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D1.2

Strengthening the Human Potential of the Institute of Information and Communication Technologies (IICT) - Month 36

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Summary	The deliverable overviews all activities of AComIn Work Package 1 (WP1) “Strengthening the IICT Human Potential”, as planned in the AComIn Description of Work (DoW) for the reporting period 1 April 2014 – 30 September 2015. It reports about the WP1 progress and assesses its added value to the IICT Research Capacity. The deliverable also discusses deviations from schedule and sketches the respective Contingency plan.	
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Executive Summary

Deliverable D1.2 reports on the activities on Strengthening the IICT Human potential in AComIn Work Package 1 (WP1) during months 19-36 of the project. It describes the long-term employment of incoming post-doctoral researchers and the short-term, one-month employments of incoming experienced seniors. D1.2 assesses the WP1 achievements in terms of publications (list of papers) authored by the employed incoming experienced researchers and lists new areas of research involving the incoming scientist. Finally, D1.2 presents deviations from schedule and contingency plan.

The deliverable contains the research plans of the employed 15 incoming post-doctoral researchers and concise information about the completed activities, current results, and their plans for future work within AComIn (having in mind that 11 post-doctoral researchers and one guest professor will continue working in AComIn by 31 January 2016).

D1.1 presents the activities during the short-term scientific missions of 5 incoming experienced researchers with more than 10 years of scientific experience. They contribute to strengthening the IICT human potential by performing: joint research activities with IICT researchers, including writing high-quality papers and monographs; lecturing at high-quality intensive seminars including events held with User Communities and other innovation-related tasks; technology transfer activities etc.

The deliverable D1.1 deals with Assessment of the Added Value of the employments in IICT in months 19-36. The Assessment is done in terms of publications (list of papers) as well as in terms of activities initiated with the participation of the employed incoming experienced researchers.

D1.2 lists 82 papers, authored by researchers recruited via AComIn during project months 19-36 and published in peer reviewed scientific journals and conference proceedings (14 of these 82 papers are accepted and in print on 30 September 2015). Some 27 of the papers have Thomson Reuters Impact factor and 23 have SJR Indicator.

The deliverable discusses also the deviations from the AComIn schedule that happened in reporting period 1 (1 October 2012 – 31 March 2014). There was a substantial delay in utilization of person-months planned for employments of incoming experienced researchers, both for the long-term and short-term recruitments. Fortunately, AComIn catches up and fully compensates the delay during months 19-36 of the project; the increased number of post-doc applications is somewhat connected to the intensive demonstrations of the AComIn devices made after the installation of the SmarLab equipment. In addition, the AComIn seniors doubled their activity in searching post-doctoral researchers.

The Contingency plan for complete utilization of the personnel budget for employment of incoming experienced researchers includes not only prolonging the activities of WP1 by four months but also concentrating the remaining budget for recruitment of post-docs. In August-September 2015 AComIn employed two young researchers at post-doctoral positions.

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1. INTRODUCTION: WP1 OBJECTIVES, PLANNED TASKS AND ACTIVITIES

The Objectives of Work Package 1 (WP1) “Strengthening the IICT Human Potential” are to ensure the sustainable development of the IICT Human Potential within the AComIn Project. In particular, WP1:

- organises the recruitment of incoming experienced researchers, via long-term and short-term employments;
- integrates the activities of the incoming experienced researchers with long-term contracts into the every-day work of IICT.

According to the AComIn Technical Annex, the WP1 activities are organised in two tasks:

Task 1.1: Recruitment of Incoming Experienced Researchers which comprises the following activities:

- To disseminate information about available positions for long-term employment of experienced researchers (post-docs) in AComIn;
- To elaborate criteria for selection of incoming experienced researchers to be employed with long-term contracts in AComIn. These criteria are to be approved by the Steering Committee on the basis of the following requirements: the applicants should have solid mathematical background, profound knowledge of the basic technologies and PhD degree in one of the AComIn areas of interest: Scientific Computing, Artificial Intelligence, Signal and Image Processing or Optimisation and Control; have publications in international peer-reviewed journals or conference proceedings, or in highly respected and world-wide known National journals in maths, computer science or engineering; have Recommendation Letters from three internationally-recognised seniors; have the potential to attack RTD tasks with high level of computational complexity, have the potential to do synergetic research and express convincingly their motivation to join the project;
- To ensure the appropriate environment for performance of high-quality scientific tasks;
- To employ at four positions foreigners - incoming experienced researchers with less than 10 years of scientific experience (post-docs), with contracts lasting between month 2 and month 36;
- To employ at three positions Bulgarians - incoming experienced researchers with less than 10 years of scientific experience (post-docs), with contracts lasting between month 2 and month 36;
- To employ via short term contracts top scientists for 34 person months (incoming experienced researchers with more than 10 years of scientific experience), both foreigners and Bulgarians, to perform lecturing at high-quality intensive seminars with User Communities, innovation-related tasks, technology transfer activities, writing joint scientific papers and so on. Their selection will be carried out by the Executive Board of AComIn.

Task 1.2: Integrating the Recruited Researchers into AComIn Activities comprises the following activities:

- To support the RTD activities of the recruited incoming scientists with long-term contracts by approving a Career Development Plan for each researcher and building a team for contextualising his/her work, including one supervising senior from IICT;
- To organise numerous internal seminars in order to present the achievements of the incoming experienced researchers,
- To monitor the progress of the recruited post-docs in terms of results, publications, demonstrators etc. as planned in their Career Development Plans.

The Deliverable 1.2, as an input for the AComIn review in month 36, reports on the achievement of the WP1 activities and contains:

- Reports on the long-term and short-term employment of incoming experienced researchers in months 19-36: Career Development Plans for incoming post-docs, Research Plans and Results of the incoming post-docs, as well as Work plans and Reports about the completed activities of the short-term employees;
- Assessment of the Added Value of the employments to the development of the IICT Research Potential in months 19-36;
- Deviations from Schedule and Contingency Plan.

2. RECRUITING INCOMING EXPERIENCED RESEARCHERS AT POST-DOCTORAL POSITIONS

Fifteen incoming post-doctoral researchers have been working in AComIn in months 19-36 (see Fig. 1). Five of them were employed in period 1: Dr. Stanislav Stoykov, Dr. Jean Michel Sellier, Dr. Ivan Georgiev, Dr. Clemens Hofreiter, and Dr. Vladimir Kotev. The last two left in period 2 (correspondingly at the end of April 2014, and end of December 2014) but the other three remained in the project and still work there by 30 September 2015. In addition, eight new post-doctoral researchers were employed in reporting period 2. On 30 September 2015 (the end of reporting period 2), some 12 post-doctoral researchers work in AComIn.

While selecting the candidates for recruitment, the Executive Board takes into account their nationality as well (because the AComIn objective is to repatriate Bulgarians at 3 positions and attract foreign post-docs at 4 positions). Summarizing the person-months (PM) utilized for employment of incoming researchers with Bulgarian nationality vs. foreigners, we present Table 1.



Figure 1. Listing the names and links to the CVs of recruited incoming post doctoral researchers in the Public Area of the AComIn project site, see http://iiict.bas.bg/acomin/incoming_postdocs.html

Nationality of incoming post-docs	Period 1 (1 October 2012 – 31 March 2014)	Period 2 (1 April 2014 – 30 September 2015)	Total PM
Bulgarians	26.06	53.44	79.5
Foreigners	18.38	51.96	70.34
PM per period	44.44	105.40	149.84

Table 1. PM for employment of post-docs in AComIn (total 149.84 PM, planned 168 PM)

2.1 SELECTION, CAREER DEVELOPMENT PLANS, AND MONITORING

The requirements and selection procedures are the same for all candidates to be recruited in AComIn with long-term contracts at positions for incoming experienced researchers with less than 10 years of scientific experience (post-docs). The list of Application documents, to be presented to the AComIn Executive Board, contains the following items:

- Diploma(s) proving the mathematical background and profound knowledge of the basic technologies;
- Relatively recent PhD degree in one of the following four areas: *(i)* Advanced computing, *(ii)* Language and semantic technologies, *(iii)* Signal and image processing or *(iv)* Optimisation and control;
- Abstract of achievements in the PhD thesis;
- Complete list of publications and citations if any;
- Recommendation letters from three internationally-recognised seniors, which include assessment of the candidate's research capacity in the AComIn areas, team work abilities and commitment to the scientific community, as well as leadership potential;
- Evidences about: *(i)* experience in applied ICT research – e.g. working with companies, *(ii)* participation of the candidate in RTD projects;
- Curriculum Vitae describing among others the candidate's skills in using various computer platforms and standard software environments as well as submitted project proposals or other kinds of grant applications;
- Evidences about spoken and written English language competence at least at 'intermediate level' (for applicants whose competence in English is not implied by the CV – e.g. native speaker, defended PhD thesis in English, worked in English-speaking environment for years etc.);
- Motivation letter why the candidate wants to join the AComIn team including statement of preferences in which area he or she wants to work (with particular Smart Lab devices) as well as candidate's view of his desired achievements and preferred position in 3-5 years;
- Earliest possible date when the applicant can start working in IICT;
- Contact details.

It has been decided that "a recent PhD" means up to 6 years after the defence of the PhD thesis. The Executive Board decided to target younger candidates because IICT needs younger but experienced staff with solid programming capacity and deep motivation to pursue high-quality research tasks.

Career Development Plans. Here we remind the principles, applied in the organisation and management of AComIn activities in order to support the personal development of the post-docs: young experienced researchers (with less than 10 years of scientific experience), employed under AComIn long-term employment scheme.

- The selection of young experienced researchers for long-term employment considers the candidates educational and professional background, their experience, skills, talents and interests in the research areas of the AComIn project;

- ii. The selected young researchers are employed to fulfill individual Research Work plans, build up together with the appointed scientific supervisors from IICT and approved by the AComIn Executive Board;
- iii. The project provides a team and research environment appropriate for work according to the individual Research plans;
- iv. The project provides training for professional use of Smart Lab devices for research tasks in case such training is needed;
- v. The young researchers present and discuss their work with wider audience on periodic scientific seminars in IICT;
- vi. The young researches have the opportunity to participate in technological support activities for the project User Communities, gaining experience in Innovation Capacity Building;
- vii. The project supports extensively the young researchers' participation in international scientific events for presentation of their results;
- viii. The monitoring of young researchers' work is performed every 6 months by means of their presentations and subsequent discussions on open meetings of the AComIn Executive Board;
- ix. The assessment of young researchers' results is made by the IICT Scientific Council for the reporting periods of the project (m. 18, m. 36) or at the end of the employment period.

These principles aim at achieving the project goals. They have also an important impact on the proactive planning and implementation of action steps towards young researchers' career development.

Monitoring. Seminars devoted to 6-months assessment of AComIn post docs are held together with meetings of the AComIn Executive Board but they are open for other IICT post docs, IICT PhD students and guests from other academic institutions. In addition, the presentations are visible to the whole Institute staff in the Team Area of the AComIn site (see Figure 2).

Figure 2. Monitoring the postdoc performance (archive in the Team Area of AComIn site)

The Procedure for internal assessment and selection proved to be very useful from management perspective as it facilitated the planning of candidates' future work and duties. The host professor, appointed at a very early stage of the applicant selection, monitors all organisational and administrative aspects of the employment including support while issuing the visa invitations for working visa, assignment of employment ID by the National Tax Agency as well as providing help for accommodation arrangements (if needed) etc.

The presentations at month 36 have been assessed by the IICT Scientific Council; the reports on intermediate results are stored at the site for references and internal monitoring. In general the interest, constantly manifested by the AComIn seniors to the achievements of the project post docs, helps the incoming researchers to feel integrated in the everyday workflow of IICT affairs.

2.2 RECRUITED INCOMING POST-DOCS IN MONTHS 19-36

In total, fifteen incoming post docs have been recruited in the Second Reporting period of AComIn (project months 19-36, 1 October 2012 – 31 March 2014). The durations of their employments are summarised in Table 2.

Name of the Post Doc	Host professor	Starting date of employment	End date of employment or end date of Reporting period
Dr. Stanislav Stoykov	Svetozar Margenov	16 October 2012	continues working as of 30/09/2015
Dr. Jean Michel Sellier	Ivan Dimov	19 November 2012	continues working as of 30/09/2015
Dr. Clemens Hofreither	Svetozar Margenov	1 August 2013	30 April 2014
Dr. Ivan Georgiev	Svetozar Margenov	2 September 2013	continues working as of 30/09/2015
Dr. Vladimir Kotev	Dimitar Karastoyanov	3 December 2013	31 December 2014
Dr. Volodymyr Kudriashov	Kiril Alexiev	12 August 2014	continues working as of 30/09/2015
Dr. Stanislav Harizanov	Svetozar Margenov	25 November 2014	continues working as of 30/09/2015
Dr. Emilia Abadjieva	Dimitar Karastoyanov	1 December 2014	31 October 2015
Dr. Mladen Savov	Ivan Dimov	5 January 2015	30 June 2015
Dr. Kristina Jakimovska	Dimitar Karastoyanov	6 January 2015	continues working as of 30/09/2015
Dr. Iurii Chyrka	Kiril Alexiev	6 January 2015	continues working as of 30/09/2015
Dr. Olga Kanishcheva	Galia Angelova	9 January 2015	continues working as of 30/09/2015
Dr. Aleksey Balabanov	Todor Stoilov	6 February 2015	continues working as of 30/09/2015
Dr. Konstantinos Liolios	Krassimir Georgiev	20 August 2015	continues working as of 30/09/2015
Dr. Jovana Ružić	Dimitar Karastoyanov	8 September 2015	continues working as of 30/09/2015

Table 2. Employed post-docs with long-term contracts in the period 1 April 2014 - 30 September 2015

Sections 2.2.1 - 2.2.15 consider the achievement of the fifteen incoming experienced post-docs in project months 19-36.

2.2.1. DR STANISLAV STOYKOV

Dr Stanislav Stoykov (<http://parallel.bas.bg/~stoykov/index.html>) received his PhD in Mechanical Engineering from the Faculty of Engineering, University of Porto, Portugal in 2012. The topic of his PhD thesis is "Nonlinear Vibrations of 3D Beams". His research interests are in the area of advanced computing (Nonlinear dynamics; Bifurcation theory; Finite element method; Models of beams, plates and shells; Modal interactions, stability, chaotic motions; Iterative methods for large-scale systems).

Individual Research Plan of Dr Stanislav Stoykov in AComIn for months 19-36 host professor: Svetozar Margenov

The research plan for the second half of AComIn project is focused on mathematical modelling of complex elastic structures and efficient numerical methods for their solutions and analyses. It is summarized in the following research directions:

Parallel implementation of shooting method for nonlinear systems

The numerical computation of the periodic responses of nonlinear systems is computationally expensive, thus this work will present parallel implementation of the shooting method and consequently numerical computation and comprehensive analysis of the bifurcation diagrams of complex structures. Scalability and efficiency of the proposed parallel implementation will be analysed. Beam and plate models will be considered for generating large-scale dynamical systems.

Vibrations of cylindrical laminated shells with curvilinear fibres

During the visit of prof. Pedro Ribeiro from University of Porto, Portugal, in November 2013, we continued our collaboration in nonlinear dynamics of structures. It is planned to investigate the dynamics of shells with variable stiffness during the next year. Structures composed of variable stiffness materials give new opportunities to the industry, so one can change the dynamical properties of the structure without changing its geometry, neither the material, just by changing the orientation of the fibres. Further analysis of the dynamics of such structures will be implemented.

Nonlinear dynamics of curved beams

The equation of motion of curved beam will be derived in cylindrical coordinate system, that is, the geometry of the structure will be taken into account exactly. It was found that there exists a curvature of the beam, for which the first two natural frequencies are equal. The full nonlinear model will be derived and the bifurcation diagrams will be computed, particularly for the case of beam under 1:1 internal resonance condition.

3D beam model of functionally-graded materials

The TOBECS tool (<http://parallel.bas.bg/~stoykov/tobecs>) will be modified, so it will compute numerically the cross sectional properties of beams with arbitrary cross sections of functionally-graded materials. The equation of motion of such beams will be derived, validated and comparison of the dynamical properties between beams with FGM and composite materials will be performed.

Mathematical model of electro-mechanical systems

Another topic of mathematical modelling is the derivation of the equation of motion of beam composed of piezoelectric materials. Due to deformation of the structure, stresses appear which generate

electrical output. The electrical output can be used to generate sensors or other small devices. A model that takes into account electro-mechanical coupling and geometrical nonlinearity will be developed. Results in time domain will be presented and different scenarios will be investigated for the power output of the system.

Research Activities and Results

The results of the main research activities, performed during the second half of the project, are organized in the following groups:

- Isogeometric analysis of beams;
- Vibrations of cylindrical shells of laminated composites with curvilinear fibres;
- Dynamic analysis of curved beams;
- Functionally-graded beams;
- Parallel methods for dynamical analysis of large-scale systems;
- Energy harvesting;
- Models of elastic structures with discontinuities.

Isogeometric analysis of beams

This work is done in collaboration with Dr Clemens Hofreither. Timoshenko beam model is used for comparison of the nonlinear frequency-response function (NFRF) of models obtained by isogeometric analysis (IGA) and p -FEM. The equation of motion is derived by the principle of virtual work, Timoshenko's beam theory is assumed and geometrical nonlinearity is taken into account. Several comparisons are performed and it is demonstrated that IGA has better convergence properties than p -FEM in nonlinear dynamic analysis of beams.

Vibrations of cylindrical shells in laminated composites with curvilinear fibres

This work is started in collaboration with Assoc. Prof. Pedro Ribeiro from University of Porto during the first part of the project and currently it is finalized. A model of cylindrical shells with variable stiffness is defined and the influence of the curvilinear fibres on the forced response were analysed. Harmonic balance method is used for expressing the periodic responses. Higher harmonic functions appear at the response of the structure, mainly because of the nonlinearities but also because of the curvature of the shell and of the curvilinear fibres. An algorithm that automatically applies the harmonic balance method to any number of harmonic functions in the Fourier series is developed. Several numerical experiments are performed, illustrating the influence of the curvilinear fibres on the periodic response of the shell.

Dynamic analysis of curved beams

Curved beams are widely used in engineering applications because they increase the resistance of materials due to bending, in comparison with straight beams. A model of curved beam is developed in polar coordinate system, taking into account geometrical nonlinearities. The model is validated by large-scale model based on three-dimensional finite elements. It is shown that by using polar coordinate system and appropriate set of shape functions, beams with high curvature can be efficiently modelled with few degrees of freedom. Further, static displacements and dynamic responses are analysed.

Functionally-graded beams

The major advance of functionally-graded materials over the composite materials is that there is no risk of delamination. The PDE for the warping function for non-homogeneous materials is different than the one for homogeneous materials. This equation is derived, solved by modifications of TOBECS tool, and the cross sectional properties of beam section with functionally-graded materials are obtained.

Parallel methods for dynamical analysis of large-scale systems

The application of mathematical models to real-life engineering structures results into large-scale dynamical systems. In addition to the large-scale systems, the parametric analysis (which is powerful tool for investigating and understanding the behaviour of the system) makes the computational process burdensome. Thus, efficient parallel implementation of the numerical methods, used to perform parametric analysis of large-scale dynamical systems, is essential for the future use of these methods into real-life applications. Shooting method can find iteratively periodic response and it is suitable for computing nonlinear normal modes or nonlinear frequency-response curves. Parallel implementation of the shooting method is presented and its scalability is investigated. Beam equation of motion is used to validate the model and to generate large-scale nonlinear dynamical system. Its applicability to real-life applications is demonstrated by structural component of bridge discretized by three-dimensional finite elements.

Energy harvesting

The research of energy harvesting systems has increased significantly in the last decades. The most popular devices use piezoelectric elements as energy transducers. These devices transform kinetic energy into electrical one and are used to provide energy sources for small devices, such as sensors. In collaboration with prof. Litak from Lublin University of Technology, Poland and prof. Manoach from Institute of Mechanics, BAS, an electro-mechanical beam model is developed. The beam is assumed to have two layers, a main layer (bras) and additional layer of piezo material (PZT-5A) which is used to generate electricity from motion. Interaction with stoppers and tip mass on the free end are considered also in the model. An isogeometric approach is used to model the discontinuities due to the interaction with the stoppers. It is shown that stoppers can increase the power output of the system if the excitation frequency and the initial conditions are appropriate.

