

Scientific report for the 1st period

PART 1 – INFORMATION ON PROGRAM

- 1.1. The title: Next Generation Information and Communication Technologies
- 1.2. The acronym: NexIT
- 1.3. The Web page address - <http://lumii.lv/resource/show/761>
- 1.4. The principal investigator (PI): Dr.sc.comp. Andris Ambainis, +371 67034517, andris.ambainis@lu.lv
- 1.5. Contact person: Ināra Opmane, 67224730, imcs@lumii.lv
- 1.6. The reporting period: 01.11.2014-31.03.2015
- 1.7. The programme aim and objectives:

The aim: to develop scientific capacity in the field of next generation information and communication technologies through creating new and competitive approaches to integrating physical and virtual worlds in cyber-physical systems, developing competitive and innovative intelligent sensing software and hardware platforms for their networks, as well as studying and developing competitive model-based information and communication technologies and their applications in modern web-based environments.

Objectives:

- to conduct a research into quantum technologies and information security, and develop ontology-based technologies;
- to develop large scale data visualization and image-processing technologies and their applications, including for acquiring biometric data and performing qualitative analysis on images of tissues;
- to develop new technologies and software for bioinformatics and biomedicine;
- to conduct a research into big data and knowledge engineering, including processing of medical, satellite and space data;
- to develop methods for mathematical modelling, high performance computing and cyber-physical systems, and to test their application in medicine and smart cities;
- to conduct a research into smart transport systems and develop innovative solutions in the field.

- 1.8. Executive summary of the programme
(max. two A4 pages. Summary of scientific results achieved during reporting period, their scientific and applicational significance)

Six universities and research institutions are engaged in implementing the programme (the University of Latvia, the Institute of Mathematics and Computer Science, Liepaja University, Riga Technical University, the Transport and Communications Institute, and Ventspils University College).

We have started research in all the projected research areas of the programme: information security and quantum computing, ontology and semantic web, data visualization and computer graphics, mathematical modelling and solving inverse problems, infrastructure for

big data, cyber-physical systems and sensor networks, ICT applications in medicine and other fields.

The programme covers a wide range of research topics and includes high-quality long-term research (for example, our studies in quantum computing, which have received very high international recognition), applied work with immediate applications for the ICT industry (for example, in the field of information systems) and interdisciplinary research aimed at applying ICT methods in other areas (for example, in medicine).

Among our research results, particularly noteworthy are the following:

- bioinformatics research by a group of scientists from several countries including the programme members E. Celms and J. Viksna (the Institute of Mathematics and Computer Science), who performed analysis of DNA sequencing data of RCC (renal cell carcinoma) biopsies. The research sample comprised the total of 2500 patients. In the result, a number of new diagnostic and prognostic biomarkers have been identified. The paper describing results of this study was published in Nature Communications, one of the most highly rated scientific journals;
- a study into the theory of quantum computing by programme member A. Ambainis (the University of Latvia) together with S. Aaronson (MIT), which determines the maximum possible gap between quantum and conventional computing and contains both a quantum algorithm that achieves this gap (for the problem of testing whether the Fourier transform has been performed correctly), as well as a precise mathematical evidence proving that no bigger advantage of quantum algorithms can be achieved. The paper describing this work has been accepted by the ACM Symposium on the Theory of Computing (STOC), which is one of the two leading theoretical computer science conferences in the world.
- the work on semantic information systems by a group of researchers lead by K. Čerāns (Institute of Mathematics and Computer Science), including the development of an original notation for describing aggregate queries over RDF databases in a visual query language, the study and implementation of mappings from relational databases to OWL ontologies, as well as development of a user interface for ontology-based data browsing and management platform, to enable users with no IT background to formulate queries to a database.
- the work on developing the Big Data platform of the Institute of Mathematics and Computer Science (an important part of Latvian national research infrastructure), on developing the concept of the new generation cloud computing infrastructure in Latvia. We have also developed a large volume image-processing solution on the existing IMCS UL Big Data platform; it uses all computational capacity of the platform and is able to simultaneously process multiple images, thus substantially reducing the time required for processing large volumes of data.
- a research into extracting information from medical images (images of CT or MRI scans) and recordings (EEG recordings), in collaboration with the local hospitals and the University of Lorraine (France).

A total of 12 research papers have been submitted or prepared for submission, with 4 of them already published or accepted for publication. (Since the reporting period is relatively short, many of the papers are still in the manuscript stage.) A number of presentations on the research results have been given, both at international conferences and local events with students among the target audience.

Several of tasks have been carried out in collaboration with researchers in other countries:

- bioinformatics research-together with partners of the CAGEKID (Cancer GENomics of KIDney) network, which involves 14 institutions in 7 countries (France, the Czech Republic, Sweden, Latvia, Russia, Germany and the UK);
- quantum computing research-together with partners of the QALGO (Quantum ALGORithmics) network, which involves 7 institutions in 7 countries (Latvia, France, the UK, the Netherlands, Belgium, Germany, and Israel), and together with our US partners (in particular, at MIT and New York University);
- biomedical research-together with the University of Lorraine, France.

Among researchers of the programme, we have 16 Ph.D. students, 8 M.Sc. students and 18 recent Ph.D.'s (who have received their Ph.D. in the last 10 years). Two Ph.D. theses and one M.Sc. thesis have been defended, based on the work of the programme in Period 1.

1.9. The programme results

Performance indicator	Results	
	Planned	Achieved
Scientific performance indicators		
1. Scientific publications:		
number of original scientific articles Z(SCOPUS)(SNIP>1)	1	4 (including 3 in preparation)
number of other original scientific articles included in Web of Science or SCOPUS databases	1	6 (including 3 in preparation)
number of original scientific articles enclosed in magazines of database <i>ERIH(A and B)</i> or in conference proceedings		2 in preparation
number of reviewed scientific monographs		
2. Within the framework of the programme:		
number of <u>defended</u> doctoral thesis	1	2
number of <u>defended</u> master's thesis		1
3. Development of the research and education IT centre that provides remote access for regional higher education institutions (Regional Partner Research Facility)		
4. Setting up a strategic research council for processing partner information		
Performance indicators of the promotion of the programme		
1. Interactive events to promote the process and results of the programme. Target groups should include students and the number of:		
conferences	1	12
seminars		2
Seminars, organized		
popular-science publications	1	1
exhibitions		
2. Press releases		
Economic performance indicators		
1. Size of the private funding attracted to the scientific institution within the framework of the		

programme, including:		
1.1. co-funding from the private sector for implementing the projects of the programme		
1.2. income from commercializing the intellectual property created within the framework of the programme (alienation of industrial property rights, licensing, conferring exclusive rights, or rights to use fees)		
1.3. income from contractual jobs that are based on the results and experience acquired within the framework of the programme		
2. Number of applied for, registered, and valid patents or plant varieties within the framework of the programme:		
in Latvia		
abroad		
3. Number of new technologies, methods, prototypes or services that have been elaborated within the framework of the programme and approbated in enterprises		
4. Number of new technologies, methods, prototypes, products or services that have been submitted for implementation (signed contracts on the intellectual property transfer)		
5. Spin-off companies established		

In case of deviation from the plan, justification of the deviation, and the projected activities for mitigating the deviation.

