s classification), dative IC (internal class) and modal IC (both external and internal classes). Internal class includes dative animate participant, which is considered to represent the experiencer of a situation.

The detailed classification of IC is presented in the table 5.

Table 5*: The classification of impersonal structures.

IC without "se"-element	Type of verb/model	IC containing "se"-element	Type of verb/model
Proper IC	<ul style="list-style-type: none"> verbs and constructions with <i>estar</i>, <i>ser</i>, <i>hacer</i>, denoting natural phenomena 	Modal IC	<ul style="list-style-type: none"> models, related to necessity or possibility with <i>deber</i>, <i>poder</i>
	<ul style="list-style-type: none"> <i>hacer</i> (temporal IC) 		<ul style="list-style-type: none"> models with verbs denoting osmesis (<i>se sabe</i>, <i>se huele</i>)
	<ul style="list-style-type: none"> <i>haber</i> (existencial IC) 		
Dative IC	<ul style="list-style-type: none"> Loc/Dat models with valuation meaning (<i>Loc/Dat+sobrar/bastar/valer+con+Obj</i>, <i>Loc/Dat+sobrar/faltar+de+nada</i>, <i>todo</i>, <i>Loc/Dat+ser/estar+bastante/suficiente+con+Obj</i>, <i>Loc/Dat+estar bien+con+Obj</i>); models related to the sensations of experiencer (<i>Dat+doler/picar/escocer+Loc</i>) models related to an occurrence (<i>Loc/Dat + pasar/suceder/ocurrir+de+todo</i>) 	Modal IC	<ul style="list-style-type: none"> models with verbs denoting osmesis (<i>se</i>) <i>huele</i>, <i>(se) sabe</i>, <i>apesta</i>)
	<ul style="list-style-type: none"> verbs, related to the mental state of the experiencer (<i>Dat+dar/entrar+vergüenza /lástima/miedo/alegría+de+Inf</i>) 		
	<ul style="list-style-type: none"> occasional models with dative experiencer or beneficiant (<i>Dat+ir muy bien</i> (<i>mal</i>, <i>estupendamente</i>, <i>fatal</i>, <i>regular</i>)+<i>con+Obj</i>) 		
Modal IC	<ul style="list-style-type: none"> models of necessity (<i>Hay que+Inf</i>, <i>Hace falta+Inf</i>); models with verbs denoting osmesis (<i>se</i>) <i>huele</i>, <i>(se) sabe</i>, <i>apesta</i>) 		

*Further details in [Danilova, 2011]

Conclusion

This paper aims to demonstrate recent approaches to the classification of impersonal constructions. Linguistic theory is meant to be the basis for selecting appropriate classes and features in order to perform the further analysis in NLP, using corresponding tools. As a result of the present review, the further conclusions are made:

- Elliphant is the first and rather effective automatic system for the classification of anaphora resolution. It identifies both explicit and omitted subject and classifies elliptic ones as referential and argumental

(zero-pronouns) or non-referential and non-argumental (impersonal constructions) by means of K^* instance-based learner (WEKA package);

- The next step is the correct automatic classification of impersonal models. The Elliphant system makes use of the linguistic distribution given in the Real Academy Spanish Grammar [2009], which doesn't represent a proper classification, as it describes the whole variety of models without clearly stated criteria for their distribution. Therewith, this distribution includes in the notion of impersonal construction those models, which have non-specific animate referents, while proper impersonals must be non-referential. Thus, the distribution of the Real Academy Spanish Grammar is not rather appropriate for the formation of linguistically-motivated classes.
- In this article another classification with more strict criteria is presented. It is based on historical and semantic data. Hopefully, it can provide some additional useful information for further development of NLP methods. Hereby, the purpose of the further work in this field is to increase the accuracy of automatic non-referential ellipsis classification by selecting adequate basis for it.

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Major Fields of Scientific Research: Semantics of impersonal structures

Automated transformation of algorithms

THE EXTENDED ALGEBRA OF ALGORITHMS WITH ADDITIONAL CYCLE ELIMINATION AXIOMATS

Volodymyr Ovsyak, Aleksandr Ovsyak

Abstract: *The existing, intuitive computation models, that is the virtual machines of Turing, Post, Kolmogorov, Schönhage, Aho-Ullman-Hopcroft as well as the algorithms of Markov and Krinitski, and the recursive functions, all lack precise, mathematical formulation. Consequently, algebra of algorithms is defined using the axiomatic method. The algebra is based on the operations of sequencing, elimination, paralleling and reversing as well as cyclic sequencing, cyclic elimination and cyclic paralleling, all of them performed on the so-called uniterms. A useful extension is offered in terms of additional cycle elimination axiomats. A simple example illustrates the usefulness of the algebra of algorithms.*

Keywords: *Computation models, algorithms, algebra of algorithms, operations.*

ACM Classification Keywords: *I.0 General Literature*

Introduction

The algorithms or models of computations are the essence of computer systems. In particular, it is important for designers to be able to precisely and formally describe algorithms for the developed operating systems, platforms, programming languages and specialized computer systems, including monitoring, control and diagnostic systems. The importance results from the fact that the cost of location and correction of algorithmic errors when implementing or operating the algorithms is very high. The well-known existing models of computations are the λ -calculus, Turing machine, Post machine, Kolmogorov machine, Schönhage machine, Markov algorithms, recursive functions, the Aho, Ullman and Hopcroft machine (with random access to RAM memory) and the analytical algorithm theory of Krinitski. These are specific tools for algorithm presentation that occurred between the thirties and nineties of the 20th century. It is well known that the above models are equivalent in that they compute 'the same functions'. It is also known that the algorithms were initially described in those models in an intuitive way. Later, the algorithms have been given a precise mathematical rigor, which has had a tremendous impact on the development of functional and structural programming languages. In the existing computational models, an algorithm appears as a specifically described sequence of specific operations. However, some algorithmic figures like sequencing of operations, realized by means of e.g. 'go to' instructions or multiple bracketing, are still described in an informal, intuitive way. Offering such formal descriptions would contribute to the treatment of algorithms as mathematical formulae, which could in turn lead to the introduction of algebra of algorithms. This could give means for transformation of the algorithms and their optimization in the sense of reduction of a number of operations and memory occupation, thus contributing to more effective implementation of the algorithms. Even if transformation of algorithms is available for some of the existing computation models, there exist no tools for formal description of some relations between their operations.

A precise, formal tool for description, transformation and optimization of algorithms is offered in this paper. An extended version of the classical algebra of algorithms [Ovsyak, 2005, 2008] is presented, in that additional axioms for elimination of cyclic operations are provided.

Introduction

Here we present the (extended) fundamentals of the algebra of abstract algorithms originally introduced in Refs. [Ovsyak, 2008]. Constructed with the axiomatic method, the algebra enables to describe algorithms by means of mathematical formulae.

ALPHABET

The **alphabet** of the theory of algorithms consists of the following:

1) symbols of operations: \frown - sequencing; \lrcorner - elimination; \sqcap - paralleling; \dashv - reversing; \curvearrowright - cyclic sequencing; \curvearrowleft - cyclic elimination; \emptyset - cyclic paralleling; $=$ - equalizing. (Note: Vertical arrangement of the denotations for sequencing, elimination and paralleling can also be used.)

2) symbols of variables, coefficients and constants, with or without indices, denoted with lower-case letters from the Latin alphabet: $x, x_0, \dots, x_j, x^0, \dots, z^j, \dots, a, b, c_0, c_1, \dots, c_j, c^0, c^1, \dots, c^j, c_j, \dots$

3) symbols of functions dependent on one or more variables, with or without indices, denoted with capital letters from the Latin alphabet: $P(x), P(a,b), \dots$

4) symbols of conditional variables assuming a) one of two values, the variables to be denoted by $u, u_0, u_1, \dots, u_j, u^j$ and b) one of a finite set of values, the variables to be denoted by $w, w_0, w_1, \dots, w_s, w^t$.

5) * - empty symbol;

6) coma (,), semicolon (;), colon (:). (Note: Coma and semicolon are used to separate commutative and noncommutative operations, respectively, whereas colon is used to denote either coma or colon.)

Definition 1. Any symbols from the above alphabet, over which the operations of the algebra of algorithms are executed will be called **uniterms**.

For instance, the following uniterms can be exemplified: $-5, -3.1, 0, 1.25, 7, a, A, c, C, x, F(a,x), \dots$. Uniterms are divided into **terminal** (or concrete), e.g. $p=q+2, S_1=2x-3$, and **functional** ones, e.g. $F(x), R(x,y)$.

OPERATIONS

Definitions of the operations in the algebra of algorithms are given below.

Equalizing is an operation on uniterms having the following properties:

- 1) identity: $A = A$,
- 2) symmetry: if $A = B$, then $B = A$,
- 3) transitivity: if $A = B$ and $B = S$, then $A = S$.

Sequencing is an operation having the following properties:

1) commutativity:

$$\overbrace{R, S} = \overbrace{S, R}$$

Note: Two noncommutative operations on uniterms will be separated by semicolon (rather than coma), so that

$$\overbrace{R; S} \neq \overbrace{S; R}$$

2) associativity:

$$\overbrace{\overbrace{R, S}, T} = \overbrace{R, \overbrace{S, T}}$$

3) idempotency:

$$\overbrace{S, S} = S$$

4) absorption of the empty uniterm:

$$\overbrace{*. S} = S,$$

where the symbol “.” means comma or semicolon;

5) extracting a common uniterm:

$$\overbrace{\overbrace{A; B}, \overbrace{A; C}} = \overbrace{A; \overbrace{B, C}},$$

$$\overbrace{\overbrace{A; B}, \overbrace{C; B}} = \overbrace{A, C; B}.$$

Elimination is an operation having the following properties:

1) selection of a conditional uniterm:

$$\overbrace{R; S; u - ?} = \begin{cases} R, & \text{if } u = 1; \\ S, & \text{if } u = 0; \end{cases}$$

2) selection of a multiconditional uniterm:

$$\overbrace{R; S; \dots; Z; w - ?} = \begin{cases} R, & \text{if } w = v_0; \\ S, & \text{if } w = v_1; \\ \vdots \\ \vdots \\ S, & \text{if } w = v_{n-1}; \end{cases}$$

where v_0, v_1, \dots, v_{n-1} are the values of the multiconditional uniterm w .

3) selection of empty multiconditional uniterm(s)

$$\overline{* ; S ; \dots ; Z ; w - ?} = \begin{cases} *, \text{ if } w = v_0; \\ S, \text{ if } w = v_1; \\ \cdot \\ \cdot \\ \cdot \\ S, \text{ if } w = v_{n-1}; \end{cases}$$

4) idempotency (absorption of a conditional uniterm):

$$\overline{A ; A ; u - ?} = A$$

5) absorption of a multiconditional uniterm (multiconditional idempotency):

$$\overline{S ; S ; \dots ; S ; w - ?} = S$$

6) selection of a condition:

$$\begin{aligned} \overline{\overline{R ; S ; u_1 - ?} ; \overline{R ; S ; u_2 - ?} ; u_3 - ?} &= \overline{R ; S ; u_1 - ? ; u_2 - ? ; u_3 - ?} \\ \overline{\overline{R ; S ; \dots ; Z ; w_1 - ?} ; \overline{R ; S ; \dots ; Z ; w_2 - ?} ; u_3 - ?} &= \\ &= \overline{R ; S ; \dots ; Z ; w_1 - ?} = \overline{R ; S ; \dots ; Z ; w_2 - ?} . \end{aligned}$$

7) absorption of a uniterm (under two eliminations):

$$\begin{aligned} \overline{\overline{A ; B ; C ; u - ?} ; u - ?} &= \overline{A ; C ; u - ?} , \\ \overline{\overline{A ; B ; u - ?} ; C ; u - ?} &= \overline{A ; C ; u - ?} , \\ \overline{\overline{A ; B ; \dots ; Z ; w - ?} ; C ; K ; \dots ; M ; w - ?} &= \overline{A ; C ; K ; \dots ; M ; w - ?} , \\ \overline{\overline{A ; B ; \dots ; Z ; Q ; L ; \dots ; M ; u - ?} ; u - ?} &= \overline{A ; B ; \dots ; Z ; M ; u - ?} . \end{aligned}$$

8) distributivity:

$$\begin{aligned} \overline{R; S; R; T; u-?} &= \overline{R; S; T; u-?} , \\ \overline{R; S; T; R; P; Q; u-?} &= \overline{R; S; T; P; Q; u-?} , \\ \overline{R; S; P; S; u-?} &= \overline{R; P; u-?; S} , \\ \overline{R; S; T; F; P; T; u-?} &= \overline{R; S; F; P; u-?; T} . \\ \\ \overline{A; B; C; u_1-?; D; B; C; u_2-?; u_3-?} &= \\ \overline{A; D; u_3-?; B; C; u_1-?; u_2-?; u_3-?} . \end{aligned}$$

9) extraction of a uniterm outside the multiconditional elimination operation:

$$\begin{aligned} \overline{\begin{pmatrix} A \\ ; \\ B \end{pmatrix}; \begin{pmatrix} A \\ ; \\ C \end{pmatrix}; \dots; \begin{pmatrix} A \\ ; \\ N \end{pmatrix}; w-?} &= \begin{pmatrix} A \\ ; \\ B; C; \dots; N; w-? \end{pmatrix} \\ \overline{\begin{pmatrix} A \\ ; \\ F \end{pmatrix}; \begin{pmatrix} B \\ ; \\ F \end{pmatrix}; \dots; \begin{pmatrix} N \\ ; \\ F \end{pmatrix}; w-?} &= \begin{pmatrix} A; B; \dots; N; w-? \\ ; \\ F \end{pmatrix} \end{aligned}$$

Paralleling is an operation having the following properties:

1) idempotency:

$$\overline{S, S} = S$$

2) absorption of the empty uniterm:

$$\overline{S; *} = S$$

3) commutativity:

$$\overline{R, S} = \overline{S, R}$$

4) associativity:

$$\overline{\overline{S, R}, T} = \overline{R, \overline{S, T}}$$

5) extracting a common uniterm:

$$\begin{aligned} \overline{\overline{R; S}; \overline{R; T}} &= \overline{R; \overline{S; T}} , \\ \overline{\overline{R; T}; \overline{S; T}} &= \overline{R; S; T} . \end{aligned}$$

Reversing is an operation having the following properties:

1) reversing of sequencing:

$$\overline{A; B} = \overline{B; A}$$

2) reversing of elimination:

$$\overline{\overline{A; B; u - ?}} = \overline{A; B; \overline{u - ?}} = \overline{B; A; u - ?}$$

3) reversing of paralleling:

$$\overline{\overline{A; B}} = \overline{B; A}$$

4) double reversing of uniterms:

$$\begin{aligned} \overline{\overline{R; S}} &= \overline{R; S} \\ \overline{\overline{\overline{R; S; u - ?}}} &= \overline{\overline{R; S; u - ?}} \\ \overline{\overline{R; S}} &= \overline{R; S} \end{aligned}$$

5) reversing of uniterms in multiconditional elimination:

$$\overline{\overline{Q; L; \dots T; w - ?}} = \overline{T; \dots L; Q; w - ?} = \overline{Q; L; \dots T; \overline{w - ?}}$$

6) selection of a uniterm based on a reversible condition:

$$\overline{A; B; \overline{u - ?}} = \begin{cases} A, & \text{if } u = 0, \\ B, & \text{if } u = 1, \end{cases}$$

$$\overline{R; S; \dots Z; \overline{w - ?}} = \begin{cases} R, & \text{if } w = v_{n-1}, \\ S, & \text{if } w = v_{n-2}, \\ \cdot & \\ \cdot & \\ Z, & \text{if } w = v_0. \end{cases}$$

Cyclic sequencing ($\overline{\cdot}$), **cyclic elimination** ($\overline{\cdot}$) and **cyclic paralleling** ($\overline{\cdot}$) are cyclic operations having the following properties:

1) reversing of a variable related with a cyclic operation:

$$\overline{\overline{x} F(x)} = \overline{x} F(x);$$

$$\overline{\overline{x} F(x)} = \overline{x} F(x);$$

$$\overline{\overline{x} F(x)} = \overline{x} F(x).$$

where x is the cycle variable and R and S are the uniterms (repeated in each cycle);

2) double reversing:

$$\overline{\overline{\mathcal{C}x F(x)}} = \mathcal{C}x F(x);$$

$$\overline{\overline{\not\mathcal{C}x F(x)}} = \not\mathcal{C}x F(x);$$

$$\overline{\overline{\emptyset x F(x)}} = \emptyset x F(x).$$

3) empty loop:

$$\mathcal{C}x * = *;$$

$$\not\mathcal{C}x * = *;$$

$$\emptyset x * = *.$$

4) cycle elimination:

$$\mathcal{C}x F(x) = \begin{cases} \overline{\overline{F(a): F(b): \dots \infty}}, \text{ if } x \in Q = \overline{\overline{a: b: \dots \infty}}; \\ \overline{\overline{F(a): F(b): \dots : F(k): F(l)}}, \text{ if } x \in Q = \overline{\overline{a: b: \dots k: l}}; \end{cases}$$

$$\not\mathcal{C}x F(x) = \begin{cases} \overline{\overline{F(a): F(b): \dots \infty; (x=b)-?; (x=a)-?}}, \text{ if } x \in Q = \overline{\overline{a: b: \dots \infty}}; \\ \overline{\overline{F(a): F(b): \dots : F(k): F(l); (x=k)-?; (x=b)-?; (x=a)-?}}, \text{ if } x \in Q = \overline{\overline{a: b: \dots k: l}}; \end{cases}$$

$$\emptyset x F(x) = \begin{cases} \overline{\overline{F(a): F(b): \dots \infty}}, \text{ if } x \in Q = \overline{\overline{a: b: \dots \infty}}; \\ \overline{\overline{F(a): F(b): \dots : F(k): F(l)}}, \text{ if } x \in Q = \overline{\overline{a: b: \dots k: l}}. \end{cases}$$

ABSTRACT ALGORITHM

An **algorithm** is defined **abstract** or **formal** if it is composed of one or more (possibly all) expressions specified below, executed in a finite number of iterations (in particular, once).

1. If $S(x)$ and $R(y)$ are fuctional uniterms, then

$$\overline{\overline{S(x): R(y)}} \text{ and } \overline{\overline{R(y): S(x)}}$$

are algorithms.

2. If $A(x)$, $B(y)$, ..., $Z(t)$ are the functional uniterms or algorithms, u is the conditional uniterm and w is the multiconditional uniterm with the number of values for w equal to the number of elimination uniterms under the condition w , then

$$\overline{\overline{A(x): B(y); u - ?}}, \quad \overline{\overline{A(x): B(y); \dots ; Z(t); w - ?}}$$

are the algorithms.

3. If $A(x), B(y), Q(z), L(t), \dots, T(s)$ are the functional uniterms or algorithms and u, w are the conditional uniterms as in the above item 2, then

$$\overline{A(x)}, \overline{B(y)}, \overline{A(x):B(y)}, \overline{A(x):B(y)}, \overline{A(x);B(y);u-?}, \overline{A(x);B(y);\bar{u}-?},$$

$$\overline{Q(z);L(t); \dots T(s);w-?}, \overline{Q(z);L(t); \dots T(s);\bar{w}-?},$$

are the algorithms.

4. If $M(z)$ and $N(y)$ are the functional uniterms or algorithms, x is the variable related to the cycle operation and u_x is the condition related to the cycle operation, then

$$\mathcal{C}x \overline{M(z);N(y);u_x-?}, \mathcal{P}x \overline{M(z);N(y);u_x-?}, \mathcal{O}x \overline{M(z);N(y);u_x-?},$$

$$\overline{\mathcal{C}x \overline{M(z);N(y);u_x-?}}, \overline{\mathcal{P}x \overline{M(z);N(y);u_x-?}}, \overline{\mathcal{O}x \overline{M(z);N(y);u_x-?}},$$

$$\mathcal{C}x \overline{M(z);N(y);\bar{u}_x-?}, \mathcal{P}x \overline{M(z);N(y);\bar{u}_x-?}, \mathcal{O}x \overline{M(z);N(y);\bar{u}_x-?},$$

are the algorithms.

5. If $F(x), S(y), T(z)$ are the functional uniterms or algorithms such that $F(x) = S(y)$ and $S(y) = T(z)$, then $F(x) = T(z)$ is the algorithm.

6. An algorithm can be only such an expression that can be presented in form of a finite number of operations specified in the above items 1 to 5.

The algebra of algorithms is defined as a system of the above specified operations on the uniterms. It provides means for formal transformation of algorithms and their minimization in terms of a minimum number of uniterms.

Intuitive Explanation Of Operations

Here we give an intuitive rationale for explanation of the meaning of the operations for our algebra of algorithms, in terms of the classical block-diagram framework.

- a. Equalizing is a classical operation not requiring additional explanation.
- b. Sequencing is executed according to the block diagram as in Fig. 1.
- c. Elimination is executed according to the block diagram as in Fig. 2.

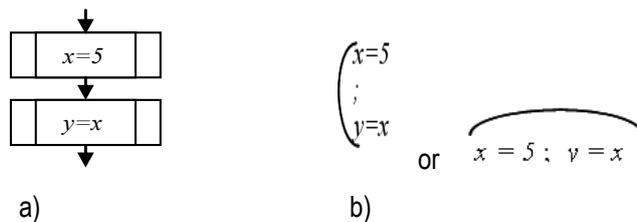


Fig.1. Diagram of a two-block algorithm (a) and its (horizontal and vertical) representations in terms of noncommutative sequencing (b),

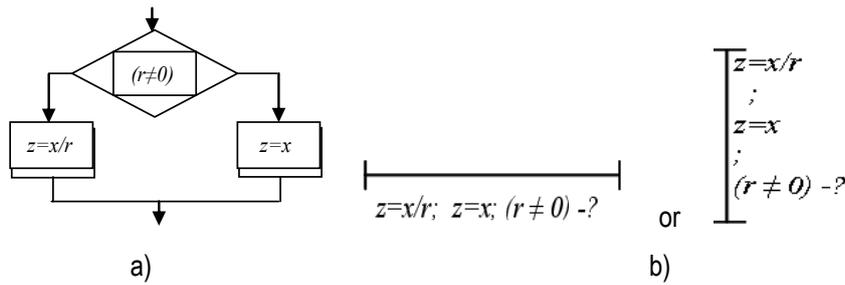


Fig.2. Diagram of an algorithm with a conditional block (a) and its (horizontal and vertical) descriptions in terms of the elimination operation (b).

d. Paralleling is intuitively illustrated in Fig. 3.

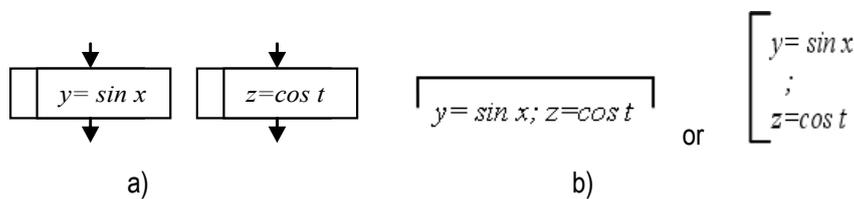


Fig.3. Diagram of two parallel algorithms (a) and their (horizontal and vertical) representations in terms of noncommutative paralleling (b).

e. Reversing is intuitively illustrated for reversing of sequencing in Fig. 4.

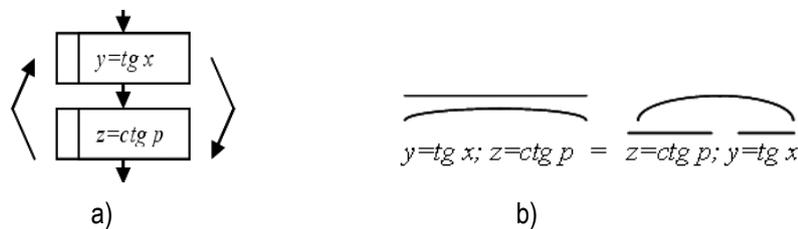


Fig.4. Diagram of a reverse-order algorithm of Fig. 2 (a) and its representation in terms of reversing of sequencing (b).

f. Operations of reversing of elimination and reversing of paralleling can be intuitively explained in a similar way.

g. Cyclic sequencing, cyclic elimination and cyclic paralleling are the operations executed in a classical loop.

Example

Algorithm for solving the quadratic equation $ax^2+bx+c=0$, consisting of the sequencing and elimination stages as below.

A) Synthesis of sequences:

- sequence describing calculation of two roots:

$$S_0 = \overbrace{a=w_0, b=w_1, c=w_2} ; \overbrace{\Delta=w_1^2-4w_0w_2; x_1=(-w_1+\sqrt{\Delta})/(2w_0)} ; \overbrace{x_2=(-w_1-\sqrt{\Delta})/(2w_0)}$$

- sequence describing calculation of a single root (for $\Delta=0$):

$$S_1 = \overbrace{a=w_0, b=w_1, c=w_2} ; \overbrace{x=-w_1/(2w_0)}$$

- sequence valid for the case $\Delta < 0$:

$$S_2 = \overbrace{a=w_0, b=w_1, c=w_2} ; M_1,$$

where M_1 is the message " $(\Delta < 0)$ – no real solutions",

- sequence describing calculation of a solution for the case $w_2=0$:

$$S_3 = \overbrace{a=w_0, b=w_1, c=w_2} ; \overbrace{x=-w_1/w_0}$$

- sequence describing calculation of a solution for the case $w_1=0$:

$$S_4 = \overbrace{a=w_0, b=w_1, c=w_2} ; \overbrace{x=(-w_2/w_0)}$$

- sequence valid for the case $(-w_2/w_0) < 0$:

$$S_5 = \overbrace{a=w_0, b=w_1, c=w_2} ; M_2,$$

where M_2 is the message " $(w_1=0$ and $(-w_2/w_0) < 0$) – no solution",

- sequence describing calculation of a solution for the case $w_0=0$ and $w_1 \neq 0$:

$$S_6 = \overbrace{a=w_0, b=w_1, c=w_2} ; \overbrace{x=-w_2/w_1}$$

- sequence valid for the case $w_0=0$ and $w_1=0$:

$$S_7 = \overbrace{a=w_0, b=w_1, c=w_2} ; M_3,$$

where M_3 is the message " $(w_0=0$ and $(w_1=0))$ – no quadratic equation".

B) Synthesis of elimination.

We eliminate all the sequences (S_0, S_1, \dots, S_7) under a general condition for m :

$$\overbrace{S_0 ; S_1 ; S_2 ; S_3 ; S_4 ; S_5 ; S_6 ; S_7 ; m - ?} \quad (1)$$

Firstly, we set a value m_1 for the condition m , for which the sequence S_0 (describing the calculation of two roots) will not be eliminated. Obviously, this concerns the case when the parameters a, b and c are nonzero ($a \neq 0, b \neq 0, c \neq 0$) and the discriminant Δ is positive. Fulfillment of the condition ($a \neq 0$) will be written as $(a \neq 0)=1$. Fulfillment of all other conditions will be denoted in a similar way, e.g. $(b \neq 0)=1$ and $(c \neq 0)=1$, whereas failing to fulfill a condition will be denoted as e.g. $(b \neq 0)=0$. Thus, we have the following sequences:

- S_0 , if $(a \neq 0)=1$ and $(b \neq 0)=1$ and $(c \neq 0)=1$ and $(\Delta > 0)=1$;
- S_1 , if $(a \neq 0)=1$ and $(b \neq 0)=1$ and $(c \neq 0)=1$ and $(\Delta > 0)=0$ and $(\Delta = 0)=1$;
- S_2 , if $(a \neq 0)=1$ and $(b \neq 0)=1$ and $(c \neq 0)=1$ and $(\Delta > 0)=0$ and $(\Delta = 0)=0$;
- S_3 , if $(a \neq 0)=1$ and $(b \neq 0)=1$ and $(c \neq 0)=0$;
- S_4 , if $(a \neq 0)=1$ and $(b \neq 0)=1$ and $(c \neq 0)=0$ and $((-w_2/w_0) \geq 0)=1$;
- S_5 , if $(a \neq 0)=1$ and $(b \neq 0)=1$ and $(c \neq 0)=0$ and $((-w_2/w_0) \geq 0)=0$;
- S_6 , if $(a \neq 0)=0$ and $(b \neq 0)=1$;
- S_7 , if $(a \neq 0)=0$ and $(b \neq 0)=0$.

C) Transformation of the algorithm

Allowing for the above specified expressions of the sequences and three-time applying the property of extraction of a uniterm outside the multiconditional elimination operation, the algorithm (1) can be minimized to obtain

$$\left(\begin{array}{l} a=w_0 \\ , \\ b=w_1 \\ , \\ c=w_2 \\ ; \\ \Delta=w_1^2-4w_0w_2; x=-w_1/(2w_0); M_1; x=-w_1/w_0; x=(-w_2/w_0); M_2; x=-w_2/w_1; M_3; m - ? \\ ; \\ x_1=(-w_1 + |\Delta|)/(2w_0) ; \\ ; \\ x_2=(-w_1 - |\Delta|)/(2w_0) \end{array} \right)$$

Thanks to the introduced multiconditional elimination operation, the algorithm minimization process is essentially simplified as compared to the original one employing the conditional elimination only [Ovsyak, 2005, 2008]. Specifically, a single multiconditional elimination is used here instead of seven conditional eliminations applied before

Conclusions

In this paper, a number of the existing, intuitive computation models have been recalled, including the virtual machines of Turing, Post, Kolmogorov, Schönhage, Aho-Ullman-Hopcroft as well as the Markov and Krinitski algorithms and the recursive functions, all of them lacking a formal, mathematical presentation. In pursue of

precise mathematical formulation, a universal notion of a uniterm has firstly been introduced. Using the axiomatic method, various operations on the uniterms have been defined, thus contributing to the definition of an abstract or formal algorithm and the introduction of a new idea of the algebra of algorithms. The algebra enables to treat algorithms as mathematical formulae and it provides tools for formal transformation and possible minimization of the algorithms.

An important extension of the elimination operation has been introduced in the paper, namely a multiconditional elimination has been offered. The extension contributes to the reduction of a number of elimination operations and it simplifies the algorithm minimization process, while improving the readability of algorithms.

An example illustrates the potential of the proposed theory and the underlying methodology for processing of the algorithms. Some other application examples are presented/reported in a complementary paper [Ovsiak, 2011].