Models of elastic structures with discontinuities

Discontinuities often appear among engineering applications. They can be due to initial design of the structure or due to damage. Discontinuities lead to non-smooth solutions and, if they are not taken into account by the finite element model, an additional error appears. The appropriate usage of space discretization functions is essential for deriving mathematical models of problems with discontinuities with sufficient accuracy. Beam structure with stoppers is considered as an example of elastic structure with discontinuities. The work is done in collaboration with Dr Harizanov. B-Splines with multiple knots are used for space discretization of the discontinuous problem. It is shown that this space discretization technique performs better than the standard h and p versions of the finite element method.

Participations and presentations at scientific events:

- The influence of geometrical nonlinearity on the dynamics of elastic structures, International Conference on Numerical Methods for Scientific Computations and Advanced Applications, 19-22 May 2014, Bansko, Bulgaria
- Frequency response of cylindrical variable stiffness composite laminated shells, 8th European Nonlinear Dynamics Conference, 6-11 July 2014, Vienna, Austria
- Isogeometric analysis for nonlinear dynamics of Timoshenko beams, 8th International Conference on Numerical Methods and Applications, 20-24 August 2014, Borovets, Bulgaria
- Scalability of shooting method for nonlinear dynamical systems, 10th International Conference on Large-Scale Scientific Computations, 08-12 June 2015, Sozopol, Bulgaria
- Space Discretization by B-Splines on Discontinuous Problems in Structural Mechanics, 7th Balkan Conference in Informatics, 02-04 September 2015, Craiova, Romania

Three additional events for young researchers were also attended:

- Lab Surfing workshop, 25-26 March 2014, Thessaloniki, Greece.
- Blue Sky Conference, 17-19 June 2014, Budapest, Hungary.
- Science Incubator Summer School, 18-23 August 2014, Metz, France.

These events were organized for young researchers. The aim was to present to them the essential steps for developing their scientific ideas and writing proposals for FET-OPEN calls. The idea with which I was participating is entitled Nonlinear Dynamical Analysis and Structural Health Monitoring of Rotating Blades.

Publications, published:

- (i) P. Ribeiro, S. Stoykov, Forced periodic vibrations of cylindrical shells in laminated composites with curvilinear fibres, *Composite Structures*, Vol. 131 (2015), 462–478. (**IF 3.5**)
- (ii) S. Stoykov, E. Manoach, S. Margenov, An efficient 3D numerical beam model based on cross sectional analysis and Ritz approximations, *ZAMM - Journal of Applied Mathematics and Mechanics* (2015), DOI: 10.1002/zamm.201400139. (**IF 1.162**)
- (iii) S. Stoykov, G. Litak, E. Manoach, Vibration energy harvesting by a Timoshenko beam model and piezoelectric transducer, *European Physical Journal Special Topics*, Vol. 224 (2015), 2755-2770. (**IF 1.399**)
- (iv) S. Stoykov, C. Hofreither, S. Margenov, Isogeometric Analysis for Nonlinear Dynamics of Timoshenko Beams, *Numerical Methods and Applications*, Springer LNCS, Vol. 8962 (2015), 138-146. (**SJR 0.339**)
- (v) S. Stoykov, S. Harizanov, S. Margenov, Space discretization by B-Splines on discontinuous problems in structural mechanics, *Proceedings of the 7th Balkan Conference on Informatics* (2015), Paper Id: 31, DOI: 10.1145/2801081.2801113.
- (vi) S. Stoykov, S. Margenov, Scalability of Shooting Method for Nonlinear Dynamical Systems, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 9374 (2015), 401-408. (**SJR 0.339**)
- (vii) S. Stoykov, S. Margenov, Nonlinear forced vibration analysis of elastic structures by using parallel solvers for Large-Scale Systems, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 8353 (2014), 381-388. (**SJR 0.339**)
- (viii) S. Margenov, S. Stoykov, Y. Vutov, Numerical homogenization of heterogeneous anisotropic linear elastic materials, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 8353 (2014), 323-330. (**SJR 0.339**).
- (ix) S. Stoykov, The influence of geometrical nonlinearity on the dynamics of elastic structures, *Proceedings of the International Conference on Numerical Methods for Scientific Computations and Advanced Applications*, May 2014, Bansko, Bulgaria (2014), 103-106.
- (x) S. Stoykov, P. Ribeiro, Frequency response of cylindrical variable stiffness composite laminated shells, *Proceedings of 8th European Nonlinear Dynamics Conference*, Vienna, Austria (2014), Paper Id: 363.

Publications, accepted:

- (i) S. Stoykov, S. Margenov, Scalable parallel implementation of shooting method for large-scale dynamical systems. Application to bridge components, *Journal of Computational and Applied Mathematics*, DOI: 10.1016/j.cam.2015.04.015. (**IF 1.365**)

Publications in preparation:

- S. Stoykov, S. Margenov, Finite Element Method for Nonlinear Vibration Analysis of Plates, *Proceedings of International Conference Advanced Computing for Innovation*, 10-11 November 2015, Sofia, Bulgaria.

- S. Stoykov, S. Margenov, Comparative analysis of scalability of shooting and harmonic balance methods for computing periodic responses of nonlinear large-scale dynamical systems.
- S. Stoykov, S. Margenov, Static and dynamic analysis of geometrically nonlinear curved beams.

2.2.2. Dr. Jean Michel Sellier

Dr Jean Michel Sellier (<https://nanohub.org/members/28836>) holds a PhD in Mathematics (thesis in electron transport in semiconductor devices) from the University of Catania (Italy). He gained experience during his postdoc visits at Imperial College London (UK) and at INRIA (Institut national de recherche en informatique et automatique), Rocquencourt (France). He has also been a Research Associate at Purdue University, IN, USA working with Prof. G. Klimeck. Dr Sellier is the developer of the GNU packages Archimedes and Aeneas - two tools for 2D and 3D simulation of semiconductor devices. He maintains nanoHUB tools as well, incl. 1dhetero (a Schrodinger Poisson simulator for heterostructures) and RTDNEGF (a RTD simulator based on the NEGF formalism).

Individual Research Plan of Dr Jean Michel Sellier in AComIn for months 19-36 host professor: Ivan Dimov

In the previous period a powerful quantum simulator, based on the signed particle Wigner Monte Carlo method, has been implemented, known as nano-archimedes, and released to the scientific community under GPL. The Wigner Monte Carlo method has been generalized to very challenging physical contexts such as the inclusion of phonon scattering into a full quantum simulation and to the many-body problem, an extremely important problem for both the comprehension of the laws of Nature and technological applications. These truly novel methods have been applied to several time-dependent and complex situations to show the validity and reliability of the method. The method needs to be applied to further complex situations and, possibly, exposed in clearer terms in order to make the community able to implement their own simulator.

Goals

- The Wigner-Boltzmann equation is a very promising model to simulate the next generation of semiconductor devices (post-CMOS). In particular it would be interesting to study the effects of the phonon scattering over a system of entangled particles. This could lead experimentalists towards the comprehension of such phenomenon in clearer details.
- The Wigner Monte Carlo method based on signed particles seems to suggest a novel formulation of quantum mechanics. This novel formulation needs to be studied in great details. This would definitely help the community to understand in a intuitive way quantum phenomena.

Simulation of Devices candidate to Quantum Computing

All candidates presented so far for quantum computing on Silicon technology are based on exploiting single dopants buried in a Silicon substrate. Preliminary calculations have been performed showing that the proposed Wigner-Boltzmann Monte Carlo approach has the potential to simulate such devices in a time dependent, full quantum fashion, including phonon scatterings (a unique capability at the present time). A generalization of this model to the case of many-body systems is needed and will be part of the goal of this project. This represents an important point and will require particular efforts

(both theoretical and computational) to be put in place, but the advantages coming from such an approach are unarguably important for a huge community of scientists and technologists.

Applications to Chemical systems

The use of pseudopotential models in the quantum/computational Chemistry community is very common. To the best of our knowledge, there is no mathematical investigation on the use of these models coupled to the Wigner equation and, in particular, to the Wigner Monte Carlo method. A thorough study is needed from this perspective to show the applicability of our novel method to this category of problems.

Research Activities and Results

The achieved results have produced advancements in the following fields:

- Development of important mathematical and physical insights in the field of quantum transport theory and Silicon based classical and quantum computing devices such as CMOS transistors with random dopants, Single Electron Transistors, Solotronic devices, etc.
- Development and applications of a truly novel numerical technique for the time dependent simulation of chemical systems, allowing the access to excited states.
- Applications of the Wigner formalism and its Monte Carlo method to technology relevant situations especially in quantum chemistry.
- Development of mathematical and physical insights in the theory of quantum mechanics.
- Development of a novel formulation of quantum mechanics.

Conferences and invited lectures:

- 2014, University of Antwerp, Belgium
- 2014, University of Tor Vergata, Rome, Italy
- Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing, April 2014, Leuven, Belgium
- International Workshop on Computational Electronics, June 2014, Paris, France
- Numerical Methods and Applications, August 2014, Borovetz, Bulgaria
- January 2015, Beijing, China: Series of 5 public lectures
- Large-Scale Scientific Computations, June 2015, Sozopol, Bulgaria.
- IMACS Seminar on Monte Carlo Methods, July 2015, Linz, Austria

Publications, published:

- (i) P. Schwaha, M. Nedjalkov, S. Selberherr, J. M. Sellier, I. Dimov, R. Georgieva, Stochastic Formulation of Newton's Acceleration, Large-Scale Scientific Computing, Springer LNCS, Vol. 8353 (2014), 186-193. **(SJR 0.34)**
- (ii) J. M. Sellier, I. Dimov, The many-body Wigner Monte Carlo Method for time-dependent Abinitio quantum simulations, Journal of Computational Physics, Vol. 273 (2014), 589-597. **(IF 2.138)**
- (iii) J. M. Sellier, I. T. Dimov, The Wigner-Boltzmann Monte Carlo Method applied to electron transport in the presence of a single dopant, Computer Physics Communications, Vol. 185 (2014), 2427-2435. **(IF 3.078)**
- (iv) J. M. Sellier, I. Dimov, A Wigner Approach to the Study of Wave Packets in Ordered and Disordered Arrays of Dopants, Physica A: Statistical Mechanics and its Applications, Vol. 406 (2014), 185-190. **(IF 1.676)**
- (v) J. M. Sellier, I. Dimov. A Wigner Monte Carlo Approach to Density Functional Theory, Journal of Computational Physics, Vol. 270 (2014), 265-277. **(IF 2.138)**

- (vi) J. M. Sellier, S. Amoroso, M. Nedjalkov, S. Selberherr, A. Asenov, I. Dimov, Electron dynamics in nanoscale transistors by means of Wigner and Boltzmann approaches, *Physica A: Statistical Mechanics and its Applications*, Vol. 398 (2014), 194-198. **(IF 1.676)**
- (vii) J. M. Sellier, M. Nedjalkov, I. Dimov, S. Selberherr. A benchmark study of the Wigner Monte-Carlo method, *Monte Carlo Methods and Applications*, Vol. 20(1), (2014), 43–51. **(SJR 0.224)**
- (viii) J. M. Sellier, M. Nedjalkov, I. Dimov, S. Selberherr, The role of annihilation in a Wigner Monte Carlo approach, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 8353 (2014), 186-19. **(SJR 0.339)**
- (ix) J. M. Sellier, I. Dimov, Towards solitonics design in the Wigner formalism, *Physica A: Statistical Mechanics and its Applications*, Vol. 417 (2015), 287–296. **(IF 1.722)**
- (x) J. M. Sellier, I. Dimov, A sensitivity study of the Wigner Monte Carlo method, *Journal of Computational and Applied Mathematics*, Vol. 277 (2015), 87-93. **(IF 2.266)**
- (xi) J. M. Sellier, I. Dimov, On the simulation of indistinguishable fermions in the many-body Wigner formalism, *Journal of Computational Physics*, Vol. 280 (2015). **(IF 2.138)**
- (xii) J. M. Sellier, M. Nedjalkov, I. Dimov, S. Selberherr. A Comparison of Approaches for the Solution of the Wigner Equation, *Mathematics and Computers in Simulations*, Vol. 107 (2015), 108-119. **(IF 0.836)**
- (xiii) J. M. Sellier, I. Dimov, Wigner functions, signed particles, and the harmonic oscillator, *Journal of Computational Electronics*, Vol. 14 (4) (2015), 907-915. **(IF 1.520)**
- (xiv) J. M. Sellier, D. Ivanova, I. Dimov, Molecular descriptors and quasi-distribution functions, *Computers and Mathematics with Applications* (2015), doi:10.1016/j.camwa.2015.06.037. **(IF 1,697)**
- (xv) J. M. Sellier, M. Nedjalkov, I. Dimov, An introduction to applied quantum mechanics in the Wigner Monte Carlo formalism, *Physics Reports*, Vol. 577 (2015), 1-34. **(IF 22.91)**
- (xvi) J. M. Sellier, R. F. Sviercoski, I. Dimov, On the Wigner Monte Carlo Method Coupled to Pseudopotential Models, *Journal of Computational and Applied Mathematics*, Vol. 29 (2015). **(IF 1.266)**

Publications under review:

- J.M. Sellier, S. Shao, Comparison of Deterministic and Stochastic Methods for Time-Dependent Wigner Simulations, *Journal of Computational Physics*, (2015).
- J.M. Sellier, G.Kapanova, I. Dimov, On Randomization of Neural Networks as a Form of Post-learning Strategy, *Applied Soft Computing*, (2015).
- J.M. Sellier, G.Kapanova, I. Dimov, A Neural Network Sensitivity Analysis in the Presence of Random Fluctuations, *Neural Networks*, (2015).

2.2.3. Dr. Clemens Hofreither

Dr Clemens Hofreither (<http://parallel.bas.bg/sc/cv-hofreither.pdf>) holds a PhD degree from Johannes Kepler University Linz, Austria. The title of his thesis, delivered in 2012, is “A Non-standard Finite Element Method using Boundary Integral Operators (supervisor: U. Langer). His research interests are in the areas of Finite element methods, in particular non-standard and Trefftz-type FEM, Isogeometric analysis, Multigrid solvers, Convection-diffusion problems, Boundary element methods and Multivariate interpolation by Radon projections.

Individual Research Plan of Dr Clemens Hofreither in AComIn month 19 host professor: Svetozar Margenov

The recently started cooperation with Stanislav Stoykov on application of isogeometric methods to structural analysis of linear and nonlinear beam models will be continued. Based on promising results

from the literature, the work is concerned with analyzing the Timoshenko beam model using isogeometric methods and performing comparisons with the p-version of the finite element method. A joint publication with the title "Isogeometric analysis for nonlinear dynamics of Timoshenko beams" is under preparation. First results will be presented at the 8th International Conference on Numerical Methods and Applications in Borovets, August 2014. Based on the results of this first step, an extension to other beam models and plates or shells is planned.

Further work also includes research towards smoothers for the geometric multigrid method in isogeometric analysis which behave robustly with respect to the spline degree and space dimension. First promising results in 2D have been achieved.

The work on GPU implementation of isogeometric methods is to be extended to the 3D case and more general geometries and spline spaces. More benchmarks are to be performed to gain insight on the speedup to be expected. The stabilisation of isogeometric methods needs more detailed study, especially as to the behavior in the multivariate case. The error estimate for reconstruction of functions which are constrained by a Poisson equation by means of Radon projections may be subject to further refinement.

Research Activities and Results in AComIn

The achieved and published results are in the following fields:

- Cubature formulae for, and interpolation and fitting of harmonic functions based on Radon projections.
- Analysis of multigrid and domain decomposition solvers for non-standard FEM systems.
- Multigrid solversfor, and applications of isogeometric analysis.

Publications, published:

- (i) I. Georgieva, C. Hofreither, R. Uluchev, Least Squares Fitting of Harmonic Functions Based on Radon Projections, *Mathematical Methods for Curves and Surfaces*, Springer LNCS, Vol. 8177 (2014), 158-171. **(SJR 0.339)**
- (ii) C. Hofreither, U. Langer, C. Pechstein. FETI solvers for non-standard finite element equations based on boundary integral operators, *Lecture Notes in Computational Science and Engineering*, Vol. 98 (2014), 729-737. **(SJR 0.260)**
- (iii) C. Hofreither, W. Zulehner, Spectral Analysis of Geometric Multigrid Methods for Isogeometric Analysis, *Numerical Methods and Applications*, Springer LNCS, Vol. 8962 (2015), 123-129. **(SJR 0.339)**
- (iv) C. Hofreither, W. Zulehner, On full multigrid schemes for isogeometric analysis, *Domain Decomposition Methods in Science and Engineering XXII, Lecture Notes in Computational Science and Engineering*, Vol.104 (2015), 272-279. **(SJR 0.260)**
- (v) I. Georgieva, C. Hofreither. Interpolation of harmonic functions based on Radon projections, *NumerischeMathematik*, 127(3) (2014), 423-445. **(IF 1.608)**
- (vi) I. Georgieva, C. Hofreither. Interpolating solutions of the Poisson equation in the disk based on Radon projections, *Journal of Mathematical Analysis and Applications*, 423(1) (2015), 305-317. **(IF 1.12)**
- (vii) I. Georgieva, C. Hofreither. Cubature Rules for Harmonic Functions Based on Radon Projections, *Calcolo*, 52, (2015), 153-166. **(IF 0.808)**
- (viii) S. Stoykov, C. Hofreither, S. Margenov, Isogeometric Analysis for Nonlinear Dynamics of Timoshenko Beams, *Numerical Methods and Applications*, Springer LNCS, Vol. 8962 (2015), 138-146. **(SJR 0.339)**

2.2.4. Dr. Ivan Georgiev

Dr Ivan Georgiev (<http://parallel.bas.bg/~john/index.html>) has got his PhD in Computational Mathematics from the Bulgarian Academy of Sciences in 2007. The thesis is entitled *Iterative Methods for Non-Conforming Finite Elements*. After PhD, he was till his AComIn employment at a postdoc position in Radon Institute of Computational and Applied Mathematics, Austrian Academy of Sciences, Linz, Austria. His primal research interests include the topics of numerical solution of partial differential equations, finite elements, multilevel methods, industrial mathematics.

Individual Research Plan of Dr Ivan Georgiev in AComIn for months 19-36 host professor: Svetozar Margenov

The background and research activities of DrGeorgiev are related mainly to the Area 1 of the project: Advanced computing and Finite Elements applications. During the 18 months of employment, a number of interdisciplinary problems will be targeted. Scientific infrastructure of IICT-BAS, including SmartLab equipment and high performance computing infrastructure will be used intensively. The problems include:

- Characterization of effective material properties of composites by CT microstructure model and numerical simulations.
- Numerical simulations of blood flow through 3D structures.
- 3D printing and rapid prototyping
- Micro structure analysis and visualization of biomedical, engineering, and anthropological objects.

Work with SmartLab equipment: Industrial CT scanning, 3D laser scanning, 3D printing and 3D visualization.

Research Activities and Results

Study of effective elastic properties of composite materials

Epoxy-clay composite materials: The numerical homogenization of anisotropic linear elastic materials with strongly heterogeneous microstructure is studied. The developed algorithm is applied to the case of two-phase composite material - epoxy resin based nanocomposite incorporating nanoclayCloisite. The upscaling procedure is described in terms of six auxiliary elastic problems for the reference volume element. A parallel PCG method is applied for efficient solution of the arising large-scale systems with sparse, symmetric, and positive semidefinite matrices. Then, the bulk modulus tensor is computed from the upscaled stiffness tensor and its eigenvectors are used to define the transformation matrix. The stiffness tensor of the material is transformed with respect to the principle directions of anisotropy which gives a canonical (unique) representation of the material properties. Numerical upscaling results are shown. The voxel microstructure of the two-phase composite material is extracted from a high resolution computed tomography image.

Wood plastic composite materials: Wood Polymer Composites (WPC) are an own class of materials. It is a material combination of wood, polymer and various additives, so it is neither wood nor polymer. On the one hand these materials show better durability and surface properties than wood and on the other hand it reinforces the matrix polymer. The main applications of WPC so far are terrace decks. During the last two years we can observe a trend for more R&D work in developing WPC formulations for the use in injection molding, in particular for the automotive business. Thus, in

this study some grades for injection molding and for comparison the pure matrix polymer, polypropylene are analyzed by different numerical methods. In addition they are characterized regarding their mechanical properties to evaluate the simulated results. Applying the numerical homogenization procedure we obtain the effective macro-characteristics of studied linear elastic materials. The effective elasticity tensor is obtained by using the module ElastoDict of the specialized software for numerical homogenization and virtual material design GeoDict. The voxel microstructure of the considered WPC material is obtained by a high resolution computed tomography image.