No deviations in the 1st period.

1.10. List of the programme outputs:
(List of publications, conference thesis, etc.)

Publications

1. Original scientific publications indexed in SCOPUS (SNIP>1)

1. G.Scelo,...., E.Celms, J.Viksna et al. "Variation in genomic landscape of clear cell renal cell carcinoma across Europe", *Nature Communications*, vol. 5, doi:10.1038/ncomms6135, 2014, (IF: 11.47 SNIP: 2.952).
2. Scott Aaronson, Andris Ambainis: Forrelation: A Problem that Optimally Separates Quantum from Classical Computing. Proceedings of the ACM Symposium on Theory of Computing (STOC'2015), (SNIP: 2.418). Prepared for publication during the reporting period, published after the end of the reporting period.
3. Andris Ambainis, Aleksandrs Belovs, Oded Regev, Ronald de Wolf. Efficient Quantum Algorithms for (Gapped) Group Testing and Junta Testing. Proceedings of SIAM/ACM Symposium on Discrete Algorithms (SODA'2016), (SNIP: 1.644).

Prepared for publication during the reporting period, published after the end of the reporting period.

4. Gundars Korats, Steven Le Cam, Radu Ranta and Valérie Louis-Dorr A space-time-frequency dictionary for sparse cortical source localization; Jurnal: IEEE Transactions on Biomedical Engineering (IF 2.347, SNIP 1.772). Prepared for publication during the reporting period, published after the end of the reporting period.

2. Other original scientific publications indexed in SCOPUS

1. Zabasta A., Kondratjevs K., Kunicina N., Ribickis L. Wireless Sensor Networks and SOA Development for Optimal Control of Legacy Power Grid. In: Proceedings of the 16th International Conference on Mechatronics "Mechatronika 2014", Czech Republic, Brno, 3-5 December, 2014. Brno: Brno University of Technology, 2014, pp.113-118. ISBN 978-80-214-4817-9.
2. Sh.E.Guseynov, J.V.Aleksejeva, S.A.Andreyev (2014). On one regularizing algorithm for comprehensive diagnosing of apparatus, engines and machinery. – Advanced Materials Research, Trans Tech Publications, Switzerland, p. 254-257.
3. Sh.E.Guseynov, A.N.Medvedev, R.Guseinovs, L.V.Baranova (2014). Investigation of one macro-level model of distribution logistics. – Advanced Materials Research, Trans Tech Publications, Switzerland, p. 311-316.
4. Andris Ambainis, Jevgenijs Vihrovs: Size of Sets with Small Sensitivity: A Generalization of Simon's Lemma. Prepared for publication.
5. Kārlis Čerāns, Guntars Būmans. RDB2OWL: A Language and Tool for Database to Ontology Mapping. Prepared for publication, to be submitted to SCOPUS-indexed journal/conference.
6. Kārlis Čerāns, Aiga Romāne. OBIS: Ontology-Based Information System Framework. Prepared for publication, to be submitted to SCOPUS-indexed journal/conference.

3. Other publications

1. Rihards Balodis, Inara Opmane. Procurement Management Experience of Scientific Cloud Facility Set Up. ACMASS-6194, ACMASS 2015, Annual Conference on Management and Social Sciences.
2. Rihards Balodis, Inara Opmane. Milestones of complex computing facility assembling . Grid, Cloud & High Performance Computing in Science. RO-LCG.

Ph.D. and M.Sc. theses

- Ph.D. thesis “Network virtualization based on effective packet transformations”, Leo Truksans, University of Latvia.
- Ph.D. thesis “Data as an ontology – storage, queries, visualization”, Mārtiņš Zviedris, University of Latvia.
- M.Sc. thesis „Development of a strategy of using cyberphysical systems for medical institutions”, Aļona Skorobogatjko, Riga Technical University.

Talks at conferences:

1. A. Ambainis. New developments in quantum algorithms. University of Latvia conference, February 13, 2015.

2. J. Vihrovs. Sensitivity and block sensitivity of Boolean functions. University of Latvia conference, February 13, 2015.
3. K. Čerāns, G. Bārzdiņš, G. Būmans, J. Ovčiņņikova, A. Romāne, M. Zviedris. Semantic database platform: possibilities and challenges (in Latvian). University of Latvia conference, February 13, 2015.
4. Martins Krasnovs, Zigurds Markovics. Computerized decision-making of treatment choices for patients with kidney stones. Proceedings of 18-th International Conference Biomedical Engineering 2014, 27-28 November, 2014, Kaunas, Lithuania, pp.93-96
5. Zabasta A., Kondratjevs K., Kunicina N., Ribickis L. Wireless Sensor Networks and SOA Development for Optimal Control of Legacy Power Grid. No: 16th International Conference on Mechatronics "Mechatronika 2014", Czech Republic, Brno, December 3.-5., 2014.
6. Skorobogatjk A., Romanovs A., Kunicina N. State of the Art in the Healthcare Cyber-physical Systems. Riga Technical University Conference, 2014.
7. Patlins A., Kunicina N., Adrian L. Sensor Networking and Signal Processing Applications in City Transport Systems. No: Transport Means 2014: Proceedings of the 18th International Conference, Lithuania, Kaunas, 23.-24. October, 2014. Kaunas: Technology, 2014, 355.-359.lpp. ISSN 2351-4604.
8. Zenina N., Romanovs A., Merkurjevs J., "Incoming generated traffic flow estimation based on transport access design and level of service". WSEAS 8th International Conference on Urban Planning and Transportation. 10-12 January 2015, Tenerife, Spain.
9. A. Pilipovecs and A. Grakovski. "Fibre-optic sensors calibration method based on genetic algorithm in weight-in-motion problem." Proceedings of the 14th International Conference "Reliability and Statistics in Transportation and Communication" (RelStat'14), 15–18 October 2014, Riga, Latvia. I. V. Kabashkin and I. V. Yatskiv eds. 2014. pp. 192–199.
10. L. Gulbe "Topicalities in urban area remote sensing" (in Latvian), Christmas conference of Ventspils University College, December 18, 2014.
11. D. Bezrukovs, B. Rjabovs, "Microwave Spectral Polarimetric Observations of the Sun in Irbene", (in Latvian), Christmas conference of Ventspils University College, December 18, 2014.
12. Vl. Bezrukovs, I. Šmelds, "Using of large scale antenna fields for ionospheric research" (in Latvian), Christmas conference of Ventspils University College, December 18, 2014.