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A CONCEPT OF A MODEL OF A COMPUTER SYSTEM FOR FORMING COMPLEX UNITERMS

Magdalena Niziołek, Volodymyr Ovsyak

Abstract: *The existing methods of intuitive and mathematical methods of application of algorithms in system are described. It is shown that in the existing formula editor of algebra of algorithms only trivial (simple) uniterms are formed. In the work to secure the ability of creating complexes uniterms a concept of an adequate computer system model is created. The essence of this concept lies in the creation of function uniterms in the main class of the formula editor of algebra of algorithms and in specific subsystems of complex uniterms, as well as in a modification of the XML described algorithms expressions generated by the editor.*

Keywords. *Algebra, algorithm, model, formula, subsystem, uniterm: formatting, editor program.*

ACM classification keywords: *F.2 Analysis of algorithms and problem complexity*

Introduction

Algorithms are usually presented in the form of a natural language description, a block-diagram or as a specialized language where the form of description is formalized for an unambiguity of the meaning. The most known methods for the last case are e.g. Post, Turing, Aho-Ullman-Hopcroft or Schönhage virtual machines, recursive functions (calculus λ , Church), Markov algorithms], Kolmogorov machine, as well as Krinitski universal algorithms.

Those methods, while easy to understand because of their intuitive notation, are not depicted formally. They contain notes of the sequence of operation needed to be effectuate to gain a certain result, but don't describe the relation between those sequences. Thus operations as optimization are difficult to perform.

The solution is to use formal description i.e. algorithm algebra [Owsiak, 2005]. Although in the formal description the algorithms aggravate their intuitiveness, the gain is in an abstraction that allows for certain transformations.

Definition of an uniterm

Uniterm is a concept that describe any given symbol or sign on which operation in algorithms algebra is executed. They can consist of numbers, letters or expressions e.g. 2, 34, -5, a, b, j,k, $y>x$, $y=z^x$, $A(x)$, $F(z,y,z)$.

Uniterms that don't depend on any variables can be divided into constants (e.g. 2,34, c, n), variables (x,y,z) and coefficients(i,j,k). Uniterms that depend on one or more variables are divided into concrete (e.g. $p=q+2$, $S_1=2x-3$) and abstract (e.g. $F(x)$, $R(x,y)$).

The existing formula editor of algebra of algorithms utilize only trivial (simple) uniterms (Img.1). However, it is easily to notice that in the case of variable depended uniterms the uniterms aren't a trivial expression, but are composed of other components. Those components can be algorithms or expressions that can be presented as formulas on their own.

As such a computer system that would take into account such complex uniterms needs to be created.

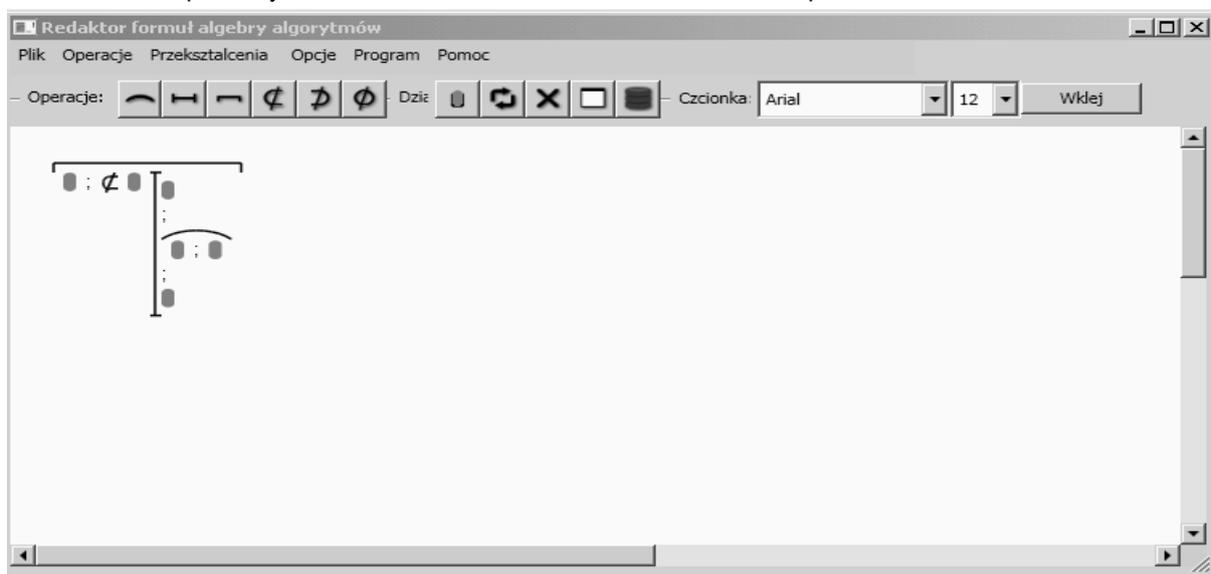


Fig. 1. Simple uniterms in the existent formula editor.

Formula editor for complex uniterms

The new system is an extension of the exiting one. In it's basic idea it's the same. However, the essence of this concept lies in the creation of complex (function) uniterms in the main class of the formula editor. Any uniterm can be changed into a complex uniterm, by creating a new object from UnitermComplex class (Fig. 2). The new complex uniterm is composed of unrestricted number of elements, though three is the most basic case (compare or assignment operations).

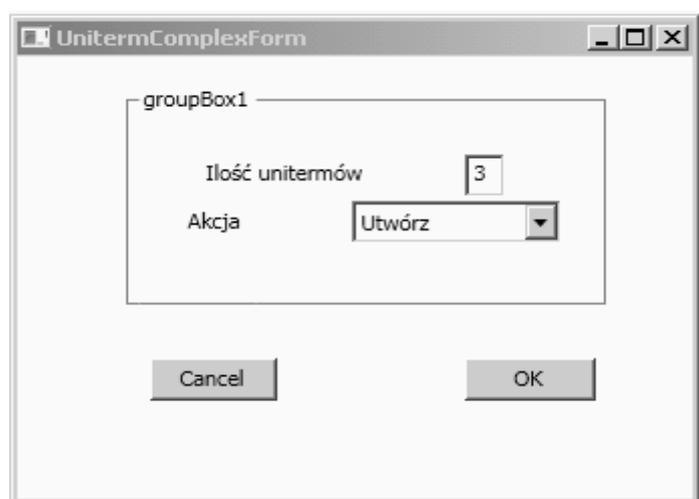


Fig. 2. Dialog for creating a new complex uniterm

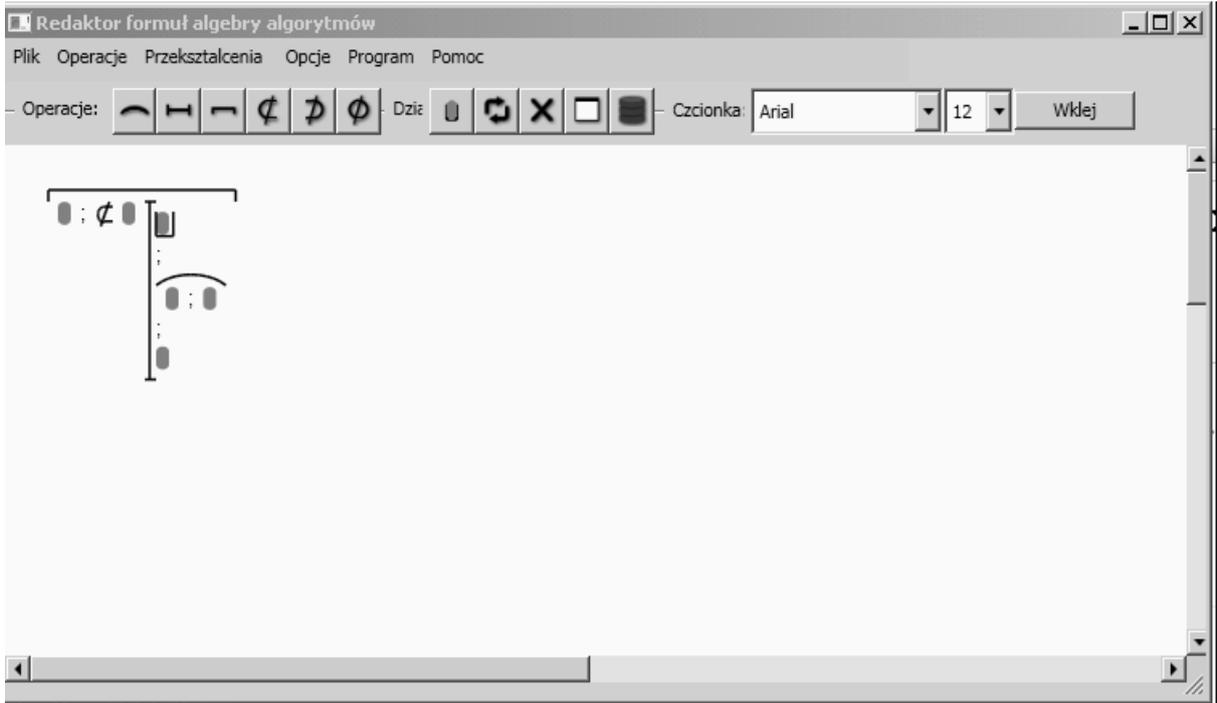


Fig. 3. Editor with one hidden complex uniterm (without data)

To differ from trivial uniterm the complex uniterm are symbolized by a container \sqcup . In the main form of the formula editor the complex uniterm can be shown in two ways: hidden – the complex uniterm is regarded as a trivial uniterm (Fig. 3), and visible – as an association of components (Fig. 4).

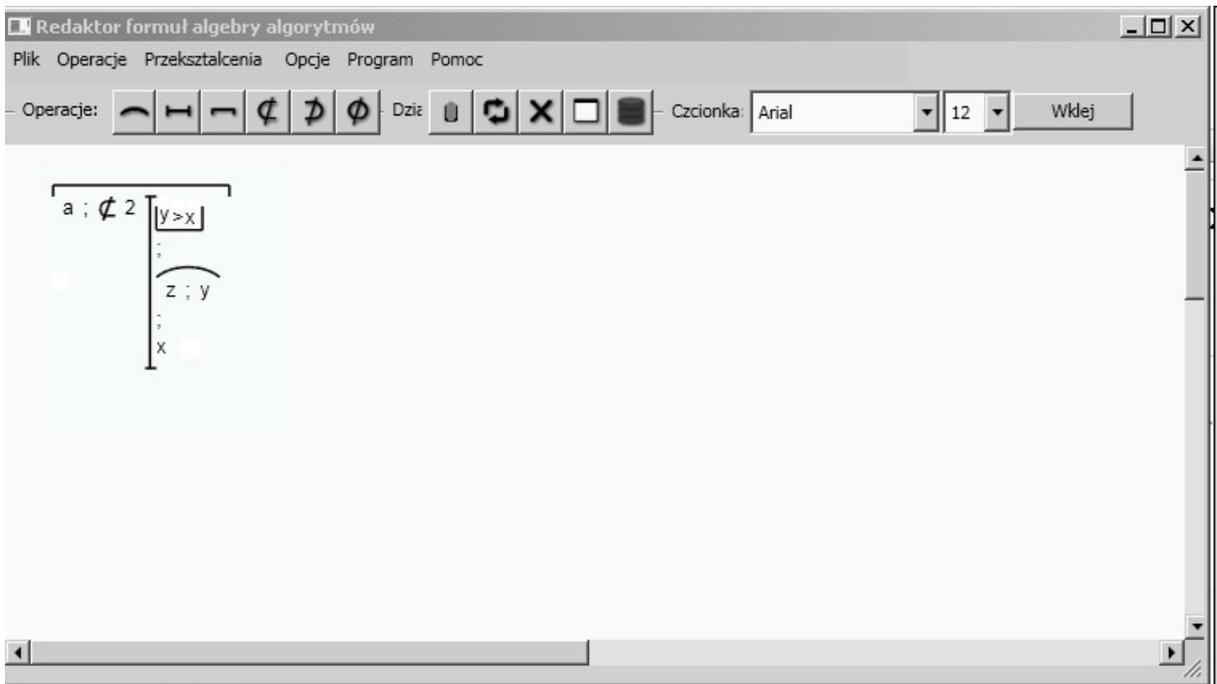


fig. 4. Editor with one visible complex uniterm (with data)

The original formula editor was written in Microsoft Visual Studio .NET 2010 with use of the modern languages XAML and C#. In the system the XML code, has hierarchical structure and access the individual elements is by the index. The index to node is text that contains more node names separated by slash marks. Each index starts from a node //root, which is superior to all other nodes, it means that it contains them. The uniterm node does not contain other under nodes. [Markuszewski, 2011].

In the new system an uniterm node can contain under nodes named subuniterm. Depending on the attribute the system will regard the subuniterm as a normal uniterm or as a new system.

Example of code:

```
public override void CreateXML(XmlDocument xmlDoc, XmlElement node)
{
    XmlElement newElement;
    XmlAttribute newAttribute;

    newElement = xmlDoc.CreateElement("subuniterm");
    newAttribute = xmlDoc.CreateAttribute("action");
    if (action == Action.Create)
        newAttribute.Value = "Create";
    else if (action == Action.Visible)
        newAttribute.Value = "Visible";
    else
        newAttribute.Value = "Hidden";
    newElement.Attributes.Append(newAttribute);
    node.AppendChild(newElement);
    //if (condition != null) condition.CreateXML(xmlDoc, newElement);
    for (int i = 0; i < TermNrUC; i++)
    {
        if (termy[i] != null)
            termy[i].CreateXML(xmlDoc, newElement);
    }
}
```

Conclusion

The original system regarded all uniterms as equal, regardless of their complex or stability (stationarity). The new system allows to expand the variable depending uniterms to a new subsystem, allowing a better accuracy and/or optimization of an algorithm written in algorithmic algebra.

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THE COMPUTER PROCESS OF OPTIMIZATION ALGORITHMS FORMULAS

Tomasz Markuszewski

Abstract: *This paper presents a model of a computerized system to optimize formulas of algorithms. For this purpose the algebra of algorithms. The computer process optimization formula of algorithm is very complex, and were decomposed to simplify. The new model described in form of formulas algorithms, and contains variables, function unierms. The variables are used for storing interim and final data used in the optimization process. Functional unierms are initiating variables, checking the possibility of optimization by introducing an additional condition, optimizing single operation algorithm algebra, and for all algorithms operations algebra with introducing an additional condition method. The built effect of the model is its simplicity. The primary benefit of implementation a model is to protect transformation formulas of algorithms.*

Keywords: algebra, formula, algorithm, transformation, optimization, model, decomposition.

Introduction

Algebra algorithms can write algorithms in the form of mathematical expressions called formulas [Ovsyak, 2005]. These formulas it's possible to transformed into a less complex (optimal) form by using the operations properties of the algebra algorithms. Applying algebra [Ovsyak, 2005, 2008] allows for the creation of a computerized system to optimize formulas algorithms [Markuszewski, 2010, Ovsyak, 2011]. The model of computerized optimization algorithms formulas is presented in the expressions algorithm algebra, and contains submodels: $@Gi$ – generating indexes xml – description of the formula algorithm [Petzold, 2002], $@Bo$ – supporting the optimization submodels: $@S$ – sequencing operation; $@E$ – elimination operation; $@P$ – paralleling operation; $@C$ – cyclic sequencing, cyclic elimination and cyclic paralleling operations; $@R$ – inverting operation; $@Eo$ – means the optimization subsystem by introducing an additional condition; $\sim I$ – subsystem that provides the necessary data. The order calls the subsystems of computer system optimization formulas algebra algorithms is presented in expression (1), and contained in $@Lo$ subsystem

$$\left(\begin{array}{l} @Gi \\ ; \\ @Bo \\ ; \\ @Eo \\ ; \\ @S, @E, @P, @C, @R, \sim I \end{array} \right) \quad (1)$$

Many processes to optimize the operation of formulas according to the properties of algebra of algorithms, and optimization by introducing an additional condition, causing great difficulty in the induction of optimization. For this reason the model is very complex and complicated, it is necessary to simplify the decomposition.

Intuitive Explanation Of Operations

The created a model shown in expression (2) contains variables used to store data, x – processed xml – description of the formula algorithm, xi – variable of subsystem generating indexes (index or trackway is a string indicating the xml fragments description of the formula, a record $(xi @Gi)$ – the creating variable $xi Gi$ subsystem, ac – optimizes formulas by introducing an additional condition, $i1, i2$ – provides access to data necessary for process optimization (the mark (\sim) indicates the sharing subsystem $i1, i2$), o – an array with variables subsystems optimization and created functional uniterms making the process of optimization, $loop$ – contains information on whether the repeated optimization, $isAddO$ – stores information on whether it is possible to optimize by the introduction of an additional condition methods, and function uniterms: $InitOp()$ – setting the initial values of variables, $ChkAddC()$ – checking the possibility of introducing an additional condition, $OneOp()$ – making the optimization for single operation algorithm algebra and $Optima()$ – performing a full optimization for all operations with optimization formulas by introducing an additional condition.

$$\begin{aligned}
 @Lo = & \\
 & (x \in @xmlid , xi \in @Gi \\
 & , \\
 & (i1 \in \sim IOp1 , i2 \in \sim IOp2 \\
 & , \\
 & (isO \in @bool , ac \in @Eo \\
 & , \\
 & (o \in @object[] , loop \in @bool \\
 & , \\
 & (isAddO \in @bool \\
 & , \\
 & (InitOp() , ChkAddC() \\
 & , \\
 & (OneOp() , Optima()
 \end{aligned} \tag{2}$$

where: $@xmlid$ – name of standard subsystem *XmlDocument* [Petzold, 2002, MacDonald, 2008], $@bool$ – abbreviated name of standard subsystem *bool*.

The functional uniterm initialing variables

Function uniterm expressed in formula (3) contains the input parameters for entering, *ss* – the entire text *xml* – description of the algorithm formula ($@str$ – means standard subsystem string [Ovsyak, 2008, MacDonald, 2008]) and *mode* – how to enter an additional condition (if the value is *true* then automatically otherwise new condition are set by user).

$$\begin{aligned}
 prv \text{ InitOp}(ss \in @str, mode \in @bool) = & \\
 & (xi \in @Gi() ; o \in @object[5] \\
 & ; \\
 & (o[0] \in @S() , o[1] \in @E() \\
 & , \\
 & (o[2] \in @P() , o[3] \in @C() \\
 & , \\
 & (o[4] \in @R() , ac \in @Eo() \\
 & ; \\
 & (xi.Lox(x) ; xi.Cr() \\
 & ; \\
 & (ac.SetArrayU(ss) , ac.auto=mode \\
 & , \\
 & (isO=false , isAddO=false \\
 & , \\
 & (loop=false , il=ac
 \end{aligned} \tag{3}$$

where $prv \text{ InitOp}(ss \in @str, mode \in @bool)$ – header of formula algorithm, *prv* – identifier of access private, *o* – an array (the standard subsystem $@object$) for storing the optimization subsystems: $o[0] \in @S()$ – the creating of subsystem $@S$ and put its into an array of objects – uniterm $o[0]$ – means the first element in *o*, $o[1] \in @E()$ – the creating subsystem $@E$ and put its into second position in array *o*, other systems are treated analogously, *ac* – subsystem optimization formulas by introducing an additional condition, $ac.auto=mode$ – attributing to variable

auto value of input *mode* (automatically when have value *true* or user mode), *xi.LoX()* – load *xml* data, *xi.Cr()* – creating indexes for *xml* data, *ac.SetArrayU(ss)* – setting array available to optimize the conditions by introducing an additional condition (*ss* – input parameter that contains only text entire formula of algorithm), and the variable *loop* – used by the cyclic eliminations, to repeat the optimization until no further transformation is possible.

The functional uniterm checking the possibility of introducing condition

Function uniterm *ChkAddC()* represented by the formula (4)

```

prv ChkAddC()=
  i ∈ @int = 0
  ;
  ⌈
  | ⌊
  | i1.txt = xi.t[i] ; * ; (i < xi.y) - ? |
  | ;
  | isO = true ; * ; (ac.IsAddC()) - ? |
  | ;
  | isAddO = true ; break() |
  | ;
  | i = i + 1 |
  | ;
  | ci
  ⌋
  ⌋
  (4)

```

where *i* – the number of processed index, *isO* – store information on whether the optimization has been *xi.t[i]* – an array contains indexes *xml* – description of the formula, *xi.y* – the number of maximum index, *IsAddC()* – testing whether for a given *xi.t[i]* the index is loaded by providing uniterm *i1.txt* can be performed optimization by introduction an additional condition, *break()* – causes the exit from the cyclic elimination.

The functional uniterm for optimizing one operation

Function uniterm *OneOp()* expressed in the formula (5) performs the optimization of a single operation algorithms algebra.

```

prv OneOp(j ∈ @int) =
  i ∈ @int = 0 ; k ∈ @int = 0
  ;
  ⌈
  | ⌊
  | i2 = (IOp2)o[j] ; i2.xd = x ; * ; (i < xi.y) - ? |
  | ;
  | i2.txt = xi.t[i] ; i1 = (IOp1)i2 |
  | ;
  | isO = true ; * ; IsAddO - ? |
  | ;
  | x = i1.xd |
  | ;
  | isO = true ; * ; i2.Blopt(x) - ? |
  | ;
  | loop = false |
  | ;
  | i = i + 1 |
  | ;
  | ci
  ⌋
  ⌋
  (5)

```

where j – the input parameter (@int – standard subsystem int for storing integers) indicate the position in the array of objects $o[j]$ which optimization subsystem can be optimizing, i, k – represents the integers numbers, uniterms $i1, i2$ – delivery indexes and the $xm1$ – description of the formulas algorithm to subsystems, $i2 = (IOp2)o[j]$ – loading the data from the uploaded uniterm $i2$ subjects and this being situated in an array of objects $o[j]$, $i2.xd = x$ – means load $xm1$ – description of the algorithm formula variable x to $i2$, $x = i1.xd$ – ask the value of processed $xm1$ – description of the algorithm, $i1 = (IOp1)i2$ – means that the uniterm $i2$ giving to $i1$ values (this is made possible by the inheritance mechanism), $i2.Blopt()$ – functional uniterm that contains a call to all optimization properties single operation algebra algorithm, $xi.y$ – the number of maximum index.

Function uniterm $i2.Blopt()$ is predefined in optimization subsystems @S,@E,@P,@C, and @R, and uses variables isO – storing the information about whether there have been optimizations, de – an array used to store the order of operation an algebra inducing properties of algorithms and functional uniterm, A – contains sequences repeatedly nested sequence of function uniterms names optimization (an example illustrated by the formula (7)), and has function uniterm $de[i]()$ – caller and the optimization of the properties of the operations of algebra algorithms, $ChkOp()$ – checking whether a formula optimization algorithms, $de.Co()$ – returns the maximum and number of functional uniterms placed in an array de (elements of an array are numbered from zero).

Function uniterm $\sim Op2.Blopt()$ presented in formula (6) gives a value of variable w , which takes *true* value if made at least one optimization, or otherwise returns *false*, and the input parameter is d , witch update x – processed $xm1$ – description of the formula algorithm, Uniterm pu means the identifier of access public, and the end $(.)$ of functional uniterm, $*$ – empty uniterm, c_i – means returns to cycle,

$$\begin{aligned}
 & pu (w \in @bool) \sim Op2.Blopt(d \in @xm1d) = \\
 & \left(\begin{array}{l}
 \overbrace{\left(\begin{array}{l}
 x = d ; isO \in @bool = false ; i \in @int = 0 \\
 ; \\
 de[] \in ^Deleg() \\
 ; \\
 de = A \\
 ;
 \end{array} \right)} \\
 \underbrace{\left(\begin{array}{l}
 \underbrace{\left(\begin{array}{l}
 de[i]() ; w = isO. ; i < de.Co()-? \\
 ; \\
 isO = true ; * ; ChkOp() - ? \\
 ; \\
 i = i + 1 \\
 ; \\
 c_i
 \end{array} \right)} \\
 ; \\
 ; \\
 ;
 \end{array} \right)}
 \end{array} \right)
 \end{aligned} \tag{6}$$

Note that, uniterm Deleg means delegation uniterm (defined as: delegate [Petzold, 2002, MacDonald, 2008]), and uniterm A for example of eliminating operation show in formula (7)

$$A = \overbrace{Abs; Ou; Ous; Oe; Od; Oc; Oa}^{\text{Handwritten arcs}}, \quad (7)$$

where *Abs* – name of function uniterm (defined in @Bo (supporting subsystem)) performing the optimization by property idempotency [Ovsyak, 2005], *Ou*, *Ous* – names of function uniterm absorption of uniterms, *Oe*, *Od*, *Oc*, *Oa* – means names of function uniterms, witch performing the optimization by distributiveness properties for operation of elimination algorithm algebra.

The names of optimization function uniterms, signed *Oxx* – where *xx* is the abbreviation of the property, which they use when they optimize (eg *Ous* where *xx* = *us* – pointing to the uniterms of absorption).

The functional uniterm for full optimizing

Function uniterm *Optima()* presented in formula (8) making the full optimization formulas algorithm

$$\begin{aligned}
 & pu (v \in @bool) Optima(ss \in @str, mode \in @bool) = \\
 & \quad \overbrace{i \in @int=0; k \in @int=0; InitOp(ss, mode)}^{\text{Handwritten arcs}} \\
 & \quad ; \\
 & \quad \mathcal{A}k \quad \overbrace{v=isO. ; (k<2) - ?}^{\text{Handwritten arcs}} \\
 & \quad \quad \overbrace{ac.x = x; ChkAddC() ;}^{\text{Handwritten arcs}} \\
 & \quad \quad ; \\
 & \quad \quad \overbrace{loop=true; i=0}^{\text{Handwritten arcs}} \\
 & \quad \quad ; \\
 & \quad \quad \mathcal{A}loop \\
 & \quad \quad \mathcal{A}i \quad \overbrace{*; (loop=true) - ?}^{\text{Handwritten arcs}} \\
 & \quad \quad \quad \overbrace{OneOp(i); xi.LoX(x); *; i < o.Cq() - ?}^{\text{Handwritten arcs}} \\
 & \quad \quad \quad ; \\
 & \quad \quad \quad \overbrace{xi.Cr(); i=i+1}^{\text{Handwritten arcs}} \\
 & \quad \quad \quad ; \\
 & \quad \quad \quad c_i \\
 & \quad \quad \quad ; \\
 & \quad \quad \quad c_{loop} \\
 & \quad \quad \quad ; \\
 & \quad \quad c_k
 \end{aligned} \quad (8)$$

where $pu (v \in @bool) Optima(ss \in @str, mode \in @bool)$ – header of formula algorithm, *pu* – identifier of access public, *v* – output parameter, return information whether at least one optimization of the formula was made, *ss* – input parameter string describing the whole xml – formula of algorithm, *mode* – the mode of introduction of an additional condition (entered the user or automatically), *Lox()* – function uniterm is used to load the *xml* – the formula describing the algorithm, *Cr()* – function uniterm creating all indexes and placing to *xi.t* tables [Markuszewski, 2010], *o.Cq()* – function uniterm that returns the maximum number object, (.) – the end of functional uniterm, * – empty uniterm, *c_i*, *c_{loop}*, *c_k* – means returns to cycles.

The variable *loop* “works” as long as it is not possible to further convert the formulas to the form of optimal algorithms. In order to ensure the iteration, which must be done twice, since the finding that it is impossible to

further optimization was introduced as a counter variable k in the elimination of cyclic. Note that, the function uniterm $OneOp()$ change a state $loop$ value of variable.

Conclusions

Made the decomposition @Lo subsystem simplified model, reduces complexity. Creating the computer system for optimization of formulas of abstract algorithms automates and save the optimization processes. Application uniterms array of objects and the elimination of cyclical loop ensure that the operations of algebra algorithms, placed in arrays will perform in accordance with the order placed in the array. An important extension of the elimination operation has been introduced in the paper, namely a multiconditional elimination has been offered. The extension contributes to the reduction of a number of elimination operations and it simplifies the algorithm minimization process, while improving the readability of algorithms.

An example illustrates the potential of the proposed theory and the underlying methodology for processing of the algorithms. Some other application examples are presented/reported in a complementary paper [Ovsyak, 2011].

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Agent and Multi-Agent Systems

INTELLIGENT CONTROLLER FOR HYBRID RENEWABLE ENERGY SYSTEM BASED ON MULTI-AGENT AND EMBEDDED TECHNOLOGY

Anton Tyukov, Alexey Uzhva, Maxim Shcherbakov, Adrian Dobrowolski, Adriaan Brebels

Abstract: *The concept of energy saving management system based on intelligent agent and embedded technology is represented here. This system is designed for management of hybrid renewable energy system (HRES). For testing of suggested approach the prototype grid of energy consumption, production and storage was designed. This grid contains energy consumption block, production block, inner storage block, external supplier block, local data acquisition modules and embedded controller (EC). The design of management system is presented: hardware level with input/output device, embedded controller and super-controller devices. The formalization of intelligent agents for both side is represented next. Internal agents are autonomic agent, local agent seller (LAS) and local agent buyer (LAB). LAS and LAB agents use forecast methods for generation of action. External agents are Agent of Weather Service, Agent Buying Supporter and Agent Selling Supporter.*

Keywords: *renewable energy system; energy saving; energy management system, embedded controller, supercontroller, embedded controller software, intelligent agents, multi-agent theory.*

ACM Classification Keywords: *Smart-grids*

Introduction

For optimal energy usage we need to avoid inefficient use of energy and the loss of energy for instance by the transport. Energy is used to reach a certain level of comfort. The unauthorized and non-optimal energy consumption increase additional costs of resources. The system should be adaptive to the requested energy and the possibilities of the production. Intelligent processes can define what resources can be used based on information from weather forecast, available production, energy consumption forecast and others. It becomes more notable in hybrid energy systems (HES) or HES with renewable energy sources and classic energy suppliers (HRES). Another issue is the scalability in size and distance that need to be managed. Using the embedded technology as a solution could decrease the expenses due to the fact that the controller function can be handled by embedded personal computer with low cost. Another idea is to do management of energy system in automation mode handling information about usage of energy in the past, preferences of the customer and based on the forecast of the behavior as external disturbance (for instance weather changes) and occupancy patterns of the customer in the future as well. This branch of automated system developing is called smart or intelligent adaptive automated systems in the energy saving domain [Cirrincione, 2009].

Background

There are several papers that present approaches to design of energy management systems based on physical aspects, multi-agent system (MAS) and embedded techniques.