Numerical simulations of blood flow in cerebral aneurysms

Cerebral aneurysms are dilations of arterial walls that can grow over time and, in case of rupture, lead to dangerous hemorrhage. We are simulating the blood flow through intracranial aneurysms including its interaction with the surrounding vessel tissue. The results of the simulation enables physicians to estimate rupture risks by calculating the distribution of blood pressure, velocity and wall stresses in the aneurysm, in order to support the planning of clinical interventions. For the numerical simulation, the computational domain is extracted from medical image data of the patient's cerebrovascular system. The blood is modeled as an incompressible Newtonian fluid, and the surrounding vessel wall as an isotropic linear elastic material. Both the Navier-Stokes equations for the fluid domain and the Navier-Lamé equations for the solid domain are handled with a finite element method, and the resulting linear equation systems are solved via parallel conjugate gradient method with algebraic multigrid preconditioner. Implicit coupling between blood flow and wall elasticity is achieved using an iterative fluid-structure interaction technique deforming the fluid mesh according to the wall displacement in each step. Boundary conditions are applied by prescribing measured waveforms of blood velocity and pressure at inlet and outlet areas. Due to the time-critical nature of the application, we exploit efficient state-of-the-art numerical methods and high performance computing on advanced heterogeneous CPU-GPU extremely parallel architectures.

Rapid prototyping of radio antenna

This study proves a new approach for rapid prototyping of radio antenna through 3D printing and chemical metallization. For this purpose, a standard metal pyramidal horn prototype is confronted with its 3D printed replica. Three different 3D polymer printers are tested. The printed samples are assessed nondestructively by the X-ray Industrial Computed Tomography (CT) scanner, therefore metalized via chemical deposition and chemical-electrochemical deposition. Copper with two different layer thicknesses and nickel materials are deployed and verified as a metallization opportunity. CT scanner, x-ray fluorescent analysis and nanoindentation technique are used to perform the metallization quality estimation. As a result, a qualitative polymer prototype is produced, having weight of 13g - ten times lighter than the original. The prototype is successfully metalized obtaining possibility for soldering, as well. The radio-measurement comparison with the metal original for frequencies 14-18GHz showed no significant differences. Finally, a simple dynamometric test confirmed the bonding between the metal and the polymer. To the best of our knowledge this is the first known comprehensive analysis of the possibility to print 3D lightweight wideband polymer antenna prototype with a stable chemical metallization and radio properties very close to the original at 14-18GHz.

Advanced structure characterization of fiber-reinforced concrete

Incorporation in concrete composition of steel macro and micro fiber reinforcement with structural function increases the degree of ductility of typically brittle cement-containing composites, which in some cases can replace completely or partially conventional steel reinforcement in the form of rods and meshes. Thus, that can reduce manufacturing, detailing and placement of conventional reinforcement, which enhances productivity and economic efficiency of the building process. In this study, six fiber-reinforced with different amounts of steel fiber cement-containing self-compacting compositions are investigated. Advance approach for the study of structural and material properties of

these type composites is proposed by using the methods of industrial computed tomography. The obtained original CT microstructure results and characterization of individual structural components make it possible to analyze the effective macro characteristics of the studied composites. The first obtained results in this topic concerns porosity distribution analysis with respect to the amount of the included steel fibers.

Applications of CT microstructure analysis in paleoanthropology

The co-occurrence of bregmatic bone and metopism is an extremely rare finding. In the present study we investigate, compare and describe this uncommon combination in two skulls belonging to infant and adult male individuals. The objects of the study have been obtained from archaeological excavations of two medieval necropoles located in the northern Black Sea coast of Bulgaria. The samples are macroscopically observed and measured. A CT scanning is performed in order to be investigated the internal microstructure and the relation between the calvarial bones. Other studied case describes a survived surgical intervention on the orbit with an excision of part of the orbital apex on a skull from the medieval town of Kabyle, Southeastern Bulgaria (12th - 14th century). The orbital defect is observed macroscopically and analyzed in detail by micro CT imaging. The most probable causes for orbital trepanation in the case could be an urgent orbitocranial trauma or serious symptoms of some orbital pathological condition. The traces of remodeling on the defect margin indicate that the individual survived for a certain period of time after the operation.

Work with Smart Lab Equipment

- Industrial CT scanning - Microstructure analysis of composite and porous materials, bone tissue, silicate, concrete and geo-polymer materials, Non Destructive Testing of aluminum castings and copper metal pressing details.
- 3D laser scanning – archaeological and paleo-anthropological artifacts, engineering applications
- 3D visual wall - 3D stereoscopic visualization of numerical simulation results.

Participations and presentations at scientific events:

- International Conference on Numerical Methods for Scientific Computations and Advanced Applications, May 19-22, 2014, Bansko, Bulgaria
- Industrial Computed Tomography and Microstructure Analysis, International conference NDT Days 2014, June 9-13, 2014, Sozopol, Bulgaria
- Numerical Simulations of Blood Flow Dynamics in Cerebral Aneurysms, International conference on Mathematical Methods and Models in Biosciences, June 22-27, 2014, Sofia, Bulgaria
- Numerical Homogenization of Wood Polymer Composite Materials, Eight International Conference on Numerical Methods and Applications, August 20-24, 2014, Borovets, Bulgaria
- 104th European Study Group with Industry (ESGI'104), September 23-27, Sofia, Bulgaria, 2014
- Understanding the Behavior of Composites based on CT-Scans and Numerical Simulations, International Workshop GeoDict User Meeting, October 13-14, 2014 Kaiserslautern, Germany
- Advance methods for structure and properties characterization of fiber-reinforced silicate composites, High Performance Computing in Science and Engineering, May 25-28, 2015, Ostrava, Czech Republic
- Numerical Characterization of Elastic Properties of Metal Porous Materials, Large-Scale Scientific Computations, June 8-12, 2015, Sozopol, Bulgaria
- Industrial CT scanning applications in porosity and inclusion analysis, International Conference NDT Days 2015, June 16-19, 2015, Sozopol, Bulgaria

- Application of 3D laser scanning in inspection and reverse engineering, International Conference NDT Days 2015, June 16-19, 2015, Sozopol, Bulgaria
- Advance Characterization of Structure and Properties of Composites, Seventh Conference of the Euro-American Consortium for Promoting the Application of Mathematics in Technical and Natural Sciences, June 28-July 3, 2015, Albena, Bulgaria
- 113th European Study Group with Industry (ESGI'113), September 14-18, Sofia, Bulgaria, 2015

Publications, published:

- (i) I. Georgiev, S. Margenov. Semi-coarsening AMLI preconditioning of anisotropic trilinear FEM Systems, Computers and Mathematics with Applications, Vol.68(12) (2014), 2103-2111 (**IF 1.697**)
- (ii) I. Georgiev, E. Ivanov, S. Margenov, Y. Vutov. Numerical Homogenization of Composite Materials, Numerical Methods and Applications, Springer LNCS, Vol. 8962 (2015), 130-137. (**SJR 0.339**)
- (iii) Ang. Liolios, A. Elenas, Ast. Liolios, St. Radev, K. Georgiev, I. Georgiev. Tall RC buildings environmentally degraded and strengthened by cables under multiple earthquakes: A numerical approach, Numerical Methods and Applications, Springer LNCS, Vol. 8962 (2014), 187-195. (**SJR 0.339**)
- (iv) M. Mironova, M. Ivanova, V. Naidenov, I. Georgiev, J. Stary. Advance study of fiber-reinforced self-compacting concrete, Applications of Mathematics in Techniques and Natural Sciences, AIP Conference Proceedings, Vol. 1684 (2015), <http://dx.doi.org/10.1063/1.4934293>. (**SJR 0.15**)

Papers, accepted:

- (v) Ang. Liolios, At. Karabinis, Ast. Liolios, St. Radev, K. Georgiev, I. Georgiev. A computational approach for the seismic damage response under multiple earthquakes excitations of adjacent RC structures strengthened by ties, Computers and Mathematics with Applications (accepted). (**IF 1.697**)
- (vi) I. Georgiev, S. Harizanov, Y. Vutov. Supervised 2-phase Segmentation of Porous Media with Known Porosity, Large-Scale Scientific Computing, Springer LNCS, Vol. 9374 (accepted). (**SJR 0.339**)

Papers, submitted:

- V. Kyovtorov, I. Georgiev, S. Margenov, D. Stoychev, F. Oliveri, D. Tarchi, Lightweight 3D printed polymer prototype antenna, metallization and experimental test at 14-18GHz
- S. Nikolova, D. Toneva, I. Georgiev, Y. Yordanov, N. Lazarov, CT-imaging of the rare combination of a large bregmatic bone with a persistent metopic suture
- S. Nikolova, D. Toneva, I. Georgiev, A case of skeletal dysplasia in bone remains from a contemporary male individual
- D. Toneva, S. Nikolova, I. Georgiev, N. Lazarov, Orbital trepanation in a medieval skull from Bulgaria

Plans for future work within AComIn

- Advanced computing applications for heterogeneous HPC systems
- Microstructure analysis, characterisation, and parameter identification of composites and porous media with engineering and geoscience applications
- 3D scanning, visualization and processing of obtained data with applications in cultural heritage and engineering

2.2.5. Dr Vladimir Kotev

Dr Vladimir Kotev (http://www.iict.bas.bg/acomin/CV_VI_Kotev.pdf) has got a PhD degree in Biomechanics from the Bulgarian Academy of Sciences in 2008. His fields of research include: Mechatronic systems, Medical and micro robotics, Dynamics and control, as well as Biomechanics. He received a post-doc scholarship from Japan Society for the Promotion of Science and was a postdoctoral researcher in medical robotics at the Gifu University – Japan from October 2011 to October 2013. There he worked on design, dynamical modeling, simulations, control and development of a drilling and cutting robotised hand-held system for the orthopaedic surgery.

Individual Research Plan of Dr Vladimir Kotev in AComIn for months 19-26 host professor: Dimitar Karastoyanov

In the framework of AComIn project Dr Kotev's research is mainly related to the following topics: optimization and intelligent control as well as signal and image processing. In particular his research is focused on the application of the mathematical modeling and control theory to mechatronics, robotics, bioengineering and manufacturing technological processes. He conducts both theoretical and experimental research using the SmartLab equipment. Dr Kotev is working on the following problems:

Mechatronic systems for medical applications

- Design and mathematical modeling of Bioreactors

Bioreactors are a part of modern biotechnologies used for growth of human cells in vitro. Usually, the chambers of bioreactors perform 3D spatial motion which is achieved by 3 motors or, in other words, they have three degrees of freedom (DoF). Dr. Kotev's research is focused on the design of mechanisms for bioreactors that allow spatial motion of the chamber with less DoF and can be controlled by simple hardware and software. Moreover, the growing cell culture into the chamber has to perform oscillations with defined amplitude. In addition the cell culture does not touch the walls of the chamber. From the engineering point of view, these circumstances require one to derive a mathematical model describing precisely the motion of the growing cell culture into biological fluid suspension and chamber's motion and acceleration in order to control the bioreactor. Furthermore, based on the motion law of the cell culture, mechanisms for bioreactors achieving spatial motion with defined velocities and accelerations have to be designed and controlled.

- Braille Screen tactile display

The graphical interfaces based on visual representation and direct manipulation of objects make the adequate use of computers quite difficult for people with reduced sight. Tactile display devices could help disabled people to interact with computers and other devices. A study to develop a new type of graphical Braille screen is carried out. The recently developed permanent magnet linear electromagnetic actuator for driving a needle in a Braille screen and the circuit testing method using micro robots are discussed. Dr. Kotev and his host professor Karastoyanov study mechanisms for development of planar and spatial motion tactile display. The aim of this research is to design mechanisms with permanent magnet linear actuators incorporated into their links in order to develop new types of tactile display. Therefore, mathematical and finite element models describing trajectories, velocities, forces, links deformations and stress have to be analyzed.

Medical and micro robotics

- Cell injection robot

Cell bio-manipulation technologies include the following base procedures such as isolation, separation, immobilization, transportation, stimulation, injection, detection, and measurement. Moreover, to enhance the performance of the above mentioned manipulation robots, micro fluid devices and other equipment are used. In addition, in biological cell injection, the control of injection

forces is important since excessive manipulation force may destroy the membrane or tissue of the biological cell, and lead to failure of the bio-manipulation task. This research refers to the development of visual based control algorithms for teleoperation of a cell injection robotized system. Dynamical and 3D CAD models as well as simulations help to develop control algorithms of the cell injection robot. The main purpose is to develop an algorithm that determines the value and direction of operator force interaction on the cell. This force information has to be calculated using the visual deformation of the cell contour. After evaluation of the force vector it is feed back to the operator through human-machine interface tool with force feedback unit. To increase performance of the cell injection process a micro fluidic cell feeding device has to be develop and added to the cell injection robot. This cell feeding device could be manufactured by a 3D printer.

- Study of the bone cutting process performed by orthopedic hand – held robot

Bone drilling and cutting procedures are widely used in orthopaedic surgery. Relatively high forces and temperatures experienced during bone drilling and cutting can cause significant damage to the bones, which can make patient recovery long and painful. It is well known that orthopaedic robots enhance surgical procedures. The main focus of the current research is to study the influence of cutting conditions on bone achieved by a hand-held bone cutting robot. The structure of bones depends on age, sex, race and personal features. Therefore, the determination of the following cutting conditions, such as thrust force, torque, speed and feed rate, detecting of bone breakthrough, temperature are very important for the orthopaedic surgery. Both theoretical and experimental studies have to be done in order to define the influence of cutting conditions on bone structure after incision. Theoretical research can be done by finite element modelling of bone and cutting blade. A part of the Smart Lab equipment such as the thermo camera FLIR P640, high speed camera NacMemrecam HX6, and industrial computed tomography (CT) device will be used for the experimental research.

Dynamical modeling of the gene regulatory systems

MicroRNAs (miRNAs) are endogenous small RNA molecules that regulate gene expression (transcription and translation) by specific interaction with messenger RNAs (mRNAs). In this way miRNAs involve in pathways of development, programmed cell death, and cancer. A mathematical model of gene expression, regulated by miRNAs is proposed. The model is presented by a system of four ordinary differential equations (ODEs). To study the impact of the time during the gene expression a time delay function is introduced in the ODEs model. Therefore, a time delay non-linear model is derived. Next, to clarify how the inclusion of time delay alters the dynamic properties of the considered genetic process, a stability analysis of delay differential equations (DDEs) has to be performed.

Design and control concept of three wheels mobile robot

This research refers to the design, dynamics and control strategies of 3 wheels mobile robots. In order for the robot to follow given preliminary trajectories, algorithms for control of 3 motors should be developed.

Industrial technological processes like forging, die forging, and pile driving

Technological processes such as forging, die forging, and pile driving are widespread in industry. Possibilities to increase forging process by rocket driven hammer are studied. In order to control the impact in forging, the dynamics of the process have to be studied both theoretically and experimentally. Some parameters necessary for the mathematical model like time, rebound forces, coefficient of rebound, are taken experimentally by high speed camera.

Research Activities and Results

The performed theoretical and experimental work is the following topics:

- Modeling and design of mechanical construction of bioreactors;
- Dynamics and control of forging process by applying of additional force;
- Development of a Braille tactile device;
- Control of a cell injection robot;
- Orthopedic bone cutting hand-held robot.

The obtained results include: (i) Study of the dynamics of a base model describing gene regulatory systems in biological cells; (ii) Design concept for development of a bioreactor for growing of cell culture is developed: the bioreactor's dynamics is considered in order to control the process; (iii) Analysis of the additional force dynamics and optimization of the forging process based on application of additional force: the derived mathematical model is based on experimental data; Design and control concept for development of a Braille tactile interface; Algorithms and programs for vision-based control of a cell injection robot.

Publications, published:

- (i) D. Karastoyanov, V. Kotev, T. Penchev, Forging Process Control by Additional Rocket Force, International Journal of Emerging Technology and Advanced Engineering, Vol. 4 (8) (2014), 297-306
- (ii) D. Karastoyanov, V. Kotev, I. Yatchev, Development of a Braille Tactile Device Driven by Linear Magnet Actuators, International Journal of Engineering and Innovative Technology, Vol. 4 (2) (2014), 35-43
- (iii) D. Karastoyanov, V. Kotev, T. Penchev, Forging by Rocket Driven Hammer: Dynamics and Experiments, Advanced in Engineering Mechanics and Materials (2014), 174-177
- (iv) D. Karastoyanov, V. Kotev, Electromagnetic Microdrives for Braille Screen: Control and Circuit Testing, International Journal of Materials Science and Engineering, Vol. 3 (1) (2015), 1-6
- (v) K. Kostadinov, V. Kotev, D. Penchev, Force Sensing of Teleoperated Robotized Cell Injection, Advances in Robotics, Mechatronics and Circuits (2014), 160-163
- (vi) V. Kotev, D. Karastoyanov, P. Genova, Application of the Spatial Mechanisms in Bioreactors: Design Concept., International Journal of Materials Science and Engineering, vol. 3, (1) (2015), 82-85

2.2.6. Dr Volodymyr Kudriashov

Dr Volodymyr Kudriashov (<http://mmsip.bas.bg/staff/kudr.html>) has got his PhD from O. Ya. Usikov Institute for Radiophysics and Electronics, National Academy of Sciences of Ukraine. The IEEE Fellow, head of Department of Nonlinear Dynamics of Electronic Systems, Prof. D.Sc. K. Lukin is his scientific advisor. The PhD theme is "Formation of coherent radiometric images with bistatic radiometer based on antennas with beam synthesis". He defended PhD in physics and mathematics (specialty radiophysics) in 2013. The State Attestation Commission of Ukraine approved the Scientific Council decision in 2014. His current research interests are in the area of signal processing, including: Acoustic Noise Source Localization, Generation of Acoustic Images and Detection of Acoustic Signals.

Individual Research Plan of Dr Volodymyr Kudriashov in AComIn months 23-36 host professor: Kiril Alexiev

The research work is focused on identification and localization of noise sources by acoustic camera. The acoustic imaging can be described as a conversion of acoustic waves to electrical signals by array of microphones, digital processing of these signals and their visualization onto camera image.

The acoustic image enables to investigate characteristics of the received acoustic noise. These characteristics are as following: acoustic pressure, frequency and direction of arrival. The software of existing acoustic imaging systems estimates the listed characteristics. The "delay and sum" beamforming is a widely used approach to generate acoustic pressure image. Its extension for microphone array focalization in near distances is the most frequently used regime of acoustic camera. In this regime, each resolution element of image is formed via focusing on every node of a rectangular grid in the near distance zone. The rectangular grid is placed on the focal plane of the microphone array. This approach requires setting the distance to the acoustic noise emitter in advance.

The AComIn Smart Lab Acoustic Camera has software that enables user to estimate many characteristics of the received acoustic signals, for example sound pressure as a function of its emitter position. Moreover, the software provides one to do post processing of received acoustic signals. The sophisticated post processing requires a good knowledge of equipment characteristics and workflow. Many applications require higher angular resolution, which depends on microphone array size. To improve resolution of available microphone array, more advanced signal processing methods have to replace the existing "delay and sum" beamforming algorithm. The development of such method will be carried out as follows:

- The first step will be focused on estimation of the Acoustic Camera technical characteristics and understanding of workflow, including research on the generation of acoustic images require configuring built-in software for obtainment of suitable "raw" signals.
- The second step is directed to generation of acoustic images on the base of conventional "delay and sum" beamforming algorithm. It is aimed to create reference point for further research and for educational purposes.
- The third step consists of development and testing of new algorithms like 3D imaging and Capon-based estimation of signals' direction of arrival. Its performance will be compared to one of built-in software.

The Acoustic Camera requires user to set distance of operation, in advance. Then it generates an acoustic image, in a pre-defined range of frequencies. The Acoustic Camera visualizes a 3D acoustic image onto optic camera image. Decision on the desired signal presence is to be adopted by user. The research work is focused on improvement of signal processing in the Acoustic Camera.

The Acoustic Camera user adopts decision on presence of desired signal. A detection criterion is capable to reduce the influence of human factor on results of analysis of images generated by the acoustic camera. A criterion for non-stationary Wiener signal detection will be considered.

