Preface

This book contains a collective scientific monograph, which presents several important aspects of Intelligent Data Processing in Global Monitoring for Environment and Security. It is a result from two years collaborating of the authors in the frame of Special Interest Group on "Intelligent Data Processing" of the ITHEA International Scientific Society. Many of the results were approbated at the ITHEA International Conferences and were published in the ITHEA International Journals and Thematic Collections.

Global Monitoring for Environment and Security (GMES) is a joint initiative of the European Commission and European Space Agency, which aims at achieving an autonomous and operational Earth observation capacity. The key for operational GMES services is to have an appropriate governance and business model structure supporting these services. GMES is the European Union contribution to the Global Earth Observation System of Systems (GEOSS).

It is clear, the Global Observation is impossible without common scientific work between scientists from all over the world. This monograph is a good example of such collaboration. It unites sixty-two authors from nine countries: Armenia, Austria, Belgium, Bulgaria, Germany, Netherlands, Russia, Sweden, and Ukraine. Editors of the text are *Krassimir Markov* and *Vitalii Velychko*. Technical editors are *Krassimira Ivanova and Iliya Mitov*. A brief explanation of the content of the monograph is given below. The authors of the chapters are given in alphabetical order.

The book is structured in introduction, fifteen chapters collected in three parts, regarding ***practical***, ***theoretical,*** and ***technological aspects*** of Intelligent Data Processing in GMES, and conclusion. In addition, indexes of tables and figures, bibliography and authors information are given.

- ✓ **Introduction**

The introduction presents the United Nations initiative UN-SPIDER and European initiative GMES – observing our planet for a safer world, which are target area of implementation of results outlined in this monograph. Special attention is given to intelligent data processing in GMES and especially to data mining and, in particular, the association rule mining and class association rule classifiers. The introduction is written by *Benoit Depaire*, *Rumyana Dimitrova, Krassimira Ivanova, Krassimira B. Ivanova, Anatolij Krissilov, Krassimir Markov, Iliya Mitov, Koen Vanhoof,* and *Vitalii Velychko.*

- ✓ **Part I. Practical Aspects**

  - ➢ **Chapter 1. Managing Risk and Safety**

Every year many collapses happen in the world, which can be divided into three groups: (1) Natural disasters, (2) Information disasters, and (3) Technogenic disasters.

Natural collapses are hurricanes, floods, earthquakes and other acts of nature, which destroy the whole cities and lead to mass deaths of people. Technogenic collapses are big accidents on industrial and transport objects which have been caused by failure in work of technical systems. Technogenic collapses are accompanied by victims among people and ecological disasters. Information collapses are collapses, which occur in information computer systems. Mainly they occur because of viruses and other harmful programs.

Several examples of these types of collapses and opinions of scientists concerning their reasons are outlined. Examples of different intelligent systems for prediction, risk analysis, and intrusion detection systems are given.

The authors of this chapter are *Levon Aslanyan*, *Venko Bojilov*, *Pavel Burak*, *Natalia Ivanova*, *Olga Korobulina*, *Anatolij Krissilov, Krassimir Markov, Kristian Milenov*, *Pavel Milenov*, *Lyudmila Milenova*, *Radko Radkov*, *Hasmik Sahakyan*, and *Anatolij Shutko*.

- **Chapter 2. High-performance Intelligent Computations for Environmental and Disaster Monitoring**

In this chapter, we present different approaches to multi-source data integration for the solution of complex applied problems, in particular flood mapping and vegetation state estimation using satellite, modeling, and in-situ data. Since these applications are data- and computation-intensive, we use Grid computing technologies. In such a case, computational and informational resources are geographically distributed and they may belong to different organizations. For this purpose, we also investigate benefits of different approaches to the integration of satellite-based monitoring systems.

This chapter is result of common work of *Oleksii Kravchenko*, *Nataliia Kussul*, *Andrii Shelestov*, and *Sergii Skakun*.

- **Chapter 3. Investigation of Geodynamics of Central and Eastern Europe, Balkan Peninsula and Bulgaria**