Popular science publications

1. Skorobogatjko A., Romanovs A., Kunicina N. State of the Art in the Healthcare Cyber-physical Systems. Information Technology and Management Science. Vol.17, 2014, pp.126-131. ISSN 2255-9086. e-ISSN 2255-9094. Available from: doi:10.1515/itms-2014-0019

PART 2: PROGRAMME PROJECT INFORMATION

2.1. Project No. 1

Title	Ontology technologies, semantic web and security	
Project leader's name, surname	Kārlis Čerāns	
Degree	Dr.sc.comp.	
Institution	IMCS UL	
Position	Leading Researcher	
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Project goal and objectives

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

The following objectives have been set:

- developing new methods of computing for quantum computers;
- analysing security of cryptographic schemes against quantum computers;
- studying mathematical objects related to quantum computing;
- designing, implementing and evaluating web-based tools for graphical OWLontology modelling;
- developing principles and language for defining and graphically presenting data ontologies, and management of the corresponding ontology-conformant data;
- developing, applying and evaluating language and tools for external data translation into RDF/OWL format;
- developing, applying and evaluating languages and web-based tools for analysis and management of data in ontology-conformant knowledge bases
- developing combined graphical and controlled natural language techniques for ontology design, lexicalization and querying.

Description of the acquired scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

1. We have analysed the power of quantum algorithms that use a very small number of quantum steps. We studied the commonly used quantum query model which measures the complexity of an algorithm by the number of accesses (queries) to input bits that it makes. We have shown that:
 - a. a quantum algorithm making one query to input data of size N can be simulated by a conventional (classical) algorithm $O(\sqrt{N})$;
 - b. this is essentially optimal: there is a computational task (the FORELATION problem) solvable with one query classically, but requiring $\Omega(\sqrt{N}/\log N)$ queries quantumly;

- c. the first result can be generalized to k query quantum algorithms being simulatable with $O(N^{1-1/2k})$ queries classically
2. We have studied quantum algorithms for property-testing problems. In property-testing problems, one has to differentiate the input data that satisfy a certain property (e.g. being sorted) from the input data that are far from satisfying this property. In many cases, very fast algorithms can be designed for addressing problems of this type.

In particular, we studied the junta testing problem (motivated by machine learning), in which one has to determine if a function f (specified by a black box that can evaluate f on arbitrary input data) depends only on a small number of variables. We have designed a quantum algorithm that is substantially faster than both the best classical algorithm and the best previously known quantum algorithm.

3. We have studied the sensitivity of Boolean functions, a combinatorial quantity with possible connections to both classical and quantum algorithms. We have shown structure theorems about the structure of Boolean functions with small sensitivity.
4. In order to prepare the technological basis for web-based graphical OWL ontology modelling tools, the principles and architecture of universal modelling tool building platform web-TDA 2.0 have been defined, implementation of the web-based superstructure to modelling repository interface RA-API (working up to now in desktop technology) has been started.
5. The existing solutions for the relational database to ontology mapping tasks (when there is no 1:1 correspondence between the database and ontology structure) have been studied; the options for the RDB2OWL database to ontology mapping tool applications have been explored.
6. The ontology import and visualization parameter structure has been developed for user-guided ontology import into the graphical ontology visualization and editing tool OWLGrEd. A notation and services have been developed for data ontology representation in the OWLGrEd ontology editor.
7. The constructions for aggregate query introduction into the visual query language, and tool ViziQuer for the custom query formulation over SPARQL-enabled RDF databases have been defined and initially prototyped.
8. The OBIS framework for generating automated data-management applications from the data schema, specified as annotated OWL ontology, has received a refined user interface annotation set, as well as generic data handling features necessary for the framework's practical usability.
9. The experiments have been conducted on co-use of graphical and controlled natural language techniques for ontology presentation, as an extension to the OWLGrEd ontology editor.

Further research and practical exploitation of the results

(Describe further research activities that are planned, describe possibilities to practically exploit results)

The following research activities have been projected:

1. to continue our investigation of quantum algorithms with a small number of queries. We will study concrete computational tasks, to determine whether our bound of $O(N^{1-1/2k})$ queries for classically simulating a quantum algorithm with k queries is optimal;
2. to study the questions about the maximum gap between quantum and classical algorithms in other settings, e.g. for computational tasks which have to be defined for any set of input data (total Boolean functions);
3. to study the mathematical objects that have emerged out of our work on quantum algorithms with a small number of steps, e.g. approximations by block multilinear polynomials;
4. to study how our result on sensitivity can be applied to better relate sensitivity to other quantities that characterize Boolean functions (including the complexity of quantum and classical algorithms computing them);
5. to investigate the security of commitment schemes and zero-knowledge proofs against a quantum attacker, in collaboration with our partner institution Tartu University, Estonia;
6. to publish web-TDA 2.0 platform for building web-based modelling tool as a proof of the concept, as well as to apply it in concrete modelling tool building tasks (e.g. a web-based analogue of OWLGrEd ontology modelling tool);
7. to apply the RDB2OWL database-to-ontology mapping tool on concrete use cases, presumably from medical domain (although the potential application area is much wider), and investigate further use-case driven requirements in the mapping language and tool enrichment, as well as its comparison against other existing database-to-ontology mapping solutions;
8. to complete implementation of the user-guided ontology import and visualization process for the OWLGrEd ontology editor, and made it readily available for the web-based version of the editor. The ontology export functionality will be reorganized also in a modular way to achieve smooth customizability of the editor, which is required both for migration into web-environment and the editor's adaptability to concrete use cases. The experiences and achievements from the migration between the conventional and UML-based ontology presentations are to be prepared as a publication.
9. to further develop the ViziQuer and OBIS tools and apply them in concrete use cases of analysis and management of data in ontology-conformant data repositories. Further publications of both the theoretical language constructs and the practical tool applications are foreseen.

10. to advance the experiments for combined use of graphical and verbal notations for OWL ontology presentations and upgrade them with metrics that demonstrate the effectiveness of the use of the combined notation.

Dissemination and outreach activities

(Describe activities that were performed during reporting period to disseminate project results)

5 preprints have been prepared, submitted or accepted for publication:

Scott Aaronson, Andris Ambainis: Forrelation: A Problem that Optimally Separates Quantum from Classical Computing. STOC'2015, accepted for publication

Andris Ambainis, Jevgenijs Vihrovs: Size of Sets with Small Sensitivity: A Generalization of Simon's Lemma. Prepared for publication.