Distance estimation bypassive "listening" systems may be done using information on time/phase difference of arrival of signals. Such approach is capable for generation of 4D images. The distance estimate enables to diminish the user interaction. The built-in software of the AComIn Smart Lab Acoustic Camera enables user to store "raw" data for further post-processing. The data is suitable for experimental investigation of possibility to estimate the distance.

The 4D acoustic images generation approach will be simulated. Reference signal in such imaging system is received from the investigated emitting object using auxiliary microphone. Time difference of arrival of signals may be estimated by cross-correlation technique. Scripts for generation of the images will be developed for the Acoustic Camera. The software will be tested using the "raw" data. Corresponding experiments are expected to show the range resolution of system, achieved by focusing of microphone array for distance span limited by means of about bistatic baseline. The imaging approach enables to suppress incoming signals from unwanted distances. Possibility to re-configure the Acoustic Camera into bistatic mode will be considered, to provide corresponding experiment.

Research Activities and Results in AComIn

The results of the research activities, performed during the working period, are organized as follows: Estimation of the Acoustic Camera characteristics and the workflow, and consideration of common algorithms for generation of acoustic images; Development and testing of new methods for acoustic noise source localization; Detection-measurement of wideband acoustic noise source; Estimation of features of emitting objects with non-acoustic systems.

Estimation of the Acoustic Camera characteristics and the workflow and consideration of common algorithms for generation of acoustic images

The built-in software of the AComIn Smart Lab Acoustic Camera is configured for "raw" data export. The data is exported using Bridge to MatLab of PULSE LabShop of the Acoustic Camera and outcomes of Vibration and Acoustics Group, University of New South Wales. A script for generation of acoustic images using "delay and sum" beamforming method is developed. It enables focalization of the microphone array to distances comparable with its dimensions. The Acoustic Camera manufacturer describes the built-in beamforming method in corresponding technical review. The method is implemented to the script. The software enables to estimate performance of the microphones, input modules and the microphone array of the Acoustic Camera.

Development and testing of new method for acoustic noise source localization

New beamforming method is proposed based-on modified Capon method, aimed to improve acoustic noise source localization. It is compared with "delay and sum" beamforming method, built-in beamforming method and the related built-in software, for center frequencies from 1 kHz to 18 kHz. The experiments show that the proposed method enables to narrow main lobe width of microphone array of the Acoustic Camera, which corresponds to resolution improvement. The improvement, comparable to "delay and sum" beamforming method (built-in beamforming method) is up to 2.72 (2.56) times. The experiment also show that two acoustic emitters may be spatially resolved, using the proposed method instead of "demo project" of the built-in software of the Acoustic Camera.

Detection-measurement of wideband acoustic noise source

The Acoustic camera may be applied for condition monitoring of Rolling Element Bearings. The remote monitoring uses estimates of acoustic emission of the bearings. Focalization of spectra of the incoming emissions is done based-on the above built-in method for generation of acoustic maps. The spectra are focalized with frequency resolution 4 Hz at "close" distances. The obtained difference between focalized spectra of bearings with lubrication loss and "normal" bearings is up to 25 dB to 1 Pa, in frequency range from 4 kHz to 6 kHz. The latter difference in sound pressure estimates shows opportunity to detect lubrication loss of the bearings.

Acoustic camera generates acoustic image and displays it onto optic camera image in order to help the user to identify emission source(s), for further consideration. The user adopts decision on presence of the emission source. Application of detection rule enables reducing such human factors. Several detection rules are obtained for monostatic and multistatic reception of acoustic signals. Multistatic system of five microphones is considered for spatial localization of acoustic emission source, using 4D images. The experiments show that the proposed approach enables to localize the source with bandwidth about 10 kHz, which is processed simultaneously.

The localization approach enables to estimate the distance to source of acoustic emission. The latter provides opportunity to avoid the necessity to set the distance in advance. The approach is applicable for tracking and health monitoring of carriers, in transport systems.

The Microphone array of Acoustic Camera is modified to operate in bistatic regime. A corresponding script for generation of acoustic images is developed. It provides estimation of time

difference of arrival of acoustic signals as well as their direction of arrival. The experimental study shows operational opportunity of this regime. Acoustic images are generated in range-azimuth plane. Enhancement of range resolution is demonstrated experimentally.

Presentation of a newly developed signal processing algorithms in Brüel&Kjær (Sound and Vibration Measurement A/S) headquarters enabled to discuss the presented achievements with employees of Innovation Group of the company. Poster presentation of improvement of angular resolution of the Acoustic Camera at Distributed Doctoral School on Metamaterials showed interest to application of the Acoustic Camera for testing of newly developed acoustic cloaks and lenses.

Estimation of features of emitting objects with non-acoustic systems

Information on sources of acoustic emission may be obtained with microwave systems, which operate in active and passive mode. Application of bistatic radiometer, which uses antenna with synthetic aperture, is considered. Algorithms for fusion of radiometric and radar images are obtained, as well. The results are tested in L band, using experimental data recordings.

A variant of the new beamforming method is proposed for acoustic monitoring with bistatic radiometer, operating in Ka band. The numerical simulations show up to 10 times better performance in time.

Participations and presentations at scientific events:

- Acoustic camera-how to see the sounds, Seminar of Mathematical Methods for Sensor Information Processing Department, IICT-BAS, Sofia, Bulgaria, 27 November 2014. The talk was also presented at: (i) Laboratory of vibration and noise in machines, TU-Sofia 20 November 2014; (ii) Acoustics 2014, 28 November, TU-Sofia; (iii) Seminar at Faculty of Transport, TU-Sofia, 21 January 2015
- Non-stationary random Wiener signal detection rule for case of monostatic reception, Acoustics 2014, Sofia 28 November. TU-Sofia
- Demonstration of Smart Lab Acoustic Camera and poster presentation Improvement of Acoustic Noise Source Localization, AComIn Doors Open Days, IICT-BAS, Sofia, Bulgaria, 17-18 April 2015. The poster is also presented at XXVII Distributed Doctoral School on Metamaterials, Department of Engineering, "Roma Tre" University, Rome, Italy, 4-8 May 2015
- Improvement of Acoustic Noise Source Localization, Acoustic Imaging and Noise Source Identification, Brüel&Kjær, Copenhagen, Denmark, 28-29 April 2015
- Mapping of acoustic noise and microwave radiation, Technology Transfer Seminar on Advanced Computing for Innovation Industrial Applications, Bankya, Bulgaria, 14 May 2015
- Resolution enhancement of acoustic source localization, AComIn Technology Transfer Workshop on Advanced Technique, NonDestructive Testing, Sozopol, Bulgaria, June 18-19 2015
- Non-stationary Random Wiener Signal Detection Criterion Variants for Case of Monostatic Reception, 7th Balkan Conference in Informatics, Craiova, Romania, 2-4 September 2015
- Non-stationary Random Wiener Signal Detection with Multistatic Acoustic System, 4th International Conference on Telecommunications and Remote Sensing, Rhodes, Greece, 17-18 September 2015
- Fusion of Images Generated by Radiometric and Active Noise SAR, AComIn International Workshop on Information Fusion, Sofia, Bulgaria, 25 September 2015

Publications, published:

- (i) V. Kudriashov, K. Alexiev, Non-stationary random Wiener signal detection rule for case of monostatic reception, Acoustics, Sofia, Bulgaria, 28-29 November 2014, Year XVI(16) (2014), 61-63.

- (ii) V. Kudriashov, K. Alexiev, Acoustic camera – how to see the sounds, Acoustics, Sofia, Bulgaria, 28-29 November 2014, Year XVI(16) (2014), 64-67
- (iii) K. Lukin, V. Kudriashov, P. Vyplavin, V. Palamarchuk, S. Lukin, Coherent radiometric imaging using antennas with beam synthesizing, International Journal of Microwave and Wireless Technologies, Vol. 7 (3-4) (2015), 453-458. (IF 0.348).
- (iv) V. Kudriashov, A Modified Maximum Likelihood Method for Estimation of Mutual Delay and Power of Noise Signals by Bistatic Radiometer, Comptes rendus de l'Académie bulgare des Sciences, Vol. 68 (5) (2015), 631-640. (IF 0.284)
- (v) V. Kudriashov, Non-stationary Random Wiener Signal Detection Criterion Variants for Case of Monostatic Reception, 7th Balkan Conference in Informatics, Craiova, Romania, 2-4 September 2015, Proceedings, DOI: 10.1145/2801081.2801089.
- (vi) V. Kudriashov, Non-stationary Random Wiener Signal Detection with Multistatic Acoustic System, 4th International Conference on Telecommunications and Remote Sensing, Rhodes, Greece, 17-18 September 2015, 1-5.

Publications, accepted:

- (vii) V. Kudriashov, K. Lukin, V. Palamarchuk, S. Lukin, A. Garbar, Mapping of Acoustic Noise and Microwave Radiation, Cybernetics and Information Technologies. (SJR 0.212)
- (viii) V. Kudriashov, Experimental evaluation of opportunity to improve the resolution of the acoustic maps. New Approaches in Image Analysis - Techniques, Methodologies and Applications, Springer Intelligent Systems Reference Library. (SJR 0.186)

Publication, under review:

- V. Kudriashov, A. Garbar, K. Lukin, L. Maslikowski, P. Samczynski, K. Kulpa, Fusion of Images Generated by Radiometric and Active Noise SAR, Cybernetics and Information Technologies

Plans for future work within AComIn

Multistatic reception principle will be applied into the microphone array. It enables generation of 4D acoustic images using the Acoustic Camera equipment. A corresponding extended abstract is accepted for presentations at International Conference Advanced Computing for Innovation 2015. The text will be further developed and extended to a full paper. The future contribution the topic of Smart Feature Extraction from Acoustic Camera Multi-Sensor Measurements concerns reception of acoustic emissions from spatial volume of interest, mainly. The work will be focused on enhancement of range resolution of the Acoustic Camera. The objective will be reached using correlation of incoming acoustic signals. Technically, it will be obtained using both beamforming and bistatic reception.

2.2.7. Dr Stanislav Harizanov

Dr Stanislav Harizanov (<http://parallel.bas.bg/~sharizanov/>) received his PhD in Mathematics from the Department of Mathematics, Jacobs University Bremen, Germany in 2011. The topic of his PhD thesis is "Analysis of nonlinear subdivision and multi-scale transforms". Until 2013, he was a postdoc at Technical University of Kaiserslautern together with Fraunhofer ITWM, Kaiserslautern, Germany. His research interests are in the area of Approximation Theory, Numerical, Harmonic and Convex Analysis, and Image Processing (Nonlinear subdivision and Multiresolution Analysis; Normal multi-scale transforms for Curves and Surfaces; Computer Aided Geometric Design; Spline approximation; Image denoising, deblurring, and segmentation).

Individual Research Plan of Dr Stanislav Harizanov in AComIn months 26-36 host professor: Svetozar Margenov

As a postdoctoral researcher on the AComIn project, I intend to simultaneously pursue two different research directions:

- Investigation of open problems and computational experimentation in the field of Subdivision.
- Development and implementation of CT data fitting algorithm, based on B-spline interpolation.

Subdivision is a process of recursively refining discrete data using a set of subdivision rules to generate limits (curves, surfaces, height fields, etc.) with desirable properties such as continuity, smoothness, reproduction of shape features, and many more. It has numerous applications, such as image reconstruction, design of curves and surfaces, shape preservation in data and geometric objects, approximation of arbitrary functions, etc. On the other hand, subdivision lies in the core of multiresolution analysis (MRA) and wavelet transforms, thus plays a central role in data compression, noise removal, and so on. The wide range of applications as well as the necessity of improving the performance of the existing algorithms leads to the invention of a great variety of subdivision schemes. This is a very active research field with many open problems that is driven by both theory and applications. Having worked in this field for 7 years, I consider giving seminar talk(s) (both introductory and advanced) on the topic to my AComIn colleagues.

Normal multi-scale transforms (MTs) for curves and surfaces were firstly introduced. Since then, they have been used for multi-scale representation and compression of geometric objects, for adaptive approximation of level curves, in image analysis, and recently for interface tracking. They allow efficient computational processing of high dimensional data and support progressive reconstruction, which makes them useful also for streaming applications in networked environments. The analysis of the S normal MT for planar curves significantly disfavors the practical use of these transforms whenever generates B-splines of degree $p \geq 3$. At the same time, the schemes are among the most favorable schemes used in practice, because of their nice geometric and analytic properties. In my PhD Thesis, I performed case studies with $p=3$ and $p=4$. During my time at ICT, I plan to extend those results to the whole family and publish a journal paper.

Apart from theoretical developments, I plan to perform several computational experiments on generating normal meshes for 3D surfaces. It is known as an algorithm that approximates any surface arbitrarily closely with a normal semi-regular mesh. One of the main obstacles is that the correct choice of the mesh connectivity is crucial for well-posedness of the normal MT. In applications the given initial triangle mesh on the surface is the finest one, it is in general not normal, and the only way to obtain a normal mesh from it is to change the initial triangulation. Therefore, one should first choose a proper base mesh (the coarsest level of the future normal semi-regular mesh) with vertices among those from the input mesh, and connectivity that captures well the surface geometry. More recently, the above normal "remeshing" technique is applied for irregular highly detailed triangle meshes and is implemented in the progressive geometry compression framework described. However, representing topologically complex models such as isosurfaces from medical imaging or scientific computing, and approximating dynamically changing, topologically complex geometries does not give good results with the novel approach, so further generalizations are expected. In particular, I would like to generate meshes via proper multivariate extensions of the univariate B-spline normal MTs from the previous paragraph.

Normal mesh techniques have been recently used for image approximation and image compression. It has been proved that normal triangulated meshes rapidly place more and more vertices directly on the edge contours, enabling a direct representation of the location and the geometry information of edges

as well as extracting the information on the singularity itself. Hence, the use of normal meshes gives a rise to a sparse, but yet truthful, image decomposition. On the other hand, the normal mesh representation relies on the implicit boundary locating property of normal meshes, and thus has only linear computational complexity. This is another application direction, worth investigating.

The subdivision schemes, considered so far, have been defined in the functional setting, i.e., the data has always been assigned to an underlying grid and interpreted as a function on it. Thus, the generated meshes and limit surfaces are not rotation-invariant. There are also geometry-based subdivision schemes and multi-scale transforms in the literature. A simple example is the circle-interpolating subdivision operators, analyzed in my PhD thesis. Such schemes have been investigated in case studies only and tools for their systematic analysis have yet to be developed. This is an ongoing research that I plan to continue, while being part of the AComIn project. A joint journal or proceedings paper is expected.

The second main direction of my research should be the development and the implementation of a CT data fitting algorithm, based on B-spline extrapolation techniques. In the context of image (curve, surface) representation as well as in the context of numerically computing weak solutions of nonlinear conservation laws, piecewise smooth data with jump discontinuities appear. Due to Gibbs and Runge's phenomena, straightforward piecewise polynomial interpolation of the data cannot simultaneously localize these discontinuities and provide smooth approximation to the initial function away from the singularities. In particular, such algorithms are neither convexity nor monotonicity preserving, whenever the polynomials are of degree higher than 1. Therefore, adaptivity should be introduced and, based on the initial CT data, different rules should be applied to different data patches. Although not necessary, one can again use subdivision to generate the limit. In a previous work I show that (quadratic B-spline) normal MT for non-self-intersecting closed planar curve C has the property to "uniformize" the fine-scale data and is suitable for adaptive procedures together with any high-regular subdivision scheme S . The proposed algorithm not only generates smooth reparameterizations of C but also detects the presence of singularities at coarse levels. Unlike in data fitting, here the limit curve C is known a priori, so additional work is needed if we want to cover the former setting, as well. Having achieved this, the next step will be to propose a suitable multivariate extension for the surface case. If we choose to use standard (non-normal) subdivision, several schemes have been introduced and analyzed so far, most of them based on cubic polynomial interpolation away from the singularities. The differences are in the way the singularities are treated, and generally they are application driven. Of course, it may appear that subdivision techniques are not applicable at all to our data sets, so different strategies would also be exploited. The algorithm output should be compatible with the standard CAD software.

Research Activities and Results

Stanislav Harizanov has worked on three major topics during his employment in AComIn and received research results as follows:

Volume-constrained Image Segmentation based on Convex Optimization

Porous materials are of current interest within a wide range of applications, where their properties strongly depend on various measurements such as absolute porosity, average pore size, size and shape of individual pores. Therefore, accurate segmentation of a 3D reconstruction image of the corresponding specimen is crucial in practice. Due to the highly irregular structure of the segmentation phases and the presence of noise in the image, classical segmentation methods are not reliable and in some cases the results between different algorithms may differ drastically (even in 50% of the voxels). To say the least, such a task is nontrivial and sometimes impossible, unless additional information on the data is provided. In particular, the volume of the solid phase can be determined

from its density and weight measurements. Stanislav Harizanov has proposed a couple of volume-constrained 2-phase segmentation algorithms, based on equality constrained quadratic optimization and fully constrained convex ℓ_2 -norm minimization, respectively. Those algorithms have been parallelized and efficiently implemented by Yavor Vutov, thus are applicable to large industrial images of high resolution, such as the 3D reconstruction of an Aluminum (AlSi10Mg) metal foam, obtained via Tomograph XTH 225 (part of the AComIn purchased Smart Lab). The conducted numerical experiments showed significantly improved results, compared to non-supervised volume-constrained segmentation.

Graph-based, supervised Image segmentation

The convex optimization approach for 2-phase image segmentation successfully captures the exact volume of the solid phase, but fails to preserve its connectivity (in industrial Computed Tomography the specimen typically consists of only one material piece). Therefore, together with Svetozar Margenov and Ludmil Zikatanov, Stanislav Harizanov has also worked on a graph theoretical approach for image segmentation which preserves both the volume and the connectivity of the solid phase. A new class of algorithms has been proposed, which give promising results and provide a framework for future research on constrained image segmentation. The approach uses three stages. Each step optimizes the approximation error between the image intensity vector and piece-wise constant (indicator) vector characterizing the segmentation of the underlying image. The segmentation is not as accurate as the one obtained via convex optimization, but it is the only one (at least up to the knowledge of the authors) that guarantees material connectivity. In addition, even though not parallelized, the graph-based algorithm is quite fast. Its running time is $O(n \log n)$ for an image with n voxels. Further improvements of the results and possible combination of the two mathematical models presented above are topics of ongoing investigations.

B-Spline-based space discretization in discontinuous structural mechanics

Elastic structures with material or geometrical discontinuities often appear among engineering applications. The appropriate usage of space discretization functions is essential for deriving mathematical models with sufficient accuracy. Using B-splines with multiple knots at the singularities, Stanislav Harizanov has investigated an efficient method for solving discontinuous problems in structural mechanics. The method was compared to the standard p - and h -versions of the finite element method (FEM) on a cantilever beam with stoppers (an elastic structure with discontinuities), modeled via the Bernoulli-Euler's equation of motion. Apart from the fact that Isogeometric analysis (IGA) has superior spectral approximation properties than FEM, the natural frequencies, themselves, and the shape of their corresponding linear modes were better approximated by the B-spline discretization approach, as well. The method is not limited to one dimensional problems and can be further generalized to higher dimensions - a subject of future work.

Participations and presentations at scientific events:

- Supervised 2-Phase Segmentation of Porous Media with Known Porosity, 10th International Conference on Large-Scale Scientific Computations, 8-12 June 2015, Sozopol, Bulgaria
- Epigraphical Projection for Solving Least Squares Anscombe Transformed Constrained Optimization Problems, Seminar on Parallel Algorithms and Scientific Computing, ICT-BAS, 9 December 2014, Sofia, Bulgaria
- Poster presentations (together with Ivan Georgiev and Yavor Vutov): "Segmentation of Porous Media with Known Porosity – Mathematical Models" and "Segmentation of porous media with known porosity - Numerical results" at the AComIn Days of Open Doors in ICT-BAS, 17-18 April 2015, Sofia, Bulgaria.

Publications, published:

- (i) S. Stoykov, S. Harizanov, S. Margenov, Space discretization by B-Splines on discontinuous problems in structural mechanics, Proceedings of the 7th Balkan Conference in Informatics, Craiova, Romania, ACM (2015), Paper Id: 31, DOI: 10.1145/2801081.2801113.