Paper [Krichen, 2007] describes modeling and control of a hybrid production unit based on renewable energies comprising two sources: wind/solar and hydrogen storage system. As a previous one approach described at [7] uses set laws and doesn't use intelligent data handling as well. Other authors describe methodologies to model hybrid renewable energy system HRES components, HRES designs and their evaluation [Deshmukh, 2008] based on physical aspects of units. Also they provide criteria for HRES selection based on loss of load probability and cost analysis.

A new approach to the HES based on the technology of the MAS and shifts to intelligent system is proposed in paper [Lagorse, 2009]. Authors use the Fuzzy-Logic-Based approaches and present a architecture of system and simulation model. The multi-agent (MAS) solution to energy management in a distributed hybrid renewable energy generation system based on JADE (Java Agent Development) is described here [Zeng Jun, 2011]. Authors [Kwon, 2008] describes project "Development of Intelligent Distribution Automation System (IDAS)" to do distribution automation system more intelligent. Authors [Dagdougui, 2007] suggest a model of integrated hybrid system based on mix of renewable energy sources and technologies. This model includes an optimization problem for the control of the different ways to store energy. Also MAS approach is considered at papers [Qui, 2008], as distributed multi-agent system (MAS) framework for market-based control in Microgrids. In this paper we suggest other approach to design energy management system based on intelligent agent and embedded technology. In contrast to other approaches, here we consider embedded device General Management Agent Control as a core for EMS and intelligent agent approaches for strategies of buying and selling electricity. This concept could be used in intelligent system of free trade in electricity

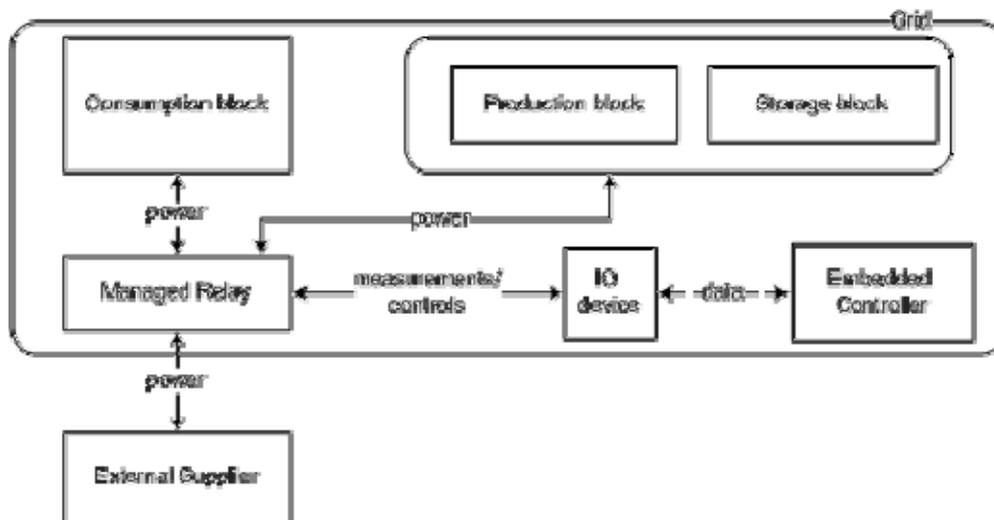


Fig. 1 - Grid architecture

It is designed to control the balance of consumption and production of electricity "zero villages" and to allow owners of private homes to buy and sell electricity according to the user's occupancy patterns.

Grid prototype overview

Standard grid contains the following units: energy consumption block with load E_c , production block with production parameters E_p , inner storage block with capacity E_s , external supplier block with permanent electricity

sources E_{ext} and local data acquisition modules and embedded controller (see fig. III-A). For prototyping of presented system we use DC electricity circuit with voltage 12V. This grid could be included into zero energy balance villages where each grid (house) could be represented as small energy plant/production/storage unit. House owners will consume energy from their batteries first and if needed they get energy for closest buildings to buy additional energy. Electricity will be bought from power plant if the building needs more electricity than available in all buildings of the zero energy balance village.

A. Energy consumption block. Consumption block (CB) includes energy consumers (such as equipment, lightning and so on). The load depends on occupancy patterns of grid owner. The power of CB is defined P_{CB} Wh.

B. Energy production block. Production block here contains photovoltaic panel (PV) with power P_{PB} . Energy production depends on input energy to PV system. Hourly power output from PV system defines according to [Dagdougua, 2010] as.

$$PP_{PB} = I_{Tj} \mu A_{PV} \quad (1)$$

where μ is system efficiency, I_{Tj} - input energy, A_{PV} - area of PV system .

Table 1- switches of the relay

Case	Input/Output 1	Input/Output 2
1	'Autonomy'	Consumption block Production/Storage Block
2	'Buying'	Consumption block External Suppliers
3	'Selling'	Production/Storage Block External Suppliers
4	'Buying'	External Block Production/Storage Block

C. Energy storage blocks

For storing the energy inside of grid the battery storage is used with required battery capacity (in ampere hour B_{rc}). It could be connected with PV through the charge controller. In this production block combines with energy storage blocks.

D. Relay

The relay is used for switching different resources depends on voltage and current in the system. The sensors are embedded into the relay and provide information output for Input/output device. The combinations of relays switches are represented in the table I. The case 1 presents production of electricity is enough for internal consumption. The case 2 occurs then need to use external supplier for inner demands. The case 3 is grid sells the electricity then consumption less than production. And last case 4 then grid buys energy and keeps in internal batteries.

E. Data acquisition

Data acquisition modules measures energy generated by solar panels, energy consumed in the building and energy accumulated in the storage.

F. External suppliers

External suppliers are represented as or batteries storage or AC/DC inventors. We assume that external suppliers are permanent source of energy. Also grid is able to get electricity from External suppliers and keep in internal storage (buying) or put electricity to external network (selling).

Design of management system

A. Hardware design

1) Input - output device: Through common user interface input - output device transfers information from sensors about voltage V , current I and/or energy consumption P to embedded device and pass control signal from ED to relay.

2) Embedded controller: Embedded controller or General Measurement Agent Control (GMAC) tracks the status of production, consumption and storage in each building and controls it and acquire to switch the relay (buy or sell) energy due the status of sensors in system or ordered by super-controller. The embedded controller is collecting data, setting control commands and transfer information to Supercontroller

3) Super-controller: The super-controller receives and analyses energy data from all grids in a village to estimate how much electricity must be bought and sold for each grid. Therefore the Super-controller predicts energy consumption and energy production analyzing weather forecast, current weather conditions, and historical values and building parameters. Each grid (house) with energy production units will become an energy dealer and will be able not only to save energy but also get some profit out of it. To buy or sell electricity the Super-controller identifies the optimal dealer/consumer which is a grid in the neighborhood or any of power plants connected in the region.

B. Intelligent agents

1) General formalization: Based on MAS theory and theory of active systems [Weiss, 1999] each agent is formalized as

$$Ag = \langle G, S, A, \theta, \varphi \rangle \tag{2}$$

where G - goal of agent, $S = \{s_1, s_2, \dots, s_n\}$ - set of environment states, $A = \{a_1, a_2, \dots, a_n\}$ - set of action, knowledge base θ and operator $\varphi: G \times \theta \times S \rightarrow A$. We define 2 subsets of agent: subset of inner agents Ag_i for each j grid and subset of external agents Ag_E for supercontroller. In this system represents as

$$S = (\{Ag_i\}_j, \{Ag_E\}) \tag{3}$$

where j - index of grid and $j = 1, \dots, N$ and N - number of grids.

2) Internal agents:

Subset of inner agents: Subset includes

$$Ag_i = (Ag_{aut}, Ag_{st}, Ag_{by}) \tag{4}$$

where Ag_{aut} - autonomic agent, Ag_{st} - local agent seller, Ag_{by} - local agent buyer.

Autonomic Agent: This agent has a goal to keep consumption block working. The local production for local needs is considered in high priority.

Action is to set relay's switch at 1st 'Autonomy' position $A1$ and 2nd position 'buying' $A2$. The environmental subset is $S_{V, CB}$ - voltage in CB, $S_{I, CB}$ - current in CB, $S_{V, PB}$ - voltage in PB and SB, $S_{I, PB}$ - current in PB and SB. It generates actions according to the rules

$$A1: S_{V, CB} * S_{I, CB} < S_{V, PB} * S_{I, PB} \tag{5}$$

$$A1: S_{V, CB} * S_{I, CB} > S_{V, PB} * S_{I, PB} \tag{6}$$

Local Agent Seller: This agent's aim is to sell energy to external net and get maximum profit during set selling period T_s . It has the following environment states: $S_{DM, j}$ - demand of other j grids from $N - 1$ in Wh, S_{PDN} -

set of prices in local net, S_{EC} - set of energy consumption profiles in the past, S_{WC} - set of weather condition in T_s . Action is set of $A_{L, AS}$ at times t , $t = 1 \dots T_s$ with elements $A_{L, AS}(t)$. Each element has one from two

values at current time: $\alpha_3 = \{A3, A1\}$, e.g. switch #3 'Selling' when local grid sells electricity and switch #1 'Autonomy' when local grid does not sell. Operator $\varphi_{LAS}(C_{LAS})$ adjusted based on forecast procedure of local grid's demand during T_s [Kamaev, 2010]. Parameters C_{LAS} are being discovered during optimization procedure. Also Ag_{LAS} provides his action to super-controller agent in advance.

Local Agent Buyer: The aim of agent is buying energy from external net to cover internal grid's demand and with minimum price during set buying period T_B . It has the following environment states: $SS_{SP,j}$ - supply of other j grids from N - 1 in Wh, S_{SP} - set of prices in local net, S_{ec} - set of energy consumption profiles in the past, S_{WC} - set of weather condition in T_b . Information has been transferred into super-controller agents as well.

Action is set of ALAB at times t, $t = 1 \dots T_B$ with elements $A_{LAB}(t)$. Each element has one from two values at current time: $\alpha_3 = \{A3, A1\}$, e.g. switch #4 'Buying' when local grid buys electricity and switch #1 'Autonomy' when local grid does not buy. Operator $\varphi_{LAB}(C_{LAB})$ adjusted based on forecast procedure of local grid's demand during T_s . Parameters CLAB are being discovered during optimization procedure.

3) External agents:

Subset of external agents: External agents compose the subset

$$Ag_E = \langle Ag_{wh}, Ag_{bs}, Ag_{ss} \rangle \quad (7)$$

where Ag_{wh} - agent of weather service, Ag_{bs} agent buying supporter, Ag_{ss} - agent selling supporter.

Agent of Weather Service: The aim for Ag_{wh} , is collecting and providing information about weather condition during forecast horizon period T_f .

Agent Buying Supporter: Agent's aim is collecting and providing information about supply during forecast horizon period T_f .

Agent Selling Supporter: The aim for Ag_{ss} is collecting and providing information about demand in the net during forecast horizon period T_f .

Case studies

A. Case 1

The result for normal work is represented in Fig. 2. The autonomic agent switches relay to mode 2 (buy) in the beginning of simulation (0:00). At time 9:30 it switches to mode 1 (autonomy). At time 19:30 it switches to mode 2 again.

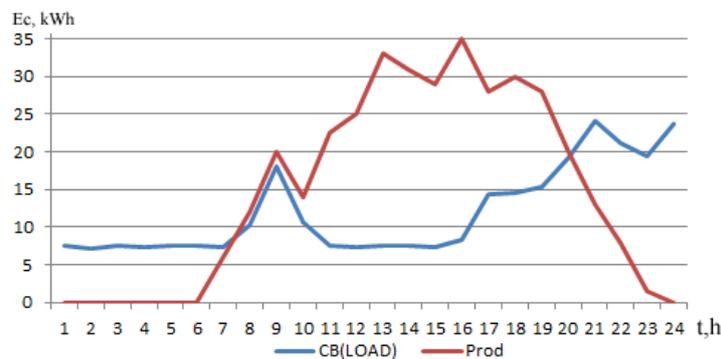


Fig. 2 - Case studies. Case 1

B. Case 2

Another example represented in Fig. 3. At 00:00 autonomic agent switches to mode 1, next at time 11:30 to mode 2, next 18:45 back to mode 1.

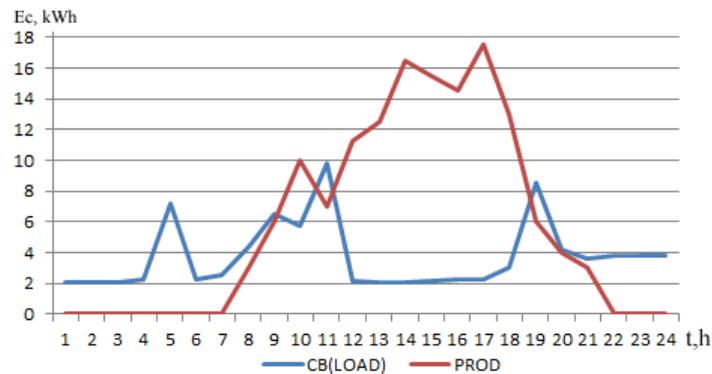


Fig. 3 - Case studies. Case 2

Conclusion

For efficient management of hybrid renewable and classical energy systems the intelligent agent-based (MAS) and embedded solution is presented in this paper. A personal embedded computer as a local controller allows expanding management system to include different devices with a similar interface.

We suggest 2 side architecture with embedded distributed controllers and a super-controller. The software includes multi-agents based on application with 2 types of agents. Internal agents with intelligent algorithms that are deployed at the local embedded device that underline autonomy in decision making process and the cooperation with other grids in the net.

Although we consider the simple grid with consumption, production and storage block in DC mode, this concept could be applied for different HRES.

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IMITATIONAL MODELING OF BEHAVIOR OF LEARNING ECONOMIC AGENTS

Sergey Maruev, Dmitry Stefanovskiy

Abstract: *Agent-oriented models (AOM) are well-known and are widely used in imitational modeling of economic processes. AOM allow researchers to take their multicomponent iterative nature into consideration and to avoid difficulties, which may stem from analytical task setting. The article suggests the use Gilboa-Schmeidler agents, which a) have a limited rationality of decision-making process which accompanies resource exchanges; b) learn, while striking deals aimed at exchange of these resources. This is what makes them different from traditional AOM, where learning and relearning is not taken into account. The peculiar feature of the agent interaction environment is the possibility of redistribution of a part of resources through the taxation of deals. The influence of institutions on deal successfulness is also taken into account. The functioning of the suggested AOM is demonstrated through the use of examples, which admit to simple economic interpretation.*

Keywords: agent oriented model, self-learning agents, partial rationality

ACM Classification Keywords: *I.2.m Miscellaneous*

Introduction

Agent oriented modeling (AOM) of economic processes is applied in cases, when analytic models are extraordinarily complex. In this case agents are attributed the quality of partially intelligent behavior, and the objective of imitational modeling (IM) is to organize their interaction within a framework of a certain program system. AOM procedure is described in literature assuming independence and partial intelligence of agents [Epstein,2005]. Work [Adami,1998] describes models of evolutionary agents, and work [Makarov, 2006] focuses on models based on agents who are similar to each other and are able to communicate with each other. AOM analysis in economic supplements is carried out in [Bakhtizin, 2008].

One characteristic feature of agents, used in economic supplements, is their so called limited rationality. G. Simon was the first scholar to draw attention to the necessity of taking this limited rationality into consideration. Since then a good number of works have focused on decision making by market players. For example, in Nelson-Winter models agents take decisions based on patterns – routines [Nelson, 1982]. At the same time, the authors' objective was not to analyze their origin and development. I. Gilboa and D. Schmeidler have developed the theory of precedent decision-making. According to this theory, the rules of decision-making by agents depend on what decisions have been taken by them in similar situations and what results they have led to [Gilboa, 1995, Gilboa, 1996, Gilboa, 1997]. It is this model that is under discussion in the present article

Model Description

2.1 Agents' Parameters

Within the developed AOM agents aim to satisfy their needs in the volume, determined by the standard consumer basket. According to A. Maslow's idea, each agent satisfied his needs in the following order: physiological needs, security needs, the need to communicate with a resource-producing group, a need for self-development.

Each agent owns one or several resources, competences and business processes. To continue living he needs to use a given number of resources, whose quantity remains the same for all agents. A business process will be performed resulting in the creation of the relevant resource if its owner has accumulated all the needed competences and resources. Agents strike deals exchanging resources, competences and business processes,

aiming to fill their own consumer basket. When doing so they aim to realize excessive resources, their competences and to execute their business processes.

In the initial position for all agents, resources, competences and business processes belonging to them are given. Initial probabilities of deal successfulness for agents are determined. As a rule this figure equals 0.5. Deal successfulness might also be affected by institutions, existing in the modeled artificial society. Institutions may support deals with certain resources or limit them. Due to this, in the initial position deal successfulness probability is determined for each type of resources. Other factors to be determined are tax payment percentage and standard consumer basket.

2.2 Agent Behavior

The following actions are taken at every step of the modeling. Agent consumes the resources at his disposal in the quantity, determined by standard consumer basket. If these resources are not enough for satisfying the first level needs, the agent dies. Business processes consume resources and create new resources owned by the agents. Some resources are consumed by business processes within several steps of modeling in equal shares. Resources left over after consumption and created at this step are brought to the market. Agents look through these resources in order to find resources to fill their own consumer basket and strike deals aimed at exchanging these resources against the ones they have. The communication of agents takes place via common information field as suggested in [Bandini, 2009].

Resource exchange might take place, when an agent finds the first option which he deems suitable. Deal successfulness depends on successfulness probability of a particular agent, deal successfulness probability in this particular society, and support or limitations regarding this type of deals by the institutions of the society. An element of probability is added to this procedure. Agent learning is modeled by the fact that at a certain modeling step the probability of a success of a deal of a certain kind increases, if at the previous step the deal of this kind was a success. If a deal didn't take place, such a probability decreases.

The result of a single step of modeling consists of calculating the given percentage of a tax, which is distributed among agents in equal shares as resources.

Modeling

Using the suggested AOM we have analyzed the dependence of the quantity of collected tax on the volume of the tax rate and on how 'powerful' tax-collecting institution is. Agents pay the tax upon completing every resource exchange deal. The growth in the number of deals leads to the increase in the volume of tax collected. At the same time there is a decrease: a) in the quantity of resources for future deals at the agents' disposal; b) the productivity of agents, who could not collect resources for their business processes. Fig. 1 indicates the change in manufactured product (the upper curve) and tax (the lower curve) depending on the tax rate. Product and tax are measured in hundreds of standard consumer baskets; tax rate is measured in percentage. The dependence between tax revenues and tax rate is shown in Fig. 2 in greater detail. The upper curve represents agent behavior when the probability of payment of taxes is close to 1 – the institution is 'strong'. The lower curve represents the situation when the tax collection is 'weak'. The outlook of the curve remains unchanged. We can see, that increase of the volume of the non-collected tax is directly connected with the growth in the number of deals in AOM. When the number of deals decreases the curve get closer to each other. The results of the modeling are in line with the criticism of the Laffer curve in [Mankiw, 2004].

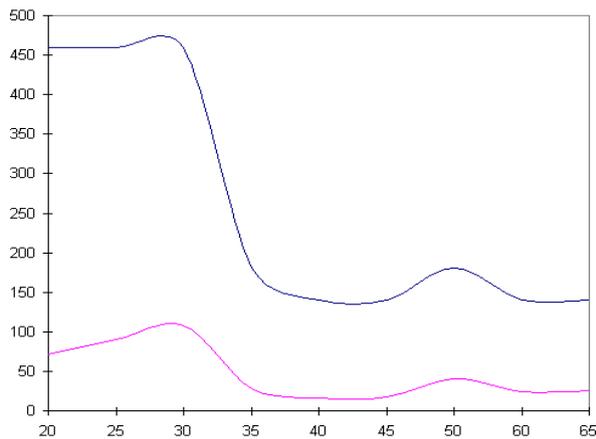


Fig. 1 Dependence of product manufactured and tax collected on the tax rate

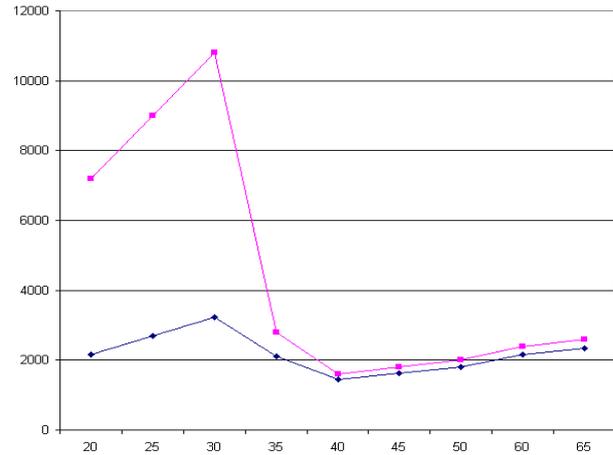


Fig. 2. Dependence of tax collected within systems with strong and weak institutions on tax rate

Upon analyzing the results of the modeling we considered the behaviour of agents when a substituting resource enters the market. The substituting resource has better consumer characteristics than the replaced resource. Its entry was conditioned by unsatisfied demand for the resource required for the completion of the business process. In the initial state agents, who did not purchase the replaced resource had lower productivity. Having purchased a substitute, they increase the productivity of their business processes. Fig. 3 shows the number of successful deals, resulting in the purchase of both resources. Axis X shows the iteration number, whereas axis Y indicates the number of deals. We can see that the substitute is introduced during the 18th stage of the modeling. Within this period agents learned to buy the first resource. That is why the second resource is first purchased by the agents, who could not purchase the first resource. Later they are joint by agents, who at a previous stage had stricken a bad deal regarding the first resource. In a little while the substitute becomes more wanted. The difference in graphs in Fig. 3 is predetermined by the incidental character of the deals' successfulness.

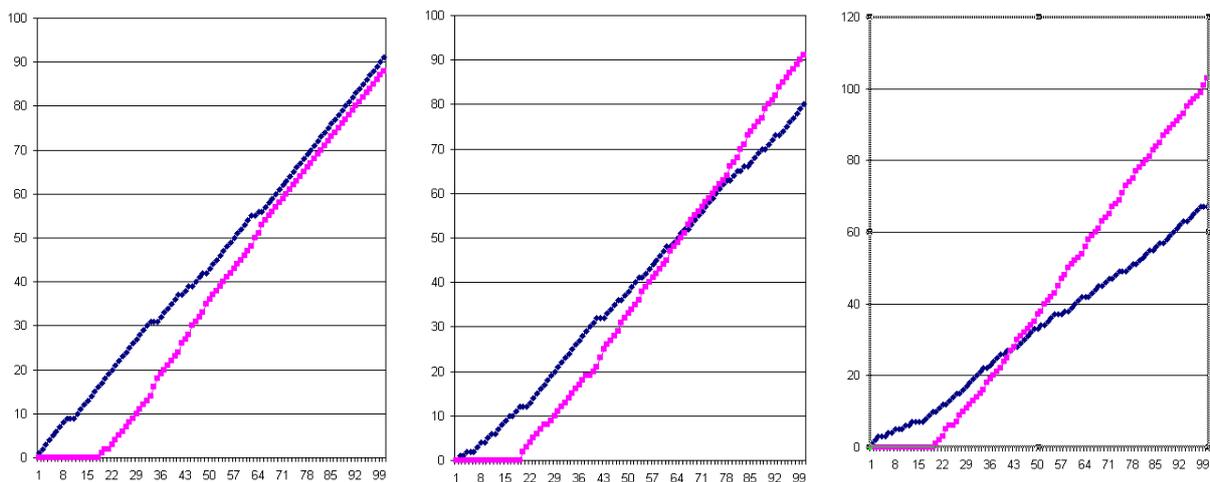


Fig. 3. The number of successful deals with the first resource.

The curves presented here demonstrate the limited rationality of agents' behaviour. Indeed, a rational agent will purchase a better product immediately upon its introduction in the market. But this does not take place, due to the fact that agents make decisions on the basis of what they learn from their previous deals.

Conclusions

The present work suggests usage of Gilboa-Schmeidler agents in multiagent economic systems. A brief description of environmental conditions as well as of rules of behaviour of such agents is also given. We have conducted initial experiments with simple models and they have proven the validity of the undertaken approach.

In the future we are planning to: a) consider more complex models using more complex agent behaviour rules. b) compare the behaviour of AOM with the behaviour of real systems.

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Authors' Information

Image Processing

DEVELOPMENT OF A COMBINED SYSTEM FOR INPUT OF THREE-DIMENSIONAL IMAGES

Alexei Mordvinov

Abstract: *A model of a mobile setup for shape reconstruction is presented. In this technique, the contouring is performed by laser scanning and image processing. The devices of this setup can be moved to examine occluded areas and small details. The algorithm of triangulation method computes the object dimensions from the deformation of a laser line and the camera position. This model improves the performance and the accuracy of the reconstruction system, because all steps of the contouring are performed by computer algorithms. In this manner, the errors of the physical measurements are not passed to the reconstruction system. This procedure represents a contribution to the methods of contouring based on laser scanning. To describe the accuracy, a root mean square of error is calculated with respect to a contact method. This technique has been tested with real objects. Also the new principle of the shaping the structured illumination suitable is considered for realization of pinpoint accuracy of the noncontact optical measuring systems for determination of the profile to surfaces greater object. Proposed method has no an analogue in Russia and overseas.*

Keywords: *three-dimensional model, 3D measurements, scanners, triangulation, phase shift method*

ACM Classification Keywords: *General Terms – Algorithms, Experimentation, Measurement, Theory*

Introduction

There are many different ways to obtain 3D measurements and the many types of scanners that are based on any one single way. Among the huge number of different methods to obtain three-dimensional model of the object can be identified several key: triangulation method, based on determining the time of the signal, the phase shift method. In practice, using the methods of determining the shape and topography of coherence and halftone images.

Three-dimensional contouring is an important research topic in industrial inspection, computer vision, navigation, rapid prototyping, reverse engineering, and object modeling. Nowadays, the contouring is achieved by noncontact systems based on lighting methods [Remondino, 2006]. These kinds of sensors use methods such as fringe projection, line projection, spot projection, time of flight, and interferometry. Many researches have been concentrated on these sensors, and new techniques are still being developed. Today, commercial solutions are available and used by the scientific community. And there is no, unfortunately, a scanning device capable of a three-dimensional model of the object immediately, without providing the necessary conditions, so any such system is narrowly applicable, and perfect. However, these sensors are still very expensive, and a long time is required to obtain the object reconstruction. Also, manual operations are required for the data collection in these

sensors [Lin, 2004]. Therefore, there is a task to develop a new universal system that includes several methods for determining the topography and the construction of three-dimensional model of the object and does not depend on the conditions of scanning and the research is now focused on low cost, good accuracy, and fast processing.

Triangulation method for determining the relief image is key and fundamental method of my master's thesis. In collaboration with the other methods it'll form a combined system of the input three-dimensional images.

Triangulation method and mobile setup for object contouring

In these researches, active triangulation has been used by the lighting methods to perform the contouring via image processing. In active triangulation, the distance between the image sensor and the laser projector provides the depth resolution. But in a static setup, holes in the surface occur due to the limitation of view field of the image sensor and to depth variation. Therefore, occlusions appear, and there are problems in detecting small details. In this case, the object reconstruction is not completed [Zagorchev, 2006].

To overcome these limitations, the object is profiled from different views to obtain the complete object. This is done by using multiple cameras or a mobile setup. Also, fringe projection, line projection, and spot projection have been applied to acquire different views of the object. In fringe projection, the object surface is retrieved by applying a phase detection algorithm. Then, the phase is converted to actual dimensions based on the setup geometry. In line projection and spot projection, the object depth is computed by triangulation using the position of the light pattern and the setup geometry. These kinds of optical sensors have been successfully applied to detect complete objects [Remondino, 2006].

A mobile setup uses a laser range scanner, and the captured object contains holes due to occlusions. In this method, the depth information is retrieved by triangulation, using the position of the laser line and the setup geometry. To fill in the holes, a weighted average is applied based on the surrounding surface data.

A mobile setup avoids occlusions and improves the resolution. However, a new equation must be deduced to compute the object depth in each modification of the geometry. This step includes a new measurement of the modified geometry and the determination of the parameters of the vision system. According to these considerations, modeling of the mobile setup is required to retrieve the object depth automatically at any camera position. Also, modeling of the mobile setup is necessary to improve its performance.

Modeling of a mobile setup is performed to achieve contouring of a complete object. The proposed model provides an equation that computes the object depth at any camera position. The mobile setup is implemented by an electromechanical device, which moves the camera and the object on an axis. To perform the contouring, the object is moved and scanned by a laser line. Based on the deformation of the laser line, the algorithm of triangulation method generates a model to compute the object dimension by means of the camera position. To detect the small details, the setup begins with a long distance between the laser line and the camera. When an occlusion of the laser line appears, the camera is moved toward the laser line to detect the occluded region. This is carried out by an electromechanical device and control software [Song, 2006].

For this mobile setup, the object dimension is proportional to the deformation of the laser line. Also, the deformation depends on the camera position. Thus, the algorithm computes the object dimension by means of the laser line deformation and the camera position. Also, this algorithm provides the intrinsic and extrinsic parameters of the vision system. In this manner, parameters such as the focal length, camera orientation, and distances in the setup geometry are deduced by computer algorithms. Thus, the mobile setup performs the contouring automatically.

In the reconstruction system, the produced information is stored in an array memory to obtain the complete object shape. This computational process improves the performance, the resolution, and the accuracy of the reconstruction system. This procedure represents a new contribution to laser-line projection methods. The experimental results are evaluated based on the root mean square error. The evaluation of these results includes measurement error, resolution, processing time, range of measurement, and limitations of the CCD array. In this evaluation, good repeatability is achieved.

Shape detection by means of multiple views is an important task in optical metrology and computer vision. In the mentioned methods, the vision parameters are computed to achieve the measurement of the object shape. Typically, these parameters are obtained by a procedure external to the reconstruction system. In the proposed mobile setup, the object contouring is performed by an automatic vision system. This means that the extrinsic and intrinsic parameters of the vision system are deduced by computational algorithms.

The mobile setup is shown in Fig. 1. This setup includes an electromechanical device, a CCD camera, a laser line projector, and a computer. In the electromechanical device, the object is moved along the x axis by means of a platform and control software. On the object, a laser line is projected to perform the scanning. In each step of the movement, the CCD camera captures the laser line. The camera is aligned at an angle to the object surface. This camera can be moved, independently of the laser projector, along the x axis. Every laser line is deformed at the image plane according to the object surface. The relationship between the laser line deformation and the object dimension is evaluated. Thus, the contouring of the object shape is performed.