Andris Ambainis, Aleksandrs Belovs, Oded Regev, Ronald de Wolf. Efficient Quantum Algorithms for (Gapped) Group Testing and Junta Testing. Proceedings of SIAM/ACM Symposium on Discrete Algorithms (SODA'2016), (SNIP: 1.644).

Kārlis Čerāns, Guntars Būmans. RDB2OWL: A Language and Tool for Database to Ontology Mapping. Prepared for publication.

Kārlis Čerāns, Aiga Romāne. OBIS: Ontology-Based Information System Framework. Prepared for publication.

Three presentations have been given at the conference of the University of Latvia, with students among the target audience:

A. Ambainis

Jaunumi kvantu algoritmu jomā (New developments in quantum algorithms)

J. Vihrovs

Būla funkciju jutīgums un bloku jutīgums (Sensitivity and block sensitivity of Boolean functions)

K. Čerāns, G. Bārzdiņš, G. Būmans, J. Ovčiņņikova, A. Romāne, M. Zviedris. Semantisko datubāzu platforma: iespējas un izaicinājumi (The Semantic Database Platform: Possibilities and Challenges).

Doctoral theses defended:

Mārtiņš Zviedris “Data as an ontology – storage, queries, visualization”

2.1.2. Project No. 2

Title

Biomertory, biosignals and non-invasive diagnostic technologies.
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Project leader's name, surname

Janis Hofmanis

Degree

PhD, Dr.sc.comp

Institution	Ventspils University College	
Position	Lead researcher	
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Project goal and objectives

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

To develop new and modern E-medicine technologies that affect acquiring and processing of biosignals/bioimages for diagnosing diseases and pathologies, utilization of computerised decision-support system with knowledge bases and artificial intelligence, providing screening and clinical approbation.

Description of acquired scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

1. During the first period, three main databases were created:
 - Medical imaging database (MRI, CT) from around 40 patients.
 - Database of invasive EEG (iEEG) and surface EEG recordings.
 - Matlab Toolbox for algorithms and methods to access and analyse medical imaging and iEEG data.
2. The conference article “Sparse cortical source localization usingspatio-temporal atoms” has been submitted to and later accepted by IEEE 37TH ANNUAL INTERNATIONAL CONFERENCE OF THE Engineering in Medicine and Biology Society. Articles published in MEDLINE/PubMED database.
3. A manuscript for the article on multimodal segmentation methods for detailed matter information extraction has been prepared. Segmenting both CT and MRI gives more accurate hard matter and soft matter distribution in head models of patients, which can be used in studies of bioelectromagnetic propagation and EEG analysis, as well as in intracranial electrode positioning.
4. A manuscript for the article “An Approach for Fast Statistical Data Extraction from Biomedical Objects” has been prepared. It analyses photographic images of aortic valve taken after surgical operation. In this study, authors use different methods for extracting statistical data from the images. The experimental results show the efficiency of the selected methods and proposed modifications. Articles will be published in EBSCO, ProQuest and VINITI databases.
5. Also, during the reporting period, it researchers worked to improve previously developed methods of solution of incorrect inverse multiparameter tasks using Tikhonov regularization. The main emphasis was put on the different regularization parameter determination methods comparison and verification using the determination of the spectral line profile as the test The solution of Fredholm first kind integral equation was done under special conditions. The different level of noise was generated and investigated.

At the same time, the work was continued on doctoral thesis of N.Zorina (Solving of inverse spectroscopy problems by means of Tikhonov's regularization method). Four chapters of doctoral thesis are finished. The chapters are devoted to 1) solution of model tasks, 2) limitation of usage of method, 3) description of the written programs (programs for real spectral line profile obtaining by means of solution of the ill posed inverse tasks), 4) summary of the articles. The research paper was prepared for submission to the journal: "Inverse problems".

Further research and practical exploitation of the results

(Describe further research activities that are planned, describe possibilities to practically exploit results)

The gathered data and developed algorithms and tools will be used in further research in EEG and medical image analysis. The work on developing several articles has already been started; the articles will discuss the results from the applied techniques.

Further research includes using WebGL technologies to provide neurosurgeons with online tools for positioning electrodes in 3D space using gestures acquired by infrared cameras. Additionally, statistics from segmented brain images can be exploited for radiologists in analysing 3D images online.

During the reporting period, research into statistical counting of objects on the images was performed. Preliminary results were obtained showing the counting error of about 8%. In the next periods research will be finished and a scientific paper manuscript will be prepared. Research will be continued in the next period, and the expected result is a DICOM file image segmentation and comparison with the previous results, as well as a scientific publication.

Also a technical specification of the set-up for biomedical application - system for early detection of cancer using CRDS (cavity ring down spectrometry) method was created. This biomedical set up will be installed until end of year. It is planned that the thesis of N. Zorina will be completed by the end of year 2015.

During this period research about natural graph graph recognition (such as neuron images, blood vessels) was performed. Research will be continued in the next period yielding a graph recognition technology and a scientific publication.

Gundars Korats, Steven Le Cam, Radu Ranta and Valérie Louis-Dorr A space-time-frequency dictionary for sparse cortical source localization; Journal: IEEE Transactions on Biomedical Engineering (IF 2.347, SNIP 1.772). Prepared for publication.

Dissemination and outreach activities

(Describe activities that were performed during reporting period to disseminate project results)

Talks at conferences:

Martins Krasnovs, Zigurds Markovics. Computerized decision-making of treatment choices for patients with kidney stones. Proceedings of 18-th International Conference Biomedical Engineering 2014, 27-28 November, 2014, Kaunas, Lithuania, pp.93-96

Several outreach activities were performed:

1. Meeting Ventspils Hospital medical personnel. Presenting the newest possibilities in signal and image processing concerning radiological images.
2. Talks with Riga Stradiņš University on developing a new project proposal about using IT technologies in rehabilitation, and signal and video analysis.
3. Talks with the Heart Surgery Centre of Pauls Stradiņš' Clinical University Hospital on developing a new IT solution proposal in using image segmentation and statistical analysis.

2.1.3. Project No. 3

Title	Sensor networking and signal processing applications in the economy	
Project leader's name, surname	Nadezhda Kunicina	
Degree	Dr.sc.eng.	
Institution	Riga Technical University, Department of Industrial Electronics and Electrical Technologies	
Position	Professor	
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	<i>E-mail</i>	Nadezda.Kunicina@rtu.lv

Project goal and objectives

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

The main goal of the project is development and practical implementation of new methods for processing large amount of data, which will allow acquiring, storing and interpreting data about the urban environment as well as modelling its processes using high performance computation and next generation smart sensor infrastructure. This will ensure automatic or semi-automatic high level decision making to minimize losses and damages in case of any critical situation.

Objectives:

- 1) To develop a safety-monitoring and modelling solution for the urban environment via applying high performance data processing technologies.