The investigations related to the global, regional and local geodynamics are particularly important taking into consideration the latest achievements of the science and engineering and as an element of the global monitoring of the Earth (for example Global Monitoring for Environment and Security – GMES, Europe). A number of projects and programs are realized or in process of realization within the framework of an international cooperation – CERGOP (Central European Regional Geodynamic Project), GGOS (Global geodetic Observing System), GMES, etc. The subject is the genesis, character, and development of the natural hazardous processes and their investigation and countermeasures or mitigation. The region of the Balkan Peninsula is one of the most active geodynamic regions not only within Europe. That is the reason for its intensive study. Within the international project CEGRN, the Balkan Peninsula and Central Europe (CE) are subjects of studies of several working groups. The results from the investigations accomplished by the CERGOP-2 project funded by the European Union are presented here. They are based on GNSS (Global Navigation Satellite Systems) campaigns, operation of GNSS permanent stations, data processing, interdisciplinary analysis and interpretation and respective generalizations presented as a special monograph for the Balkan Peninsula (BP). The existing geodynamic picture of BP is confirmed, supplemented, and expanded. Respective measures for reaction are proposed. Within these investigations, a considerable part is devoted to the territory of Bulgaria. Concrete results of them are given here. Additionally an overview is given concerning the movements of the permanent stations from different Balkan networks in the frame of CERGOP. The

complex interdisciplinary significant investigations outline the contemporary approach of regional and national study of such a type.

This chapter is contribution of *Matthias Becker*, *Georgi Milev*, *Ivo Milev*, *Guenter Stangl*, and *Keranka Vassileva*.

- **Chapter 4. Intelligent Tools for Environment Monitoring: Features and Applications**

In this chapter, we present different approaches and tools for monitoring of environment. It is described Bulgarian and Ukrainian experience in development of measurement devices and an organization of express and continuous field electronic measurements for evaluation of main environment parameters.

The authors of this chapter are *Igor Galelyuka*, *Volodymyr Hrusha, Nikola Kolev*, *Martin Nenov*, *Aleksandr Palagin*, *Volodymyr Romanov, Yevgeniya Sarakhan*, and *Vitalii Velychko*.

- **Chapter 5. Intelligent Gamma-Ray Data Processing for Environmental Monitoring**

This chapter discusses machine-learning techniques for intelligent data processing in environmental and security-related monitoring employing gamma spectroscopy. We provide a concise survey of a diversity of methods and algorithms from the machine-learning arsenal applied to multichannel gamma spectroscopy and airborne gamma-ray spectrometry in order to improve the performance of the previous methods. Intelligent data processing techniques observed included sparse approximation, model selection, blind source separation, as well as the Tikhonov regularization and random projections. The chapter is enhanced with experimental results provided to illustrate the comparative performance of the discussed methods.

The contribution is given by *Dmitri Rachkovskij* and *Elena Revunova*.

- **Chapter 6. Acquisition, Processing and Analysis of Space Images at Risks Management of Natural and Technogenic Emergencies**

The chapter is devoted to one of possible approaches to automation in the field of the risk management, based on data processing of remote space monitoring of the spatially-distributed natural and technogenic objects for timely detection maintenance, diagnostics and the development predicate of the dangerous phenomena and emergencies. For acquisition of a digital image set for Earth's surface it is offered to use shooting from space satellites and unmanned aerial vehicles. We propose to eliminate a disadvantage inherent in standard unmanned aerial vehicles management schemes, which are associated with a limited range of management using digital imaging systems, included in the control loop. The visualization system synthesizes a three-dimensional image of cockpit-exterior space based on the unmanned aerial vehicles position and terrain. The set of mathematical methods and stage-by-stage procedures of computer processing of the space images are offered, allowing making a preliminary filtration, to estimate them information compatibility, to carry out qualitative recognition, fixing and tracing of artificial objects. The considered integrated automation means complex provides necessary reliability and quality of achieved results, and also differs high speed that allows to use it and for the analysis of situations in real time.

This chapter is result of common work of *Nataliya Bilous*, *Michael Bondarenko*, *Victor Borisenko*, *Andriy Bugriy*, *Gleb Kobzar*, *Dmitry Makivsky*, and *Andrii Ostroushko*.

✓ Part II. Theoretical Aspects

➢ Chapter 7. Elaboration of Geoinformation Regional Monitoring Environmental System ("GERMES-I") Enriched by Artificial Intelligence Instruments

In last decades and especially within the last few years, there was a steady growth of interest in joint use of both the new methods (and techniques) of advanced geophysical measurements and GIS-technologies, on one hand, and intellectual methods of information processing on the other hand in environment monitoring and territorial management. The chapter presents some leading ideas: use of effective methods and algorithms of estimation, comparison, generalization and decision making under uncertainty; use of contemporary methods of basic earth and water parameters measuring, specifically aerospace microwave radiometry; combining these effective means in the big Regional Monitoring System. Superposition of means mentioned above becomes an indispensable tool for the present when problems of Risk Collisions and Risk Assessment are to be solved.

The presented results reflect experience and common work of *Roland Haarbrink*, *Vladimir Krapivin*, *Anatolij Krissilov*, *Victor Krissilov*, *Eugenij Novichikhin*, *Anatolij Shutko*, and *Igor Sidorov*.