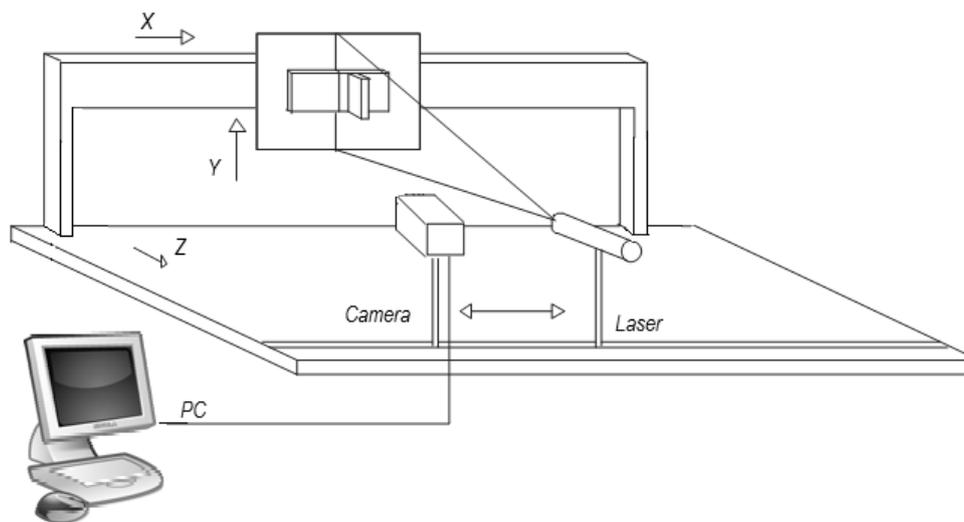


Fig. 1 Experimental mobile setup

The relationship between the position of the laser line and the object depth is described by the geometry shown in Fig. 2. For this geometry, the reference plane is the platform of the electromechanical device. In this reference plane, the three-dimensional Cartesian coordinates are defined. The coordinates (x, y) are on the reference plane, and the coordinate z is perpendicular to the coordinates (x, y) . The plane (x, y) is the reference from which the object depth is measured. The reference $z=0$ is obtained based on the projection of the laser line on reference plane. In this case, the coordinate of the laser line on the x axis is the same as on the y axis. In the geometry of Fig. 2, the x axis and y axis are located on the reference plane, and the object depth is indicated by $h(x, y)$. The points A and B correspond to the projections of the laser line on the reference plane and on the object surface, respectively. The laser line is deformed in the image plane due to the surface variation and the

camera position. Thus, the coordinate of the laser line is changed from x_A to x_B in a step of the scanning. This displacement of the laser line is described by

$$s(x, y) = x_A - x_B \quad (1)$$

The object dimension is proportional to the displacement $s(x, y)$.

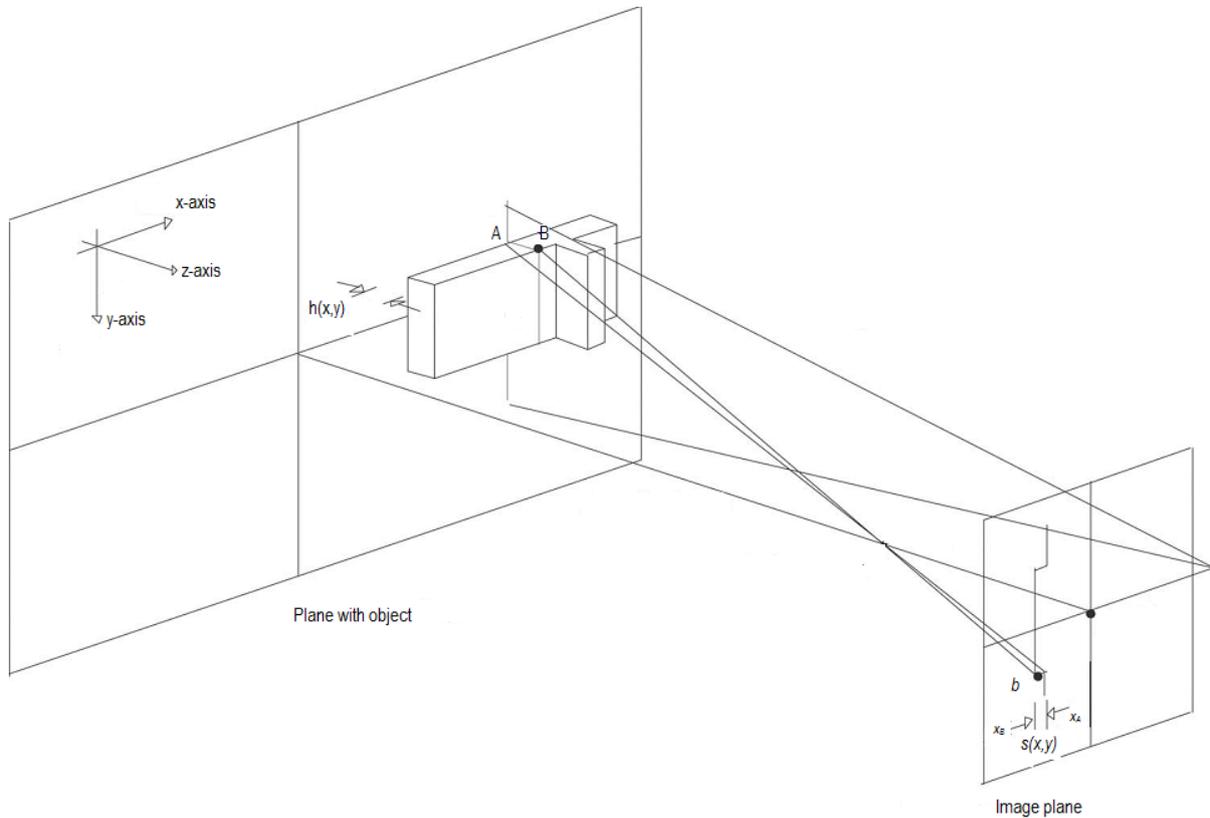


Fig. 2 Geometry of the experimental setup

To detect the displacement, the maximum of the laser line is measured in the image. To do so, the pixels of each row are approximated by a continuous function. The procedure to detect the maximum is applied to all rows of the images Fig. 3(a) to obtain the object contour. Figure 3(a) shows also the laser line. In this image, the position x_B is computed along the y axis. Then, the displacement $s(x, y)$ is computed via Eq. (1) to obtain the contour shown in Fig. 3(b). Typically, occlusions of laser line appear in the initial configuration due to the surface variation. This lack of data is observed in the line occlusion and its broken contour. To avoid this occlusion, the CCD camera is moved toward the laser projector. In this manner, the occlusion is avoided and the object contour is completed. However, the scale factor of these contours is not the same. This is because the contours are computed in different camera positions. In the model of the mobile setup, the scale factor is corrected according to the camera position.

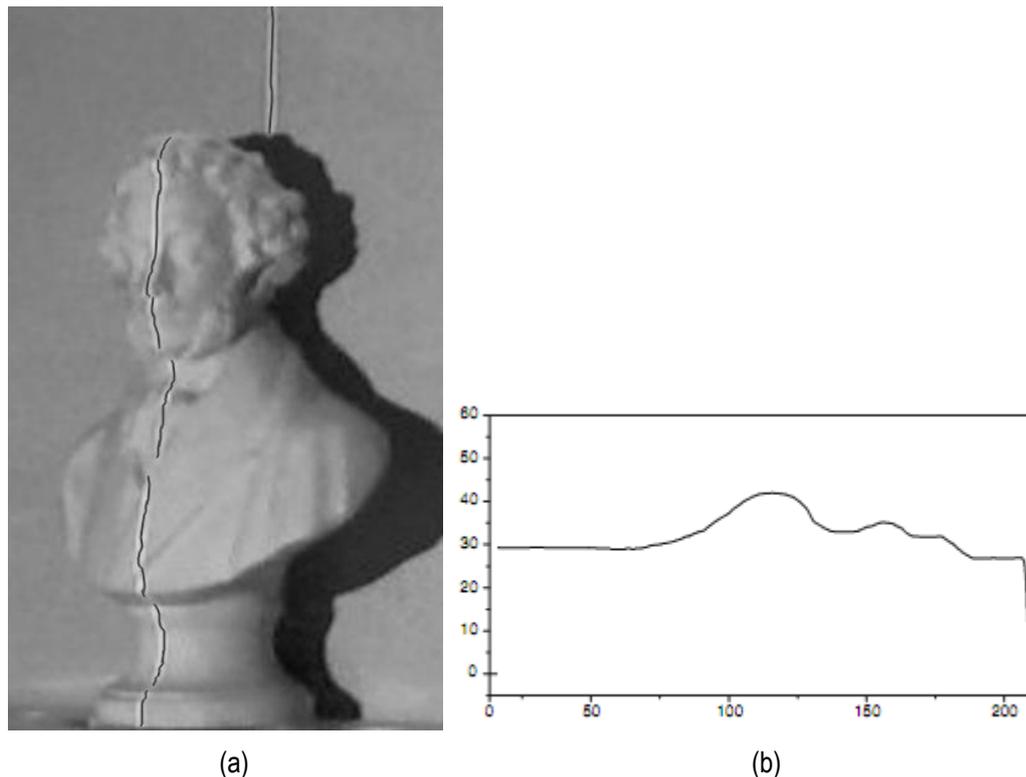


Fig. 3 (a) Laser line projected on the Pushkin's bust. (b) Displacement $s(x,y)$ extracted from a part of the image via Eq. (1).

Experimental Results

The model of the mobile setup is available to perform the contouring from different views of the object. Thus, occlusions are avoided, and small details are detected. Also, the vision parameters are obtained, and physical measurements on the setup are avoided. Thus, the contouring is performed automatically by the model of the mobile setup.

In the arrangement Fig. 1, the object is moved along the x axis in steps of 1.27 mm. This device can be moved 0.0127 mm as a minimum step along the x axis, y axis, and z axis. A laser line is projected on the target by a 15-mW laser diode to perform the scanning. The laser line is captured by a CCD camera and digitized by a frame grabber of 256 gray levels. The displacement of the laser line is computed based on the maximum intensity. The resolution in the x direction is deduced by detecting the laser line in two different positions. To do so, the laser line is moved 127.00 mm away from the initial position by means of the electromechanical device. Then the number of pixels between these two positions is 328.324. Thus, the resolution on the x axis is computed by the relationship $\text{resolution} = (\text{pixel number})/\text{distance}$.

The resolution in the y direction is obtained by detecting the object on the laser line at two different positions on the y axis. To do so, the object is moved 95.00 mm away from the initial position on the y axis. Then the maximum displacement of the laser line is detected in each movement.

The resolution in the z direction is provided by the displacement of the laser line along the x axis. The position of the laser line is measured with a resolution of a fraction of a pixel. Also, the displacement in Eq. (1) is achieved with a resolution of a fraction of a pixel.

The experiment was performed with one object. The object to be profiled was the Pushkin's bust shown in Fig. 3(a). An occlusion appears due to the surface variation. This occlusion was detected and recovered by the mobile setup. Thus, the contouring was performed completely. To do so, data produced was scanned along the x axis in

steps of 1.27 mm. Data produced by the algorithm generate the complete object shape. The results of reconstruction of the Pushkin's bust is shown in Fig. 4.



Fig. 4 Three-dimensional shape of the Pushkin's bust

New way of phase shift method

The technology of projection methods (three-dimensional scanning) with high accuracy and speed shooting information on the object surface (depth), using the principle of structured illumination. All data are obtained by projecting the objects of the scene of the special lattice. Projection of the lattice distortion created by the geometry of objects allow us to calculate the exact position of each of its points in three dimensions. These systems can measure three-dimensional surfaces in video mode. Experience of using projection methods of measurement shows that the major source of measurement error is a distortion of the profile of the structured emission due to nonlinear processes: the illumination of the object (the nonlinearity of the luminance characteristics of the projection equipment), the reflection from the object (the nonlinearity of the reflection coefficient) and photo detection of radiation (non-linearity of the luminance characteristics of the photo - or a camcorder).

In the proposed approach to eliminate the effect of brightness distortion is invited to form a gray scale image as a structured sequence of bits (two gradational) fields. For a practical test of this approach was used projection measurement system consisting of a structured light shaper - a digital projector with a resolution of 800x600 pixels and streak - 8-Bit Web camera with a resolution of 1600x1200 pixels. The size of the projected image was 2x2 meters. Sequence of projected images and recorded eight bit fields of the sinusoidal grating image with 256 gradations of brightness, which are then reflected from an object shaped halftone pattern. Grating are perpendicular to the plane passing through the optical axis of the respective lighting systems and detecting optical system. Optical axis of the recording and lighting systems intersect at one point in the object. Angle between the recording and lighting system is 10°. The distance from the object plane to plane the registrar of 3m. The whole structure is mounted on a movable platform. Figure 5 shown formed a sinusoidal grating and a corresponding set of bit planes.

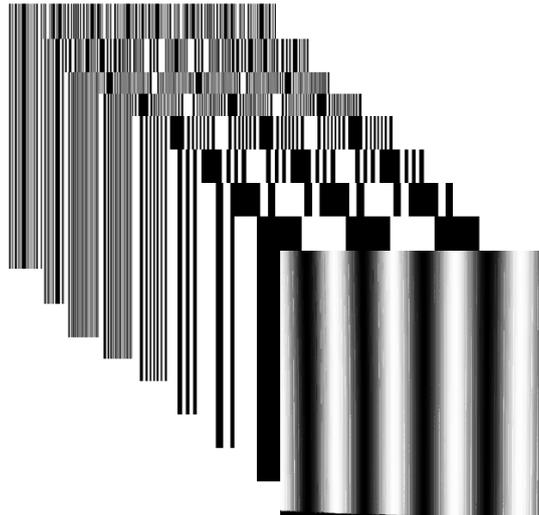


Fig. 5 Method of forming a structured image

In figure 6 shown the reconstructed profile of sinusoidal bands. It should be noted that the profile of the bands do not contain harmonic distortion inherent in projections of "analog" sine wave on the surface of the object.

For bad pixels due to the inaccuracy of the front fixing binary of images and can be eliminated by the introduction of additional redundant coding bit image corresponding to, for example, the code of the Reed-Solomon, Hamming or similar methods of error-correcting coding. Note that the proposed principle of forming a structured light can significantly improve another important characteristic of the projected image, the dynamic range of transmitted intensity levels.

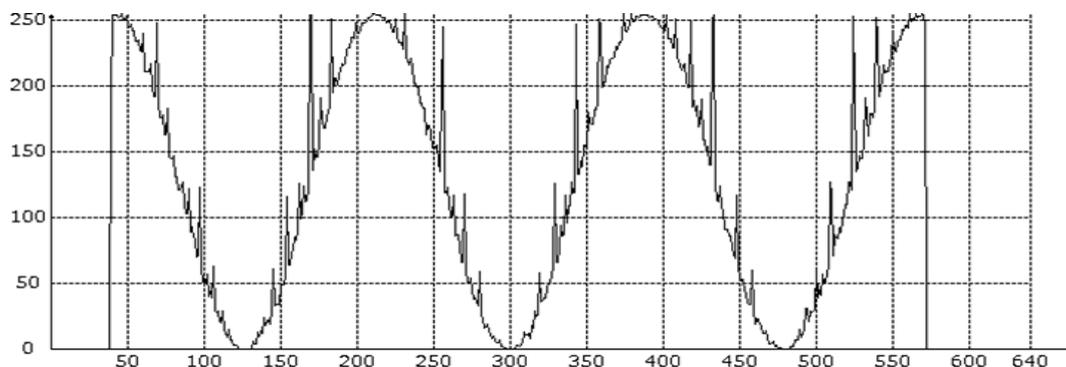


Fig. 6 Reconstructed profile of sinusoidal fringes

In real-world digital systems, this feature is limited to the projector and the digit streak. As a rule, used an 8-bit device coverage and 8-12 bit photo detection device. In our case, using a fairly cheap device, you can create a virtually unlimited dynamic range of brightness variation of structured light.

Conclusion

A technique of contouring performed by a model of a mobile setup has been presented. The technique described here provides a valuable tool for industrial inspection and reverse engineering. The automatic process avoids physical measurements on the setup, which are common in methods of laser line projection. This procedure improves the accuracy of the measurement, because measurement errors are not passed to the contouring system. This step is achieved with few operations. By using this computational-optical setup, good repeatability has been achieved in each experiment. A new principle of formation of structural coverage was developed. This

method is suitable for implementing high-precision non-contact optical measurement systems for determining the surface profile of large objects. High accuracy allows the use of such systems for the analysis of the stress-strain state of objects, as well as the instantaneous three-dimensional model of a large number of objects. At this point, unfortunately, no satisfactory results of our new way of phase shift method, but now implement the software part of the method. In the future we plan to combine the two above-described method of obtaining information about relief to improve the accuracy of scanning up to 10 microns.

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Major Fields of Scientific Research: Computer vision and image processing

METHODS OF IMAGE RECOGNITION AS A TOOL IN ANALYSIS OF INTERNAL COMPOSITES STRUCTURES

Arkadiusz Rzucidło

Abstract: *The theme of the article is to discuss the suitability of image recognition software to study the structure of composites. These materials are already used for many years as an alternative to many higher-priced used in the aerospace industry and beyond. Research of composite structures are conducted on a regular basis. Application of pattern recognition methods can give a new perspective on analysis and measurements in the features of the composites.*

Keywords: *foam composites, image recognition*

ACM Classification Keywords: *I.3.3 Picture/Image Generation*

Introduction

Composite materials are used in the aviation industry for many years. Due to their properties, their characteristics are desirable in constructions, which through the use of composites are gaining, in many respects. By modifying the properties of materials we usually get increased hardness, stiffness, resistance to wear caused by friction, etc. By using such a solution we can lower the cost of manufacturing of machine parts made of composite material compared to more difficult to process parts from solid material - usually an expensive metal for airborne applications such as aluminum, magnesium, titanium. The participation of composite materials in constructions (specifically aircraft) reduces their weight, very often without losing the strength parameters. Due to such low weight we can gain on decreasing such parameters as: aircraft fuel consumption which is very important in matters such as savings and environmental protection. For example, about 25% by weight of the Airbus A-380 are the composite elements. With the aircraft weight of approx. 240 tons it gives a reduction of about 15 tons of "overweight." As you can see it is quite a significant saving, the more that it translates to the real possibility of taking an additional 150 passengers, or similar load eg. increase the amount of fuel the aircraft in order to obtain greater range. The Airbus A-380 uses a high quality carbon composites especially in: inner wing, pressure chamber, vertical and horizontal stabilizer with the rudder of direction and altitude as well as engine nacelles and other components of wings and body [Netcomposites, 2011].

Although composite materials are undoubtedly the future, also in their case the strength parameter has its limits. Excellent characteristics of composites lose their strengths at the time of the damage which is the reason for the continuous search for new solutions in this class of materials and methods of their testing. In the case of composite materials very important issue are non-destructive testing methods, which enable us to examine the internal structure of parts or samples. They are particularly useful during the test phase, which allow for a specific product to be used. Implementation of appropriate tests is the more important due to the fact that in the composite aircraft constructions there is much lower range of tolerance for , safety factors [Belzowski, 2005]. Another important group of tests in the research phase are destruction tests, which allow examination of the structure resulting in the production process in terms of both structural correctness - consistent with requirements. Traditional methods of testing in the diagnosis of composites are: X-ray methods and, ultrasound. They allow insight into the structure without destroying the composite. Analysis of data collected during the research takes different forms depending on what form the results of the method offers. One of the characters is a graphic visualization of the test structure, which is subject to further digital analysis. In the following, special attention will be directed to the usefulness of studies using image analysis for diagnosis of composites.

Composites

The Composite is a material that is composed of at least two components (phases), each with different physical-chemical properties and characteristics of such component bear hallmarks of synergy. In other words, the characteristics of the composite are better or at least different to other components used. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites are used because overall properties of the composites are superior to those of the individual components. For example: polymer/ceramic composites have a greater modulus than the polymer component, but aren't as brittle as ceramics. In the general division of materials, composites can be divided into: laminates, sandwich structures with cellular filler (honeycomb structure), or hybrid structures [Mackiewicz 2005].

The basic structure can be presented as matrix system and placed in it second component with much better mechanical properties (Figure 1).

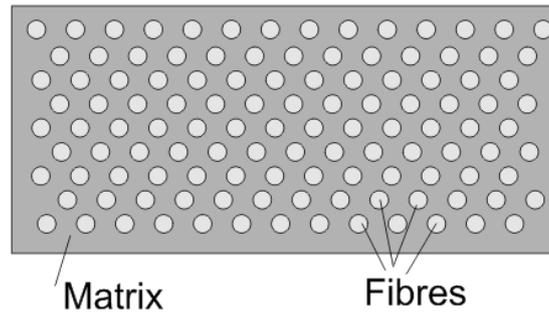


Fig .1. Example of composite structure

Matrix holds together the reinforcement, provides sufficient compressive strength, moves of external stresses to the reinforcement, stops growth of cracks and gives the products the desired shape. Wrap is usually a polymer, metal, alloy or ceramics.

Reinforcement's task is strengthening the material and improve its mechanical properties. Its arrangement (design) may take various forms, from structural (fixed direction of reinforcement) to completely random (eg. molecular), which is shaped by processes occurring during the formation of the composite.

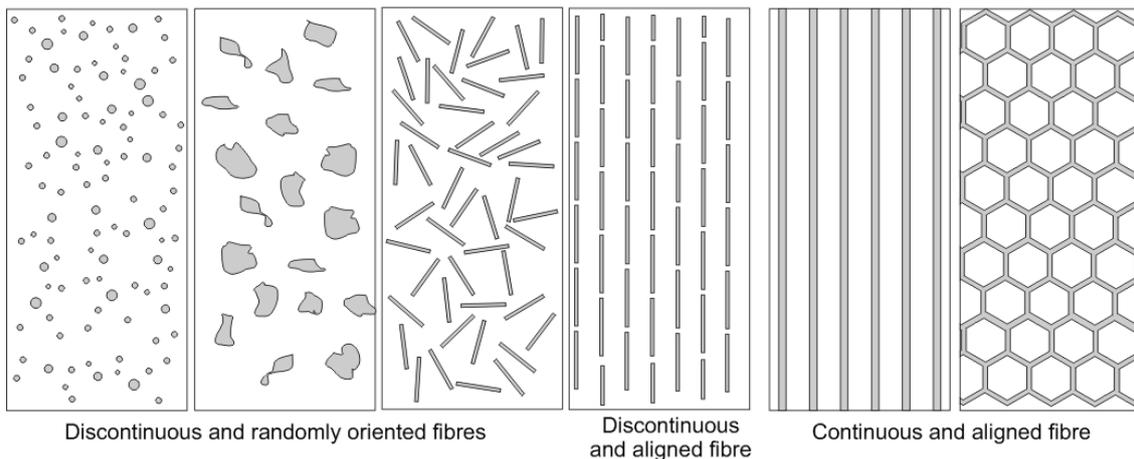


Fig.2. Fibre orientation

Analysis of composites of regular structure, where shape and arrangement of reinforcement and the wrap is easy to predict seems to be relatively simple. Selection of the spatial parameters of sample, which will be a representative miniature of the material should not be difficult and usually depends on the size of materials (and their location) used in composite. The issue of size is usually associated with shape and volume of the reinforcement, while location (arrangement) is characterized by parameters such as resolution, accumulation, or orientation (Figure 3).

Slice (sample) of material for analysis must contain specific ingredients in quantities that are "stored" in its construction. Selection of sample size of composites with irregular structure needs different approach. Examples of such materials are, powder or foam composites. Their construction is random, despite the possibility of influencing the shape and size of the matrix or reinforcement. Selection of sample size to study the structure properties in this case is more difficult. Distribution of powder or foam is random, hence the "cutted" section of structure may contain too much of one phase in relation to total volume of material. Looking at volume, the whole product can be constructed correctly, but localized and selected sample can be built incorrectly.

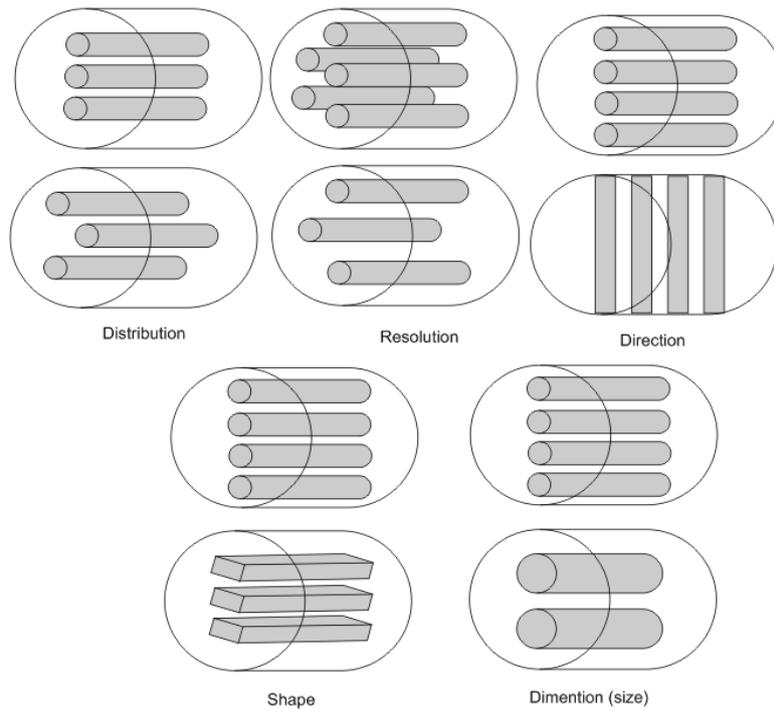


Fig.3. Fibre parameters

Too small sample with large concentration of excess phase will definitely affect the measurement of tested parameters badly and distorts the results (fig. 4a). At the same time oversized sample may not cover important details. Due to that fact size of characteristic elements in the composite will be insufficient to make the test. The measurement will be inaccurate.

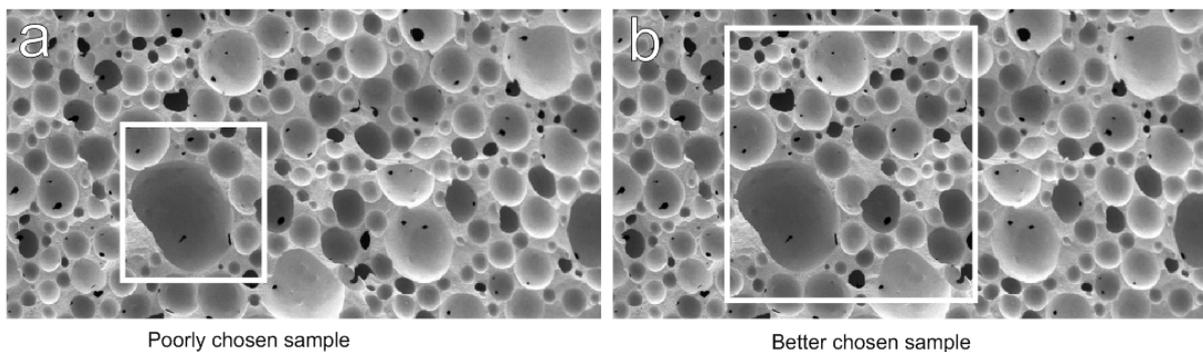


Fig. 4. Determination of sample filed [Potoczek, 2010].

The structures of materials such as foam based composites are materials with random structure. In the literature they are classified as C4-type structure (called co-continuous ceramic composite) [Potoczek 2010]. They are usually two phase polymer-metal form. Polymer foam produced by foaming the polymer, infiltrates itself with metal to form three-dimensional composite. Structure of such material depends on the instantaneous system of air bubbles, which modify the gelling element, thus creating space to fill with metal. Technology is developing very fast and now there are known techniques that allow to control with some probability, both qualitative and quantitative arrangement of foam in composed material. It is possible to control size of the bubbles, their number and most importantly the space, which is very important in infiltration process. It is represented by “windows” between the bubbles that are in contact with each other. Infiltration parameter control allows to quantify the composite-metal structure. It prevents the formation of closed vesicles. Such closed vesicles are the weakest

point for whole designed element by lowering its mechanical properties. Control of created composite is therefore absolutely necessary. It is also recommended to run test with non-destructing method. Good results can be achieved with tomography samples test. It allows for precise digital projection of the tested structure. Such model is subject of visual inspection, verification and measurements control. In this matter, method with good results is image recognition technique.

For testing foam composites choosing the right size of test sample is one of the most important parameters affecting further results of image recondition analysis. Analyzed foam have different sizes of air bubbles, therefore area for testing should contain structure of a similar sized air bubbles, both the largest possible acceptable size and also the smallest structure of similar size. Both in first and the second case, sample sizes may differ from each other and will be subject to the findings. There is also different case of foam composites where structure is irregular and sizes of air bubbles is heterogeneous. In this case, analysis of a sample size will be the most important. Another important parameter is the method of recording digital image data acquired for research, which will determine accuracy of details of projected sample. The goal of the research is to determine the best and acceptable parameter of image resolution and the number of bits that describe various points of the image.

Image recognition software in study the structure of foam composites

The image recognition techniques can be divided into three stages: image acquisition, its pre-processing or in other words filtration and the analysis of optimized digital data. The first two stages are independent of issues in which they need to be applied. They cover all activities well-known and developed in the form of filters or macrocommands for graphic programs of image processing or classification. In this matter, actions on the examined issues will be limited to trials of composition of appropriate techniques to obtain the image with specified object of study. The key goal of the research will be defining methodology of image recondition through selection of techniques contained in the programs for images analyze or developing a new method that is appropriate in the research topic.

In addition to determining mentioned parameters of the sample, not directly related to the same method of analysis it will be important to establish parameters for initial preparation of data processing of acquired images. Such processing is aimed at the best possible preparation and separation of phases of the composite for testing. Limiting of the spread of proposed values for each settings will allow for accurate identification and proper selection of filter and further exact analysis of the sample.

Foam composites usually consist of two phases one of which is gelatinized non-metallic part and a second metal infiltrated into the foam. Due to such an arrangement, initial processing of samples for image analysis will consist mainly of binarization, which will determine the contrast range of both materials in the composite. The main issue will be setting proper, characteristic limit which will give the most effective image for the analysis of digital data.

Data prepared for analysis must be processed with a use of suitable software base. Current programs for analyze are very powerful. The scope of their applicability makes this kind of software very popular and commonly used for digital data laboratory testing. Therefore quite large group of useful applications can be found on the market.