Currently, the urban environment monitoring in Latvia is based on the efforts of human-operator, who monitors the current situation and makes decisions when and where necessary. The variety and amount of data provided by the next generation smart sensors in cities like Riga will allow a more precise interpreting and forecasting of the city processes. To provide means for processing the acquired data, it will be necessary to increase processing capacities, which without novel data processing methods and appropriate technical equipment will not be possible. Therefore, this task will address development of new data processing methods, which will enable consolidation and interpretation of different by their nature big data in order to provide means for human – operator and automatic reasoning solutions to make high

quality decisions about the urban environment processes and their unwanted developments. Within the project, our intension is to integrate data streams form different types of sensors including surveillance cameras, which will provide very intensive real time data streams. Currently, the research activities are concentrated on single camera data processing, or small number of camera data processing, which is relevant within robot navigation applications. Therefore in order to enable large amount of data processing the methods elaborated within this project have to address the use of new types of hardware – of high performance computers, which have been introduced within the State Importance Research Centre projects and are available to Latvian scientists. The big data challenges defined hereby are of high research importance internationally as well, including the European Commission research programme H2020, where the problems are defined under challenge ICT-16 and the first calls are open this year.

- 2) To develop and explore intelligent sensor network technologies and applications of intelligent transportation systems.

Sensor technology review. This task will be implemented within the framework of the sensor technology review and analysis. Advantages and disadvantages will be identified. Results of the analysis will identify the existing inconsistencies between the requirements of a new system and existing technologies. The identified discrepancies will be remedied by developing new types of sensors (or upgrading of existing)

The case study is based on applying sensing technologies to collect data on the traffic flows (such as average speed, structure of traffic flow, etc.). The obtained information can be used in managing traffic flows from a single traffic control centre. Moreover, the obtained data can be used as a source data for modelling. In this case, model could be used as short-term forecasting tool. It is important to combine four elements of the system: sensing technologies, data transfer, simulation of traffic flows, and decision-making. It also must be noted that different additional services could be added to the system, such as weight control system (WinM problem) etc. One of the expected project results is development of a detailed concept of the on-line traffic management system.

The goal of the project subtask is to research and develop the concept of using sensing technologies for organizing a traffic control centre. In a frame of the concept, the system's structure, functionality, input / output data etc.will be described.

Description of acquired scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

The original scientific publications included in the SCOPUS database – 1

Zabasta A., Kondratjevs K., Kunicina N., Ribickis L. Wireless Sensor Networks and SOA Development for Optimal Control of Legacy Power Grid. In: Proceedings of the 16th International Conference on Mechatronics "Mechatronika 2014", Czech Republic, Brno, 3-5 December, 2014. Brno: Brno University of Technology, 2014, pp.113-118. ISBN 978-80-214-4817-9.

Conferences - 5

"Mechatronika 2014"

Zabasta A., Kondratjevs K., Kunicina N., Ribickis L. Wireless Sensor Networks and SOA Development for Optimal Control of Legacy Power Grid. No: Proceedings of the 16th International Conference on Mechatronics "Mechatronika 2014", Czech Republic, Brno, December 3.-5., 2014. Brno: Brno University of Technology, 2014.,pp 113.-118. ISBN 978-80-214-4817-9.

RTU scientific conference 2014:

RTU 55th International scientific conference. 14-17 October 2014, Riga, Latvia. "State of the Art in the Healthcare Cyber-physical Systems. Information Technology and Management Science". Skorobogatjko A., Romānovs A., Kuņicina N.

Transport Means 2014:

18th International Conference "Transport Means", Lietuva, Kaunas, 23.-24. October 2014. "Sensor Networking and Signal Processing Applications in City Transport Systems". Patļins A., Kuņicina N., Adrian L.

WSEAS 2015:

WSEAS 8th International Conference on Urban Planning and Transportation. 10-12 January 2015, Tenerife, Spain. "Incoming generated traffic flow estimation based on transport access design and level of service". Zeņina N., Romānovs A., Merkurjevs J.

RelStat 2015:

14th International Conference "Reliability and Statistics in Transportation and Communication" (RelStat'14), 15–18 October 2014, Riga, Latvia. Referāts: "Fibre-optic sensors calibration method based on genetic algorithm in weight-in-motion problem". A. Pilipovecs and A. Grakovski.

Popular-science publications - 1

Skorobogatjko A., Romanovs A., Kunicina N. State of the Art in the Healthcare Cyber-physical Systems. Information Technology and Management Science. Vol.17, 2014, pp.126-131. ISSN 2255-9086. e-ISSN 2255-9094. Available from: doi:10.1515/itms-2014-0019

Number of defended master's thesis - 1:

- Alona Skorobogatjko. Cyberphysical system user strategies and development of medical institutions . RTU ITI prof.masterprogram, defended January 2015, mark 10.

Further research and practical exploitation of the results

(Describe further research activities that are planned, describe possibilities to practically exploit results)

Descriptions of activities are structured according to the above-mentioned tasks:

- 1) To develop a safety monitoring and modelling solution of urban environment via applying high performance data processing technologies.

In a frame of the activity, a study aiming to integrate and elaborate new methods for consolidating, interpreting and modelling data acquired from different sensors has been started. This is important for planning and maintaining the urban environments, and thereby - for providing novel methods applicable in high performance computing environments. Unfortunately, at the moment HPC (High performance computing), which in fact is the next generation computing, is hardly used to address the problems mentioned above. The activity is focusing on the use of GPU (Graphical Processing Units) accelerators, whose energy consumption is several times smaller in comparison with the conventional computing units, but provide up to 100 times higher computing power. A new research group that would possess the knowledge and skills currently unavailable for Latvian researchers has been established.

The used technologies will allow implementing sensor data processing, which is required for fulfilling other tasks in the programme, and hence they will highly contribute to the overall performance of the project.

It is envisaged at the next project phases to verify the developed methods and tools in normal and critical situations in urban environment: water supply and associated infrastructure (e.g. electricity, telecommunications).

In order to realize the experiment at RTU Water laboratory equipment, a procurement procedure for the instruments and telecommunication equipment is started.

- 2) To develop and explore intelligent sensor network technologies and applications of intelligent transportation systems.

Sensor technology review. In a frame of this task, based on the results obtained, a survey of the existing sensor technology in order to identify strengths and weaknesses has been started.

Traffic control centre concept. Within this task, a study to develop a concept of traffic management centre (system structure, functionality, input / output data, etc.) is initiated.

Sensor technology development. Using the results of the previous task, at this stage has been developing a new sensor technology. This task is focusing on measuring the weight sensor design and development (WiM - weight in motion), based on optical fibre.