Publications, accepted:

- (i) I. Georgiev, S. Harizanov, Y. Vutov, Supervised 2-phase Segmentation of Porous Media with Known Porosity, Large-Scale Scientific Computing, Springer LNCS, Vol. 9374, accepted. (**SJR 0.339**)
- (ii) S. Harizanov, S. Margenov, L. Zikatanov, Fast Constrained Image Segmentation Using Optimal Spanning Trees, Large-Scale Scientific Computing, Springer LNCS, Vol. 9374, accepted. (**SJR 0.339**)

Publications, in preparation:

- S. Harizanov, Deblurring Poissonian Images via Multi-Constraint Optimization, Proceedings of the International Conference "Advanced Computing for Innovation 2015", 10-11 November, Sofia, Bulgaria.

2.2.8. Dr Emilia Abadjieva

Dr Emilia Abadjieva holds a Ph.D. in the field of Applied Mechanics from the Bulgarian Academy of Sciences. She spent 2 years (2012-2014) as a post-doctoral scientist in Department of Human and Information Systems, Faculty of Engineering at Gifu University–JAPAN. Her research interests include the following fields: mathematical modelling of the processes of spatial motion transformations, oriented to the synthesis of spatial mechanical transmissions; mathematical modelling of vehicle collisions, intended for reconstruction of their origin and for the needs of the jurisprudence.

Individual Research Plan of Dr Emilia Abadjieva in AComIn months 27-36 host professor: Dimitar Karastoyanov

In the framework of AComIn project Dr Emilia Abadjieva's researches are mainly related to the priority topic (iv) optimization and intelligent control. In particular her research is focused on mathematical modelling of spatial motions transformations, oriented to the synthesis of the engineering objects (hyperboloid transmissions and spatial rack drives), that realize the above mentioned transformations. Dr. Abadjieva will conduct both theoretical and experimental researches using the Smart Lab project equipment. These studies are subjected to the pursuit of the effective realization of above mentioned engineering systems.

The following problems are the focus:

Improvement of mathematical models oriented to synthesis of spatial mechanical transmissions

The development of hyperboloid gears with external and internal mating is of particular interest for industry. Mathematical models that describe the regular (predefined) motions of the links of complex mechanical multibody systems are oriented to their synthesis and design. The applications of solving such class of problems are motivated by her aspiration to create innovative technical solutions of mechanisms realizing regular motions transformation.

Synthesis of hyperboloid gear transmissions with application in robotics

One promising application of the precision spatial mechanical systems is as a drives in medical robots and manipulators. Of particular interest are three-link hyperboloid gears with face mating movable links. The application of spatial rack drives into constructions of manipulators and robots is considered. The current research of Dr. Abadjieva is oriented to adapting the exploitation characteristics for the application into specialized high precise devices: robots, manipulators, devices for military techniques.

Analytical and software synthesizing of hyperboloid gears through 3D virtual generation, printing and/or scanning

The analytical and software synthesis of types of gear type hyperboloid Helicon gear with small gear reduction ratios (under 10) requires special 3D approaches. The novelty of the design solution is that such types of hyperboloid gears have a boundary small gear ratio. This is a challenge both for their optimization synthesis and design in terms of the technical realization. The reason for this is that such gear pairs usually ensure rotations transformation with gear ratio more than 10. The difficulty of elaboration with available technical and technological device, give us reasons to use software generating and 3D printing.

Research Activities and Results

Improvement of mathematical models, oriented to synthesis of spatial mechanical transmissions

Dr Abadjieva study two basic types of spatial motions transformations, applicable in engineering practice:

- motion transformations of type “rotation into rotation”;
- motion transformations of type “rotation into rectilinear translation” and vice versa.

Dr Abadjieva explores similarities and differences between these two spatial motions transformations in order to develop mathematical models with identical characteristics that describe them.

In light of the above, spatial rack drive can be considered as a special case of hyperboloid gear transmissions when: (i) the number of the teeth of one of the movable link is increased „adinfinitum”, without increasing the number of the meshed tooth surfaces between the mated links; (ii) the axis of rotation of the above mentioned link is displaces in infinity and its motion is transformed into rectilinear translation; (iii) number of the teeth and the type of motion of the second movable link remain unchanged; (iv) rotating link with finite number of teeth will call pinion, and the link with endless number of teeth, realizing rectilinear translation, will call it gear rack.

Synthesis of hyperboloid gear transmissions and spatial rack drives with application in robotics

The created models belong to the following type mathematical models for synthesis: “upon a pitch contact point” and “upon a mesh region”. The basic model for synthesis of hyperboloid mechanisms uses the “pitch contact point” approach. The most important element in the algorithm for synthesis of hyperboloid transmissions is the “pitch configurations”. They are used to define the dimensions of the gear blanks/the actual gears and the dimensions of the active tooth surfaces of gears. Archimedean surface of action and the active tooth surfaces of the second link, realizing rectilinear translation, algorithms and computer graphics for synthesis and design of the face spatial rack mechanisms are elaborated. These mechanisms are suitable for implementation as actuators in various fields of techniques. Of particular interest is their incorporation into the constructions of bio-robots, as an alternative of spatial hyperboloid gears.

Analytical and software synthesizing of hyperboloid gears through 3 D software technology

The novelty of the design solution is that the developed Helicon and Spiroid gears have a boundary small gear ratio and extremely small dimensions. This is a challenge both for their optimization synthesis and design in terms of their technical realization. The reason for this is that these gear pairs usually ensure rotations transformation with gear ratio more than 10. Gears of this type with boundary gear ratios are rarely used in techniques. The necessity to use such drives, incorporated into the fingers of the Japanese bio-robot hand, was determined by the requirements for smoothness of rotation transformation and control of the backlash in the mating. The difficulty of elaboration with available technical and technological devices, give reasons to use 3D printing for the realization of such gear sets.

Participation, presentation at scientific events

- Mathematical models for synthesis and software 3D realization of spatial motion transformers (poster) and demonstration of the 3D printed models of small modules and small dimensions hyperboloid gears, AComIn Open Doors, IICT-BAS, Sofia, 17-18 April, 2015.
- 3D Software Technology for Practical Realization of Special Hyperboloid Gear Mechanisms, 27th European Conference on Operational Research, Glasgow, Poland, 12-15 July 2015
- One Application of the International Terminological Standard BDS ISO 10825 for the Damage Identification of the Teeth of Gear Transmissions, (oral), 6th International Conference on Mechanics and Materials in Design, Ponta Delgada, Azores, 26-30 July 2015
- Spatial Face Rack Drives: Mathematical Models for Synthesis and Software Illustrations, (poster), 6th International Conference on Mechanics and Materials in Design, Ponta Delgada, Azores, 26-30 July 2015

Publications, published:

- (i) E. Abadjieva, V. Abadjiev, On the Synthesis of Spatial Rack Mechanisms: Mathematical Modelling-Analytical and 3D Software Creating of the Face Rack Drive Teeth, Machine Design, Vol. 7 (2), 2015, Faculty of Technical Science, University of Novi Sad, pp 47-54, ISSN 1821-1259. (This study is presented at *The International Workshop KOD 2015 MACHINE AND INDUSTRIAL DESIGN IN MECHANICAL ENGINEERING, 11-14 June, 2015, Balatonfüred, Hungary*), Index Copernicus Value ICV: 4.43
- (ii) V. Abadjiev, E. Abadjieva, D. Karastoyanov., Gravity Dress Device, Bulgarian Patent Application, No 111918, February 3, 2015

Presented at International Conferences, in Print in International Journals:

- (iii) V. Abadjiev, G. Dimchev, E. Abadjieva, D. Karastoyanov. One Application of the International Terminological Standard BDS ISO 10825 for the Damage Identification on the Teeth of Gear Transmissions., 6th Int. Conf. on Mechanics and Material Design M2D'2015, July 26-30 2015, Ponta Delgada, Portugal, PAPER REF: No 5691, pp. 509-516 (published on CD), International Journal of Mechanics and Material Design, ISSN 1569-1713, (in print).
- (iv) E. Abadjieva. Spatial Face Rack Drives: Mathematical Models for Synthesis and Software Illustrations, 6th Int. Conf. on Mechanics and Material Design M2D'2015, July 26-30 2015, Ponta Delgada, Portugal, PAPER REF: No 5760, pp. 601- 612 (published on CD), International Journal of Mechanics and Material Design, ISSN 1569-1713, (in print).

2.2.9 Dr Mladen Savov

Dr Mladen Savov (http://iict.bas.bg/acomin/cv_M_Savov.pdf) received his PhD in probability theory at the School of Mathematics, University of Manchester, UK in 2008. His research interests lie in the field of stochastic processes and especially in the area of Levy and Markov processes. Dr Savov has worked on a number of projects independently with many international researchers and he has won a couple of individual fellowships with his research ideas.

Individual Research Plan of Dr Mladen Savov in AComIn months 28-34 host professor: Ivan Dimov

Description and Goals

The Wigner-Boltzmann equation is the most suitable model for nanodevices as it includes all quantum effects at a fundamental level and all relevant scattering terms. It is deduced from the Wigner equation with the addition of the Boltzmann scattering terms. Two approaches have been proposed for dealing with this equation: the “quantum affinity” approach and the Monte Carlo (MC) approach. The latter will be the focus of our investigations. The MC approach to numerically solving the integral form of the Wigner-Boltzmann is based upon the adjoint integral representation. It is used to numerically evaluate the integration with respect to any observable A , in the space, phase and time variables. The approach then consists of either sampling N randomized particles (RP), i.e. the single particle MC, or using the particle creation mechanism (PCM), i.e. the many particles MC. The latter is employed to compensate one at first sight drawback of (RP), namely the growth of the variance which is induced by the randomized particles. Our first set of goals will be to:

- Scrutinize the underlying probabilistic structure of (RP) and (PCM) in order to reduce the variance of MC;
- Study the existing algorithm theoretically, and rigorously estimate some of its main quantities;
- Improve the existing software by automatic procedures using theoretical estimates and knowledge based on the previous goals.

Having analysed the probability behind the model we will pursue deeper fundamental improvements of the approaches for the computation of the Wigner-Boltzmann equation. For example, the operator K gives rise to a q -potential of an explicit Markov chain and we will seek hidden renewal events/random walks to reduce the computation of this potential to well-known quantities. Our goals can be summarized as follows:

- investigate the connection between the operator K and the potential theory of random walks/renewal events via a hidden random walk/renewal events;
- look into the possibility of using random times instead of deterministic ones in view of the fact that Markov processes in general and Levy processes and random walks in particular become much more tractable when considered at independent exponential or geometric random times;
- seek other processes whose expectation coincides with the solution of the Wigner-Boltzmann equation.

Since the MC approach computes the transient solution of the Wigner-Boltzmann equation and is thus fit to simulate the time-dependent behaviour of devices, e.g. devices that work with high frequency, etc., it is of immense importance that the developed numerical scheme is improved, and the understanding behind the MC is advanced. Such a development has the potential to save computer time and thus make efficient usage of expensive resources. The prospect of fundamentally improving the way the Wigner-Boltzmann equation is numerically solved is even of greater value since it offers the opportunity to reduce the complexity of the current algorithms and thus significantly improve the way these equations are solved.

Research Activities and Results

Having analysed the probability behind the model Dr was able to deploy deeper fundamental improvements of the approaches for the computation of the Wigner equation. For example, the operator K gives rise to a q-potential of an explicit Markov chain and he worked on seeking hidden renewal events/ random walks to reduce the computation of this potential to well known quantities. The main results of Dr. Savov's work can be summarised as follows:

- investigation of the connection between the operator K and the potential theory of random walks/renewal events via a hidden random walk/ renewal events;
- looking into the possibility of using random times instead of deterministic ones in view of the fact that Markov processes in general and Levy processes (random walks) in particular become much more tractable when considered at independent exponential or geometric random times;
- seeking other processes whose expectation coincides with the solution of the Wigner equation.

Since the Wigner MC approach computes the transient solution of the Wigner equation and is thus fit to simulate the time-dependent behaviour of devices, e.g. devices that work with high frequency, etc., it is of immense importance that the developed numerical scheme is improved, and the understanding behind the MC is advanced. This has the potential to save computer time and thus make efficient usage of expensive resources.

Participation and Presentations at Scientific Events

- Adventures in Self-Similarity, University of Cornell, USA, 8–12 June 2015, invited talk;
- BL-PRO15, University of Liege, Belgium, 29–30 June 2015, invited talk;
- 44th Spring Conference, Camchia, Bulgaria, June 2015, invited talk;
- Internal Seminar of the group parallel algorithms, 24 March 2015.

Publications, Published:

M. Savov, S. Wang, Fluctuation limits of a locally regulated population and generalized Langevin equations, Infinite Dimensional Analysis, Quantum Probability and Related Topics, Vol. 18 (2) (2015), DOI: 10.1142/S0219025715500095. (IF0.65)

2.2.10. Dr Kristina Jakimovska

Dr Kristina Jakimovska holds (http://iict.bas.bg/acomin/CV_KJakimovska.pdf) a PhD in Mechanical Engineering from the University Ss. Cyril and Methodius – Faculty of Mechanical Engineering in Skopje. Her research interests are mostly related to transport systems maintenance, safety and diagnostics.

Individual Research Plan of Dr Kristina Jakimovska in AComIn months 28-36 host professor: Dimitar Karastoyanov

The work of Dr Jakimovska in the framework of AComIn project is related mostly to the area of maintenance of transportation systems with predictive maintenance techniques using SmartLab devices. The following problems are the focus of DrJakimovska's research:

Research Activities and Results

Transformer state assessment using MCDM (Multi-Criteria Decision Making) methods

The transformer is a very essential apparatus in an electric power system and its reliability is of utmost importance as a transformer failure results in a very costly and difficult to predict interruption of energy delivery. In turn, transformer's performance depends heavily on its insulation system; therefore the insulation is perhaps the most critical transformer part. In case that a determination of the real insulating state of a transformer and then lifetime of insulation are required, it is necessary to analyze some measurements in individual types of assays and then determine their exactness and reliability with mathematical models. Dr. Jakimovska can exactly prove the importance of these assays by mathematical and statistical models in the field of analysis of the insulating state of transformers. The statistical method of data analysis (fuzzy TOPSIS /The Technique for Order of Preference by Similarity to Ideal Solution/ and AHP method) are used in this study. The main task is to find the importance of each criterion and upon this to determine the one indicator which characterizes the technical condition of the transformer.

Analysis of the trolleybuses defects by MCDM (Multi-Criteria Decision Making) methods

The failure rate of vehicles is a relevant task, which is strictly connected with the reliability of the transportation system. Vehicle failures cause financial losses related to the need to remove defects, not using the vehicle and the consequent disturbances in the transport system. Therefore, the observation and analysis of the reliability coefficients are necessary. In this research Dr. Jakimovska is trying to find similarity and differences between failure rates of several parts of trolleybuses using methods of data analysis. By their very nature, trolleybuses require a power distribution system to supply electric traction current. The main components comprise:

- substations to receive, transform and rectify the local 11 kV a.c. electricity supply from the power grid;
- feeder cables, feeder pillars and line taps to convey the traction current to "the overhead";
- apparatus to support the overhead, including traction poles, brackets and building attachments; and
- those elements that constitute the overhead itself, including trolley wires, span wires, and special work for junctions and crossings.

This research deals with the statistic data of failure of trolleybuses from the municipal transport company of Gdynia (Poland).

Control of railway vehicles in motion by predictive maintenance techniques

The ambition of specialists from the Bulgarian Academy of Sciences, the Technical University of Sofia and T. Kableskov University of Transport to develop a scientific approach to prevent emergency events in transport requires electronic devices for continuous monitoring on railway vehicles in motion. This research study is proposing a methodology for examination of the temperature changes occurring in zones important in terms of their operational security and located in the undercarriage and brake systems (with infrared thermograph and Thermo Camera FLIRP640). An attempt is made to implement the country's commitments, stipulated in international agreements, to develop an adequate approach for implementation of the monitoring system components increasing the transport process safety and efficiency. Conditions created for the study and analysis of information from a real experiment in MATLAB environment are determined by the capabilities of specific devices. The comparative analysis of data from two different devices is going to be conducted to identify their strengths, weaknesses and areas of application. The rating made by importance of thermography in current and planned repairs was based on the current technical condition of the rolling stock of the Bulgarian railways (thermography measurements are performed on railway station "Gara Iskar" in Sofia).

Wireless controlled mobile robots for transport

This study presents the research of a kind of autonomous mobile robots, intended for work and adaptive perception in unknown and unstructured environment. The objectives are robots, suitable for multisensory environment perception and exploration. At that ground classification of the different types mobile robots in accordance with the way of locomotion, used drive mechanisms, kind of sensors, end effectors, area of application, etc. is made. A modular system for the mechanical construction of the mobile robots is proposed. Special PLC for robot control is developed. Electronic modules for the wireless communication as well as the specific software are developed. The methods, means and algorithms for adaptive environment behavior and tasks realization are examined. An algorithm for the full covering of a surface with obstacles, using group of mobile robots is described. The methods of group control of mobile robots and different areas of application are discussed.

Working with the Smart Lab Equipment

- AComIn Smart Lab Thermo Camera FLIR P640 was estimated (non-contact temperature measurements were performed on different railway vehicles on railway station "Gara Iskar" in Sofia. Obtained characteristics enable to improve its usage. Applicability of the Thermo Camera was considered.
- Active work and collaboration with colleagues from Department of Electrical Engineering in Transport, Faculty of Electrical and Control Engineering, Gdansk University of Technology as well as with colleagues from Trolleybus Communication Enterprise Sp.z.o.o. in Gdynia.
- Active work and collaboration with colleagues from the Todor Kableshkov University of Transport and Technical University of Sofia.

Publications, Published:

- (i) Jakimovska K., Duboka, C., Application of fuzzy AHP method for vehicle roadworthiness evaluation, In: Proceedings of the 25th International Automotive Conference „Science and Motor Vehicles 2015“, 14-15 April 2015, Belgrade, Serbia, ISBN 80941-39-4, pp 241-251
- (ii) Jakimovska, K., Duboka, C., Karastoyanov, D., An AHP/DEA method for measurement of the vehicle roadworthiness performance index – VRWPI, In: G. Kartnig, N. Zrnica, S. Boshnjak (Eds.), Proceedings of the 21th International Conference „Material Handling, Constructions and Logistics 2015“, 23-25 September 2015, Vienna, Austria, ISBN: 978-86-7083-863-5., pp 217-220

Papers accepted for presentation at International Conferences (to appear in International Volumes and Journals):

- (i) Jakimovska, K., Duboka, C., and D. Karastoyanov. Application of fuzzy TOPSIS and AHP method in evaluating vehicle roadworthiness performance, In: C. Andreescu, A. Clenci (Eds.), Proceedings of the 14th European Automotive Congress “EAEC-ESFA 2015” 25-27 November 2015, Bucharest, Romania, will be published in a Springer Volume (in print)
- (ii) Kandeveva, M., T. Grozdanova, D. Karastoyanov, B. Ivanova, K. Jakimovska and A. Vencl. Wear Under Vibration Conditions Of Spheroidal Graphite Cast Iron Microalloyed By Sn., 1st International Conference on Tribology, Turkey Trib'15; October 7-9, 2015, Istanbul, Turkey, will be published in the International Journal of the Balkan Tribological Association, book 2, vol. 22 (2016), (in print, IF 0.443)

Publications, accepted as conference papers:

- (i) Jakimovska K., Vasilev V., Stoimenov N., Gyoshev S., and D. Karastoyanov. Train control system for railway vehicles running at operational speed, 22nd International Scientific Conference on Achievements in Mechanical and Materials Engineering (AMME'2015),

Zakopane (Poland), 06-09/12/2015, Abstracts Proceedings, ISBN: 978-83-63553-39-5, pp. 68, Accepted for Publication

- (ii) Ruzic J., Jakimovska K., Stoimenov N., Gyoshev S., and D. Karastoyanov. Influence of mechanical alloying time on particle size of copper matrix composite, 22nd International Scientific Conference on Achievements in Mechanical and Materials Engineering (AMME'2015), Zakopane (Poland), 06-09/12/2015, Abstracts Proceedings, ISBN: 978-83-63553-39-5, pp. 96, Accepted for Publication

Publications in preparation:

- An analysis of the trolleybuses defects by Multi-Criteria Decision Making - MCDM methods
- Transformer state assessment using Multi-Criteria Decision Making - MCDM Methods
- Wireless controlled mobile robots for transport

Plans for futurework

Dr. Jakimovska plans to continue working with 3D laser scanner and Thermo Camera FLIR P640 and to search for possibilities for its implementation in NDT (non-destructive testing). She has established connections with various industrial and academic partners. She already made good collaboration with companies in Macedonia interested in non-destructive testing and defect detection in order to increase the quality of their production: APAVE SEE is known as one of the world's leading, research and technology organizations in construction inspection, non-destructive testing, integrity assessment etc.; Doyran Steel Ltd. is known as steel company which constantly invests in state of art technologies with the aim to guarantee high quality of the product, better work conditions, environmental protection and higher standards for customer services. As their work equipment operates under high temperatures, regular inspection is of great importance to them; BUCIM DOO Radovis is known as open copper mine in Macedonia which is equipped with modern mechanization. Because of intense usage of its mechanization, regular inspection is very important issue of the same. Working on pilot projects with the above-mentioned companies is planned.