After comparison of popular graphics software for digital data analyze there are two positions worth to be mentioned which seem to be proper for analysis of the structure of foam composites. They are: Aphelion Amerinex Applied Imaging Inc.. [MediaCyb, 2011], and Image Pro Plus by Media Cybernetics, Inc. [Amerinex, 2011].

Suggestions of using these programs are not random. These are applications that are doing well both in two-dimensional images environment as well as can ease research in three-dimensional environments. Such flexibility

is desirable due to the subject of research, and plans that involve measurements of three-dimensional spaces. Both programs have similar functionality, that was checked for several samples. They contain similar tools needed in images preparation and tools for measurement and analysis of data obtained during testing. Also automatic statistics tools are very useful due to possibility of a quick way to give the analytical results. These tools have the additional advantage which is the graphical interface for visualizing data in both digital and graphical character. The programs also have ability to create macrocommands that can accelerate the entire research process.

The techniques for the study of images of foamed composites

The basic test for foamed composites are quantitative tests. In case of two-dimensional samples contained in the classical images, process of research is identification of phases in the sample and counting percentage share in flat image of the sample. Tests can be performed only on the previously prepared (cut) cross-sections of the sample, which are photographed using scanning electron microscopy (SEM images) (fig. 5)

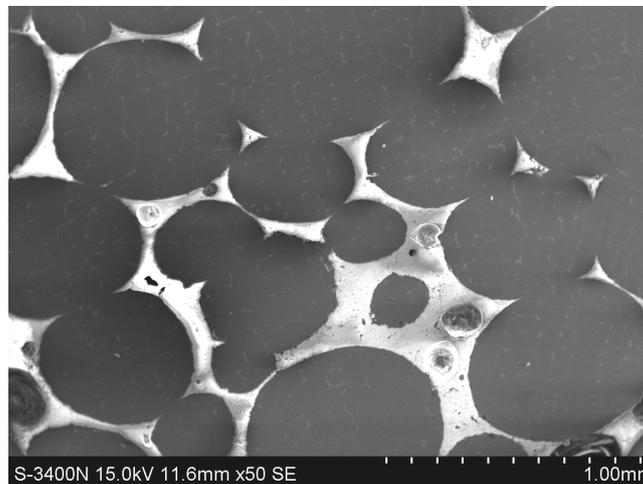


Fig 5. SEM image of Polished section of AlCu5/Al₂O₃ composite obtained by pressure infiltration [Potoczek 2010]

Testing of two-dimensional samples can be extended by identification of an area which has not been infiltrated with metal. Closed Al foam cells create a notch, which badly affects the strength of the composite. It is therefore undesirable phase.

Studies on 2D images are also measurements of infiltration surface. This is the area of windows caused by contact of air bubbles in the foam. This is a very important parameter for this type of composites. However, this measurement made on two-dimensional images is not accurate and is rather an intermediate data to determine distribution of the windows in the whole sample. This way of determination of the surface infiltration will require analyzing large numbers of images.

In addition to tests run on classical two dimensional images, it is planned to make a much more sophisticated analysis. This will be the study of spatial structures. Using classic images, one can identify what you see in the picture of the sample and not in the whole sample as a three-dimensional object (fig. 6). By analyzing a block a lot more can be said about the composite structure and parameters of interest such as infiltration areas or undesirable closed spaces with bubbles of foam. With such an analysis chemical components forming such a matrix can be precisely selected. It also allows for better choice of parameters of filling the foam with metallic phase.

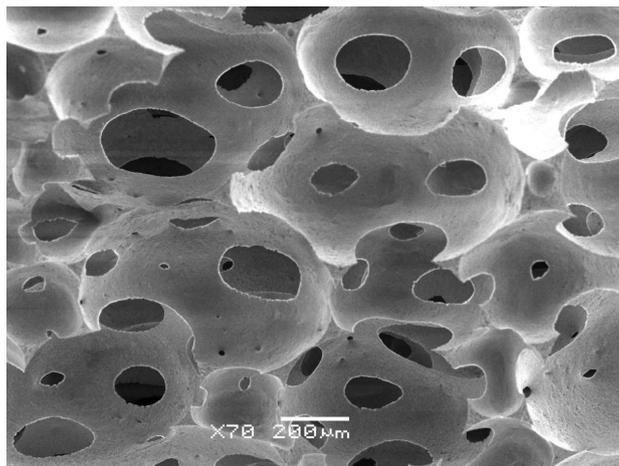


Fig. 6. SEM image of porous ceramics obtained by the gelcasting of foams method [Potoczek 2010].

Both presented here image analysis software allow to create three-dimensional structures of obtained two-dimensional images. In case of this issue the levels that make up the 3D image will be created based on materials obtained from computer tomography of tested samples technique.

The design of foam samples reminds densely packed spheres, which overlap each other in places forming infiltration surface (Fig. 6). By combining successive cross-sections and creating the a three-dimensional image, one can make visual inspection and measurements of samples in any plane.

Both studies of two and three dimensional images allow to characterize technology of manufacturing and testing of foam composites in a slightly different approach as it was before.

Conclusion

Conducted research in the field of image recognition software, and methods contained in them confirms the possibility of analysis and measurements of interesting parameters of foam composites samples. Initial benchmarks have shown that both of these programs are good tools for analyze of phenomenon of composite infiltration and characteristic features of the foam. A choice of software is not determined by its functionality because in this respect because both programs are equivalent. Decisive factor will be the criterion of cost, which indicates so far for choosing the Aphelion software.

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Business Applications

CLUSTERING IN THE SPACE OF INDEPENDENT COMPONENTS AS A TOOL FOR REVEALING CONTAGION EFFECT ON FINANCE MARKETS

Konstantin Dylko, Mikhail Alexandrov

Abstract: *This paper introduces a new method for analyzing time-series of stock market indexes (Dow Jones, NASDAQ etc) in order to reveal the quantitative level of their interference. In literature, the interference between stock indexes is usually called 'contagion'. Strictly, contagion – is transmission of shocks from one region to another. In order to prevent destructive effects of crisis it's very important for the government to predict them. The proposed method consists of two steps: transformation of time series to the space of independent components and clustering in this space using the principle of stability. The contents of clusters just define companies, countries, and regions related by the effect of contagion. To complete the mentioned steps we use: the lcaLab tool from MatLab package to construct independent components, MajorClust method and DEM index for clustering and testing its quality. MajorClust and DEM were developed in Benno Stein research group. The results of experiments showed the essential advantage of the proposed method over the traditional approach based on formal relations in correlation matrix. Notably, we marked out the groups of market indexes, which were most likely connected via 'contagion'. Such a conclusion was made using external data like geographical position, level of country development, macroeconomic rates, etc.*

Keywords: *independent component analysis, clustering with MajorClust, contagion effect, financial market*

ACM Classification Keywords: *I.2M Miscellaneous*

Introduction

There are many different types of crisis in economy. For example: currency, bank, stock, world crisis and etc. Asian crisis in 1997, crisis in Latin America, Great Depression and, finally, recent world crisis has shown their destructive power [Sakho, 2006; Yeyati, 2008]. Some indicators of financial crisis were created. One of them is effect of contagion. There is no strictly accepted definition of contagion in literature. There are many definitions of this effect, but all of them connect this phenomenon with transmission of shocks between the markets [Allen, 2000; Bradley, 2004; Bradley, 2005; Francel, 1998; Kodres, 2002, Serva, 2006]. Let's give a definition of contagion on which we will base our work.

Effect of contagion – is phenomenon of transmission of shock or crisis which had begun in one country to another country or region. One also says that effect of contagion occurs when there is a strong bound between the markets in shock periods of time.

The contagion is relatively new topic, although many working papers have been issued. Kodres and Pritsker in their paper [Kodres, 2002] determined and analyzed main channels for contagion. Their paper gives a good understanding of issue of contagion. Siu-Ming Cha and Lai-Wan Chan in their work [Siu-Ming Cha, 2000]

introduced mathematical methods in factor model analysis in finance and gave number results. The period of high correlation was called shock period [Loretan, 2002]. Bradley and Taqqu, in their papers [Bradley, 2004; Bradley, 2005], proposed another method for contagion definition based on local correlation. The main idea was that markets are more bounded in crisis period than usually.

But, this entire works don't take into account the structure of financial data. It mean that, for example, stock market index could be explain using complex factor model in which only few of factors are responsible for the contagion effect.

In this paper we propose methodology, which takes into account the structure of data. This methodology consists of two steps:

- 1) Transformation of stock market time-series in the space of independent components. This step gives us a possibility to find factors responsible for the contagion effect and to erase noise. The problem is to define optimal number of components. We give more detailed view on this problem in section 2.
- 2) Cluster analysis with automatic define of number of clusters in the space of independent components. This allows to avoid the distortion of results, as influence of external factors is decreased significantly. The main problem here is to find the optimal number of clusters as this number is sensitive to the links matrix. We give more detailed view on this problem in section 3.

To show the advantage of methodology proposed, we make experiments with grouping of indexes in two cases: with transformation and without transformation. The results of experiments are shown in section 4. In section 5 we give conclusions.

Independent component analysis

2.1 Procedure description

There is an example in the book [Hyvarinen, 2001] , which explains ICA method. Imagine that you are in a room where three people are speaking simultaneously. You have three microphones, which you hold in different locations. The microphones give you three recorded time signals, which we could denote by $x_1(t), x_2(t), x_3(t)$. Each of this recorded signals emitted by the two speakers, which we denote by $s_1(t), s_2(t), s_3(t)$.

$$x_1(t) = a_{11}s_1(t) + a_{12}s_2(t) + a_{13}s_3(t)$$

$$x_2(t) = a_{21}s_1(t) + a_{22}s_2(t) + a_{23}s_3(t)$$

$$x_3(t) = a_{31}s_1(t) + a_{32}s_2(t) + a_{33}s_3(t)$$

Or we could also write it as matrices: $X=AS$."

The task is to find S using only X. It means that using ICA method we find how to S depends on X.

We make some suggestions in ICA. First of all let $s_1(t), s_2(t), s_3(t)$ be independent. It means that $s_i(t)$ has no information about $s_j(t)$, while $i \neq j$. Secondly, we assume that $s_1(t), s_2(t), s_3(t)$ have a distribution different from normal.

Here first suggestion allows to build algorithm with isolated account of components $s_i(t)$, and the second one allows to filter white noise.

The algorithm is based on the central limit theorem, which denotes that with certain conditions sum of independetly distributed random quantities is seeking normal distribution as we increase number of summands.

So we seek combination that makes distribution of independent variables as much as possible unlike to normal distribution

We use algorithm called JADE. It consists of two steps:

- Decorrelation. We diagonalize correlation matrix.
- Turn. We find such a turn matrix that outgoing components are as much as possible independent.

This method allows finding hidden structure of stock returns.

2.2 Preprocessing

Usually, time-series is non-stationary. In this case ICA method works incorrectly. We take first differences of time-series to avoid non-stationarity.

Also we make such procedures as:

Norming time-series on the interval $[-1;1]$ on the basis of its standard deviation

Centring on the basis of its mathematical expectation.

Back et al in their work [Back, 1997] used this preprocessing and procedure JADE to analyze data from Tokyo stock exchange. Independent components were divided on two categories: higher than threshold and lower. First category is responsible for the significant changes in economy which take place not often. And the second category is responsible for the noise. This method gives a fresh look on the understanding of structure of stock returns.

Clustering

3.1 MajorClust description

For a moment, there are dozens of methods and their modifications in cluster analysis, which can satisfy practically all necessities of users. The most popular ones are K-means, oriented on the structures of spherical form, and Nearest Neighbor (NN), oriented on the extended structures of chain form [Hartigan, 1975]. In our work, we use the MajorClust method, developed by Stein et al. [Stein, 1999], which has the following advantages over the mentioned two:

- MajorClust distributes objects to clusters in such a way that the similarity of an object to the assigned cluster exceeds its similarity to any other cluster. This natural criterion provides the grouping of objects, which better corresponds to the users' intuitive representation. Neither K-means nor NN methods possess such optimization property: they do not evaluate the similarity between clusters.
- MajorClust determines the number of clusters automatically and in all cases tends to reduce this number. K-means requires the number of cluster to be given, and NN does not determine this number at all: cutting of the dendrite is performed by the user.

MajorClust has been successfully used with various data sets and demonstrated very good results especially in Text Processing [Stein, 2003a; Alexandrov, 2005]. The main disadvantage of MajorClust is its runtime. However, in case of sparse matrix of relations this disadvantage is not essential. In our problem, we are faced just with this case because of weak similarity between the majority of objects. These weak connections are eliminated that leads to the mentioned matrix.

3.2 Cluster validity

For testing cluster validity we use so-called DEM, density expected measure, which reflects the contrast of object distribution in the space object parameters. This index was firstly introduced in [Stein, 2003b]. It is easy calculated by the formula

$$\lambda = \sum (n_i / n) (w_i / n^p), \quad n^p = w$$

where: n_i and n are the number of objects in i -th cluster and total number of objects, w_i and w are sum of closeness in i -th cluster and totally in matrix of closeness. Higher values of λ mean better clustering. Stein *et al.* showed that DEM correlates well with expert opinion [Stein, 2003b]. Thus DEM can be an indicator of quality.

The main criterion for choosing the best number of clusters is the criterion of stability. The procedure consists in the following: 1) one eliminates weak links in the matrix of closeness on a low level, 2) clustering and calculation of DEM 3) these steps are repeated on higher level of closeness

Naturally, the higher level of threshold the more number of clusters we have. The sharp change of this number is a point of stopping.

Experiments

4.1 Source data and tools

In experiment we analyzed 13 stock indexes from different countries for the period of 2005-2010 year. We were expecting to find effect of contagion between USA indexes and EU indexes. Other indexes could be marginals.

We made preprocessing for all data.

In the first experiment we used independent components as it was described in chapter 2.1. Constructing of independent components was made with the help of ICALAB software, which is a part of well-known package MatLab [www.bsp.brain.riken.jp]. In the second experiment transformation into the space of independent component wasn't produced. Clusterisation with MajorClust and calculation of DEM were made on the basis of library procedures of cluster analysis, made in Autonomus University of Barcelona on C++.

4.2 Experiment without independent components

In the first experiment we made clusterization of initial data correlation matrix after preprocessing but without ICA implementation. In the Table 1 one can see the results. The data in columns represents number of cluster relative to the index in the row. Therefore, we have here the following 7 clusters on the best threshold, which is equal 0.4:

(RTS) , (CAC, FTCE) , (AMEX, DAX, DOW, NASDAC, S&P), (FTSE Bursa), (Heng), (IPC), (NIKKEI)

Table 1. Results of clustering (experiment without independent components)

	Threshold	0,3	0,35	0,4
	Number of clusters	4	4	7
	DEM	1,27	1,25	1,49
Indexes of financial markets		No. of cluster	No. of cluster	No. of cluster
RTS		1	1	1
AMEX HONG KONG		2	2	2
CAC		2	2	3
DAX		2	2	2
DOW Jones Industrial		2	2	2
FTSE Bursa Malaysia		2	2	4

FTSE		2	2	3
Heng seng index		2	2	5
IPC (MMX)		3	3	6
NASDAQ		2	2	2
NIKKEI		4	4	7
S&P 500 INDEX RTH		2	2	2
STI		2	2	4

4.3 Experiment with independent components

In the second experiment we made the same thing but using ICA method. We have Found the correlation matrix for the data after cleaning with ICA from the noise. The results are represented in the Table 2.

The data in columns represents number of cluster relative to the index in the row. Therefore, we have here the following 6 clusters on the best threshold, which is equal 0.4:

(RTS) , (CAC, DAX, FTSE, STI), (AMEX, FTSE Bursa), (Heng, IPC), (NASDAQ, S&P), (NIKKEI)

Table 2. Results of clustering (experiment with independent components)

	Threshold	0,3	0,35	0,4
	Number of clusters	3	4	6
	DEM	1,15	1,36	1,45
Indexes of financial markets		No. of cluster	No. of cluster	No. of cluster
RTS		1	1	1
AMEX HONG KONG		2	3	3
CAC		2	2	2
DAX		2	2	2
DOW Jones Industrial		3	3	5
FTSE Bursa Malaysia		3	2	3
FTSE		2	2	2
Heng seng index		2	4	4
IPC (MMX)		2	4	4
NASDAQ		3	3	5
NIKKEI		2	2	6
S&P 500 INDEX RTH		3	3	5
STI		2	2	2

As we can see the results of this table are much better then the previous. There are clear clusters of USA indexes and EU indexes. Other indexes are marginal. It means that our methodology give better results than usual methodology whose results are reflected in the Table 1.

Conclusions

Results of research:

- We have proposed a new method for constructing of indicator of effect of contagion. This indicator is a modified coefficient of correlation. We remove noise from the time-series using ICA method which hides effect of contagion.
- We have proposed methodology of selection of groups of indexes interconnected with effect of contagion. This methodology consists of joint implementation of clustering method MajorClust and criterion of stability of grouping DEM. MajorClust allows automatic chose of number of clusters. DEM allows to define transition point to sherp desc of number of clusters while cutting of weak bounds between indexes.
- We have made experiment with 13 stock market indexes on the period from 2005 to 2010 year. The 13 indexes included Russian stock index RTS.
- Experiments show that proposed methodology gives better results than traditional indexes. Clustering of indexes shows expected groups (USA, EU, others). The attempt to find groups of indexes using usual correlation matrix didn't give the expected results.

Implementation of obtained results:

- Proposed indicator could be used to predict and prevent crises, while government anti-crisis measures
- Investors can also use this methodology to diversify their portfolios.

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Major Fields of Scientific Research: data mining, text mining, mathematical modeling

BPMN AND BPR: A NEW SHAPE OF BUSINESS PROCESSES

Łukasz Paśko

Abstract: *The aim of this paper is to perform the main part of the restructuring processes with Business Process Reengineering (BPR) methodology. The first step was to choose the processes for analysis. Two business processes, which occur in most of the manufacturing companies, have been selected. Afterwards, current state of these processes was examined. The conclusions were used to propose own changes in accordance with assumptions of the BPR. This was possible through modelling and simulation of selected processes with iGrafx modeling software.*

Keywords: *Business Process Reengineering, modelling and simulation processes*

Introduction

Importance of changes in organizations has been growing steadily for many years. Moreover, meaning of the word 'change' is still evolving. At the beginning of its history, it was associated with increase of productiveness. Currently, changes are introduced in order to improve the identification, comprehension and fulfilment of customers' needs [Hammer M., 1999]. The implementation of the new ideas should not be done in chaotic manner. This assumption is provided by the concept 'restructuring'. It gives conceptual model, which allows for arrangement of the restructuring process [Durlík I., 2002], [Durlík I., 1998]. The model is especially important when the changes have a deep character and they cause modification of companies' mission or strategic objectives. The changes have to be adapted to current, dynamic environment [Hatch M.J., 2002]. It is possible, in particular, when companies carry out the reorganization with the use of Business Process Reengineering (BPR). According to the name, we cannot talk about a radical restructuring without focusing on the business processes [Hammer M., 1999], [Manganelli R.L., Klein M.M., 1998].

The aim of this paper was to perform the main part of the restructuring process by using BPR methodology. The first step was to choose the processes for analysis. Two business processes, which occur in most manufacturing companies, were selected. Afterwards, current state of these processes was examined. The conclusions were used to propose own changes with accordance to assumptions of the processes reengineering. This was possible through modelling and simulation selected processes with iGrafx software.

Methodology and tool

Literature [Durlík I., 2002], [Durlík I., 1998], [Sapieżska Z., 1997] distinguishes two approaches of the restructuring: traditional and radical. Traditional approach based on more than a century of experience. Determinants of this type of restructuring were technical and economic. They were created based on scientific achievements of authors of the scientific management, such as: F.W. Taylor, K. Adamiecki, H. Ford. These criteria assume exploit materials, energy, productive area and machines, as great as possible. It is done by overall burden of production employees. The assumption connected with this kind of restructuring allowed for gradual development (at most 10% per year). It required rebuilding organization's structure and improving management. It was related with computerization and automation. However, improvement concerned the 'old' processes. These processes were not adjusted for computerization, because they were designed according to traditional way of information processing. The high investments on hardware and software caused that it was not

cost-effective. Thus, improvement can be achieved through traditional restructuring, but effects are often insufficient.

Radical approach is used to gain appropriate level of effectiveness. In this case, range of changes is wider. They include modification of many areas of company's activity. The basis is an examination and a fulfilling of customers' needs. Taking into account the employees, more important is creation and introducing a new way of thinking of each organization's member, than just participation in trainings and courses. The meaning of their work evolves from realizing tasks to achieving strategic objectives. Radical restructuring is, first of all, a thorough redesign of processes, which give a value for external and internal customers.

The radical restructuring is closely related with BPR concept. This methodology allows to achieving a several times higher results compared with the traditional approach. It is the modern approach to technical and economic restructuring of companies and institutions. Literature treats BPR as a radical rebuilding of processes from scratch which provides significant improve. Moreover, it is fundamental change of the thinking of all employees [Hammer M., 1999].

The term, which occurs the most frequently in this paper, is a "business process". According to literature it is orderly set of tasks that require one or more factors of production and generate result, which is focused on fulfilling customers' needs .

Modelling and computer simulation have an increasingly important position amid tools are used by engineers and managers. This is the result of need to make quick and accurate decision in response to constantly changing environment. Furthermore, manufacturing systems are more complex than before. Through information technology that are applied in conjunction with software for modelling and simulation, issues difficult to solve due to the high complexity, can be deeply analysed. Modelling is to build a virtual model, which illustrates a real business process. Then, simulations are carried out on this model.

In literature [Podstawy projektowania..., 1993] shows both advantages and disadvantages of a simulation. The positive aspects, among other things, include:

- simplicity of changes the model;
- possibility to easy observe a business process in various situations;
- lower costs of creating model and carry out a simulations, than the real implementing and experimenting on a business process;
- shorter duration of simulations, than a time devoted to analyse process in the real world;
- chance to testing a process without modifying its flow and shape in reality.
- At the same time, literature lists disadvantages, such as:
 - possibility of inappropriate mapping a process;
 - necessity of having knowledge and experience with modelling;
 - simulation of the various models that describe the same process, may be given different results.

After the simulation phase, the obtained results should be analysed. Afterwards, improvements are implemented into examined process. It is not easy and obvious operation, but time-consuming and often requires major investments. Also, the desired results of these actions are not guaranteed. Therefore, a modeller's experience is so important. The different ways to creating models are distinguished. The formal rule of modelling, which is generally acceptable, does not exist [Fertsch M., Grzybowska K., Stachowiak A , 2009]. However, at the beginning, objectives and issues of the design task are always defined. They affect range and level of detail of the model. In this phase, analyst's role is to collect information and data, then prepare them for carrying simulation. Second phase is to build and validation of a model. In the first step, data that describe mapped

process are provided. Then compatibility of the model with reality is verified. If this part is omitted, results of simulation may be incorrect. After approval, follows the third phase. It has a gradually character. Firstly, is carried out a simulation of previously created model. The main goal is to find dependencies between model's parameters and results of simulation. For this reason, model's properties are changed by analyst and he moves into next step. After making changes, the same model is examined. Simulation and modification process is repeated while mentioned goal is not achieve. When the most appropriate version of model was chosen, objectives and issues of the design task should be analysed again. The result of simulation is a dataset, which is used to making decision upon the examined business process.

In this paper, for modelling were used Business Process Modeling Notation (BPMN). It is overall accepted standard created for describing business processes. An idea on this notation has appeared in organisation called Object Management Group (OMG). It is a consortium, which participations are software vendors, customers, institutions of government and academic. Recent release of BPMN (version 2.0) was published in June 2010. The main goal of creating BPMN was to provide notation understandable for each kind of users. It should be clear and readable for business analysts, who create outline of processes, for employees, who are responsible to implementation of a designed process, and finally, for managers, who supervise the process [White S.A., 2011].

A process presented in this paper, was described by a collaboration global process. This is one of types of processes provided by BPMN (Fig. 1.).

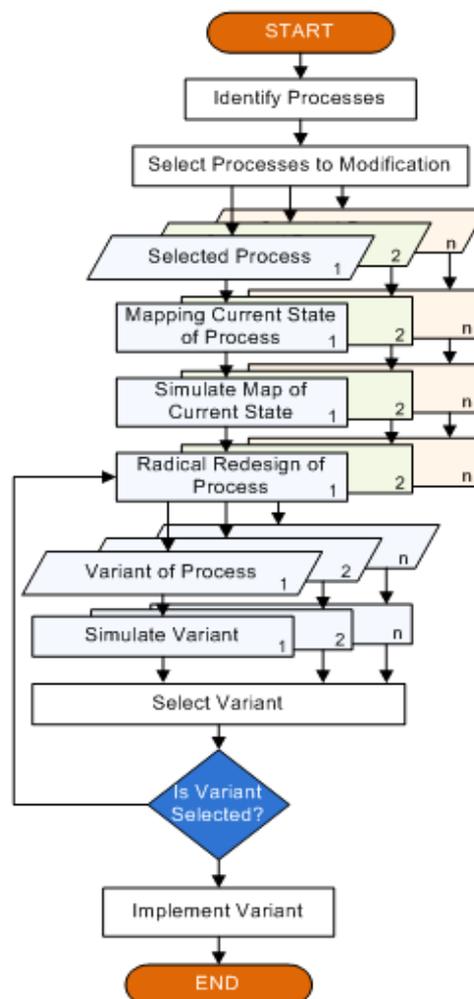


Fig.1. The modelling and simulation flowchart

A tool used in this paper

A tool that was used in this paper is integrated software. It was developed by iGrafx – a Division of Corel, Inc. iGrafx was created to improve modelling, analysis and advancement of business processes. Its main objective is to cause that these activities will be user-friendly, in particular for a members of teams which reorganize processes. The software is dedicated to create simple maps of processes that are located in small companies, as well as to mapping expanded business activities in large corporation. The software provides support assumptions of Lean Manufacturing and quality management - Six Sigma.

iGrafx consists with several applications, which differ in capabilities that are offered for users. In this paper was used iGrafx Process for SAP that provides possibilities such as modelling of business processes using BPMN and carrying out simulations of created models. This application allows designing all types of processes that may occur in BPMN [Lasek M., Otmianowski B., 2007].

Supply choice process

The process has several objectives. The main goal is to choose a supplier and buy needed materials. The supplier cannot be random or accidental. For this reason, an important issue is to make market research before complete a transaction. It is provides choice a supply from the best source and at an advantageous price. Moreover, the process should provide appropriate relationship between company and supplier. Design task is to analysis and modify the process. Purposes of the design task are to decrease of:

- amount of incomplete transactions to two per month;
- labour intensity of company management of at least 50%;
- process costs of at least 30%.

In relation to first purpose, keeping a low level of the incomplete transactions provides an opportunity to clear a backlog quickly, through overtime or an involvement of additional employees for a short time. Second purpose is associated with a general trend in the company that involves assigning of too many tasks for a senior staff. Since the tasks can be done by subordinates, a change of the process is justified. The last objective concerns reduction costs that are generated through the excessive participation of company management in the process.

The design tasks were realized in accordance with BPR assumptions. Due of used this approach, was possible rapid and radical achieved of the objectives.

In first phase, the current state map was created, which contain of process users, such as: Head of Production, Board Member for the Production, Head of Financial Department, Analyst of the Materials Market, Head of Supplies Department, Supplier. **The initial flow of the process was as follows:**

1. Head of Production notices a demand for materials and decide to order missing raw materials or semi-finished products;
2. Head of Production formulates The Notification for the Required Materials and passes The Notification on to Board Member for the Production;
3. Board Member for the Production, after receives The Notification, formulates The Financial Query, which concerns financial capabilities of the company, and next passes this query on to Head of Financial Department;
4. Head of Financial Department prepares needed information about the financial capabilities and passes The Financial Report on to Board Member for the Production;
5. Board Member for the Production checks a compliance of a demand of materials with the financial capabilities. If this is not approved, the Board Member generates The Report of The Incompatibility that is

- passed on to Head of Production, who familiarizes oneself with the Report. Afterwards, the process returns to step 2;
6. If the compliance is approved, Board Member for the Production formulates The Guidelines for Market Research and passes them on to an appropriate Analyst;
 7. Analyst of the Materials Market begins research of possible suppliers. It is embedded subprocess, which accomplishes the following substeps:
 - a. Establishing the proper way of the research and choice a method of data analysis;
 - b. Gathering a required information;
 - c. Processing the information onto data that are useful to analysis;
 - d. Data visualisation and analysis;
 - e. Preparing The Report of the Materials Market Analysis, saving The Report in a report's database and passing it on to the company's management;
 8. Board Member for the Production familiarizes oneself with the Report. It is a basis for a preparation of The List of Suppliers;
 9. Board Member for the Production formulates The Request for Proposal, which is sent to suppliers from The List and next he waits for The Offer to Supply. At the same time, he puts The Request in the Internet.
 10. After four days, Board Member for the Production chooses the most advantageous offer and passes The Supplier Data on to Head of Production;
 11. Head of Production together with the Supplier negotiate terms of the transaction. This embedded process has substeps, which aims are to establish:
 - a. a price and payment conditions;
 - b. a quality of supplied products and materials which were used to manufacture the products;
 - c. amount of the delivered goods;
 - d. a delivery deadline and conditions of breaking the contract;
 12. Supplier carries out the contract.

In this phase starts a process of maintaining an appropriate relationship with the Supplier. The process has a continuous character. Head of Supplies Department is responsible for it. The process concerns all suppliers who collaborate with the company and it relies on tightening economic and social ties with them. Taking care of the relationship may lead to negotiations of the contracts that are more beneficial to the company.

Process simulation and analysis of results

Due of the objectives of the design task, analysis and simulation do not include duration and costs of steps which are realised through the Supplier (formulate The Offer to Supply and contract realisation). Moreover, the tasks, which involve maintaining relationship between the company and sources of the supply, also are not included in analysis, because these are continuous processes that going on since passing The Request for Proposal on to suppliers. In the map, this situation is described in the form of a infinitive loop. It joins together swim lanes that belong to Head of Supplies Department and to the Supplier. Simulation was carried out by six month. Assumed, that demand for materials appears at least once per week (from 3 to 5 days after the last demand). The following tasks are bottlenecks of the process:

- preparing information about financial capabilities,

-
- analysis of a materials market,
 - negotiations of a transaction conditions.