Also is started a research on the traffic counting and classification solution, as well as data transmission module (responsible for the transmission of data from the sensor to the data centre). The system's core is a macroscopic traffic flow model. Model data will be updated in real time. This will enable the model to use as a short-term forecasting tool. Simulation results will be used for system management and development alternatives for system automated control and decision making.

Dissemination and outreach activities

(Describe activities that were performed during reporting period to disseminate project results)

<http://www.tsi.lv/lv/content/nakamas-paaudzes-informacijas-un-komunikaciju-tehnologiju-ikt-petniecibas-valsts-programma>

http://www.tsi.lv/sites/default/files/editor/science/nextit_relize.pdf

2.1.4. Project No. 4

Title	New generation large volume data processing systems	
Project leader's name, surname	Juris Viksna	
Degree	Dr.sc.comp.	
Institution	Institute of Mathematics and Computer Science, University of Latvia	
Position	Leading researcher	
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Project No. 4.1. Bioinformatics and biomedicine

Project goal and objectives

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

1. To develop new methods and supporting software tools for laboratory information systems (LIMS) for collecting and integrating phenotype and experimental sources of biomedical data.
2. To develop methods for analysing and visualizing large sets of bioinformatics data.
3. To develop methods and supporting software tools for integrating local biomedical databases and other data sources with centralized European and other international data repositories (EGA, ICGC and others), in accordance with the set standards for data formats, and in line with the security requirements for data storage and data transfer procedures.
4. to further develop cooperation between Latvian research institutions and institutions of other European Union countries in the fields of bioinformatics and biomedicine; to ensure a sufficiently high research capacity of Latvian research institutions to make them attractive for participating in European research projects; to facilitate integration of Latvian research institutions into the existing collaborative research projects and networks, in particular inclusion of Latvian institutions in ELIXIR consortium.

Description of the acquired scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

1. After the CAGEKID project (EU 7th Framework Program project within which KIDREP was initially developed), a further development and maintenance of KIDREP database and software have been performed; development of the open source version of KIDREP software has been launched, and a preparation of a journal article on the software is under way.
2. New methods for visualising and analysing bioinformatics data have been developed; approbation of the developed methods for protein structure homology studies has been started.
3. Jointly with collaboration partners, a scientific paper has been prepared and is published (the paper is indexed in Scopus and Web of Science databases):

G.Scelo,..., E.Celms, J.Viksna et al. "Variation in genomic landscape of clear cell renal cell carcinoma across Europe", *Nature Communications*, vol. 5, doi:10.1038/ncomms6135, 2014.

The paper is devoted to RNA and DNA sequencing data analysis of RCC (renal cell carcinoma) biopsies collected from a sample of 2500 patients. A number of new diagnostic and prognostic biomarkers have been identified. Also a statistically significant non-homogeneity between different groups of patients have been detected.

Work has continued on preparation of RNA and DNA sequencing data according to ICGC specifications for data formats and ontologies. During the reporting period of the project, the data were prepared and submitted to the 18th release of ICGC Data Portal (published on 20.12.2014). Due to the fact that ICGC specifications are still subject to ongoing corrections and re-developments, it is expected that the submitted data sets still need to be revised to ensure compatibility with the future ICGC Data Portal releases.

4. A project proposal "Determinants of kidney cancer risk and survival" was prepared and submitted to the project call in programme H2020-PHC-01-2014. Programme H2020-PHC-01-2014 project call involved two evaluation stages, the submitted project was approved in the 1st evaluation stage, but unfortunately was not selected for funding in the 2nd evaluation stage.

Further research and practical exploitation of the results

(Describe further research activities that are planned, describe possibilities to practically exploit results)

Expected main results:

1. Development of methods for analysing and visualizing large sets of bioinformatics data:

- Preparation of research publication (SCOPUS) (0.5);
- Continuation of work on the doctoral thesis (0.25);

2. Development of methods and supporting software tools for integrating locally hosted databases and services with the centralized European and other international repositories (EGA, ICGC etc.), according to the required standards and specification on data formats, and data privacy protection requirements during data storage and transmission:

- Developed methodology and software platform (1);
- Preparation of research publication (SCOPUS) (1)

Dissemination and outreach activities

(Describe activities that were performed during reporting period to disseminate project results)

Published papers:

G.Scelo,...,E.Celms, J.Viksna et al. "Variation in genomic landscape of clear cell renal cell carcinoma across Europe", *Nature Communications*, vol. 5, doi:10.1038/ncomms6135, 2014.

Project No. 4.2. Large-volume data and knowledge infrastructure

Project goal and objectives

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

Approbation of the solution for large volume image processing on the existing IMCS UL Big Data platform.

Development of a new generation cloud computing system concept for hosting Big Data and other services, of the procedure for deploying such a cloud, as well as their implementation. Development of an effective Web-harvesting technology.

Development of a technical solution for sharing specific device components in a cloud infrastructure.

Description of acquired scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

A large volume image processing solution has been developed and approbated on the existing IMCS UL Big Data platform. It uses all computational capacity of the platform and is able to simultaneously process multiple images, thus substantially reducing the time required for processing large volumes of data.

The concept of new generation cloud computing infrastructure has been developed. It details provision of multiple layer services (infrastructure – IaaS, platform – PaaS, software – SaaS), as well as ready platform services, e.g., Big Data platform. The innovative element is the ability to migrate certain services among the layers depending on requirements of undivided access to the underlying physical resources. With this approach, it is possible to provide high throughput computing (HTC) service on demand, for instance. The procedure of the new cloud deployment has been created. Its implementation is under way.

The technical solution has been developed for sharing specific components in the cloud infrastructure, e.g. GPU or SMP co-processors. It allows the provision of such computing services on demand.

Thus the new generation IMCS UL cloud is a universal complex that provides traditional cloud services popular in the industry, as well as specific large volume and large capacity services that are demanded by scientific and research communities.

A new and effective web harvesting technology has been developed. It is able to identify which Web URLs, potentially, contain the already seen content and avoids requesting those. Thus the effectiveness of harvesting original content is significantly better, and the resources are freed from mining and processing duplicate content.

In preparation 2 articles for conference - Rihards Balodis, Inara Opmane. Procurement Management Experience of Scientific Cloud Facility Set Up. ACMASS-6194, ACMASS 2015, Annual Conference on Management and Social Sciences un Rihards Balodis, Inara Opmane. Milestones of complex computing facility assembling . Grid, Cloud & High Performance Computing in Science. RO-LCG.

Doctoral student L. Truksans has defended doctoral theses “Network virtualization based on effective packet transformations”. It describes effective packet tunnelling technology use in cloud and large data volume infrastructure interconnects.