2.2.11. Dr Iurii Chyrka

Dr Iurii Chyrka (http://iiict.bas.bg/acomin/CV_Chirka.pdf) has got his PhD in Radio-technics (thesis title: "Robust Methods and Algorithms of Radar Signals Parameters Estimation") in 2014 from the National Aviation University, Ukraine. The topics of his research interest include: computer simulation; Monte Carlo simulations; digital signal processing; parameters estimation; time-frequency analysis; statistics; electroencephalography; video compression.

Individual Research Plan of Dr Iurii Chyrka in AComIn months 28-36 host professor: Kiril Alexiev

The research work to be carried out is focused on the Near-field Acoustic Holography (NAH) as a part of AComIn research topic 3 ("Signal and image processing"). Acoustic Holography is quite new independent branch of acoustic technologies and is focused on near-field noise source identification. The available equipment for research is manufactured by Bruel&Kjaer and consists of an 18-microphone array, a front end for cables connection and a laptop with pre-installed data acquisition and post-processing software. The array has irregular aperture geometry, optimized for beamforming (far-field noise identification). The traditional approach in acoustic holography consists in using of the Fourier Transform (FT) of a sound field in order to reconstruct a 3D field of sound parameters from 2D measured data. In spite of some disadvantages, it appeals with high accuracy of near field noise identification. For a pity, it requires a regular microphone array, which is not available. Another class of

methods usually called as “patch” methods are based on the direct transformation of sound fields in spatial domain that eliminate some negative effects of the FT-based approach. These methods allow for using of microphone arrays with irregular aperture even if it is optimized for beamforming tasks.

The **main goal** of research is to estimate the technical characteristics of the available equipment for NAH and maximally enhance them by aperture modification and algorithm improvement. Several tasks are outlined:

- Establishment of features and potential of the Bruel&Kjaer equipment for NAH;
- Rearrangement of microphone deployment into a new aperture with uniform lattice spacing;
- Implementation of relevant NAH methods including Fourier-based NAH (only for a regular geometry), statistically optimized near-field acoustic holography (SONAH) and equivalent sources method (ESM)-based NAH. ESM is the most preferable due to its low computational complexity and meshless nature;
- Comparison of the implemented methods and built-in ones. It also includes discovering of sound frequency and holography range limitations, estimation of effective signal to noise ratio, setting different regularization parameters in solving of inverse problem;
- Optimization of equipment parameters (suitable algorithm and aperture geometry) for applications.

In addition to this NAH research, the narrowband signal parameters (central signal frequency in particular) estimation methods are planned to be investigated in the case of high-resolution direction of arrival estimation. Especially it relates to big angles of arrival.

The results will be presented and published in proceedings of one or two international conferences. It is planned to present the results on two seminars held at the ICT. At least one journal paper must be submitted during the reporting period.

Research Activities and Results

The results of the main research activities, performed during the working period, are organised in the following groups: Establishment of the equipment features and performance; Resolution improvement approaches; Direction of arrival estimation; Multichannel frequency estimation; Practical use of the acoustic camera.

Establishment of the equipment features and performance

Nearfield Acoustic Holography (NAH) is a technique that makes it possible, based on the 2D recording of sound waves, called a hologram, to reconstruct the entire 3D sound field from the source's boundary to the measurement plane. In view of irregular placement of microphones in the array the main attention was paid to Statistically Optimized NAH (SONAH) (also implemented in the built-in software) and Equivalent Source Method (ESM). The experimental investigation of microphone array performance was carried out in indoor conditions. There were found some limitations of the built-in software that produce difficulties in the research, for example, cutted upper frequency, quite limited field of view close to field of view of the optical camera and limited distance to the object that result in comparatively small reconstruction area. This was the main reason to develop new software that enables obtaining of realizations of the sound pressure map of pressure at any desired distance, signal frequency and in full size matching physical dimension of the array. It uses a matrix-form implementation of three NAH methods. The results of resolution comparison has demonstrated that algorithms SONAH and ESM show close results in the low frequency range. But at higher frequencies SONAH has some worsening of resolution that is more significant at bigger distance.

Resolution improvement approaches

In view of comparatively small number of microphones, research also was focused on the resolution improvement techniques, especially by using virtual microphones. This means that measurement surface density and/or area are numerically enlarged. Improvement of resolution of SONAH method in high frequency range in the case of single source localization has been achieved. The key idea is to use autoregressive relation for a sinewave signal for signal interpolation, but due to nonlinearity of the signal front in the near-field the problem of the defining virtual microphone coordinates arises. The position of virtual microphone is calculated for each pair of real microphones based on their coordinates and estimated coordinates of the sound source. Estimation of the source position is taken as argmax of a reconstructed map of sound pressure from the first stage of calculations by the conventional holography method. This approach allows by adding up to 2 times more signals from virtual microphones to existing real signals increasing of SONAH resolution in frequency range upper than 2 kHz that was shown by the carried out research. The second proposed approach is rather the extrapolation than interpolation, because it allows calculation of the signal value in the arbitrary point of the measurement plane. In the case of single source, the acoustic field on some distance around each real microphone can be easily predicted, if position of the source, its frequency, power and instantaneous phase of the signal from the microphone is known. The idea of signal generation at interpolation points is based on the model of spherical wave. Because the initial phase and amplitude of the source are unknown, the interpolated signal should be calculated by the modified wave equation. As in the previous case, it requires rough estimate of source position and additionally estimates of signal amplitude and initial phase at each microphone, that can be obtained from the likelihood equations. Simulation results showed that the proposed technique gives better precision of the source localization, especially near the borders of microphone array, even with a coarse initial estimate of the source position. Moreover, this approach allows simulation of a signal from arbitrary geometry of the array when there is only one source of the signal. In this way, the efficiency of the traditional Fourier NAH method has been estimated on the regular geometry. It has been approved that this method is less precise in comparison to the more advanced methods.

Direction of arrival estimation

The problem of direction-of-arrival (DOA) estimation of waves generated by narrowband signal sources have attracted considerable interest in the literature due to a variety of applications. The problem of single source localization by a uniform linear array (ULA) has been considered. The signal from far-field received by the microphone array has a linear wave front and builds a multichannel matrix of measured values. These signals captured by each microphone/channel have constant phase shift between each other. This shift is a spatial frequency that has to be estimated. The minimal sufficient information for frequency estimation is contained in only one vector taken in any arbitrary moment of the discrete time. Therefore, any known method for single-frequency estimation by a short sample of a real signal can be used. Here, the method based on autoregressive moving average model, synthesized in the previous work, is used. Simulation results have shown that the proposed approach works pretty well when a source is located between boresight and endfire positions because they correspond to boundaries of the estimation range. The studied method almost reaches the ML-estimator efficiency, especially at high SNR. In the near-field case the received signal is not a plane wave anymore. Therefore, we must estimate multiple local frequencies and use multiple angles to find the source position. A single frequency can be calculated on the basis of at least three data samples, therefore we should take at least three consecutive samples, assume that on this short interval the signal is sinusoidal and apply the mentioned earlier estimation method for obtaining the set of local estimates. Having a set of local frequencies one can calculate a set of direction angles and draw several rays from corresponding points. Estimation of the shift parameter of the distribution of these points gives us coordinates of the source. Simulations have shown that the proposed approach requires quite high SNR for decent estimation quality, even with comparatively big number of sensors.

This can be explained by the fact that local spatial frequency is estimated only in 3-point running window and under this condition the algorithm is pretty sensitive to the noise action.

Multichannel frequency estimation

The problem of multichannel frequency estimation has been considered. In the most general case the problem of multichannel spectral estimation consists of estimation of the power spectral density matrix, which consists of elements related to auto-spectrums and cross-spectrums for each pair of channels. In many real situations only limited number of narrowband signals are presented in the recorded data and the most frequently used methods are autoregressive (AR) model based ones. Our attention has been paid to the case when only the single-tone narrowband signal is presented in each channel. Using the maximum likelihood (ML) approach, the autoregressive parameter estimator has been synthesized. It has been shown that in the single channel case it is equivalent to the known modified covariance method obtained by the least squares (LS) approach. Simulation results for the new estimator in comparison to a simple one averaged by multiple channel have shown that both methods have similar precision in the middle frequency range, but the new method becomes much better at low frequencies. The difference between the two methods is bigger when the number of samples in each channel approaches the minimum of $N=3$, and vanishes when N is big enough. Additional attention has been paid to the problem of frequency estimation robustness to appearance of the impulsive noise. The proposed solution assumes removing of noise impulses by separation of the input sample and interpolation of the detected corrupted values. It has been shown that the proposed approach has an advantage over the conventional filtering techniques.

Practical use of the acoustic camera

The available acoustic camera equipment has been used in the noise diagnostics of bearings and noise measurement of the valve in the heating system. Measurements of bearings were done on the test bench in the test laboratory at the Technical University – Sofia. The idea is to use acoustic images or recorded signal spectra to identify specific defects of bearing, which already appeared or will appear soon. The analysis of measured data has shown that it is hard to get specific acoustic image for different defects and usually it shows only a wide enough single peak near the center of bearing. There were obtained several spectra of bearings with different “health” levels. Carried out analysis has shown that ambient noise is the most powerful in frequency range up to 2.5 kHz and the SNR or “contrast” is not sufficient for clear and confident detection of components with any of characteristic frequencies. The experimental results have shown that acoustic holography and low-frequency spectral analysis can be hardly used for bearing diagnostics due to low resolution and low SNR. As a perspective way of further research the attention has to be paid to middle and higher frequency range and possibly, beamforming as a localization technique. The second considered application of acoustic camera was noise measurement and localization of the valve in the test heating system. The analysis of measured data has shown that the valve noise can not be distinguished by the acoustic camera in the typical room conditions. Neither captured spectra nor reconstructed acoustic field map do not have significant differences in cases of closed and fully opened valve.

Participations and presentations at scientific events:

- Brüel & Kjør course on Acoustic Imaging and Noise Source Identification, 28-29 April 2015, Copenhagen, Denmark.
- Acoustic Field Reconstruction, Technology Transfer Seminar on Advanced Computing for Innovation - Industrial Applications, 14–15 May 2015, Bankia, Bulgaria
- Nearfield Acoustic Holography, Technology Transfer Workshop on Advanced Techniques in Non-Destructive Testing, 18–19 June 2015, Sozopol, Bulgaria
- Non-contact acquisition of sonic emissions of bearings, Technology Transfer Workshop on Advanced Techniques in Non-Destructive Testing, 18–19 June 2015, Sozopol, Bulgaria

- A Narrowband Sound Signal Frequency Estimation with Impulsive Noise Filtering, 7th Balkan Conference in Informatics (BCI 2015), 2–4 September 2015 Craiova, Romania
- Fast Direction-of-Arrival Estimation for Single Source, International Conference on Telecommunications and Remote Sensing, ICTRS-2015, 17–18 September 2015, Rhodes, Greece
- Multichannel modified covariance estimator of a single-tone frequency, International Workshop on Information Fusion, 25 September 2015, Sofia, Bulgaria

Publications, published:

- (i) Iu. Chyrka, A Narrowband Sound Signal Frequency Estimation with Impulsive Noise Filtering, Proceedings of the Balkan Conference on Informatics: Advances in ICT, Craiova, Romania (2015), pp. 40–44, CEUR Workshop Proceedings series Vol. 1427, 2015, <http://ceur-ws.org/Vol-1427/paper6.pdf>
- (ii) Iu. Chyrka, Fast Direction-of-Arrival Estimation for Single Source, International Conference on Telecommunications and Remote Sensing, ICTRS-2015, Rhodes, Greece (2015), 54-58

Publications, under review:

- Iu. Chyrka, Interpolation of acoustic field from nearby located single source, International Conference Advanced Computing for Innovation, AComIn-2015, 10–11 November 2015, Sofia, Bulgaria
- Iu. Chyrka, P. Koprinkova-Hristova, V. Kudriashov, K. Alexiev, V. Ivanov, Smart Feature Extraction from Acoustic Camera Multi-Sensor Measurements, International Conference Advanced Computing for Innovation, AComIn-2015, 10–11 November 2015, Sofia, Bulgaria
- Iu. Chyrka, Acoustic Fields Reconstruction, Cybernetics and Information Technologies
- Iu. Chyrka, I. Omelchuk, Multichannel modified covariance estimator of a single-tone frequency, Cybernetics and Information Technologies

Publications, in preparation:

- Chyrka, Iu., I. Omelchuk. An advanced autoregressive moving average estimator of a real sinewave

Plans for future work within AComIn

Further improvement of the direction-of-arrival estimate will be targeted by developing new methods for frequency estimation and using multiple channels/segments of data. It is expected that autoregressive moving averaged model based method has a big advantage over the autoregressive model based method known as modified covariance one.

2.2.12. Dr Olga Kanishcheva

Dr Olga Kanishcheva (http://www.iict.bas.bg/acomin/CV_OKanishcheva.pdf) received her PhD in Computer Science from the Faculty of Informatics and Control, National Technical University “Kharkiv Polytechnic Institute”, Ukraine in 2010. The topic of her PhD thesis is “Information and logical models of knowledge identification in automated information library systems”. Her research interests are in the area of Language and semantic technologies (Natural Language Processing; Sentiment Analysis; Named-entity recognition (NER); Vision & Language Integration; Summarization and Information retrieval).

Individual Research Plan of Dr Olga Kanishcheva in AComIn months 27-36 **host professor: Galia Angelova**

The research work to be carried out is focused on Language Technologies esp. a feasibility study of the ideas laid down in AComIn research area 4 ("Large-scale approach to multilingual terminology"), see AComInDoW Part B, page 9. The research work is focused on the keywords (annotation tags), which are used in large-scale collections of multimedia digital objects. Multimedia collections integrate electronic text, graphics, images, sound, and video. Their objects are usually annotated by keywords which characterize, describe or refer to categories in certain classifications. These tags help to distinguish the objects and often form folksonomies: user-generated categories for organizing digital content. Folksonomies are derived from the practice as a method of collaboratively creating and translating tags to annotate and categorize content; the approach is known as collaborative tagging, social classification, social indexing, or social tagging. Collaborative development of content is good, on the one hand, since it is clear that resources with a high-quality annotation will help to improve automatic recognition algorithms and the search in multimedia collections. But the main challenge is how to produce high quality annotations that describe the object semantics, with least effort and minimal costs. In this way the automatic annotation is a hot research topic worldwide. Automatic assignment of keywords to images is a rather difficult task per se; the available solutions based on machine learning are unsatisfactory. Additional semantic post-processing of the keywords might help to reduce the noise, delete contradictive tags, or recognize images with similar meanings. Applying external resources like Wordnet and Wikipedia would help to solve these problems. Another motivation is that NLP techniques are rarely used in image annotation. Third, algorithms for post-processing and improving of the tags will have significant practical impact. The research work employs computational NLP techniques as well as large external resources of English (like WordNet, associative thesauri and Wikipedia) to keyword post-processing. Due to the variety of data structures, the study mixes NLP tools, WordNet as a lexical ontology, Wikipedia as a wiki system and various thesauri as graph- or net-based structures. The research work, which will be carried out during the AComIn months 27-36, is divided into several research directions: Selection of "core" keywords that annotate an image; Sentiment Analysis of Image Tags; Semantic similarity between images based on tags; Word Sense Disambiguation (WSD) approaches applied on tags; Optimization of keyword sets for video fragments.

Research Activities and Results

The results of the main research activities, performed during the working period, are organized in the following groups:

- Selection of "core" keywords that annotate an image;
- Sentiment Analysis of Image Tags;
- Semantic similarity between images based on tags, with aspects of tag sense disambiguation

Selection of "core" keywords that annotate an image

We propose an approach for post-editing of keywords which are assigned to images by a realistic auto-tagging platform. The suggested post-editing tackles "noisy" tags: mistakes, inflexions, doublets, normalization of keywords-names (e.g. "Muenchen" and "Munich", "Vienna" and "Wien"), abbreviations (LA, NY, "pov" etc.), and various linguistic and punctuation phenomena that occur at token level. We also suggest employing linguistic resources that define English lexical semantics (WordNet) for consolidation of tags. Various metrics for semantic similarity were overviewed and approaches how to apply them for sense recognition have been studied. In addition keywords might belong to various synsets (e.g. "vine", which is Food and Plant) so we need to find some techniques to

cope with the semantic ambiguity. Last but not least we notice that the relevance score, assigned by the auto-tagging platform to the suggested keywords, is not included in our present considerations. Further empirical studies are needed to invent a certain feasible approach that takes the relevance score into consideration (given that we trust the auto-tagging quality). We made some experiments with the pre-processing – detection of redundant tags in sets of keywords assigned by the Imagga's auto-tagging platform. For the pre-processing experiment we took 700 sets of more than 14,400 keywords, assigned as tags to different images. At the beginning we checked the typographical errors; the conjoint phrases were corrected whenever possible. This normalization did not affect the number of keywords. Then the Porter's stemmer was applied to remove endings. The quantity of tags decreased almost by 268 words (about 2% of the total number of keywords). Using WordNet we identified and grouped synonymous terms. The total reduction constituted about 4%. The semantic analysis was tested on a collection of 300 keyword sets that belong to the major ImageNet categories Animal, Plant, Activity, Material, Instrumentation, Scene, and Food. Interesting results were achieved in the categories Food and Animal: significant amounts of tags were interpreted as "redundant". For the categories Activity, Material, Instrument and Scene, our approach identified little redundancies because in principle the corresponding images consist of multiple elements. The Imagga's auto-tagging assigns high-relevance scores to images in Activity, Material, Instrument and Scene relatively rarely. This is probably due to the fact that the content of images in Scene and Materials is usually a more complex assembly therefore it is difficult to define redundant elements (for example, beach includes sea, coast, sky, sand etc. but there are no hierarchical relations among them). The experiment suggests that our approach makes sense for images related to Animal, Food and Plant. This is due partly to the depth of the WordNet noun hierarchy for these domains. The reduction might seem to be unnoticeable for Food and Plant especially but this might be due to the particular test corpus. Our results shows that research on image tagset refinement should be based on external dictionaries, thesauri, encyclopedias and so on. We plan to use the additional resources in our future work which includes full implementation of the post-editing tool that is sketched here. Although we are focused on the Imagga's auto-tagging platform at present, the proposed approach is flexible and can be easily extended to deal with a variety of online media repositories, such as Zoomr and other image databases with noisy tags. User studies are needed as well, to define groups of users that need specific services while searching in large multimedia collections. In this way the suggested tag filtering algorithms can be better tailored to well-specified search tasks.

Sentiment Analysis of Image Tags

The emotional classification of images depends on the individual opinion of each person, but we propose and investigate an idea how to compute image sentiment scores using external resources. We present an approach for analysis of sentiments and emotions in image tagging using SentiWordNet as an external linguistic resource of emotional words. Our aim is to design and implement algorithms that assess the emotions and polarity given a set of image tags. The approach is not only limited to object analysis (considering informational keywords) but deals with the involvement tags and employs some techniques used for sentiment analysis in social networks too. We consider the issue of a tag sense disambiguation when image keywords are mapped to SentiWordNet. The Lesk WSD algorithm helps to identify correctly the meaning of about 50% of the ambiguous single keywords of 200 images. The total number of tags we process is about 10,000. Calculating a "sentiment score" for each image, the system classifies images into three classes (positive, negative, and neutral). These classes are compared to emotional assessments done (i) by humans and (ii) by training of a SVM classifier that provides the baseline of 69.7% precision, 29.9% recall and 41.8% F-measure. Our approach works with 63.53% precision, 58.7% recall and 61.02% F-measure. The experiments are performed using the annotations of the industrial auto-tagging platform Imagga that identifies automatically image objects with high precision. As future work we plan at first to include colors in the emotional assessment of images.