➢ Chapter 8. Microsituation Concept in GMES Decision Support Systems

A set of situation representation levels of subject domain naturally increases in emergent situations. This is connected with increased influence of subject domain factors on prototype system, independently of emergency conditions. Therefore, for emergent situations of possible snow avalanches microsituations could differ of small differences of temperature or changes in wind speed. Development of financial crisis as emergency economic situation is characterized by separate characteristics of microsituations of different facilities, involved in economical process.

Hence, situation includes a set of separate microsituations, each describing properties of prototype system in some characteristic category of its subject domain. Such categories for subject domain could represent internal and external processes, characteristics, advices from both prototype system's point of view and set of factors, which influence from subject domain to prototype system. Separate set of such characteristics without interconnections could hardly precisely describe a situation, because such characteristics are interconnected with each other, involved in different process of prototype system studying.

The presented results are structured and formed by *Alexandr Kuzemin* and *Vyacheslav Lyashenko*.

➢ Chapter 9. Methods and Means for Protection of Software Critical Infrastructures

In this chapter main methods of prevention, protection, and recovery of file objects, exposed to information attacks are discussed. In particular, analysis of different file objects, information attacks, and protection methods most frequently used in Software Critical Infrastructures is made. The analysis is made on the base of available information of National Laboratory of Computer Virology at the Bulgarian Academy of Sciences for accomplished attacks in Bulgaria, Balkan Peninsula, and Southeast Europe.

This overview is written by *Eugene Nickolov* and *Dimitrina Polimirova*.

- **Chapter 10. The MLRP-method for Analysis of Some Problems in Climate and Seismology**

An application of the heterogeneous variables system prediction method to solving the time series analysis problem with respect to the sample size is considered in this chapter. It is created a logical-and-probabilistic correlation from the logical decision function class. Two ways is considered. When the information about event is kept safe in the process, and when it is kept safe in depending process. The very actual problems from hydrological and seismology domains are presented here by MLRP-method.

The chapter represents main results of work and experience of *Tatyana Stupina*.

- **Chapter 11. Polyhedral Coherent Risk Measures and their Application to Investment Decisions Support under Catastrophic Flood Risks**

In this chapter we review some results of the PCRM theory, consider applications to decision making support in conditions of risk, and develop numerical methods for searching optimal decisions. An investment decisions making under catastrophic flood risks is considered as a particular application.

The results are presented by *Vladimir Kirilyuk* and *Vladimir Norkin*.

- **Chapter 12. Techniques for Robust Bayesian Estimation**

This chapter analyzes statistical techniques that are usually used for estimation of reliability parameters. It compares two main approaches: the classical sampling theory methods and the Bayesian approach. It is known that sampling theory methods are inappropriate for treating scarce data samples. In contrast to sampling theory methods, the Bayesian approach allows naturally to incorporate data from various sources in reliability parameters estimates by considering each source as a sample from the same population. However, the justification of a prior distribution frequently is a practical difficulty in the application of the Bayesian approach.

In cases when small datasets of past reliability data are available, it is desirable to estimate how far the calculated Bayesian estimate is from the true Bayesian estimate. Therefore, when only partial prior information is available it is necessary to search upper and lower bounds for Bayesian estimates which can be derived for any prior distribution satisfying the given partial prior information. The chapter considers models for searching such bounds.

The chapter is written by *Alexandr Golodnikov*, *Pavel Knopov*, and *Vladimir Pepelyaev*.

- **Chapter 13. Application of Information Theories to Safety of Nuclear Power Plants**

To this date, strategies aiming at a safe operation of nuclear power plants focused mainly on the prevention of technological breakdowns and, more recently, on the human attitudes and behaviors. New incidents and challenges to safety, however, motivated the nuclear community to look for a new safety approach. The solution became a strong focus on knowledge management and associated theories and sciences as information theories, artificial intelligence, informatics, etc. In all of these, the fundamental role is played by a category of information.

This chapter reviews a number of information interpretations and theories, among which of great relevance are those capturing the fundamental role information plays as a mean to exercise control on the state of a system, those analyzing information communication between agents involved in safety-related activities, and, finally, those, which explore the link between information and the

limits of our knowledge. Quantitative measures of information content and value are introduced. Completeness, accuracy, and clarity are presented as attributes of information acquired by the receiver. To conclude, suggestions are offered on how to use interpretations and mathematical tools developed within the information theories to maintain and improve safety of nuclear power plants.

The text reflects main viewpoints of *Elena Ilina*.