Dissemination and outreach activities

(Describe activities that were performed during reporting period to disseminate project results)

1. Rihards Balodis, Inara Opmane. Procurement Management Experience of Scientific Cloud Facility Set Up. ACMASS-6194, ACMASS 2015, Annual Conference on Management and Social Sciences.
2. Rihards Balodis, Inara Opmane. Milestones of complex computing facility assembling . Grid, Cloud & High Performance Computing in Science. RO-LCG.

Doctoral theses defended:

L. Truksans “Network virtualization based on effective packet transformations”, 2015

Project No. 4.3. Cyber-physical systems’ platform

Project goal and objectives

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

1. Development of algorithms for recognizing specific sites and urban areas (for example, green areas, industrial regions, etc...) in high-resolution satellite images; to improve the results by using multiple data sources of information.
2. Carrying out of the computational complexity assessments of algorithms specified in the Project tasks (GMEM, CLEAN and others). Their adaptation to the possibilities of parallel computing facilities by using high-performance computing clusters in order to automate the processing of data in information systems.
3. Model development of the programmable directional antenna array field and its received signal for observation simulation of radio source in space.
Development of antenna array beamforming algorithm and its application using high performance cluster. Performing antenna array beamforming simulations. Analysis of beamforming algorithm realization methods and the necessary computing power for realization.
4. Develop solutions for establishing large-scale sensor fields, their operation, and data acquisition and processing.

Description of acquired scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

1. One of the project activities is “to develop algorithms for identification of specific urban sites and areas (for example, green areas, impervious surfaces and industrial regions etc.) using high spatial resolution satellite images”. Remote sensing sensors on satellites and aircraft enable to acquire detailed information about vast areas. These data sets can be transformed into thematic maps and reports using automated, computerized methods. Such maps and reports could provide additional knowledge about our environment and to facilitate spatial planning and decision making.
Urban remote sensing is a challenge because urban areas contain various materials and land cover types (like asphalt, trees, water, glass etc.). Topicalities in urban remote sensing are

related to mapping of green vegetation, impervious surfaces and calculation of environmental variables.

During the first months of the project realization, satellite image classification scheme was developed for mapping the land cover. It is particularly suitable for urban-area mapping and analysis. Classification scheme was complemented by calculating bio capacity, which is one of the most important indicators characterizing the ecosystem. Bio capacity describes the ability of the ecosystem to produce useful biological materials and to absorb waste materials. Thematic maps for the first tests were prepared for Talsi, Kuldīga and Ventspils, three largest urban areas in the western part of Latvia. In addition, methodology was developed for report generation, which allows the user to perform supervised classification, and it generates diagrams about land cover distribution around the cities and bio capacity in global hectares. Request was prepared in order to receive satellite data from Latvian Geospatial Information Agency for further research.

2. The 32-meter radio telescope of the Ventspils International Radio Astronomy Centre is equipped with the 16-channel spectropolarimeter for radio mapping of the Sun. The signal-to-noise ratio of the gained radio maps is of about 20 dB. The zero drift is inherent in the microwave images of the Sun as well. It depends on the environment temperature and the fluctuations of the gain. Sampling with the rate of 15 Hz produces the specific noise. We start with the preliminary cleaning of radio maps of the Sun through spatial wavelet analysis. The fluctuations of the gain are diminished by subtraction of 2D wavelets from the radio images. In that way the signal-to-noise ratio is increased prior to the application of the CLEAN and MEM procedures. Preliminary cleaning of radio maps of the Sun performed with the help of spatial wavelet analysis. In that way the signal to noise ratio is enhanced prior to the application of the CLEAN and MEM procedures.

3. The beamforming technique and algorithms of the non-directional antenna arrays, acquires an increased importance. This technique, in fact, permits to combine different signals received from many antennas and to form a single coherent signal. Moreover, beamforming permits to give directionality to an array of non-directional antennas.

During the first period of the Project, the review of the possible ways of the realization of the beamforming algorithm realization was made (see supplement). The theory of the beamforming basic principles was described and the calculation power necessary for realization of the beamforming algorithm was estimated.

4. Within the framework of the Project, work on the tasks related to analysing general properties of the upper atmosphere layers and ionosphere was continued. To estimate electron density at different heights in the ionosphere, artificial turbulence was produced in the local ionosphere areas by means of impact on the media by high power radio transmission in Megahertz frequency band from Sura heating facility, located near Nizhny-Novgorod. Studies of ionosphere properties were carried out by sounding Earth ionosphere. The navigation space satellite - NAVSTAR GPS and GLONASS - signals were used for this task. Radio signal emitted from satellite propagated simultaneously through excited and quiet regions of ionosphere and were received by Radio telescopes located in Latvia (RT-32) and Russia respectively. Very Long Baseline Interferometry (VLBI) methods were used for data processing. The experiments allowed the modelling of the natural processes of turbulence excitation, and generation of electromagnetic emissions during injection of energetic solar particle fluxes in Earth's atmosphere.

Activities related to enhancement of VLBI data post-processing methods and algorithms were also continued. Additionally, modernization efforts on radio telescope RT-32 were

undertaken; specifically, 1.6 GHz receiving system was upgraded and antenna pointing was improved.

Further research and practical exploitation of the results

(Describe further research activities that are planned, describe possibilities to practically exploit results)

1. Further research includes building detection, using aerial photos obtained from Latvian Geospatial Information Agency (LGIA). LGIA maintains countrywide data base of ortho-photo images at spatial resolution 0.25/ 0.4 meters per pixel. Automated building detection would facilitate the process of updating urban maps and tracking changes in urban areas.
2. Application of the CLEAN and MEM procedures to restore the radio images of the Sun after the preliminary cleaning by means of spatial wavelet analysis will be continued. The next step is to restore the beam pattern of the radio telescope RT-32 immediately from the radio images of a microwave sunspot-associated local source.
3. Further research into the possibilities of developing directional antenna array field includes model development of one-dimensional programmable directional antenna array field and its received signal for observation simulation of radio source in space. Development of tools for automatic code generation for signal processing algorithm realization will also be carried out.
4. Future research for the task of developing solutions for establishing large-scale sensor fields implies enhancing VLBI data post-processing methods and algorithms for studying general properties of ionosphere. One more activity will be related to developing methods for calibration of radio astronomical instruments, especially precision tools, such as Very Long Baseline Interferometry (VLBI). It is a necessary procedure to ensure high accuracy of coordinate and time measurements. In this activity, calibration methods of interferometers with antennas, having a small effective area will be studied. The quasinnoise signals of navigation satellites GLONASS and GPS will be used. Algorithms for calculating antenna's coordinates and instrumental delay on the basis of the analysis of correlation interferometer response to signals of satellites in the near field of the instrument will be proposed.