In the first case, time required for preparing The Financial Report through Head of Financial Department, is from 1 to 2 days. It is long enough, that during 6 months, queue of The Financial Query is still increasing, reaching a size of 21 unprepared financial reports at the end on this period. Due of this, the Board Member makes decisions about compliance of demand of materials with the financial capabilities without current data. In the second bottleneck, the Analyst prepares The Report of the Materials Market Analysis for too long. It lasts longer than preparing The Financial Report. Similarly in the last case wherein final shape of the contract is determined. For this reason, after simulation period only 7 transactions were finished. Places, where are generated the highest costs, are located in the tasks belonging to The Board Member and the heads of departments.

Variants of a modified process

In the **first variant**, competencies of Head of Production were increased. In this moment, he formulates The Financial Query, which is passed on to Head of Financial Department. In addition, he receives an answer and makes decision about the financial capabilities himself. In case of incompatibility, he revises The Notification for the Required Materials. Otherwise, he formulates The Guidelines for Market Research. Also, the Analyst has got more competencies. Besides carrying out the analysis, he generates The List of Suppliers. However, the largest increase was occurred in Head of Supplies Department. In opposite to previous users, the results of the simulation show a forming of bottlenecks in all tasks carried out by this user. Apart from negotiating, he must formulate The Request for Proposal and put it in the Internet. Moreover, the most beneficial supplier is chosen by him. This accumulation of the tasks is a reason of small amount of finished transactions. Only 5 of them were realised, and unfortunately, 18 got stuck in the Supplies Department. A positive fact is decrease of overall process costs. Total sum of process costs fall down from over 170000 zł, at the initial process flow, to circa 124000 zł in current version. The main reason of the drop is a withdrawal the Board Member and assigning his jobs to the heads of the departments.

Second variant assumes implementation of software for management of finance in the company. It is the module of ERP system, which makes easier management of company resources. Using this software, one bottleneck is relieved - Head of Financial Department devotes considerably less time to generate The Financial Report. The implementation and system maintenance are involved with added costs, however this investment pay for itself after some time. After simulation period, the Financial Department is the lowest costs generator. Improvement of this part of the process, causes creating of a queue during a carrying out the market research. This issue requires an individual improvement in the next variant. Furthermore, this version assumes engaging an additional worker of the Supplies Department. It provides relieving of the bottleneck in this part of the process. The extra employee formulates and passes The Request for Proposal on. Besides, he chooses an appropriate Supplier. The contract negotiations are left for Head of Supplies Department. Recruitment of additional staff causes increase of costs. Moreover these operations do not yield a radical improvement the amount of the realised transaction, because the negotiations' subprocess is still the bottleneck.

In the **third variant**, the process was improved to such a degree that total costs after simulation time are decreased to about 110000 zł, and process flow is devoid of all bottlenecks. The only place where the transactions are accumulated is the Department of Supplies. On average, one transaction per month is not finalized. This situation may be repaired rapidly through introducing overtime into the company, at the end of a month.

The improvement causes several changes in the process flow, compared with earlier variant. First of all, the ERP is used more effectively. The Head of Production do not have to formulate The Financial Query, because he has got an access to the system. He generates The Financial Report and makes decision about the financial capabilities himself. A new concept was applied also in the subprocess of market research. The bottleneck in this place was cleared by dint of a database of reports, which functioned earlier, but demand for using it, did not exist. The subprocess of materials' market research was also modified. At its beginning, the Analyst checks whether results of analysis of examined market segment are included in the database. If they do not exist, the process proceeds as previously. Otherwise, the Analyst updates the data, carries out the analysis and generates the report. After that, the report is saved in the database. Another change is an inclusion the negotiations' subprocess to competences of a Worker of Supplies Department. The maintenance of appropriate relationship was left for Head of this department. So far, he devoted for the negotiations nearly 100% of his time. After assigning another tasks for him, three new employees was engaged in this point. It causes increase the costs, which are incurred in the Supplies Department, but total process costs are lower. Furthermore, subprocess flow was changed. At the beginning, an employee checks whether company has collaborated with an analysed Supplier. If yes, the employee prepares contract alone. After approving the conditions through the Supplier, negotiations' process was skipped. If the company did not collaborate with the Supplier, or when he does not approve the contract, then appears a need of negotiations.

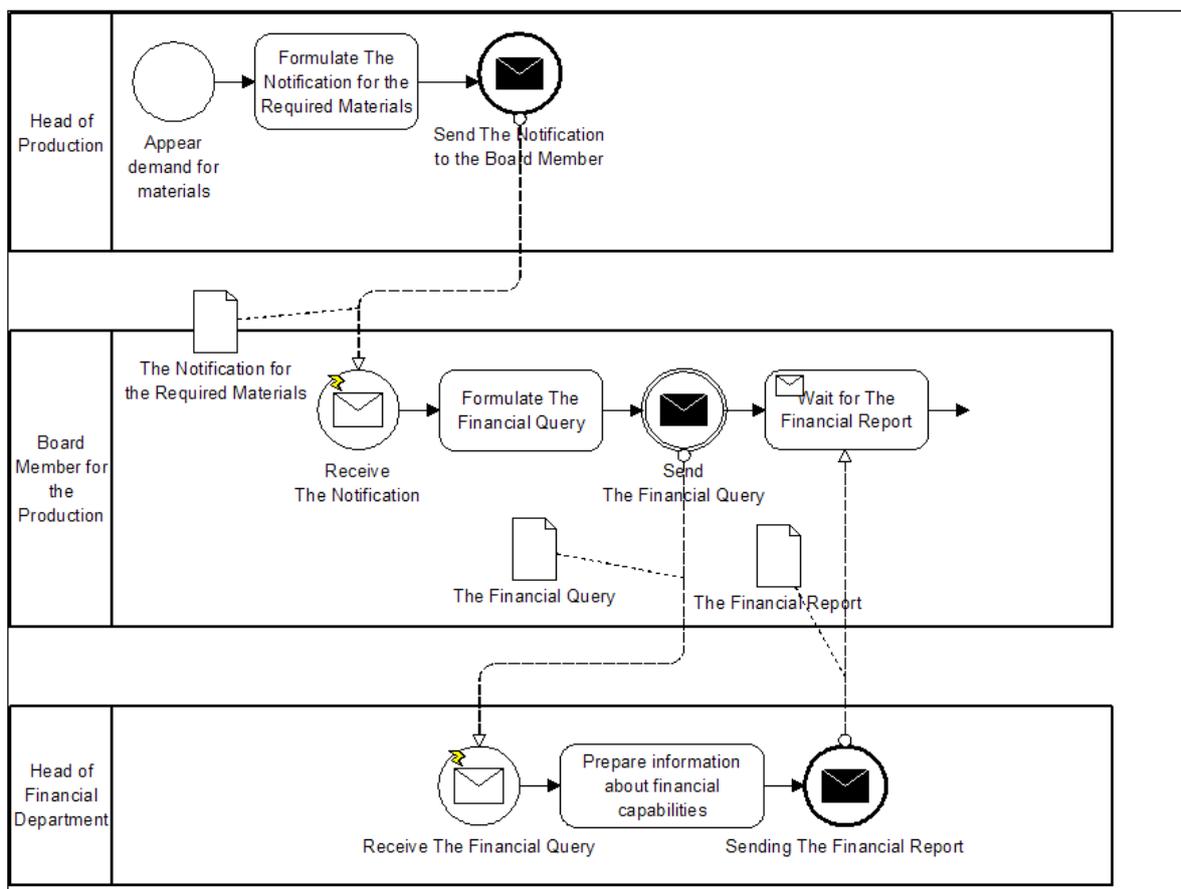


Fig. 2. The initial flow of the process – part 1

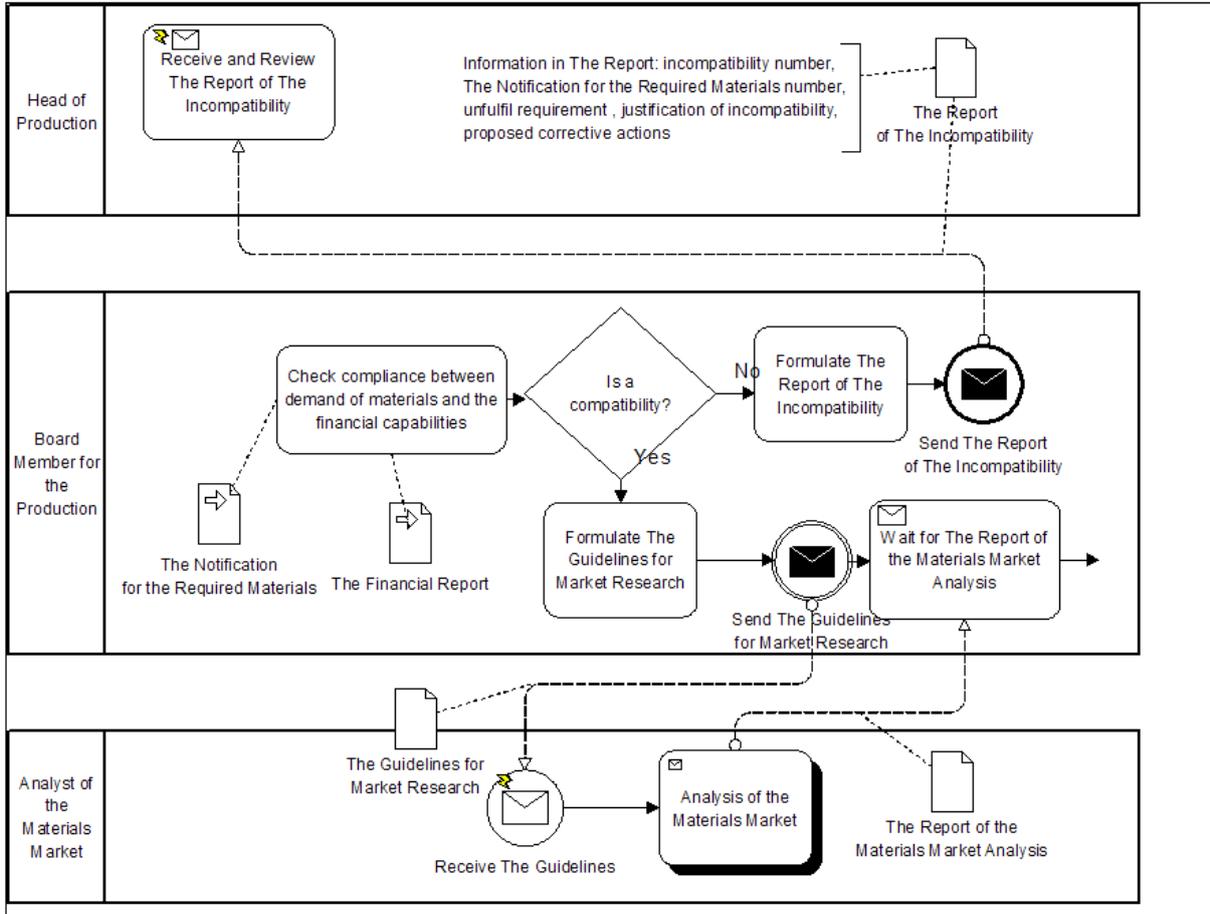


Fig.3. The initial flow of the process – part 2

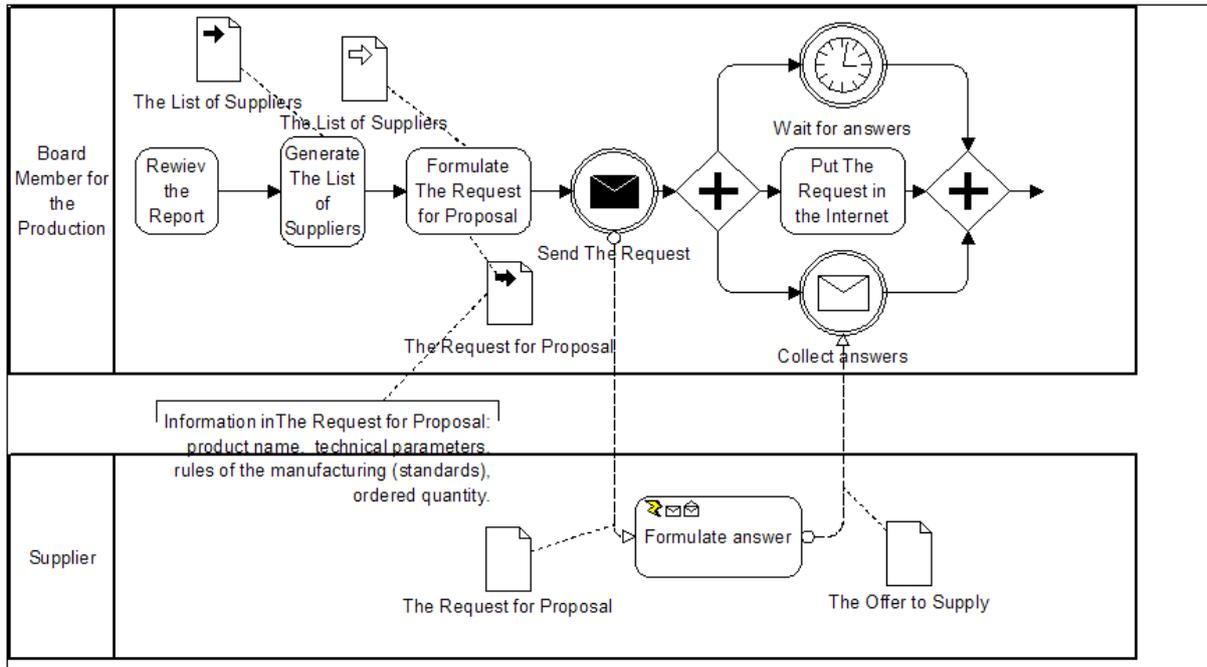


Fig.4. The initial flow of the process – part 3

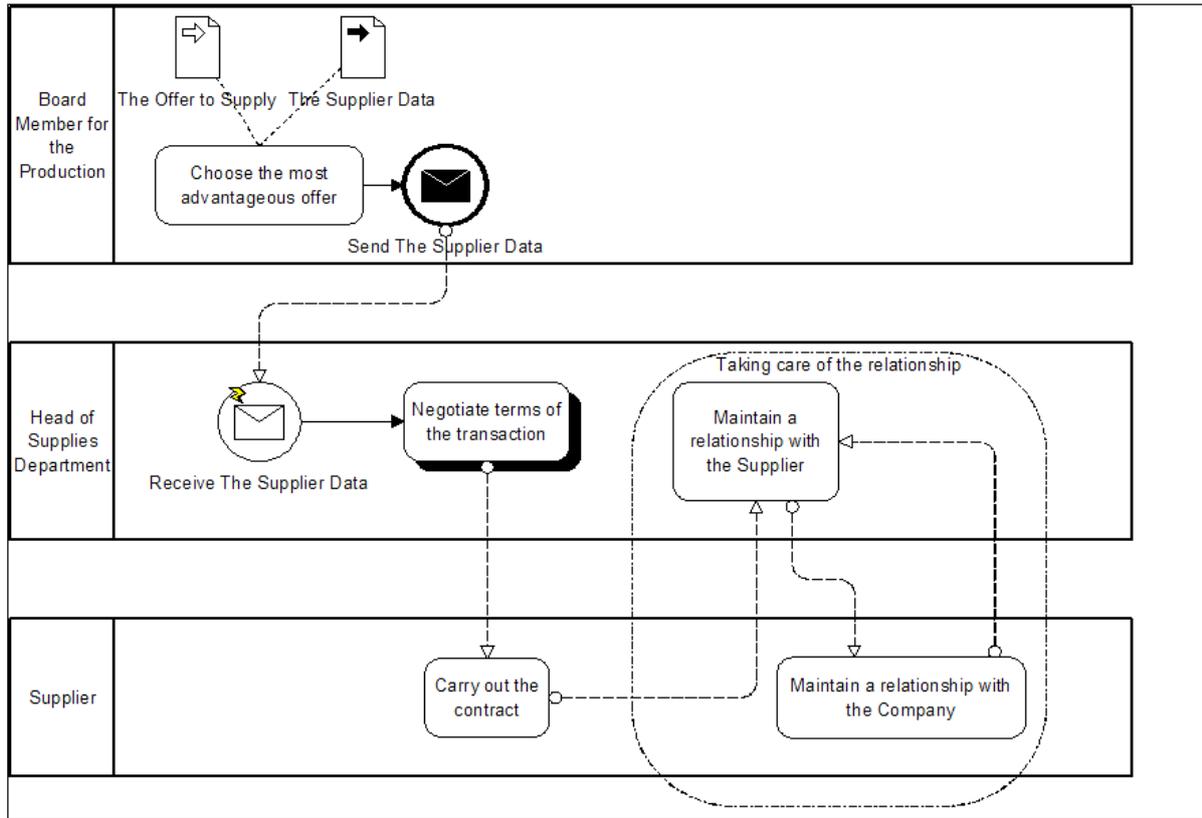


Fig.5. The initial flow of the process – part 4

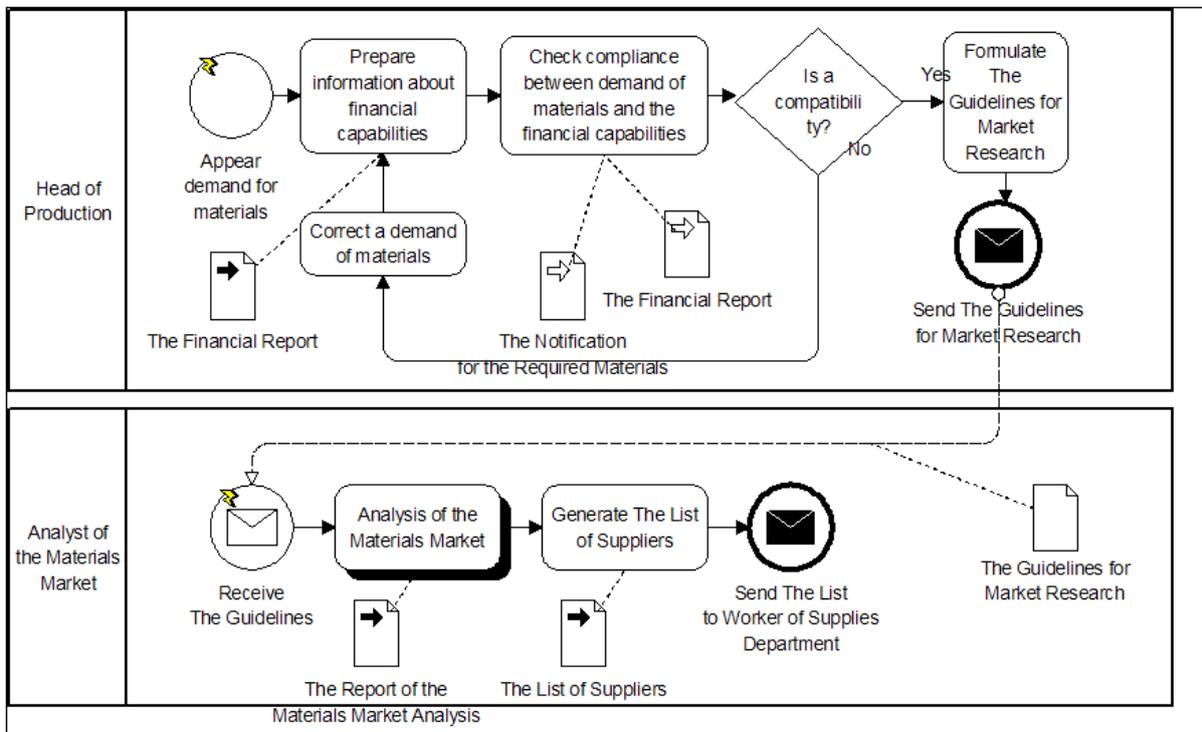


Fig. 6. The final flow of the process - part 1

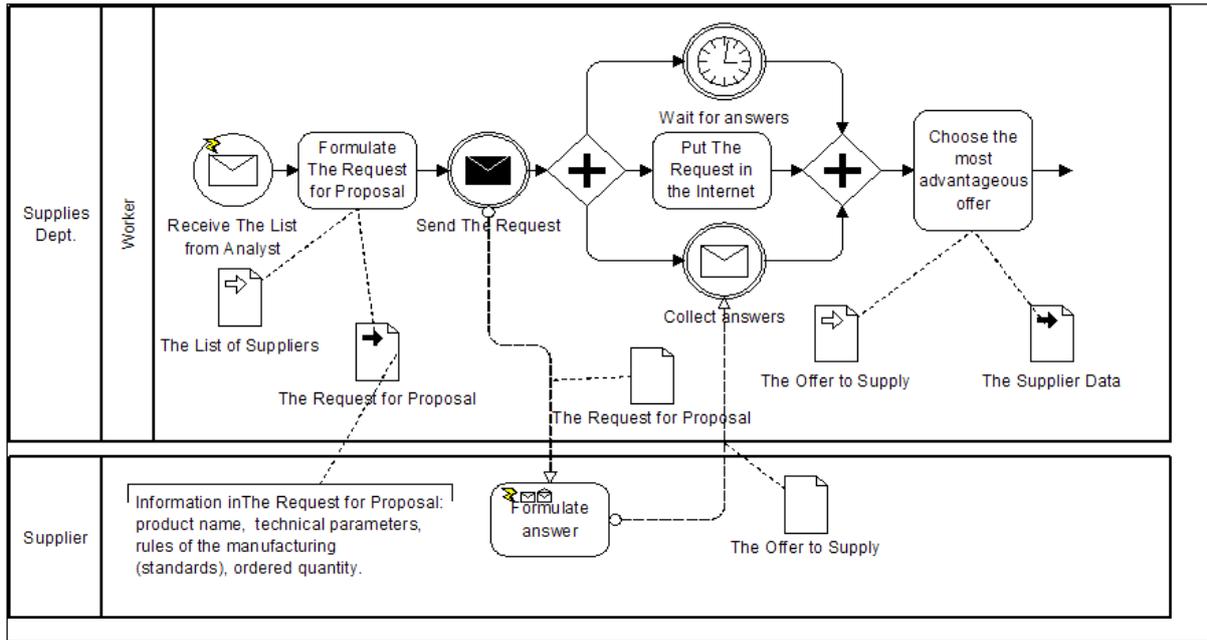


Fig. 7. The final flow of the process - part 2

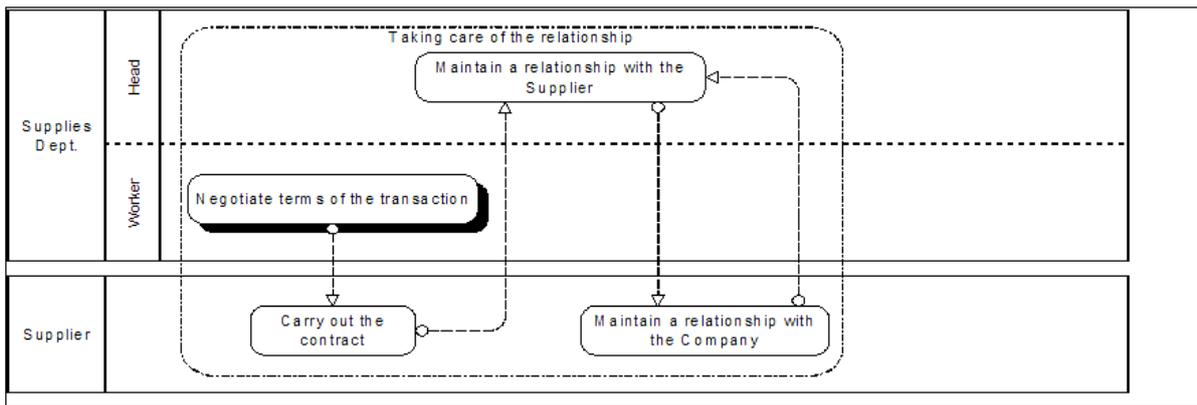


Fig. 8. The final flow of the process - part 3

Conclusion and Future Work

Based on the results of the simulations conducted, third variant is regarded as the most appropriate solution. Achievement of all objectives was possible through changing of a concept of the analysed process. The new flow avoids involving two users, who participated in the initial flow of the process. There are: Board Member for the Production and Head of Financial Department. It provides to attainment of assumed decrease of:

- labour intensity of the Board Member – worker is excluded;
- total process costs – over 60%;
- amount of incomplete transactions – two per month.

While the versions of the process were created, several assumptions of BPR were used. Firstly, the ERP system was implemented. Using Information Technology is the main rule of restructuring modern companies. Currently, all institutions should use with technology achievements to be competitive and fulfil customers' needs. Another assumption is to increase executive ability of the staff. This involves with increase of responsibility all employees but on the other hand, for this reason they feel more appreciated in work. BPR gives employees lots of freedom during participation in the process. They have full information about the process and they must make decisions

alone. It causes that labour intensity of management staff may be reduced. This is one of the most revolutionary postulates of BPR.

Achievement of the aims was strongly supported through iGrafx. This software has mechanisms to facilitate mapping of processes. Due of this fact, modelling becomes rapid and user-friendly. In addition, it allows to simulating of created maps. The software shows several kinds of results such as: costs, bottlenecks, amount of finished transactions. The results are generated for each task, process user and finally for overall process. They are available both in numerical and graphical form.

Process-oriented companies have still the advantage over the other. Moreover, a term 'process-oriented' is identical with 'customer-oriented'. Due of that, companies which adopt BPR assumptions have chance to improve effectiveness and quality of customer service. In addition, the Reengineering can be implemented in various kinds of institutions. Importance of BPR and orientation on the processes is still grows. As a result of this, importance of modelling and simulation using computer tools is also higher. For this reasons, issues described in this paper can be develop in future.

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E-Learning System

THE E-LEARNING SYSTEM WITH EMBEDDED NEURAL NETWORK

Anna Plichta

Abstract: *Perhaps the most efficient of modern didactic policies is e-learning course. E-education shapes the culture of life-long learning and teaching and enables contemporary learners to meet the requirements of the outward reality. Learning is a daunting and time-consuming task. Its final success depends on many factors, so it's crucial to choose the proper enhancing software, able to adapt the teaching process to an individual learner and able to verify and assess his improvement in learning. According to the Ebbinghausen forgetting curves, reasonably frequent revisions give student both the knowledge and methods of its consolidation: as a result he learns more efficiently. Hence, the salient part of our e-learning system is the neural network able to establish the best possible timetable of revisions. The e-learning system we provide pertains to the knowledge of the Polish orthography. By means of it we have proved, that e-learning is didactically effective only if the educational software is interactive and flexible enough to adjust itself to the user's needs, requirements and perceptual skills.*

Keywords: *e-learning, neural network, forgetting curve*

ACM Classification Keywords: *I.2.6 Artificial Intelligence- Learning*

Introduction

Among various solutions, the e-learning course is one of the most effective teaching strategies, but intrinsic motivation, self-discipline and method are required from the learner. It obliges the learner to independently plan his/her learning process, promotes initiative, engagement and energetic action. The e-learning course uses those methods which are suited to the needs of the learner. They are organised when they are needed and allow satisfactory mastery of the material. The suggested teaching methods increase the effectiveness of teaching through the positive impact on the learner's motivation and thanks to adapting to his/her perceptive and intellectual abilities.

E-learning is an innovative method of knowledge transfer which uses IT tools; however, what is most important in this method is the learner and methods of solidifying the learning material. Effective knowledge acquirement, selection of important information and its use require regular repetitions, thus mnemonic techniques are crucial.

There is no universal learning method which would guarantee to every learner knowledge on a suitable level. Everyone prefers different learning methods and that is why systems which support the learning process and the process of solidifying knowledge use various techniques which speed up the process of memorising and facilitate recalling the memorised material [Szewczyk, 2005].

Human memory is the most important factor in mnemonic techniques. Numerous research and medical and scientific experiments concerning the construction and functioning of the brain clearly prove the existence of potential, though still not discovered, possibilities of memory processes.

The suggested application of learning orthography of the Polish language refers to the above-mentioned recommendations, emphasising above all the interactivity and virtuality of the learning reality.

Methods of memorising the learning material through e-learning courses

The standards of an e-learning course regarding the design of the learning material concern establishing and describing training aims, defining the conditions of the course distribution and using the prototypes of the projected system. The learning content should be subordinated to educational needs in the first place. Hierarchization of the content, legibility and cohesion of the transfer strengthen the content answer to the user's needs, making it possible for him/her to gain new competences and skills. It is necessary to remember about the well-thought out layout of the course, cohesive navigation and equipment limitations of the users.

To learn better one should not forget about the crucial role of the memory, for which the brain is responsible. When a person eats a heavy meal, he or she gets lazy. Before a bigger mental effort one should avoid heavy meals and sugars, which increase the level of insulin in blood; however, it is important not to starve either, because the brain needs fuel to operate.

We remember better the things we read at the beginning and at the end, worse the middle part of the material. Breaks have a beneficial effect on the process of learning, because thanks to them we have more beginnings and endings. For a learning process to be effective, the material which is supposed to be memorised should be divided into smaller fragments, i.e. lesson units. Portioning the material is a significant element, because we better learn smaller fragments than big portions. A kind and method of division also influences the quality of the learning process [Hyla, 2005].

Methods of planning repetitions

An important element of the learning process is repetition. Repetitions are very important because learning means creating new tracks in one's mind. The more often they are used, the better are formed connections between neurons. Revising the material is a necessity so it needs to be carefully planned. Thanks to repetitions, knowledge is not only systematically solidified but above all it stays longer in memory. The optimum time after which a material should be revised varies for different people, it depends on individual predispositions of a learner. To be able to remember the memorised material for a longer time, repetitions should be organised not accidentally but with suitable breaks. Subsequent revisions can be planned in the following way:

- after about ten minutes from studying
- the same day before going to sleep
- in the morning of the next day
- after a week
- after a month
- right before using the gained knowledge, e.g. before the exam

The forgetting curve

A German psychologist, professor Hermann von Ebbinghaus, in his research on the memory observed regularity in the learning and forgetting process whose reflection is the forgetting curve, known also as Ebbinghaus curve. It shows the dependence between the memory retention and time which from the moment of studying. In the beginning the curve descends very rapidly, to become almost a horizontal line (figure 1).

After the end of studying a fast decrease in the amount of the remembered information can be observed. Half of the material gets forgotten within the first hour. After the second day the process of forgetting slows down distinctly.

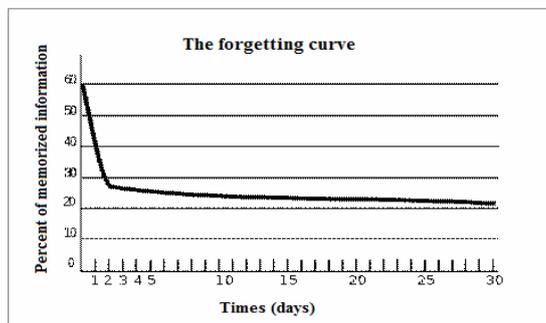


Fig.1: The forgetting curve

Thanks to repetitions of the material, every time the tilt of the remembered information is slower. The curve can be approximately presented by the:

- exponential function:

$$m = (a - c) * e^{bt} + c \quad (1)$$

where

m is memory retention,

b is forgetting factor,

a – remembering factor,

c – asymptote ,

t – time.