✓ Part III. Technological Aspects

➢ Chapter 14. Growing Pyramidal Networks

The key enabler of increase of search operations efficiency is use of network structures for modeling environments in which problems solving. Orientation to real applied environments essentially raises a level of requirements to network models. The real environments, in which the problem-solving processes operate, have some typical features, such as multicoupling, heterogeneity, hierarchiness, and dynamism. In order to give proper representation of the examined processes, the network structures, used for representing the environment, must take into account these specifics. By their construction, Pyramidal Growing Networks, proposed by Prof. Victor Gladun, were created as answer of these requirements.

Methods for solution of regularities discovery tasks based on pyramidal networks, and methods of using of the retrieved regularities for decision-making are implemented in program complex CONFOR (Abbreviation of CONcept FORmation). In the case of decision-making in risk management, the described objects are assigned to specific disasters and/or emergency situations. This makes it possible to apply universal approach of growing pyramidal networks to analysis of attributive risk management and disaster emergencies.

This chapter is written by *Victor Gladun* and *Vitalii Velychko*.

➢ Chapter 15. Multi-dimensional Information Spaces as Memory Structures for Intelligent Data Processing in GMES

The advantages of multi-dimensional information spaces, used as a memory structures in the processes of data mining and knowledge discovery, is discussed.

Data mining analysis environment "PaGaNe" collects variety of algorithms for statistical analysis and association rule mining. The main focus in the realization is using the advantages of multi-dimensional information spaces, such as: the possibility to build growing space hierarchies of information elements; the great power for building interconnections between information elements stored in the information base; the possibility to change searching with direct addressing in well structured tasks.

The "class association rules" (CAR) algorithms have their important place in the family of classification algorithms. The advantages of associative classifiers can be highlighted in several very important directions, such as: very efficient training; possibility to deal with high dimensionality; no assumptions for the independence of attributes; very fast classification and the result is understandable by humans. The latest two advantages make CAR algorithms irreplaceable assistant in the processes of disaster risk management. Special attention is made on the description of MPGN classifier and its using in the field of disaster prediction.

The authors of this chapter are *Benoit Depaire*, *Krassimira Ivanova*, *Krassimir Markov*, *Iliya Mitov*, *Koen Vanhoof*, and *Vitalii Velychko*.

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The idea to write this book was inspired from several initiatives of the Bulgarian Information Office for GMES, which role is to support this process through exchange of information, transfer of knowledge and good experience, promotion of initiatives, and establishing contacts between potential partners, services providers and users. Main events in this area are First and Second Workshops on GMES Operational Capacity – a joint initiative of the Bulgarian Government and the European Commission. The First Workshop was officially opened by the Prime Minister of Bulgaria – Mr. Boyko Borissov. The participants were also welcomed by a video address from European Commissioner for International Cooperation, Humanitarian Aid, and Crisis Response – Mrs. Kristalina Georgieva. More than 160 participants from about 15 EU Member-states and representatives from different EU organizations and institutions such as DG ENTR, DG ENV, DG ECHO, DG JRC, European Space Agency, European Environmental Agency, EUMETSAT, etc. took part in the event. The second GMES Operational Capacity Workshop has been planned to be in March 2011, again in Sofia, at the same high governmental level. This event is after time of publishing of this monograph. Because of this, we recommend readers to visit http://gmes-bg.org where one can find more information about the event as well as presentations, pictures, and movies.

The Bulgarian EO-GMES initiative aims to support the participation of Bulgaria and other member-states and candidate countries in the European Earth Observation Program – Global Monitoring for Environment and Security. The establishment of a single national point called Bulgarian Information Office for GMES (BIOG) concentrates information, advisory and support activities related to GMES in one institution, what should result in an increased efficiency and synergy.

The project focuses on the following priorities:

- support for participation of Bulgarian institutions, organizations in GMES thematic projects and introduction of institutions from other candidate countries into these projects;
- support in developing national and regional operational capacity in GMES services;
- support for growth of user segment of GMES-related projects;
- enhancing the active participation of the Community's small and medium enterprises, especially those from the (new) member states still not so experienced in the space applications market;
- support to the realization of a special capacity building unit as part of the GMES program (including the space segment) in the (new) member states;
- clear distinction and different approach between environmental monitoring and risk and security management;
- support to the close cooperation between EU Program GMES and EU Directive INSPIRE and the use of reference information systems (data bases) for harmonization in the process of integration of the spatial data base;
- support for the establishment of a European Mediterranean Network for risk and security management

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It is represented that book chapters will be interesting for experts in the field of intelligent technologies for global observation as well as for practical users.

Krassimir Markov, Vitalii Velychko

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