Dissemination and outreach activities

(Describe activities that were performed during reporting period to disseminate project results)

Three contributions at the Christmas Scientific Conference of Ventspils University College (18.12.2014.):

- L.Gulbe "Aktualitāte spilsētvides kartēšanā, izmantojot tālziņpētes datus.", "Topicalities in urban area remote sensing" (Latvian);
- D.Bezrukovs, B.Rjabovs "Saules mikroviļņu starojuma spektro polarimetriskie novērojumi Irbenē", "Microwave Spectral Polarimetric Observations of the Sun in Irbene", (Latvian);
- V.Bezrukovs, I.Šmēlds "Liela mēroga antenu lauka izmantošanas jonosfēras pētījumiem", "Using of large scale antenna fields for ionospheric research" (Latvian).

Rewiev:

Evita Vavilina "Beamforming Algorithm Realization Principles".

Project No. 4.4. Mathematical modelling, inverse problems' analytical solving methods and algorithms, oriented to data processing technologies

Project goal and objectives

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

Aims of the Project 4.4.

1. Development of mathematical models as well as stable analytical and numerical methods for solving multi-dimensional problems, including inverse problems, which occur in technical and technological processes, economic planning, and optimal ecosystem management, for identification, diagnostics and forecasting.
2. Development of complex software for accurate and appropriate realization of the constructed models, analytical and numerical methods for modern highly productive computing systems.

Objectives of the Project 4.4.

1. Mathematical models will be created by using the language of the inverse problems theory. The constructed mathematical models will adequately describe real technical and technological processes and objects while identified, diagnosed, and/or managed.
2. Stable analytical and numerical algorithms will be developed for solving inverse problems of control of dynamic systems.
3. The main original results (mathematical models; analytical methods; numerical methods) will be presented as academic articles and published in peer-reviewed international academic journals.

Description of acquired scientific results

(Describe scientific results achieved during reporting period, give their scientific importance)

Two mathematical models have been developed (within the framework of Objective 1).
Two analytical numerical methods are developed (within the framework of Objective 2).
The achieved results are presented in the following articles, which have been published:

1. Sh.E.Guseynov, J.V.Aleksejeva, S.A.Andreyev (2014). *On one regularizing algorithm for comprehensive diagnosing of apparatus, engines and machinery*. – Advanced Materials Research, Trans Tech Publications, Switzerland, p. 254-257.

The problems with evaluating the efficiency of technical system by following its measured structural constructive parameters have been studied. The paper presents a mathematical model constructed in the form of terminally measured operator equation, where we seek the weights of influence of calculative constructive parameters, as well as the indicator of the efficiency of technical system. The initially built model reduces to the normal system of higher dimension, after that for the resulting problem it is applied the apparatus of the theory of ill-posed and inverse problems: regularizing operator has been constructed; special algorithm for finding regularization parameter has been developed.

The obtained results can be used in the following fields:

- Evaluation of efficiency of functioning of complex technical systems consisting of large amount of interacting mechanisms and aggregates;

- Processing interfered experimental data of large volumes;
- Reconstruction of medical images in case of unclear or incomplete data.

2. Sh.E.Guseynov, A.N.Medvedev, R.Guseinovs, L.V.Baranova (2014). *Investigation of one macro-level model of distribution logistics*. – Advanced Materials Research, Trans Tech Publications, Switzerland, p. 311-316.

Distributive logistics is a complex of interconnected technical economic, financial, and management operations which are performed in the process of spread of flows of divisible and/or non-divisible resources in between various divisible or non-divisible consumption points. In the actual paper, there is a problem of identifying the optimal spread of non-divisible points of consumption under the conditions of presence of multi-nomenclature divisible resource limitations of unclear pattern: so, it is supposed that the limitations on volume of multi-nomenclature resources are not set clearly. In the studied division problem, Boolean variables have been used, which makes the addressed problem fall into the class of solid-numerical problems of mathematical programming with unclearly set initial data. The specialty of such problems (they do belong to the class of NP-complete problems) is in the efficiency of optimization combinatorial methods, which are being used for solving them, but very rapidly get minimized both with growth in dimension of the problem and in case of the rise in number of limitations present. Consequently, application of combinatorial algorithms for solving such type of problems is linked to the problem of the inability to detect precise values of some managed parameters. In the given paper, the authors create mathematical model for the given problem from scratch, in one of the many possible framings; approximating model in the dual framing has been constructed; exact algorithm for solving the original model has been developed exact algorithm for solving approximating problem in dual framing has been developed; moreover, this algorithm first is applied in combination with the method of possible directions and with the method of common gradient decline; then, rules for exclusion of not perspective variants are formulated in this algorithm, are proven, and used through the dual evaluations.

*Commentary by Sh.E.Guseynov: A mathematical model is a description of the problem under consideration using mathematical concepts and language. Therefore, a mathematical model is the statement of problem which is described in mathematical language. Consequently, solving the stated problem is the same that solving the constructed mathematical model (see, for instance, A.A.Samarskii, A.P.Mikhailov (2001). *Principles of Mathematical Modelling: Ideas, Methods, Examples*. – CRC Press, 360 p.)

The achieved results can be applied while solving the following problems:

- when allocating resources to communication networks, seaports, border control, manufacturing enterprises, farms, retail networks, etc. Additionally, the resources that need to be divided (and allocated) can be the following: flow of transferred information, heat and electricity supply, capital and exploitation expenses, transport expenses, etc.
- when developing strategic plans for the national defence (number of military personnel; the volume of funding; extent of military equipment, etc.).

Further research and practical exploitation of the results

(Describe further research activities that are planned, describe possibilities to practically exploit results)

Expected main results:

1. Developed mathematical models through inverse problems theory language. The constructed mathematical models will adequately describe real technical and technological processes and objects through identification, diagnostics, and management:

- Mathematical models (2)

2. Developed stable analytical numerical algorithms for solving inverse problems of control of dynamic systems:

- Analytical methods (2)

- Numerical algorithms (1)

3. The achieved original results (mathematical models; analytical methods; numerical methods) will be presented in academic articles and submitted for publishing in internationally peer-reviewed academic journals:

- Articles (3)

4. Participation at international conferences; organization of workshops; authorship and publication of a popular science paper on the relevant theme:

- Conferences (1)

- Workshops (1)

- Popular papers (1).

PART 3: INFORMATION ABOUT PROGRAM FINANCE

Short information about the use of program finances

		Year 1	Year 2	Year 3	Year 4
1000–9000	EXPENSES - IN TOTAL	131 575			
1000	Remuneration	102 858			
2000	Goods and services	22 539			
2100	Study, work and official missions, official and work trips	4 620			
2200	Services	15 250			
2300	Stock, materials, energy resources, goods, office supplies and inventory	1 758			
2400	Expenses for the purchase of periodicals	911			
5000	Establishment of core capital	6 178			