Semantic similarity between images based on tags

The problem of defining image similarity based on image tags has many solutions. Our aim is to deal with images from various resources and to propose a reasonable definition for image similarity. But this is uneasy task because close images may be annotated by different amounts of tags. In addition the tags might be correct but the meaning might be expressed by different words. In our work we address the dimensionality problem in similarity vectors definition for images from various resources. For our experiments we use images from a professional photo hosting site. Each image is assigned to a rather large number of different tags. Based on previous experiments with images from different resources we came to the conclusion that it is possible to use an auto-tagging platform (Imagga, <https://imagga.com>) for receiving image annotation by keywords, and then to find similarity of images. However the success of the whole enterprise will depend on the auto-tagging quality. Practically the annotation quality varies from very good to poor. Therefore we offer the following approach. At the beginning for each image we search for "initial" tags, then for each tag we find the corresponding list of associative words using the word2vec method. We plan to use as a training corpus the annotated images in professional stock image marketplaces StockPodium (<http://www.stockpodium.com>). Choosing an appropriate training corpus and running the experiments requires further research and implementation of prototypes. After receiving updated lists of tags, we'll merge them with the initial tags and will calculate the similarity of vectors. We plan to use the cosine as similarity measure and make experiments with further metrics as well.

Participations and presentations at scientific events:

The results achieved in AComIn were presented at the following conferences and workshops:

- About Emotion Identification in Visual Sentiment Analysis, International Conference RANLP 2015, 5-11 September, 2015, Hissar, Bulgaria
- A Pipeline Approach to Image Auto-Tagging Refinement, 7th Balkan Conference in Informatics, 2-4 September, 2015, Craiova, Romania
- Sentiment Analysis of images depending on their resource, AComIn Workshop "Big Data in Education and Large Digital Collections", 29 June 29, 2015, Sofia, Bulgaria
- Poster presentation at the AComIn Doors Open Days in IICT-BAS, Sofia, 17-18 April, 2015

Publications - published and accepted:

- (i) Kanishcheva, O. and G. Angelova. About Emotion Identification in Visual Sentiment Analysis, In Proceedings of the 10th International Conference on "Recent Advances in Natural Language Processing" RANLP 2015, 7-9 September 2015, Hissar, Bulgaria, 258-265, ISSN 1313-8502.
- (ii) Kanishcheva, O. and G. Angelova. A Pipeline Approach to Image Auto-Tagging Refinement, Proceedings of the 7th Balkan Conference on Informatics Conference, Craiova, Romania, 2015, ACM Proceedings Series, ACM New York, ISBN: 978-1-4503-3335-1, doi>[10.1145/2801081.2801108](https://doi.org/10.1145/2801081.2801108)
- (iii) Van-Hieu Vu, Hai-Son Le, O. Kanishcheva, and G. Angelova. Fine-tuning SIMPLE based Content Based Image Retrieval system, Proceedings of the Sixth International Symposium on Information and Communication Technology (SoICT 2015), 3-4 December 2015, Hue, Vietnam, ACM Proceedings Series, ACM, (accepted).

Publications, in preparation:

- O. Kanishcheva, G. Angelova. About Sense Disambiguation of Image Tags in Large Annotated Image Collections. To be presented at the International Conference AComIn-2015, 10-11 November 2015, Sofia, Bulgaria.

Plans for future work within AComIn

The previous results allowed formulating the following tasks for future work:

- Semantic similarity between images based on tags (further work in this direction);
- Optimization of keywords sets for video fragments.

Especially for the task “**Optimization of keywords sets for video fragments**”, our motivation and plans are as follows: The advances in computer and network infrastructure together with the fast evolution of multimedia data has resulted in the growth of attention to the digital video’s development. The scientific community has increased the amount of research into new technologies, with a view to improving the digital video utilization: its archiving, indexing, accessibility, acquisition, store and even its processing and usability. Our main goal is the construction of a system that optimizes the number of tags describing video resources, without any loss of sense. By using the textual information, a user is facilitated on the one hand to locate a specific video and on the other hand is able to comprehend rapidly the basic points and generally, the main concept of a video without the need to watch the whole of it. The textual information derives from a key-word-based video annotation approach.

2.2.13. Dr Aleksey Balabanov

Dr. Aleksey Balabanov (http://www.iict.bas.bg/acomin/CV_Balabanov.pdf) received master’s degree in “Automatic and control systems” in 2006. In 2013 he defended his PhD thesis on the specialty “Systems and Processes of Control” at the Sevastopol National Technical University. Dr. Aleksey Balabanov has worked as a senior lecturer at the Technical Cybernetics department during the period 2007–2014. His past research activities are devoted to development and application optimization methods to automatic control systems such as mini submarine and servo-mechanism of an artillery unit. The topic of his PhD thesis is “Application matrix algebraic equation Riccati linear reduction methods for control systems optimization problems”.

Individual Research Plan of Dr Aleksey Balabanov in AComIn for months 29-36 host professor: Todor Stoilov

The research during the reported period of the AComIn project will constitute a feasibility study of the ideas laid down in optimization and intelligent control area. The main aim of the research will be design, modeling, test and simulation of the optimization algorithms, which will be applied for large-scale and complex systems. The targeted systems for control and optimization will be from transport domain. The methods, which will be used for solving modeling and formalization problems, will belong to the classes of difference equations and ordinary differential equations. The following general classes of transport systems will be under consideration: longitudinal cooperative movement of intelligent vehicles in a platoon with decentralized linear-quadratic optimal control strategy and traffic light controlled urban network presented in the well-known Gazis and Potts store-and-forward model.

The optimization problems will be directed to the design of close loop control structure. In this case the personal experience in the quadratic optimization will give a benefit in the real time control design and state estimation.

Methodology of researches:

- Contemporary overview of the problems, related to the control of transport systems, particularly for vehicles platoon control.
- Analysis of the control strategies, applied for real time management of the longitudinal cooperative movement of vehicles in a platoon.
- Analysis of algorithms for real time state space variables estimation of an urban traffic network.
- Development of mathematical models for the transport systems.

- Development of optimization algorithms of real time management. Main attention will be paid to implementation of quadratic optimization problem.
- Numerical simulation of optimization algorithms for transport systems in Matlab.
- Test and validation of transport systems optimization by simulation in SmartLab environments. The theoretical experience will be gathered by simulation tests on AIMSUN software.

Research Activities and Results

In a problem of longitudinal control laws computation for intelligent vehicles in a platoon, a decentralized linear-quadratic optimal control is considered. The platoon is a large scale system and may be as large as the number of vehicles in it. A control synthesis in on-board computers of vehicles during their move of such a large scale system is still a problem. The main goal of the research is to reinforce a decentralized linear-quadratic optimal control. The problem of creating a high-performance numerical algorithm for vehicles in a platoon is solved by applying Bass' relation and resolvent method. These methods use feature of controlled object. More precisely, the proposed approaches use the advantage of structure of not completely controllable dynamic system. In the appropriate papers is shown how to reduce the decentralized linear-quadratic optimal control synthesis in that case. Also, as a part of this research, a general Bass' and resolvent methods are developed. At the first step, an attention is given to a multiple search of stabilizing solution of algebraic Riccati equation. The numerical performance of the proposed methods is evaluated to show their efficiency. The simulation results of the control strategy show a good performance and satisfy all required conditions of platoon move, such as string stability and robustness.

In the problem of urban transportation network state estimation the well-known Gazis and Potts store-and-forward model is studied. To improve the performance of the urban transportation network traffic management and monitoring, an intelligent urban transportation system is required based on current accurate traffic information. Traffic data may be obtained from various types of sources which are not accurate in cause of noisy sensor data. Kalman observers show good estimation performance in literature. At the same time urban transportation network models may be large enough and require efficient algorithms to build Kalman estimator. The research was devoted to finding an effective solution of this problem. The mentioned problem consists of the efficient solving of a discrete type algebraic Riccati equation. The proposed approach is based on the relation between discrete type algebraic Riccati equation and the continuous one. According to the special structure of state-space urban transportation network model, we are able to effectively implement a resolving method. There are proved some useful properties which led us to significant reductions. The main result of this study consists in a simple representation for solution of discrete type algebraic Riccati equation. Also the numerical performance evaluation proved some advantages of the proposed representation.

Working with the SmartLab software

The SmartLab environment is used for gathering the urban transportation network traffic flow data for Gazis and Potts store-and-forward model. The data includes: traffic volumes, flows rate, traffic splits at nodes, correlations between queues length in different links, etc. The AIMSUN software is used to create a part of the scheme of urban transportation network in Sofia along Gurko Street. The AIMSUN microscopic simulator is also used for testing and validating the transport system optimization.

Participations and presentations at scientific events:

- Poster presentation at the AComIn Doors Open Days in IICT-BAS, Sofia, 17-18 April, 2015;

- *A decentralized linear-quadratic optimal control of vehicles in a platoon. The issue of control for not completely controllable dynamic system.* Presentation at a scientific seminar of the Hierarchical Systems Department, IICT, 27.4.2015, Sofia, Bulgaria;
- 7th Balkan Conference in Informatics, September 2-4, 2015, Craiova, Romania.

Publications, published:

- (i) A. Balabanov, Fast decentralized optimal control algorithm on the basis of Bass' relation for vehicles in a platoon, In BCI'15 Proceedings of the 7th Balkan Conference on Informatics(2015), ACM Digital Library, ACM NY, [Doi:10.1145/2801081.2801106](https://doi.org/10.1145/2801081.2801106)
- (ii) A. Balabanov, E. Soldatenko, Application procedures of the resolvent method for the checking of the matrix stability, Intelligent Systems, Control and Mechatronics. May 13-15, 2015, Sevastopol, Proceedings, 70–74
- (iii) A. Balabanov, Solutions construction of some particular types of matrix algebraic Riccati equations, Intelligent Systems, Control and Mechatronics, May 13-15, 2015, Sevastopol, Proceedings, 62–69
- (iv) A. Balabanov, I. Slobodyanyuk, An H infinity optimization of neighbour vehicles in the platoon, Intelligent Systems, Control and Mechatronics, May 13-15, 2015. Sevastopol, Proceedings, 53–56

Publications, under review:

- A. Balabanov, Building of Numerically Effective Kalman Estimator Algorithm for Urban Transportation Network, International Conference Advanced Computing for Innovation – 2015
- A. Balabanov, An Issue of Multiple Solutions Search of the Linear-Quadratic Optimization Problem for not Completely Controllable Dynamic System, Cybernetics and Information Technologies

Publications, in preparation:

- A. Balabanov, Kalman Observer Building by Frequency Characteristic of Dynamic Object, Information Technologies and Control, Sofia, Bulgaria.
- A. Balabanov, A. Barabanov, Building of linear reduction equations of algebraic equations Riccati by minimal polynomial vector of system state, Izvestiya RAN, Theory and Control Systems, Moscow, Russian Federation
- A. Balabanov, An optimal control computation of an underwater mini device at stabilization on a periscope depth in the conditions of frequent wave disturbance model change, Environmental Management Systems - 2015, December 18, 2015. Sevastopol

Plans for future work within AComIn

The research will constitute the development of perspective theoretical ideas which are studied in the reported period and will constitute mainly in further practical implementations in SmartLab environments.

The gathered theoretical experience of studying large scale and complex transportations systems lead us to the following problems:

- Applying and adapting of linear reduction methods of continuous and discrete type matrix algebraic Riccati equations for not completely controllable dynamic systems. This will include extending of the well-known Bass' relation and resolvent method to discrete matrix algebraic Riccati type equation. To show an efficiency of the proposed approaches the computational performance and results accuracy will be evaluated with comparison to other known methods.
- Building of decentralized linear-quadratic optimal control by vector minimum polynomials of extended state space of overlapping structure system.
- Kalman filter building by frequency response of the system.

The targeted systems from transport domain for applying solutions of the problems are longitudinal cooperative movement of intelligent vehicles in a platoon with decentralized linear-quadratic optimal control strategy and traffic light controlled urban network presented in the Gazis and Potts store-and-forward model. The store-and-forward model could face some weakness. For this reason, a feasibility study of the contemporary scientific materials will be continued. The work will include the following tasks:

- Testing of control and estimations strategy in AIMSUN software. The optimization strategy will be compared with the TRANSYT software in terms of evaluating benefits of the designed control algorithm.
- SmartLab hardware exploring of available traffic light controller on the base of Xilinx chip.
- Studying Vivado Design Suite 14.7 development tool and high speed integrated circuits hardware description language of field-programmable gate arrays devices.
- Validation of the proposed approaches will be provided by the above mentioned traffic light controller.

2.2.14. Dr Konstantinos Liolios

Dr Konstantinos Liolios (http://www.iict.bas.bg/acomin/CV_K-Liolios.pdf) has got his PhD degree in 2014 from Democritus University of Thrace, Xanthi, Greece. The title of his thesis is "Analysis of Hydrodynamic Behaviour and Transport and Removal of Pollutants in Porous Media: Investigation in Horizontal Subsurface Flow Constructed Wetlands". His research interests are in the fields of: groundwater flow and quality, microbiological degradation of pollutants constructed wetlands, MODFLOW computer family code, wastewater treatment, numerical modeling, and estimation of parameters for optimum design, flow in porous media, climatic effects (rainfall and evapotranspiration).

Individual Research Plan of Dr Konstantinos Liolios in ACom in Months 35- 36 host professor: Krassimir Goergiecv

Working areas

The planned work is in the AComIn priority advanced computing. The main field of research will concern Computational Environmental Engineering. Emphasis will be given to the following aspects:

- Environmental hydraulics;
- Groundwater quality;
- Flow through porous media;
- Numerical modelling in groundwater flow and contaminant transport;
- Wastewater treatment and pollution removal;
- Horizontal Subsurface Constructed Wetlands (HSF CWs);
- Simulation of available experimental results concerning pilot-scale HSF CWs;
- Optimum design parameters for HSF CWs.

Working methodology

First, the general problem of wastewater transport and removal of pollutants in porous media will be analyzed. The mathematical formulation of this problem usually results in a system of partial differential equations and appropriate boundary and initial conditions. Next, the most suitable type of the chemical reaction (zero-order, first order or Monod type) concerning the removal of a pollutant will be investigated numerically by simulating available experimental results. These experimental data have been obtained from five pilot-scale HSF CW units, which were operated for two years in the facilities of the Laboratory of Ecological Engineering and Technology of Democritus University of Thrace, Xanthi, Greece. The case of a multispecies reactive transport will be also investigated. The mathematical

formulation of this problem results to a system of four partial differential equations. For the chemical reaction, the double Monod model will be applied, where the pollutant Biochemical Oxygen Demand (BOD) is the electron donor and oxygen is the electron acceptor. The MODFLOW computer family code will be used for all the above numerical treatments of flow and transport problems. All the above concern advanced computing and numerical applications including multiscale and multiphysics simulations of strongly heterogeneous media with strongly nonlinear and/or anisotropic behavior as well as high-performance computing in engineering and environmental problems.

Expected results

An analysis of BOD removal in pilot-scale Constructed Wetlands (CW) will be presented taking into account interactions of BOD with other contaminants. The best choice of the chemical reaction type (zero-order, first order or Monod type) will be investigated. The obtained results will be presented at the research seminar "Parallel algorithms and scientific computations" in IICT and at specialized international conferences and workshops. The obtained results will be submitted for publication in refereed journals and book series. We expect to submit at least one journal and two proceedings papers.

Publications, in preparation:

- K. Liolios, V. Tsihrintzis, K. Georgiev and I. Georgiev. A Computational Investigation of the Optimal Reaction Type Concerning BOD Removal in Horizontal Subsurface Flow Constructed Wetlands. Proceedings of the International Conference "Advanced Computing for Innovation 2015", 10-11 November 2015, Sofia, Bulgaria.
- K. Liolios, V. Tsihrintzis, K. Georgiev and I. Georgiev. Geothermal Effects for BOD Removal in Horizontal Subsurface Flow Constructed Wetlands: A Numerical Approach. Proceedings of the 10th Annual Meeting of the Bulgarian Section of SIAM (BGSIAM' 15), 21-22 December 2015, Sofia, Bulgaria.

2.2.15. Dr Jovana Ružić

Dr Jovana Ružić (http://www.iict.bas.bg/acomin/CV_JRuzic.pdf) received her PhD from Faculty of Technology and Metallurgy, Department of Metallurgy, University of Belgrade, Serbia in 2014. Her research interests include the topics of: Powder metallurgy; Particle reinforced metal matrix composites; Mathematical modeling; Mechanical testing; Safe disposal of radioactive elements.

Individual Research Plan of Dr Jovana Ružić in AComIn month 36 host professor: Dimitar Karastoyanov

Objectives

Today, metal matrix composites (MMCs) have a wide range of applications in aerospace, automotive, military and electrical industry. The greatest challenge is to create a material with the best combination of excellent mechanical and physical properties. Low content of alloying elements in metal matrix enables the highest possible ratio mechanical/physical properties sufficient to withstand demanding operating conditions even in nuclear technology and rocket industry. The overall objective of this research plan is to experimentally investigate the influence of process parameters on mechanical, tribological and physical properties of MMCs obtained by powder and casting metallurgy. Also, influence of alloying elements amount (nano ceramic) on MMCs properties will be investigated.

Equipment selection and Experimental work

Since SmartLab equipment is suitable for characterization of MMCs powders and compacts it is expected that obtained data will determine connection between material properties and process parameters. The **Laser Particle Sizer** will be used for analyzing mechanically alloyed powders which will show the influence of milling time on present amount of nano-sized particles. The **Tomograph XTH 225** will be used for inspection of obtained MMCs by powder and casting metallurgy, such as microstructural analysis, distribution of pores, reinforcing particles and agglomerated particles. The application of **EDEM software** in production of MMCs will be of great importance for analyzing experimentally obtained data, too. The rest of the equipment will be employed as needed during the experimental work.

Data analysis

It is expected that experimental results will show how combining adequate mechanical alloying time with proper densification process may lead to more homogeneous distribution of fine reinforcements in metal matrix and lower porosity which is a requirement for excellent mechanical/physical properties. The obtained results will be analyzed and compared to the latest literature data.

Writing scientific papers

The obtained results will lead to new knowledge of MMCs and will be published in internationally recognized, peer-reviewed journals which will improve MMCs production and widen potential applications. The results will be presented at ACOMIN conference in November 2015. Additionally, results will be presented at international conferences. Journals and conferences will be chosen after analysis of obtained experimental data. Also, a presentation will be prepared for the next IICT seminar.

3. RECRUITED INCOMING EXPERIENCED RESEARCHERS WITH SHORT-TERM CONTRACTS, MONTHS 19-36

In the AComIn DoW, short-term scientific missions are planned for incoming experienced researchers with more than 10 years of scientific experience, both foreigners and Bulgarians, to perform:

- lecturing at high-quality intensive seminars including events held with User Communities,
- innovation-related tasks,
- technology transfer activities,
- joint research activities including writing high-quality papers and monographs etc.

Table 3 lists the employments of five incoming experienced scientists during the first Reporting period of AComIn. Figure 3 shows the Research plans and Reports of all visiting scholars in the Team Area of the project site. This section overviews their contributions to AComIn objectives.

Experienced researcher	Permanent job affiliation	Starting date of employment	End date of employment
Prof. Darina Dicheva	Department of Computer Science, Winston-Salem State University, NC, USA	9 June 2014	8 July 2014
		1 June 2015	30 June 2015
Prof. Christo Dichev	Department of Computer Science, Winston-Salem State University, NC, USA	9 June 2014	8 July 2014
		1 June 2015	30 June 2015
Prof. Milena Dobrova	Faculty of Media and Knowledge Sciences, University of Malta, Malta	9 June 2014	16 July 2014
		12 June 2015	11 July 2015
Prof. Ludmil Zikatanov	Department of Mathematics, Pennsylvania State University, PA, USA	25 May 2015	24 June 2015
Prof. Aleksandar Vencel	Faculty of Mechanical Engineering, University of Belgrade, Serbia	1 September 2015	continues working as of 30.09.2015

Table 3. Employed incoming experienced researchers with short-term contracts by 30 Sept. 2015

The screenshot shows the AComIn website interface. The top navigation bar includes 'HOME', 'ABOUT THE HOST', 'E-NEWSLETTERS', 'APPRECIATION', 'NEWS', and 'CONTACT'. The main content area is titled 'WP1: Incoming experienced researchers' and contains a section for 'Short employments of experienced researchers (plans and reports)'. This section is divided into two years: 2015 and 2014. For 2015, it lists Prof. Aleksandar Vencel (1 September – 31 December 2015), Prof. Milena Dobrova (12 June – 11 July 2015), Prof. Darina Dicheva (01 June – 30 June 2015), Prof. Hristo Dichev (01 June – 30 June 2015), and Prof. Ludmil Zikatanov (May 25 – June 24 2015). For 2014, it lists Prof. Darina Dicheva (09 June – 08 July 2014), Prof. Hristo Dichev (09 June – 08 July 2014), and Prof. Milena Dobrova (09 June – 16 July 2014). Each entry includes links for 'plan' and 'report'.