- power function:

$$m = g(1 + bt)^{-t} \quad (2)$$

where

m is memory retention,

g level of the non-volatile memory,

t is time,

i is forgetting factor.

Thanks to revising the material, a high level of remembered information is maintained. The main problem to be solved is defining the time when the learnt material is to be revised so that it gets solidified. To do this, the forgetting curve can be used; it shows interrelation between the memory retention and time passed from gaining the knowledge. According to the forgetting curve, after ten minutes from the end of studying, the learner remembers 90% of the information which he/she has been studying. The system uses the transfer of the forgetting curve in the power shape, to be more exact the formula: $R=e^{-t/s}$, where R is the amount of information easily recalled from the memory, t time in days that passed from the revision and s is relative strength of memory. The value wanted in the calculation process of the time for the next revision is time after which it should take place. The formula should be changed into: $t=-s*\log(R)$.

s is the factor of stability of facts calculated as 2^n , where n is the number of repetitions. To make it easier, it has been assumed that R equals 70%. It is at the same time the boundary value for the system, which means that the repetition should take place when the level of the remembered information reaches 70%. The diagram showed in picture 2 illustrates what influence on the shape of the curve repetitions have.

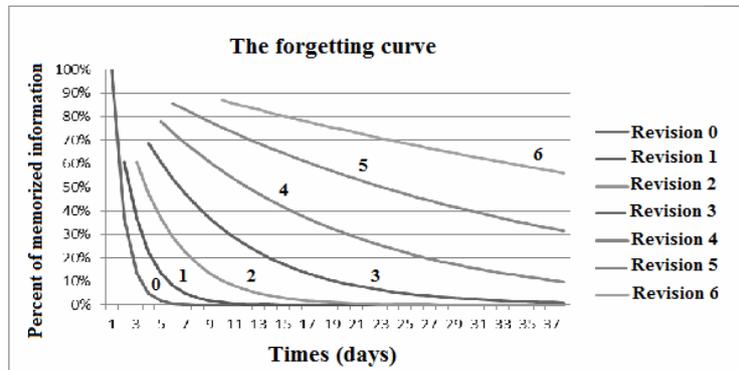


Fig.2: Forgetting curves projected when the learning material is revised

When a piece of information is repeated, relative strength with which it is remembered gets strengthened, thanks to which it is remembered longer. It should be noted that when deciding on the time of the repetition using the forgetting curve, the time of the repetition is calculated using universal methods, so individual characteristics of a learner are not taken into account [Lindsay, Norman, 1991].

The proposed e-learning system to indicate the next repetition uses the neural network of the Multilayer perceptron type. The concept of an artificial neural network comes from the human brain research and connections between the artificial neurons. The proposed network is taught by using the method with a teacher. It is a method of reverse mistake propagation, it consists of giving a set of input signals along with the expected output signals during the learning process. The learning of the network consists of such a neuron weights correction that in the final effect the mistake made by the network is smaller than the given. To achieve a better effect, a number of learning cycles is established, which allow the decrease of the value of the made mistake. The picture 3 shows the used neural network, whose task is predicting on the basis of the signals given on the input what the value of the output function should be [Tadeusiewicz, 1993].

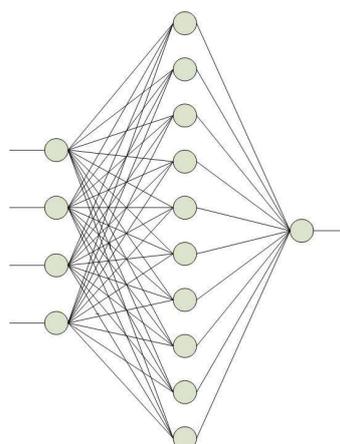


Fig. 3: Neural network provided for the purpose of the e-learning system

The suggested network has four inputs and one output. The network has been shaped and suited to the needs of the designed system. It is responsible for indicating the optimum value of the forgetting factor. Input arguments have been assumed:

- the time from the last repetition
- the number of repetitions
- the average calculated from the grades
- the last grade

In the proposed system, the learner gets a provisionally learnt network, which helps him use the system, in which the time for repetitions has been carefully planned. Thanks to the used neural network it is possible to indicate the optimum time for the next repetition, because it is set to the method of working of the learner's memory. Setting the network does not apply to one question only but the whole set of questions concerning a specific spelling rule – therefore the setting has a global character. The neural network can be coached, but only to some threshold value, which defines the maximum number of coachings of the network, it is a kind of a protection so that it is not over-coached [Plichta, 2011].

E-learning course to learn Polish orthography

In the proposed e-learning system the learner has a possibility to get to know the theoretical knowledge about the principles and rules of the Polish spelling and its practical application by completing a series of exercises illustrating the correct spelling within the specific rule. The learner checks the answer and verifies his/her mistakes. The system makes use of the navigation between the websites to move around. Such a way of moving is clear and easy to use. Text on the buttons precisely shows their destination, limiting wandering through the application's sites. Searching the electronic content allows learners to get to know the course's content and choose the suitable exercise from the module fast. Cohesion makes everything very simple – placing navigation elements in the same place on all the screens, using the same symbols and colours, the same fonts used for the same content elements, using the same rules while designing the layout of every screen. This solution makes it easier for learners and teachers to use the e-learning course.

The course's visual attractiveness is increased by the dynamically changing graphic signs placed in every module of the course, which have a high educational value. Graphic signs change with the change of a spelling rule, which makes it easy for learners to associate the picture with the rule. Correlations between the graphic and textual elements and also proper composition of those elements on the screen have been taken care of.

As text is the most common form of transfer in the e-learning course, its proper preparation is crucial, so that reading is easy and effective. The important information, which is a spelling rule, is repeated during every exercise concerned, and in different places of the course. It is shown on the user's demand.

Aesthetic rules are obeyed, also visual legibility of the screen has been taken care of, i.e. appropriate margins, spaces, light on the screen and appropriate font size. The size of the monitor and its resolution also influences the legibility of some of the course's elements.

Thanks to the data base of the questions, the system is able to organise repetitions. Repetitions involve showing subsequent questions by the system on the main panel of the application, to which the learner answers. The answer is then verified by comparing it with the correct one. The system enables also course and user's accounts administration, their rights to get to specific functions and platform's resources. It allows adding a new course or adding new information to the existing ones. The important element is communication between the individual members of the course and the teacher in a synchronous way (chat) and asynchronous one (forum, email) and creating virtual groups of members and teachers. The valuable source of information about the effectiveness of

the proposed course is the ability to examine the activity of the learners, surveying the members and teachers and checking the learning progress.

Conclusion

The e-learning system supporting learning spelling at school offers additionally a module managing the gained knowledge, making it possible to plan repetitions. These kinds of systems are the future of the modern education. Nowadays, the choice of the repetition times in the programme concerns all spelling rules. A solution worth thinking about is transferring such decisions onto the specific rules. The change, concerning transferring the artificial neural network factors so that it adapts to the conditions of the specific spelling rule, will make it possible to increase the correctness of indicating the next repetitions for a chosen group of questions. As the questions concerning a specific spelling rule can be easier or more difficult, it will influence the process of remembering the information.

The system might be extended by adding statistics, on which the terms and effects of subsequent repetitions could be presented for a specific spelling rule.

The system I have designed uses the .NET platform by Microsoft because it provides tools which facilitate designing process. This platform is still developed by many experienced programmers. The artificial neural network is executed by the software.

On the basis of the statistics, the learner will have such information as the improvement of his knowledge and which spelling rules are the most problematic for him, which material is difficult for him and whether he needs to change his learning method.

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GENETIC ALGORITHMS IN E-LEARNING SYSTEMS

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Abstract: - An approach for the problem of building such tools of e-learning system that gives the user a chance to get the desired knowledge of teaching course in a user adaptable manner is suggested in this article. This approach is based on so-called "teaching scenarios" (sequence of teaching units) being constructed during the process of learning. We introduce a tool that builds user adaptable teaching scenarios based on Genetic Algorithms, built-in the Genetic Chooser Algorithm (GCA). These scenarios are being constructed via the quality and quantity characteristics of the teaching units and user's knowledge. A course-map building tool is also introduced in GCA that helps user to see his /her progress through the course. The considered method is realized and introduced in the TeachArm e-learning system [S.G. Sargsyan, A.S. Hovakimyan, and all, 2002]

Keywords: Genetic Algorithm, e-learning system, user adaptable scenario, knowledge, L-Systems.

ACM Classification Keywords: A.0 General Literature - Conference proceedings

Introduction

We have a teaching course and are going to construct such a system that would organize the whole material in such a way that will make the process of learning easy and effective for the user.

The teaching process in learning systems is presented as separate teaching cycles, and each ends with testing the user's knowledge. Several types of teaching scenarios are distinguished: free, fixed and manageable via the teaching system. The third one is generated by the teaching system during the teaching process. The teaching material is divided into logical units that a teaching scenario is constructed of. Having the users' base of knowledge after a test, user is offered a scenario to study. A scenario is being constructed of teaching units sequenced in a way that provides a learner an effective way to get new knowledge.

An approach is suggested to solve this problem. It is worth mentioning that a solution will be an acceptable one rather than an exact one because Genetic Algorithm is an approximation method. In particular an exact solution for this kind of problems is almost impossible to find because they have a very large set of possible solutions where we will have to search the exact solution from. Besides no two learners are the same. They are of different backgrounds and different knowledge-base, which makes difficult to define exactly what does a good solution mean for a particular learner.

We find a user adaptable scenario of a teaching process phase using GA [Z. Michalewicz, 1999], [George F. Ludger, 2003]. A course-map building tool, which also shows a user's progress through the course, is implemented using L-Systems [Jon McCormack, 2003].

The Problem and the solution model

The problem is the following. Organize an effective teaching system having the teaching material and information about learner's knowledge base. We will define such concepts as teaching scenario, dependency matrix, teaching stage for a learner, acceptable scenario. Saying effective teaching we understand giving the next best teaching scenario to the learner in the given teaching stage taking into account the level of knowledge that the learner has gained studying the past teaching scenario.

Let's define the mathematical model for this problem.

Let's mark the teaching course as D . The course D is divided into teaching units that are numbered by d_1, d_2, \dots, d_n , where $d_i \in N$. Each teaching unit contains a particular set of key concepts that a learner should master. Each such set we will mark by U_i ($1 \leq i \leq n$). For each teaching unit d_i , ($1 \leq i \leq n$) we define the value $C_i \in N$ and is limited by $\theta \in N$, which describes its complexity. If the teaching unit d_i takes more time and efforts to master, than the teaching unit d_j then $C_i > C_j$.

Let's take $U = U_1 \cup U_2 \cup \dots \cup U_n$, that is U is the whole set of key concepts in the course D . Now let's define dependency matrix $K = \{K_{ij}\}, (1 \leq i, j \leq n)$ of teaching units, where. If d_j depends on d_i then $K_{ij} = 1$, else $K_{ij} = 0$.

A teaching scenario is a sequence of teaching units $X = X_1, X_2, \dots, X_m$, where $m < n$, $X_i \in D$ and $(\forall i \neq j) \Rightarrow X_i \neq X_j$.

The scenario X is acceptable, if every unit appears in it only once and a unit appears in the scenario sooner than those that depend on it.

Formally, the scenario X is acceptable if $(\forall i \neq j) \Rightarrow X_i \neq X_j$, and if for any pair (X_p, X_q) , where $X_p, X_q \in X$, if $p < q$, then X_p teaching unit does not depend on X_q teaching unit (as matrix K states), $1 \leq p, q \leq m$.

Let's define the complexity of the scenario X as, $\sum_{X_i \in X} C_i(X_i)$ where $C_i(X_i)$ is the complexity of the teaching unit X_i .

For each (X_i, X_{i+1}) pair of the scenario X let's define the concept of distance $r_i(X_i, X_{i+1}), 1 \leq i \leq m-1$. $r_i(X_i, X_{i+1})$ is the number of those teaching units that the teaching unit X_{i+1} depends on after the learner has mastered the teaching unit X_i . Let's define

$$F(X) = \sum_{i=1}^{m-1} C_i(X_i) \bullet r_i(X_i, X_{i+1}) + C_m(X_m).$$

We will say that $X = (X_1, \dots, X_m)$ acceptable scenario is better than $Y = (Y_1, \dots, Y_m)$ acceptable scenario if $F(X) < F(Y)$.

$X = (X_1, \dots, X_m)$ acceptable scenario is the best if $F(X) \rightarrow \min$. There may be several best scenarios; in that case we will just take one of them.

The sequence of knowledge of a learner we will denote as $Z = Z_1, Z_2, \dots, Z_n$, where Z_i is a sequence itself and reflects which key concepts are learnt and which of them not in the teaching unit d_i . It can be either mastered ($Z_{ip} = 1$) or not ($Z_{ip} = 0$), Z_{ip} refers to the p^{th} key concept of i^{th} teaching unit.

Let's define the concept of teaching phase of a learner. It is defined in two steps:

- The best X scenario is being given to the learner. Testing is held after the learner has studied the units in the scenario X .
- Taking into account the results of testing Z vector and the matrix K are being updated to reflect the knowledge of the learner and the dependency between teaching units respectively.

Note here that each time when a learner passes a teaching phase the units, which have been included in the provided scenario and have been completely learnt by the learner (the corresponding Z_i sequence consists of ones only), are being removed from the whole teaching material thus removing the corresponding dependencies from K .

So, having defined the data domain of our problem let's state it formally. Build such a scenario X for each teaching phase, that $F(X) \rightarrow \min$.

Now let's depict the parameters of our problem into parameters that are meaningful in the GA. Teaching units will be the genes of the GA. Teaching scenarios will be the chromosomes of the GA. The set of teaching scenarios will be the population of the GA. If a teaching scenario is allowable then the corresponding chromosome is allowable as well. If the teaching scenario X is better than the scenario Y then the chromosome X is better than the chromosome Y in the GA.

There are many ways to solve this problem, but we have chosen the way that is provided by Genetic Algorithm. So, you may ask why GA? If GA can be used here then a regular algorithm may exist and possibly be better. Here we can answer, that the GA is used to optimize the problem. It is not used to find an exact solution. The problem itself is an optimization problem and it is hard to find a regular method for it. The GA guarantees that it will eventually find a good solution, because the GA has a "jumping" nature [George F. Ludger, 2003]. Mutating a chromosome or crossing over two chromosomes can yield much better chromosomes. Of course these operations can yield bad chromosomes as well. But the point to be considered here is that good chromosomes are constructed during the execution of the GA. And if we modify the GA so that it saved the best chromosomes after each cycle of its execution, we can be sure that in the end the GA will output the best result that it has found during its run.

The GA Problem and Its Parameters

A gene is represented as a whole number, namely it is the number of the teaching unit. Whole numbers are preferable here because it makes the logic of the GA easier [Z. Michalewicz, 1999], [George F. Ludger, 2003], and A.S. Hovakimyan, S.G. Sargsyan, 2005].

We have chosen *order crossover* and *double mutation* as the operations of GA [George F. Ludger, 2003].

Let's define the main concept of the GA, namely the fitness function for our problem. We will take $F(X)$ as fitness function for our problem. GA states that if X chromosome is better than Y chromosome if $F(X) < F(Y)$.

Here we can say that the chromosome X is the best if $F(X) \rightarrow \min$.

The Genetic Chooser Algorithm (GCA) Description

We assume that course author provides such information as the dependencies between the key concepts and the complexities of the key concepts. This kind of information will let us compute all the parameters of our problem.

For the beginning we assume that a learner knows nothing about the teaching material, and all the teaching units are still unstudied. Or the learner can take a test to find out his/her knowledge. If the learner knows nothing his/her vector Z is a zero vector. If the learner has taken a test and proved to know something, the corresponding elements of the vector Z will be set to ones.

Now let's describe the current step of GCA algorithm:

- Update the vector Z setting the members that correspond to learnt units to ones;

- Remove all the teaching units that are mastered. In this case some dependencies between the key concepts of the whole teaching material will disappear. If there is a key concept in a teaching unit which is not mastered that unit is not removed. Instead, its complexity value is decreased. The new complexity value

$$C'_i(X_i) = C_i(X_i) \cdot \frac{|U_i| - M}{|U_i|} + a$$

is calculated by the following formula:

- $C'_i(X_i)$ is the new complexity value, and $C'_i(X_i) < \theta$, $C_i(X_i)$ is the old complexity value, $|U_i|$ is the total number of key concepts in the teaching unit, M is the number of key concepts in the teaching unit that are mastered, a is a constant corrector value, $a < \min_i C_i(X_i)$. Its meaning is the following. If the learner has passed this teaching unit and the testing discovered that no key concepts are mastered, $M = 0$, it means that this teaching unit may be more difficult for this particular learner, and it is worth to have a higher complexity value.
- Having the updated vector Z , the new complexity values, the possibly decreased set of teaching units, run the GA for these input values.
- After the GA has completed its job and returned the best scenario, forward that scenario to the learner.
- Repeat all the steps mentioned above while the set of the teaching units is not empty.

Now let's detail what GCA does.

- Construct the matrix K taking into account the vector Z after testing,
- Construct the initial population of chromosomes,
- While the end-condition is not true do the following:
 1. Select some chromosomes (usually 1% of the entire population) using the roulette wheel method [Z.Michalewicz, 1999],[George F. Ludger, 2003],
 2. Order crossover the big part of the selected chromosomes,
 3. Double mutate the rest of the chromosomes,
 4. Check the offspring against acceptability,
 5. Compute the fitness values for all acceptable chromosomes,
 6. Add these chromosomes to the population,
 7. Save the best ten (or other number of) chromosomes in a separate place.
 8. Throw away the worst chromosomes so that the entire number of chromosomes in the whole population remained the same.

Some aspects can be optimized. For example, a bad chromosome can contain a good "sub-chromosome" that is worth keeping around. For this purpose a "bucket brigade" algorithm is suggested to use [George F. Ludger, 2003]. The "end-condition" can be

- Completing some fixed number of cycles, or
- Testing if the difference between the average fitness of the previous population (the population before selection, order crossover, double mutation, and offspring addition) and the average fitness of the new population is small enough, or
- Testing whether the number of good chromosomes is big enough, etc.

Note that every time when testing is made the set of the teaching units are decreased. So we will eventually reach a situation when GA is neither good nor applicable because the set of teaching units is very small. In this case the "simple choosing" algorithm can be quite good (the fitness function is used here anyway to compare the chromosomes).

Having a set of chromosomes the GCA system gives another set of chromosomes where we can choose the chromosome which has the highest fitness value.

The GCA has been realized in the Java programming language. Experiments gave encouraging results. The entire GCA has been tested on hypothetical course with randomly generated dependencies between the key concepts. The test showed that the larger is the problem domain the better the GCA behaves comparing to the simple choosing algorithm.

The effectiveness of GCA also depends on the size of the population that the system operates on. The tests have shown that the larger is the population the better is the final fitness values. We can also see that the fitness value shrinks faster and faster but from some point it starts to shrink slower and slower. And there is some point where it stops changing. This also means that the best chromosome in of the final population is very close to the best chromosome entirely. See Figure 1.

L-systems in GCA

Having the matrix K (defined in section 2) we can construct the so called "dependency tree" of the entire material. That would be an oriented graph, where the nodes are the units of the teaching course, and two nodes are connected to each other if there is a dependency between them.

In the GCA system there is a support for showing the dependency graph of the course, which serves as a map for it. That map will be useful for a user to see the structure of the course.

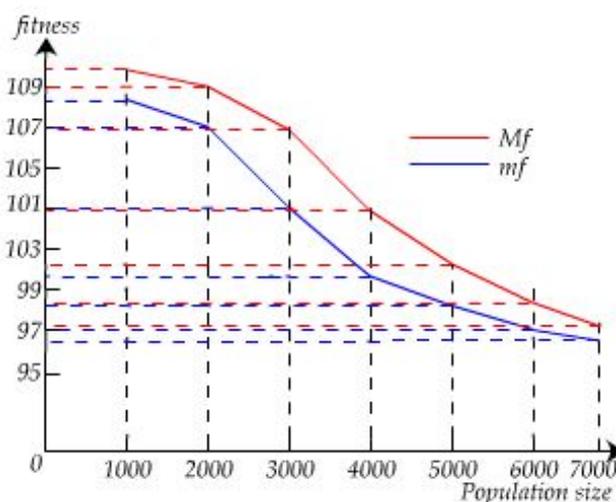


Figure 1

It is being updated with each passed scenario, drawing the mastered units with alternate color. This way a user can also see which parts he/she has passed and which parts still remain, which, we think is useful information for him/her. To actually draw this graph we have used the method of L-Systems [Jon McCormack, 2003].

This method suggests to have some starting formulas (axioms) and rules to be applied to them. Applying the rules to the axioms gives other formulas that we can apply the rules on, and get more formulas.

So having the matrix K and the starting point of the course we can draw the course map by the following way:

- Take a unit A , and all those units that directly depend on it. Let's mark them $B_1 \dots B_m$.
- Draw oriented edges from A to $B_1 \dots B_m$.
- Do the first two steps until the entire course is considered.

Note that the K matrix that we will talk about through this section is the initial K matrix of the GA. GA changes it during its run, but we need to have the entire unit-dependency set in order to draw the course map, and note all those units that are already learnt.

Let's define the formal description of the steps brought above, that will help us to actually draw the map of the course. Let's define the basic elements for our L-system.

The alphabet is the following.

$$\Sigma = \{U_1, \dots, U_n, >, [,], I, O\},$$

where U_i is the i^{th} node-drawing action. ">"-marks the arrow-drawing action, "[" and "]" mark the "turn one unit left and push into the stack" and "turn one unit right and pop out of the stack" respectively, I and O mark the "change color" and "restore color" actions respectively.

Looking at the matrix K , find out all those units that do not depend on other units: i.e. the starting points of our course. Those units will be the axioms of our L-system. Thus

$$\omega \subset \{U_1, \dots, U_n\}.$$

Any combination of symbols from Σ is called a formula. So axioms are formulas.

Let $CS = \{U_1, \dots, U_n\}$, and LS is the set of learnt units. LS is constructed taking into account a learner's current knowledge vector Z (section 2).

The set P of production rules that are being applied to formulas of L-system is defined by the following way.

1. If unit U_i depends on U_j (as the matrix K states) and $U_i \in CS$, replace it with $[U_i > U_j]$, $CS = CS \cup U_j$.
2. For every $U_i \in LS$, replace U_i with IU_iO .

$$\text{So } P = \{U_i \rightarrow [U_i > U_j], U_i \rightarrow IU_iO\}.$$

Let's take $F = U_1 \dots U_p$; ($U_1 \dots U_p \in \omega$) as the starting formula. Perform the rule 1 on F , while $CS \neq \emptyset$.

This way we will get the *course-map formula* CF .

Perform the rule 2 on CF while applicable. This way we get a learner's *knowledge-map formula* of the course KF .

Using KF the knowledge-map of a user is drawn. So a user can see his/her progress through the course with an alternate color.

Conclusions

In the presented article we discussed a problem dealing with the issues of the optimal management of teaching process in e-learning systems. This problem's aim is to construct such tools that adapt teaching materials to a user, which will allow the student to get knowledge effectively. We developed the GeneticChooser Algorithm (GCA) using the Genetic Algorithms' and L-Systems' concepts to solve this problem. We continue our researches in using GA-s and L-Systems in problems of developing e-learning systems and managing teaching process in them. The results we plan to present in our further papers.

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Major Fields of Scientific Research:

THE TECHNIQUES FOR DEVELOPMENT OF E-LEARNING COURSES ON COMPUTER NETWORKS

Iwetta Turek, Michał Szczurowski, Grzegorz Rzeźnikiewicz, Arkadiusz Rzucidło

Abstract: *The paper describes the application of distance learning techniques to presentation of instructional materials on Computer Networks. The subject of the work is the discussion on the effectiveness of selected lectures creating methods for workshops. The techniques presented have been applied to the development process of newly built distance learning platform used at Rzeszow University of Technology.*

Keywords: *distance learning, virtual courses,*

ACM Classification Keywords: *K.3. computers and Education, Computer used in education, Distance Learning*

Introduction

An integral part of the educational process are teaching aids, which are usually complementary but also a key element of the cognitive process. They make the transferred knowledge from ineffable chaos transform into an outline structured by the imagination of something that we try to fathom. They can speak vividly to the senses of a man who uses them to shape the view of studied issue. The attractiveness of teaching aids, or rather the materials related to teaching makes the transferred knowledge become accessible. Certainly the rate of assimilation and the satisfaction of science itself grows in the eyes of students.

There will be no revelation to say that the attractiveness of the materials has a direct influence on the exploration of knowledge by the same way. The question is rather what is attractive and how to express it? Of course the answer is not simple only because of the diversity of knowledge transfer and ways to reach students. There is no universal standard methods, however, for individual cases (as in this article) it is possible to study certain known forms and techniques of action. With some probability they will allow an effective selection of learning solutions.

The Transfer of Knowledge

Distance learning, as the classic form of cognitive process, is associated with motivation for learning by students. This motivation comes from the cognitive needs, the desire to acquire certain skills, explore materials and other sociological needs such as belonging. Power of motivation is an element that is crucial. There is a problem in finding verbalization of knowledge and its counterpart in the form of distance learning.

In traditional teaching the teacher establishes more direct contact with the student through the use of verbal techniques. The appropriate voice modulation having intrigue the listener, or relevant examples from reality told in an interesting way should be mentioned. Non-verbal techniques go along with the verbalization of communication. In order to intensify the effect of listener curiosity in transmitted information gestures and multimedia presentations filled with elements of sound and moving are used. In transmission of information dynamics of communication is also very important. The passion with which the teacher should provide the information often is passed to the audience. By this action the teacher "moves" part of the enthusiasm on the audience, which makes the audience get knowledge faster and improve the rate of lecture leader in the eyes

of students. Lecturer uses aids in the transmission of teaching materials and these aids give adequate expression to make this transmission complete.

The techniques used in teaching classical way may also be applied to distance learning. To provide information multimedia presentations are used, passively or actively transforming the listener into the reader. To avoid such transformation, in order to diversify communication, mobile audio components such as videos, animations and sounds clear instructions, are implemented. Materials containing dry text of the lecture contents are less interesting than those which have examples of practical applications. Such activities contribute to the teaching method as "non-verbal element". The listeners can fully understand the topic in question, knowing its real destiny. Then they see the merits of acquiring the information collected in the context of the problem under consideration. This will ensure that the listeners are likely to reach the next topic. Distance learning often puts the listeners in the role of decision makers. It gives them some choice, which materials they want to acquire at the time, and which allow for subsequent assimilation

The age of the learner plays major role in the use of distance learning. Young people, by virtue of living in times of extremely rapid technological progress, are much better predisposed to benefit from this form of learning than older people. Materials for distance learning must be prepared in the universal form, because you never know what age group will have to deal with them.

The quoted characterization of the two learning technologies in the context of the way of transmission of educational content shows with how a big problem we face. Although in the short way this method treats the problem, it highlights some important themes that you might consider building or designing the virtual equivalent of the traditional pattern of teaching [Rzucidło, 2011][distance learning, 2011] [Giurko, 2008].

The Gamson's report [Gamson, 1987] concerning education, conducted over several decades at universities, can specify the following principles of good educational picture. It should be characterized by:

- activity,
- co-operation,
- demanding (labor intensity) (classes should be absorbing.)

Contrast material should be:

- accessible,
- understandable,
- practical
- wide range of applications.

Despite the passing years the principles set out in the report have not lost value. This is confirmed by subsequent publications on the human predisposition for the effective assimilation of knowledge and information [5].

Comparing the preferences of students with learning pyramid [5] one can conclude that students like effective teaching methods. E-learning in order to be an effective method of teaching must go hand in hand with practical teaching. It should also be aware of the possibilities of students [e-learning raport, 2005].

According to the report for 2008 [Peterson, 2009] on e-learning market in the UK 57% of study participants have been using this tool in teaching. At the same time, this form of distance learning is only 12% of the time spent on education. For comparison, e-learning in the U.S. represents 30% of teaching time. The vast majority (95%) believe that e-learning is effective only in conjunction with other forms of learning. Respondents see the need for a new attitude towards people using the service.

The same report notes that the value of e-learning market in the UK increased between 2007 and 2008 by 25% (from 160 to 250 millions £), and between 2006 and 2007 12%. However, the leader in this regard is Scandinavia,

where the e-learning seems to be one trillion euros (in the UK about 700 million). At the same time increase in the market value at the same time between 2008 and 2009 was only 8%. [Peterson, 2009].

In Poland, e-learning is not growing so fast. One of the problems in popularizing this form of teaching is the lack of official standards that the State Accreditation Committee could add to the evaluation of the curriculum by using e-learning. On the other hand, the development particularly in higher education has been recognized [e-learning in Polonia, 2006] .

On the other hand, government authorities take measures to develop e-learning in Poland. In 2006, the Ministry of Education organized a tender for the high-quality e-learning in economics and information technology (IT) [e-learning in Polonia, 2006] . Courses designed in this was are widely available.

The development of e-learning in Poland was influenced by the availability of the Internet. According to the CSO in 2006, only 36% of the population had access to the Internet. For comparison, the average for the EU was then 52%.

In addition to the availability of an impact on changes in the e-learning skills affect Internet users. In 2006, only 20% of Poles had e-mail account (e-mail), and 23% actively used the forum and chat [eurostat, 2007] .

Another problem is that only about 5% of Polish citizens are educated for life. As the main cause (67% in 2007) people provides the improve of their work or improve of their careers (niejasne). Only 7% learn complex in the direction of their interests. For comparison, the UK, up to 82% of residents are trained to acquire new knowledge, skills, according to your interests. [eurostat, 2007] .

In all countries, more than half of their residents choose to participate in various forms of teaching because of the desire for better jobs or careers. Another worry is the learning rate according to people interests aimed at their development. Only in Poland from all EU countries, its value falls below 20% and not the entire 8%. For e-learning it means that the average Pole is not working enough to be interested in training, and the main aspect, which will look at the form of teaching is useful for work or career. This can lead to the fact that the main criterion for selection will be, what value will have a certificate, a certificate or diploma that will get after completing the course, training, seminars and other forms of education.

A chance for the development of e-learning is higher education. This group is open to new teaching methods, and more willing to deepen their knowledge and skills according to their interests. To interest working people with further training would familiarize students with this form of teaching and make the opportunities in order to seek further training. The problem may be cash, which can allocate a person for the purpose. It should also be noted that in many cases, e-learning is cheaper or even free, which may contribute to one's development.

E-learning should be addressed to specific recipients, so they want to continue using this method. Consideration should be given to individual preferences and skills of the group, so that the form was attractive and effective for them. After reviewing the potential participants, the advantages of this specific project should be demonstrated. With skilful use of techniques and forms of teaching and the software the author or authors of the training course or other form of teaching use, e-learning can succeed.

Teaching Techniques

The largest percentage in remembering the content (90%) applies to students who teach others, or "on the fly" use the acquired knowledge. Active methods are the most enjoyable [5] (Fig. 1).

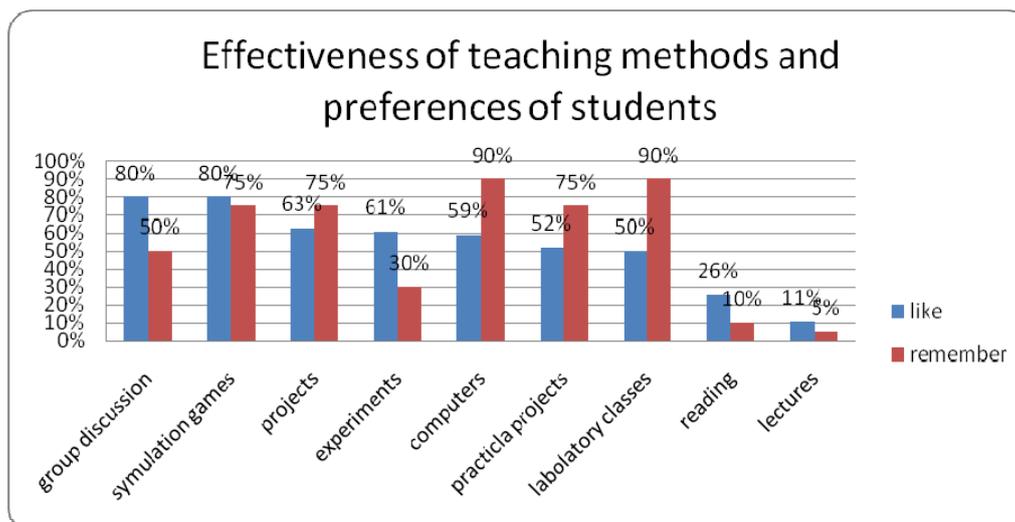


Fig.1 effectiveness of teaching methods [Geoff, 2010]

During the process of teaching a student uses a variety of senses. Studies have shown that the more senses students will use the better they will assimilate new knowledge. The most effective method of teaching are one student by another and the application of knowledge "on the fly." In both methods, the students acquire knowledge as much as 90%. Additionally, studies have shown that 80% of students like group discussions, games and simulations [5]. It is worth noting that in the Polish higher education knowledge transfer takes place in lectures, exercises, labs and project activities.

The lecture is a form, which has the lowest efficiency of transfer of knowledge from those used in education. According to Geoff Pette [5], the student is not able to concentrate on the lecture more than 15 minutes. After this time, followed by involuntary short-term deconcentration and rapid return of concentration, but no longer such a high level as at the beginning. These spikes occur periodically, although the time between successive cases of loss of concentration can be at once less. Long-term loss of concentration during the lecture is also possible. The effectiveness of the lecture as a teaching method sums up the following quote: "The lecture is an event during which teachers' notes and information go to the students' notes without passing through the head of any of them" [5]. Given the obvious shortcomings of the lecture, a question arises why it is used as a form of teaching? The answer is prosaic. It is the simplest form to forward any new material in a short time.

Conductors of lectures are trying to interest students of the subject classes using various teaching aids such as presentation on the projector, store design / important information on the blackboard. Often, teachers are not aware that the concentration of the substance of the lecture are repeated over and over words specific(niejasne) to the lecture such as "do you understand ?", "Mr. and Mrs., please listen to me", body language and tone of voice. It is not easy to capture all those aspects oneself, not to mention the controlling factors arising from the behavior distracting teacher. Using lectures in the form of distance learning described distracting factors can be eliminated easily. The teacher can prepare to the lecture in the form of a multimedia presentation, or in the form of a text file. Such materials may be used as an e-learning course. In addition, this eliminates the problem of distraction associated with the time and amount of knowledge. The student may stop at any time and return later to lecture. The period between successive stages of acquiring knowledge from the course can be quite long. In order to consolidate critical information and reminders lecture should have an implementation plan in the form of bulleted or mind map. Examples of practical applications of knowledge are fun, but related to the topic illustrations, or anecdotes will help to better comprehend the material by a student. At the same time course should preferably be short and pithy, so that the student was not saturated with newly acquired knowledge. On the other hand too summarized lecture without graphical support may not be readable to the recipient. Text

and figures should be seen against the background of the template of the course. Too fancy background or a large amount of graphics can distract from the merits of the lecture. It is important that the layout was clear, the font was too small and sophisticated, and that the paragraphs were not too long.

Sometimes the lecture as an e-learning material containing images and text is not sufficient to transfer the knowledge of a topic or field. You can spice up a lecture with recorded voice of lecturer (teacher), preach or with video from recorded lecture. These are two ways to increase interest and intelligibility of the lecture topics e-learning require a greater commitment from the operator and attention to detail that had previously been described. The advantage, however, is that such recordings may arise in environment suitable for the teacher and the teacher will not have to try to do well every time, only once during the recording.

Much more challenging is to create an effective course design. Manual execution of the project should be available at every stage of its implementation. Additionally, each stage of the project should be described in detail in a separate statement.

User Guide should be short and provide a summary of the stages of the project. Depending on the specific project may be specific deadlines for putting the next part, or the approximate duration of individual stages and the whole project. User Guide can be made in the form of a text file, as a plan. The projects carried out using a computer a good method for the presentation of such instructions may also be an interactive mind map, but also the course skillfully done.

A detailed description of the various stages of the project should be mainly clear and complete for this project to do. But it is not easy. If the instruction is too large then the students will overlook some important parts of looking for those that interest them. In some projects it may be useful to include glossary of terms used, which may be interpreted differently, or inventory of used abbreviations, markings, bibliography.

Same statement concerning the stage of the project depending on its characteristics can be made with the help of e-learning course, or video. In the first case it may be helpful to use photographs, drawings, screenshots, etc. to facilitate the realization of the project. They require a proper description and can be referenced later in the instructions (for example, technical drawing, the menu includes a screenshot). These graphic aids may be interactive so that pupils can see some parts of the transition between each stage of the project during execution. If such material to show the move is a lot or easier to show than to describe it is better to record a video. It is not easy to carry out a good instruction video. You have to take into account not only the factors described in the lecture (body language, voice, etc.), but also a skilful show different parts of the project such as the object during processing, so that the student can later restore it yourself.

The greatest difficulty in carrying out project activities such as classes of network structures or equipment or software setup are all kinds of questions students about the project. Even the most accurate, understandable instructions did not prevent specific questions related to the project. Problems faced by students can be very surprising to lead to such an extent that even when personal contact is hard to find the cause. In the case of projects carried out by means of computer files can be sent by e-mail, put on the page, where you can download (eg chomikuj.pl, send it!). But this is insufficient, because you do not see the steps performed by the project. Another problem is that the design may look different on your computer, the student than teacher. In such situations you can use programs (eg, TeamViewer) to allow the screen to show the student along with this, and its proceedings, whether the teacher showing the student to solve the problem. It is also useful verbal communication for this purpose can be to support programs like Skype, Teamspeak, etc. In the case of projects carried out without a computer or parts will be useful to use the video call, which allows more and more programs such as Skype.

The same tools can be used in laboratories. However, you do not need to follow the main or detailed instructions. You can follow the instructions for each lab in the form of course, video, or text file. Pay attention to the same aspects as for instructions for the projects.

Laboratories can be done via video - a conversation with the Internet and relevant software. It is not easy to perform such a laboratory. Teacher must be well prepared and be able not only to present the material, but also encompass the group.

To sum up, materials must be comprehensible to the recipient, complete topic in the desired range, but possibly informative and attractive form presented to the recipient.

The Tools of Presentation of Knowledge for The Subject Computer Networks.

Some of the popular methods of distance learning include:

- Methods in asynchronous mode - based on individual learning. During the study there is no interaction between teacher and student (also called the student at). The students themselves choose a term of science, which should perform the tasks and tests.
- Methods in synchronous mode - teaching takes place in real time and is taught by a teacher. The method is based on communication with the teacher and student participants of the course. With this method, students have the opportunity to ask questions and get immediate answers.
- Databases - this method provides multimedia encyclopedia, instructions for exercises, etc.
- Online BB - allows quick response to questions and obtain complete answers. Information is exchanged through various forums, chats, e-mail.
- methods combined - rely on a combination of these methods in order to better teaching. It is used when there is a large diversity of groups and some students prefer their own pace of learning, while at the appointed time, led a discussion on the course [e-nauka, 2011] .

In the process of teaching the subject "Computer Networks" it is important to select the appropriate methods. But they cannot provide rigid guidelines for implementing e-learning course. Lectures on this subject require proper communication. The best way to be here for the presentation, which should be further enriched by a variety of illustrations in order to better assimilate knowledge. Presentation itself, however, is insufficient, it is necessary in this situation, to help the operator provide answers to questions asked by students in a specified time.

Laboratories with the subject "Computer Networks" require a completely different approach. You cannot use the presentation here, because during exercise the student may experience difficulties because of their number and different levels of complexity can not be described in the presentation. Necessary instructions are therefore enriched with short instructional clips that step will lead the student to complete the task within the laboratory. These films should also include a lectureship. The person that captures video should clearly make the next steps of the exercise which probably contribute to its understanding by the student.

An important choice in creating the course with the subject "Computer Networks" is the selection of appropriate tools. With the help of coming here and free software, free Moodle, based on Apache, PHP, MySQL or PostgreSQL. Undoubtedly, the advantage is the ability to install software platform for different operating systems. Additionally, the software supports almost 30 languages. It allows communication through forums, chat and exchanging messages. E-learning platform Moodle supports the SCORM standard, which allows you to create materials free programs that allow you a record of courses to this format. For these programs include:

ELearning XHTML editor (eXe)

ELearning XHTML editor (eXe) is a Web-based development environment designed to support teachers and researchers in the design, development and web publication for learning and teaching materials, without having to become proficient in HTML, XML or complicated applications published on the Internet. [EXELearning, 2011]

The Web is a revolutionary educational tool because it presents teachers and students from the perspective of technology, which simultaneously provides to talk about (content) and the means to store the conversation (interaction). Unfortunately, the power of this medium is constrained in educational settings because most teachers and researchers do not have the skills to build their own websites. It must therefore be based on the creators of websites creating professional-looking content online. EXE is still under development, to overcome a number of constraints identified:

- Traditional software is associated with a steep learning curve and it is not intuitive and conclusions were not intended for publication curriculum. Therefore, teachers do not accept these technologies for publishing content on the Internet for learning. eXe aims to provide an intuitive, easy to use tool that allows teachers to publish professional websites for teaching purposes;
- Currently, learning management systems do not offer powerful tools for creating Web content (compared to the software capabilities to create content published on the Internet and the skills of experienced web developers). eXe is a tool that provides the ability to publish professional content on the Internet, giving the ability to easily import by reference or standard learning management systems;
- Most content management systems and learning management systems use a centralized server model, which requires an authorized connection. This is a limitation for authors with low bandwidth or the total lack of connection. eXe is a program working offline without an Internet connection required.
- Many content management systems and learning management systems do not provide an intuitive WYSIWYG environment where authors can see how their material will appear in the browser after the publication, especially when working offline. eXe will mimic WYSIWIG functionality that allows users to see how the didactic material published by them in the network will look like.

With eXe, users can create educational structure that corresponds to their content delivery needs and build resources that are flexible and easy to update. The Outline of the Control Panel window eXe enables users to design an outline that reflects their own preferred hierarchical structure and taxonomy, i.e. topics or units-of books, chapters, poems, etc. This can be fixed at the beginning or it can grow with user demand .

IDevice (instructional equipment) consists of a collection of components that describe the content of the course. Curriculums are developed by selecting from the menu iDevices iDevice and the introduction of teaching content. Educational resources may consist of several or many iDevices required for the effective delivery of content.

eXe offers users the ability to tailor the content published by selecting multiple sheets of graphic styles.

eXe enables the publication of materials in two ways. As a standard web site or as a SCORM content that allows you to place the course in any learning management system.

Moreover, among the applications you can use to create courses, can also be found:

CourseLab

This is a free program for advanced functionality that is used to create high quality e-learning courses. Their power is equal to commercial counterparts. After opening the application and selecting a new project, it offers several built templates to create courses. You can also upload your own template for the program.

The application has a WYSIWYG editor (called What You See Is What You Get). Editing text is done by adding a text box and double-clicking on it. The program allows you to import different kinds of objects using drag and

drop, including: Objects of Adobe ® Flash ®, Adobe ® Application ® Shockwave, Java applets, video clips in various formats, navigational facilities, forms for creating test questions for students.

The program lets you record rates, inter alia, the format LMS SCORM 1.2 and SCORM 2004 LMS.

Learning Content Development System(LCDS)

LCDS is a free application from Microsoft for creating e-learning courses in 16 languages, including Polish. This tool offers basic functionality, and Upper Intermediate. The basic feature concerns the appearance of the course, its layout, font size.

After creating a new project course is divided into lessons, which you can choose among various options. The application has 6 major divisions conducting the lesson. These sections are further divided into 6 different ways of presenting course content.

The first way is "Interaction." Here are five methods of topic: fiction exercises, drag and drop, interactive assistance in completing the task, the slider, the game: Place the order. They provide the student's active participation in exercises.

The second way is to teach classes, "Watching." There is a choice of 4 possibilities of multimedia: animation, demonstration, multimedia material from the key issues and a table with animations. The application, in addition to standard media formats, can also add material created using Silverlight.

Further methods of conducting lessons include games, reading, practical exercises (providing laboratory simulations and scenario / offline) and the classroom.

We provide prepared materials in the form of web pages. It is also possible to import the course into a Word document and export to a package conforming to SCORM 1.2. The new version also offers export to Learning Snacks. These short, interactive presentations, delivered in a Microsoft environment Silverlights. Such files can contain animations, tutorials, and other media. Unfortunately, the program has limitations, which allows you to export only the 6 subjects for a Learning Snacks.

In assessing the above schemes in terms of created materials for the course with the subject "Computer Networks" can be seen that the application eXeLearning offers advanced text editing (color, font size). This is especially important when there is a need to highlight specific text (eg definitions). The program offers a highly intuitive user interface, which allows for quick and easy way to create materials. Therefore, the program will be used to create lecture materials.

Advanced ability to create interactive courses offer two other programs. They allow the creation of various types of quizzes, tests and trials, and the addition of instructional videos. Unfortunately, Microsoft's program has a flaw, which is undoubtedly a poor ability to edit text. The manufacturer has limited his practice to the minimum possible, even forgetting that the basic element as the size of text editing. This causes the program LCDS cannot be used to create lecture materials, which will dominate the text and graphics.

The most appropriate program for creating materials in the subject "Computer Networks" is an application CourseLab. It is a complete program that allows creation of all these materials, enriched the library of objects, which allows adding different types of footage.

Conclusion

The paper has presented the history of distance learning. Description of methods and their analysis are presented as well as programs for creating courses. These courses will be divided into two main types: lecture materials and laboratory materials. The first of these will replace the information provided in lectures in the traditional forms of teaching. This information will, in turn, be divided into materials, containing only text, and such

information will be dry but enhanced with graphics. Some of the lectures will also include films, which in a practical way can assimilate new information.

The second group of materials will be laboratory materials. Due to their specificity, they must in addition to the standard instructions also include instructional videos that provide step by step how to perform exercises. It will be both movies with a teacher, as well as screenshots.

The above-described materials will be made available to students through the use of e-learning platform Moodle. It allows you to manage materials and share them with the right people, while blocking access to unauthorized persons. The application will also enable contact between the student and the teacher and other students, so that any potential problems will be quickly dispelled.

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Models of Petri Nets

MODELING AND SOLVING TECHNOLOGICAL TASKS BY LANGUAGE OF PETRI NETS

Nataliya Golian, Vera Golian, Olga Kalynychenko

Abstract: *The tasks of technological processes' modeling with using of Petri nets are considered in this article. Procedure of presentation and coding maxims of gas discharge circuit's filling by gas composition is shown as example of Petri nets usage. Implementation of those methods and their program realization allow getting results in a minimum time frame.*

Keywords: *model of a gas laser, gas-discharge circuit, Petri net, graph, arc, transition, node.*

ACM Classification Keywords: C.4 Performance of systems - Modeling techniques

Introduction

Graphically Petri net is a directed bipartite graph in which the nodes represent transitions (i.e. events that may occur, signified by bars) and places (i.e. conditions, signified by circles). These two types of nodes are united by the oriented arcs. By the way, every arc can be a link only for different types of nodes.

Also there are exists a notion of token or label of position. The transition is fire when in each of its input positions exist at least one token. Location of the tokens is called a marking of the net. The main lack of the Petri nets is the fact that the time of transition firing is equal to zero. [Dan'ko, 2003].

Analytical representation of Petri nets

Analytically Petri's net is represented by following way:

$$P=(B, D, I, O, M)$$

Where:

B - finite not empty set of places;

D - finite not empty set of transitions;

$I: B \times D \rightarrow (0, 1)$ – input function (direct function of incidence) specify the set of input places for every arc;

$O: D \times B \rightarrow (0, 1)$ - output function (inverse function of incidence) specify the set of output places for every arc;

M – Function of initial net marking. It set each position of a net in conformity with a non-negative integer which is equal to number of tokens in the given position.

Executing of the Petri's net is controlled by the number and distribution of tokens. The necessary condition of firing d_j transition:

$$M(b_i) \geq I(d_j) + 1$$

Tokens in the input position that make transition fire are named enabling tokens. Firing a transition in a marking consumes tokens from each of its input places, and produces tokens in each of its output places.

By another words, firing of the transition d_j change the marking of the net $M(B)$ on the marking $M'(B)$ by the following rule:

$$M'(B) = M(B) - I(d_j) + O(d_j)$$

Petri nets can be described as having different degrees of liveness.

The transition d_j is L0-live (dead), if it can never fire.

The transition d_j is L1-live, if it may fire (i. e. there exist such M that make it enable in this marking).

The transition d_j is L2-live, if it can fire arbitrarily often (i.e. if for every integer n occurs such sequence of firing where d_j attends at least n times).

The transition d_j is L3-live, if it can fire infinitely often (i.e. there exist the infinite sequence of firing where d_j attends often without limits).

The transition d_j is L4-live, if it may always fire (i.e. for every M' exists such sequence of firings that make it enable in this marking).

The transition of zero activity is passive. The transition with L4-live is active.

The main attention in analysis of Petri net is paid for the following directions:

- the reachability problem for Petri net with initial marking M_0 is to decide if there exist some reachable marking M' .

- the coverage problem for given Petri net with initial marking M_0 and marking M' is to decide if there exist such reachable marking M'' that $M'' \geq M'$ [Gusev, 2007].

Review of transitions liveness of the net. Liveness of the net transition implies possibility of its firing in given net with initial marking M_0 . Analysis of liveness allows showing prohibitive states in modeling system.

Review of persistence. The net is preserving when the number of tokens is the same after firing of any transition.

Review of net safety. The Petri net is safe if there is no any condition that make appearance more than one token in every place.

The task of gas discharge circuit's filling by gas composition

This part of article considers the tasks of using the program for modeling the process of gas-dynamic circuit filling by gas composition, where time delays are realized.

Decision of such task can be presented as:

$$HC = \{ N, D, F, \tau, M_0 \},$$

where N – a directed bipartite graph (i.e. Petri net),

D – a set of tokens' descriptors,

F – load-applying reflection which consists of control and operation functions set,

τ – the function that define the time of transition opening,

M_0 – initial marking of the net.

The algorithm of the task is built on the program of uniform technological processes modeling.

The class of loaded nets has high presentation ability and can generate more simple types of nets, too. So, if $D = F = \tau = \emptyset$, then presented upper loaded net with marking lose its load-applying reflections and turn into the class of Petri nets. The program WinPet that is created and supported in order to make the work with Petri nets more easy belongs exactly to such class.

This program is realized and tested on real tasks of time delay modeling and design of joining computer nodes with objects. Interface of the program is shown on fig. 1.

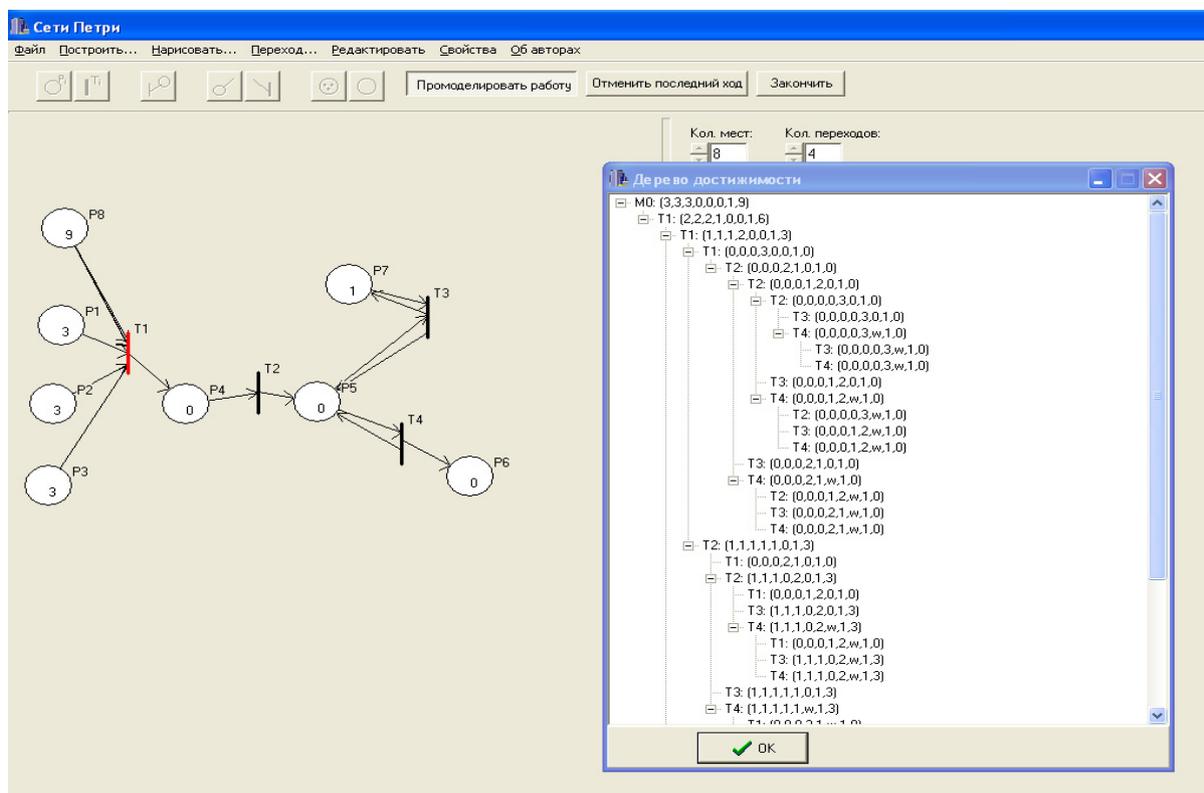


Fig. 1 – Interface of WinPet

Realized method of arcs' specifies extension of bipartite graph Petri allows to order tokens in subject to situation.

The program that represented in this article can be rate as fuzzy Petri nets in sense that allowing variation of depending on initial markup time results.

Logistic approach gives the opportunity to provide modeling of fuzzy Petri nets using this program because fuzziness is appropriated to natural language.

Program can be used by specialists in logistics as computer report document.

Evaluation of graphical abilities' rising of new graphical language class and evaluation of design labour-intensiveness comparing with program (WinPet) for Petri nets was given.

Example of gas-dynamic circuit of gas laser filling was considered for verification of examined method. The model of introduced example with using of colored Petri nets is shown on figure 2.

The method of matrix equation is very hungus and has a lot of lacks. That is why the method of reachability tree is often used.

Reachability tree is a reachability set of Petri net. Every its node is corresponds with one of its markups.

The following method is used to make the tree of reachability not infinite. Let's consider the sequence of transition starts which has begin in markup M and end in $M' > M$.

M' is coincide with M except some additional tokens $M' = M + (M' - M)$. The same sequence of transition starts can give $M'' = M' + (M' - M)$ and so on. Let's present the infinite number of markups that is got from such type cycles by letter w which will identify infinity.

The algorithm of reachability tree building is following.

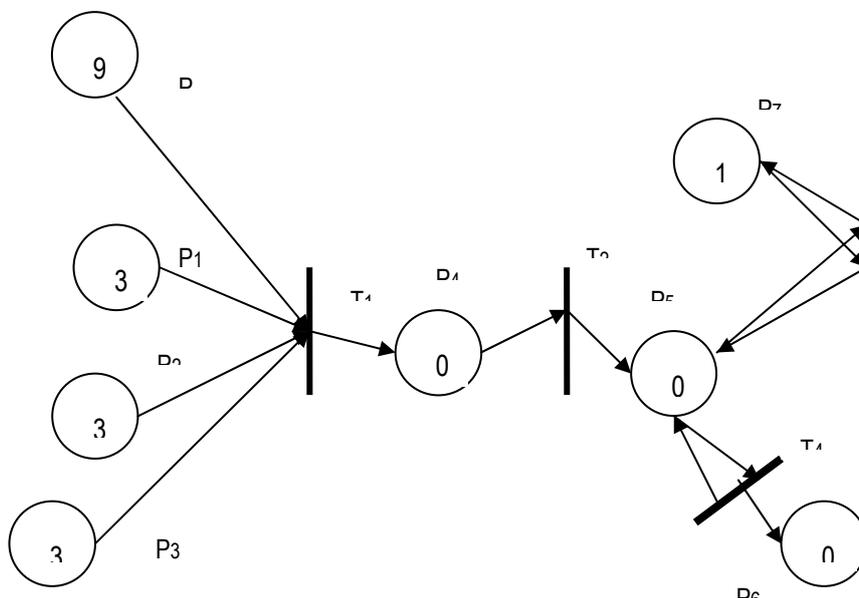


Fig. 2 - The model of introduced example

Every node is classified as boundary, terminal, duplicating and internal. Boundary node is a node which is not processed by algorithm. The algorithm converts it into terminal, duplicating or internal.

The algorithm begins from definition of root node by the input markup.

Let x will be boundary node that is necessary to treat.

- 1) If the tree has another node y which correspond with markup $M[y]=M[x]$, then node is duplicating.
- 2) If there is no any enabled transition for the markup $M[x]$, then x is terminal node.
- 3) To create new tree node z for every transition $d_j \in D$, that is enabled in $M[x]$. The markup $M[z]$, which is connected with this node, is defined for every position p_i by the following way:
 - if $M[x]_i = w$, then $M[z]_i = w$;
 - If there exists the node y on the way from the root node x with $M[y] < d(M[x], d_j)$ and $M[y]_i < d(M[x], d_j)_i$, then $M[z]_i = w$.

- in another case $M[z]_i = d(M[x], d_j)_i$.

Reachability tree for the task of gas discharge circuit's filling by gas composition is shown on fig. 3. The new program WinPet was used for its constructing.

Petri net is safe if and only if the letter w is absent in the tree of reachability and the largest value of the markup component that is correspond with every position, not more than one [Ovezgeldyev, 2002].

Conclusion

Implementation of described methods and their program realization allow getting result of solving the task of gas discharge circuit's filling by gas composition in a minimum time frame. Many other technical tasks can be solved by such way and give optimized parameter of the time.

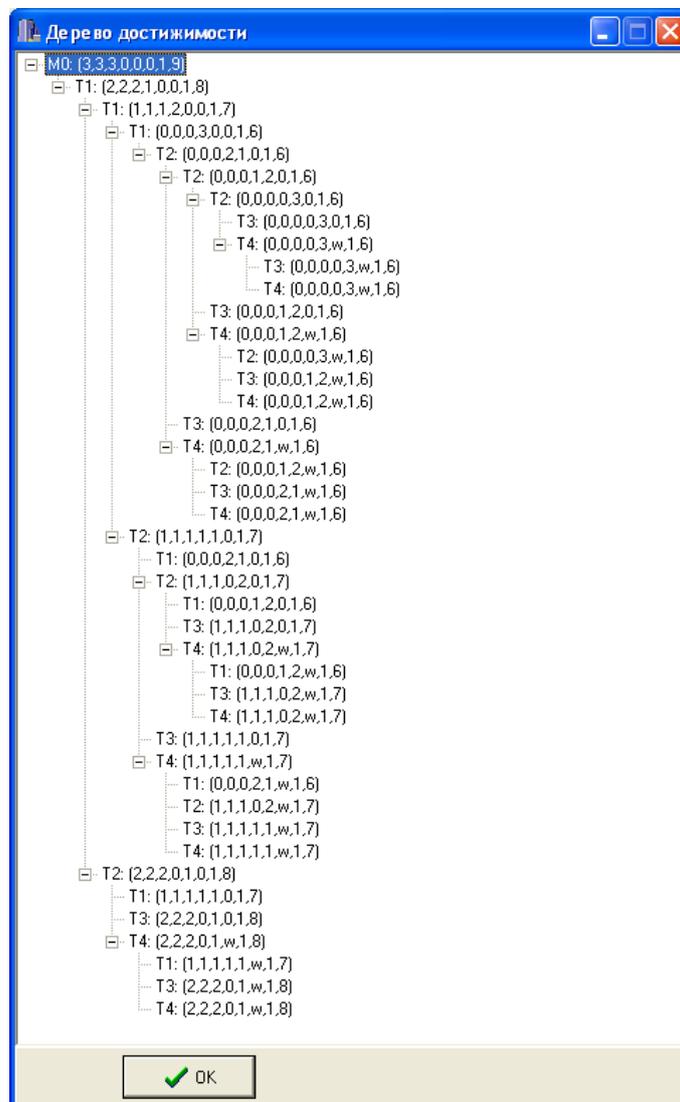


Fig. 3 - Reachability tree for the task of gas discharge circuit's filling by gas composition

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