Figure 3. Research Plans and Reports of Visiting Experienced Researchers in the Team Area of AComIn site

3.1 PROF. DARINA DICHEVA

In 2014, Prof. Dicheva was an incoming experienced researcher in AComIn in the period 9 June – 8 July 2014. Her working program contained activities in the AComIn topic “Language and Semantic Technologies”, in the area “Intelligent management of digital content” focusing on the IT challenges in developing and using educational digital repositories as well as semantic and game techniques for supporting educational systems. The local hosts were Prof. Gennady Agre and Prof. Galia Angelova. The following interrelated activities were planned and accomplished during this visit:

- (i) **Reviewing the state of the art and the trends in the use of Gamification in Education.** This research was aimed to contribute to the understanding of how gamification can effectively be utilized in educational contexts. A meta-study was conducted to overview the published peer-reviewed case studies of using gamification in education, by reviewing the relevant papers in the popular digital libraries: the ACM Digital Library, IEEE Xplore, ScienceDirect, Google Scholar, SCOPUS, and Springer Link, as well as in the proceedings of the major education-related conferences. The joint team examined the different gamification design approaches to education, contexts of educational uses of gamification, employed game elements with respect to their usage and effectiveness, and types of studies performed on the gamified systems. When surveying the existing literature on gamification, it is found that there is no commonly agreed classification of game design elements. Focusing on the educational context, a two-level framework consisting of game mechanics and gamification design principles is proposed. The empirical research is summarized evaluating the acceptance of gamification in education by using the proposed framework. Some recommendations for future research and development are provided. The conducted research was presented in a manuscript and later published in the IETE Technical Review journal (Taylor & Francis):
Dicheva D., Dichev Ch., Agre G., and G. Angelova. Gamification in Education: A Systematic Mapping Study. *Educational Technology & Society*, 18 (3), 2015, 75-88, ISSN 1176-3647 (IF 1.34)
- (ii) **Presenting the prepared review of the state of the art in Gamification in Education at an AComIn seminar.** This activity is directly relevant to the goal of the AComIn project for transferring of innovations to Bulgaria, in this case the innovative Gamification technology in the area of blended and online learning to the Bulgarian K12 and higher education. The goal was to familiarize a user group including representatives from relevant academic, administrative and educational communities with the state of the art and future trends of the use of gamification in education. A lecture entitled “Използване на Игрови Елементи в Образованието: Какво, Защо, Как?” (Gamification in Education: What, Why, How?) was held on 3 July 2014, at the Institute of Information and Communication Technologies, BAS. The presentation was followed by a lively discussion on the possibilities of using gamification in Bulgarian educational institutions.
- (iii) **Activities related to the User Community “Intelligent Management of Digital Content”.** The initiated in 2013 joint research with the hosting institution on semantic technologies and annotation targeting large educational repositories was continued. The initiated in 2013 joint research on semantic technologies and annotation targeting large educational repositories was continued. One of the last year accomplishments of the team, consisting of Darina Dicheva, Christo Dichev, Milena Dobрева, Galia Angelova and Gennady Agre, was the establishment of the AComIn User Community “Intelligent Management of Digital Content”. In 2014 the team worked with the e-learning enthusiasts on the expansion of both the user community and the employed innovative technologies. With regard to the former, the team involved additional

companies interested and willing to adopt emerging technologies in their educational products, and advocated the use of gamification in educational contexts. In this relation, Darina Dicheva carefully evaluated the popular Bulgarian online learning portal “Уча.се” (www.ucha.se). As a result, several recommendations to the developers’ team of the portal were made. The recommendations were grouped in four topics:

- Recommendations about a richer semantic annotation of the learning content, which can be used for more efficient navigation, search and content/unit recommendation. The later can be implemented as a recommender service using the semantic annotation and based on open software, such as the search server Apache SOLR (lucene.apache.org/solr/).
- Recommendations related to the personalization of user experiences in the portal based on comprehensive user modeling. Processing user logs by utilizing data mining methods was proposed as a useful strategy for collecting information for modeling users.
- Recommendations related to gamifying “Уча.се”. The portal designers have already incorporated some basic game mechanics, such as points and badges. However, much more can be done in this direction. In particular, of interest is the integration of game techniques with semantic technologies, for example, building of “knowledge maps” to semantically organize the metadata of the content in the portal. These can be used for the provision of feedback, freedom of choice, leveling-up, and other game mechanics.
- Recommendations related to the Graphical User Interface (e.g. the use of icons, links, breadcrumbs menus, scrollable areas, etc.)

The conducted activities included also two working meetings with Darin Madzharov, Founder of the company “Уча.се”. The meetings took place on June 13, 2014 and July 3, 2014. Through knowledge transfer to the developers of “Уча.се”, the AComIn User Community is actually reaching the large community of end-users of the site who will benefit of those innovative technologies.

In 2015, Prof. Dicheva visited ICT as incoming experienced researcher in AComIn in the period 1-30 June 2015 and continued the joint research tasks, started in 2014, as well as the technology transfer tasks. The accomplished activities are as follows:

(i) *Applying Educational Data Mining to the educational portal UCHA.SE*

Educational Data Mining (EDM) is an emerging discipline “concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students, and the settings which they learn in.” Typical questions addressed by EDM are: What student actions are associated with better learning? What actions indicate satisfaction and engagement? What features of an online learning environment lead to better engagement and learning? Educational data mining is typically applied to student information systems, learning management systems (LMS), web-based courses, adaptive intelligent educational systems, personal learning environments, open data sets, and social media. The targeted data are of two main categories: student-performed actions with a given outcome (e.g. content viewing during a time span, completing an activity with a given result, etc.) and student profile (incl. age, gender, interests, etc.). EDM leverages data mining techniques to analyze education-related data. The primary categories of methods used for educational data mining are classification, clustering, regression, relationship mining, and discovery with models. For online educational websites/learning environments, educational data mining can provide valuable information on user behavior on the site pages, such as how often are students using the site, what they are interested in, are they finding what they are looking for when searching, what learning materials are used the most, etc. These findings can be effectively used to improve customer experience and increase the engagement and the rate at which people learn. This research was aimed at improving the quality of educational services and the subscription rate for the online educational portal UCHA.SE by leveraging educational data mining. Intensive work

jointly with UCHA.SE was carried out, to organise in a proper manner about 8 mln system logs provided by the portal team, to transform data to format suitable in order to apply algorithm for searching patterns and association rules, and finally, using WEKA, to discover patterns of typical learners' behaviour.

- (ii) **Presenting the findings and results at an AComIn workshop.** The findings and results of the study were presented at the International Workshop on Big Data in NLP, Education and Digital Collections, held on 29 June 2015, in the Institute of Information and Communication Technologies, Bulgarian Academy of Sciences. The talk entitled “Emerging applications of learning analytics in Bulgaria: the case of UCHA.SE” was followed by a lively discussion on the possibilities and advantages of using educational data mining in Bulgarian educational e-learning portals and other educational applications.
- (iii) **Preparing a paper for the upcoming AcomIn'2015 Conference.** The conducted activities included also several working meetings with the host team participating in the project, as well as with Darin Madzharov, Founder of the company UCHA.SE, and other representatives of the company. Through knowledge transfer to the developers of UCHA.SE, AComIn is actually reaching the large community of end-users of the site who will benefit of those innovative technologies. The conducted research was also described in a joint paper with the hosting institution entitled “Emerging Applications of Educational Data Mining in Bulgaria: The Case of UCHA.SE” which was submitted to the International Conference ADVANCED COMPUTING FOR INNOVATION - ACOMIN 2015, held on November 10-11, 2015, in Sofia, Bulgaria.

3.2 PROF. CHRISTO DICHEV

In 2014, Prof. Dichev visited IICT as an incoming experienced researcher in AComIn in the period 9 June – 8 July 2014. His working program contained activities in the AComIn topic “Language and Semantic Technologies”, in the area “Intelligent management of digital content” focusing on the IT challenges in developing and using educational digital repositories as well as semantic and game techniques for supporting educational systems. The local hosts were Prof. Gennady Agre and Prof. Galia Angelova. The following interrelated activities were planned and accomplished during this visit:

- (i) **Reinforcing the established user community** through collaboration, studying and evaluating the online learning site “Уча.се” and proposing methods for enhancing the existing platform. This activity was planned and guided based on the observation that online learning is a reflection of today's technological and pedagogical environment and is often more effective than traditional classroom instruction. Yet it is met with variable support. Thus our initial goals included acquaintance with the online learning development in Bulgaria. Accordingly we had a meeting with the development team of “Уча.се” - a comprehensive platform for online learning, which includes more than 4300 video lectures, exercises and algorithms for linking exercises with video lessons, and for supporting online interactive sessions with teachers. The discussions with “Уча.се” team was focused on enhancing the online platform to meet the growing students' needs and to increase its acceptance from the teachers. This meeting also renewed the interest of the growing community of Bulgarian educators and researchers interested in the widespread implementation of online learning and its advancement. The discussion ended with suggestions for improving the site functionality and strategies for boosting the personalization aspect of learner experience.
- (ii) **Delivering lecture** on the psychology of gamification in education and training coupled with the emerging trends, their evaluation and framework for improvement based on gameful design

The lecture was held on July 3, 2014 at the Institute of Information and Communication Technologies, BAS. It was attended by educational technology and educational psychology researchers, educational software developers, teachers, academics and administrative staff. The lecture covered a broad range of relevant topics with focus on psychological models pertinent to games, gamification and education. The discussed models were centered on motivation, engagement, behavior change and in particular on relevant theories and sources of intrinsic motivation. From this perspective the lecture shifted to explaining how to create a motivating learning experience. The exposition clarified that this implies, reconstructing the learning process rather than adding game mechanic to the existing structure. The lecture ended by proposing framework for such reconstruction. During the discussion a significant part of the lecture attendees debated and commented on several topics including: the granularity level of the proposed “game atoms”, the sources of human motivation, the advantages of systems allowing “freedom to fail” and offering space for learners’ experimentation, and the existing tools supporting gameful experience.

(iii) Writing a paper entitled “From gamification to gameful design and gameful experience in learning”

The comprehensive studies carried out during the visit resulted in a joint paper with the researchers from the hosting institution. The primary motivation for this work was to propose a framework for designing gameful learning environments. The parallel between games and education makes the idea of gamifying education logical. Contrary to gamification the paper's proposal is focused on intrinsic motivation. It utilizes the existing methods developed within the game design in order to elicit framework for a gameful approach for learning design. The paper is published in the journal CIT:

Christo Dichev, Darina Dicheva, Galia Angelova, Gennady Agre – From Gamification to Gameful Design and Gameful Experience in Learning, *Cybernetics and Information Technologies* 2014, Vol. 14, No 4, pp. 80-100. DOI: 10.1515/cait-2014-0007 (**SJR** 0.212)

In 2015, Prof. Dichev visited again the ICT as incoming experienced researcher in AComIn in the period 1-30 June 2015 and continued the joint research and technology transfer tasks, started in 2014. The accomplished activities are as follows:

(i) Familiarization with the available information and the data generated by the learning portal UCHA.SE and analyzing the potential for its utilization in accordance with the company needs and goals. Currently Ucha.se offers more than 4,150 videos in 17 subjects, including the basic K-12 subjects, as well as Introductory level English, German, French, and Spanish, and Introduction to Programming. This research was aimed at improving the quality of educational services and the subscription rate for the online educational portal UCHA.SE by leveraging educational data mining (EDM). The primary categories of methods used for EDM are classification, clustering, regression, relationship mining, and discovery with models. The most popular are classification and clustering – together they reach 69% of the DM tasks used by EDM. Prediction is one of the important categories of EDM. The discussions at the working meetings between the teams of Ucha.se and AcomIn were focused on:

- Analyzing what information can be possibly extracted from the site UCHA.SE and used to contribute to the targeted goal;
- Categorizing the available information and defining all included information category profiles;
- Formulating analytical tasks to be performed with regard to the targeted goal.

These in turn resulted in the following analytical tasks:

- Assessing the quality of individual educational resources.
- Assessing the public interest to the resources from the different subject categories and level in order to inform the planning of the future resource production.

- Finding relationships between users' behavior and their use/subscription to the site.
The information needed for these analyses was grouped into three categories: resource-related information, resource category-related information and user-related information.

(ii) Presenting the findings and results at an AComIn seminar/workshop. The findings and results of the study were presented at the International Workshop on Big Data in NLP, Education and Digital Collections, held on 29 June 2015, in the Institute of Information and Communication Technologies, Bulgarian Academy of Sciences.

(iii) Studying the trends and opportunities offered by current OER development and examining emerging practices in the light of its use in Bulgarian K-12 and higher education. The Open Educational Resources (OER) movement began in 2001 when the Hewlett and Mellon foundations jointly funded MIT's OpenCourseWare (OCW) initiative. OER are freely accessible, openly licensed documents and media that are useful for teaching, learning, and educational, assessment and research purposes. Open content is often interpreted as meeting the "5R's": retain, reuse, revise, remix, and redistribute. The development of OER is driven by a desire to provide an alternate educational paradigm and limit commercialization of knowledge. Much of the motivation for the prepared review paper came from the results of the Babson/Pearson survey, which aimed at assessing the awareness about and adoption of OER. According to the survey, almost three quarters of college faculty were unaware of OER. The outcomes of the Babson survey are consistent with reports of earlier surveys conducted with higher education faculty and students. These findings reveal also the existing potential for a much wider adoption of OER. While different aspects of OER adoption have been widely reported, little is known about the state of the art, the advancement, the emerging trends, as well as the actual impact of OER across different disciplines. Even less is known about what kind open resources are available compared to what is used and needed. Despite major advances in recent years, Open Educational Resources (OER) are still not in the mainstream of course development. Motivated by the need to fill this gap, the paper analyzes the evolution of the OER development and the emerging trends relevant to education. The paper was published in the CIT journal:

Christo Dichev, Darina Dicheva, Gennady Agre, Galia Angelova. Trends and Opportunities in Computer Science OER Development. Cybernetics and Information Technologies 2015, Volume 15, No 3, pp. 114-126, DOI: 10.1515/cait-2015-0045 (SJR 0.17)

3.3 PROF. MILENA DOBREVA

In 2014, Prof. Dobreva visited IICT as an incoming experienced researcher in AComIn in the period 9 June – 16 July 2014. Her working program contained activities in the AComIn topic "Language and Semantic Technologies", in the area "Intelligent management of digital content" with an emphasis on applications within digitalization of, access to and preservation of cultural heritage; application of 3D models in this domain, and finally, synergies between access methods to digitalized cultural content and educational resources. The local hosts were Prof. Gennady Agre and Prof. Galia Angelova. The following interrelated activities were planned and accomplished during this visit:

- (i) Research on improving user experiences in digital cultural heritage environments*, including wider engagement with the citizens. This area of work focused on use of crowdsourcing and citizen science in contextualization and enrichment of digital heritage collections. It included a study of the intensity and type of use of citizen science in the Humanities research within the context of memory institutions (libraries, archives, galleries, museums). Comparing data on

previous citizen science initiatives, the research identified slower uptake of citizen science in the Humanities compared to a sound experience in crowdsourcing. Further research would help to identify possible mechanisms for increasing the use of citizen science in the memory institutions and look into the most typical activities around digital cultural heritage libraries which would benefit from citizen science.

- (ii) **Research on potential synergies between access methods to digitalized cultural content and educational resources.** In this task, the main focus was on the various contemporary approaches to use digital libraries of cultural heritage content in education. An initial survey showed that the most common approach in using digital libraries in education is via direct engagement of teachers rather than creating tools which would assist in populating digital learning objects with relevant examples. Further work would be needed to identify areas where such tools could enhance current eLearning and mLearning.
- (iii) **Research on using linked data technologies in digital cultural heritage repositories.** Linked open data could potentially help to retrieve digital heritage objects for eLearning purposes; this is not currently developed but is of interest to Europeana which established Europeana for Education group.
- (iv) During her visit, Prof. Dobрева also took part in the organisation of the *International workshop “Challenges in Using Big Digital Libraries Resources in the Education and Citizen Science”* on 9 July 2014. She delivered a presentation on “Good Practices in Digital Resources Use in Education and Citizen Science”. The Workshop involved other visiting scholars and representatives of local companies active in the domains of eLearning and digital cultural heritage. Dr Dobрева was session chair and led the discussion about potential applications of digital cultural content in eLearning settings.

In 2015, Prof. Dobрева visited again the IICT as incoming experienced researcher in AComIn in the period 1-30 June 2015 and continued the joint research and technology transfer tasks, started in 2014, with focus on the IT challenges in developing and using large digital repositories as well as using semantic techniques for supporting educational systems. The accomplished activities are as follows:

- (i) **Research on potential synergies between digital cultural heritage content and e-learning resources.** The main objective was to explore what methods can facilitate the use of digital cultural heritage libraries in education. This research looked into two aspects, how the process of creating digital resources can be supported by prompting illustrative materials from the digital libraries, and how specialised tools like building paths in cultural heritage collections can be used in the educational practice. Based on a systematic literature review, which started in 2014, the resulting review report provided an overview and a gap analysis of educational use of DLs. It provides a range of examples which build a multifaceted picture of the ideas digital library community has on their use for learning. There is a substantial showcasing work on teaching applications around specific domains of knowledge; most active within the cultural and scientific heritage context are the development in the domains of history and natural history. Some digital libraries chose to brand this work as ‘re-use’ of digital objects, which might create confusion among teachers and learners, especially those who are not well versed in digital libraries terminology and encountered such applications for the first time. Bringing novel applications to the teaching domain, digital libraries might act as educational innovators. However they are still not integrating strongly channels to reach tools used within the current e-Learning environments. A SWOT analysis accompanies the gap analysis. This review was published in the journal CIT: Milena Dobрева, Galia Angelova, Gennady Agre. Bridging the Gap between Digital Libraries and e-Learning. *Cybernetics and Information Technologies* 2015, Volume 15, No 4, pp. 92-110. DOI: 10.1515/cait-2015-0057 (SJR 0.17)

(ii) **Exploration on the widening participation** in digital cultural heritage via crowdsourcing and citizen science. This theme was partially addressed during the previous visit. Besides its societal importance for digital cultural heritage engagement with broader audiences, it has an educational aspect which tackles the skills and expertise of participating citizens. Another possible direction for widening participation concerns presentation issues. In particular the visualisation aspects are specifically important. Summarizing the research results, a paper entitled Milena Dobрева, Fernando Loizides, Galia Angelova, and Gennady Agre. Information Visualisation Skills: an Initial Investigation of Industrial Demand and Educational Supply was submitted to the International Conference ADVANCED COMPUTING FOR INNOVATION - ACOMIN 2015, held on November 10-11, 2015, in Sofia, Bulgaria.

(iii) Prof. Dobрева **delivered presentations and had meetings** as follows:

- Presentation on the topic of educational applications of cultural heritage at the International Workshop on Big Data in NLP, Education and Digital Collections, held on 29 June 2015, in the Institute of Information and Communication Technologies, Bulgarian Academy of Sciences.
- Meetings and discussions with Bulgarian stakeholders in the area of cultural heritage digitization especially those who are partners of ICT in the frame of AComIn digitization and 3D visualisation activities.

3.4 PROF. LUDMIL ZIKATANOV

Prof. Zikatanov was employed in AComIn in the period 25 May – 24 June 2015. The working program of his visit contained activities in Advanced Computing, in particular Area 1: “Advanced computing and Finite Elements applications including multiscale and multiphysics simulations of strongly heterogeneous media with strongly nonlinear and/or anisotropic behaviour” as well as high-performance computing in engineering and environmental problems. The local host was Prof. Svetozar Margenov. Two inter-related activities were planned:

(i) **Joint research in the topic “High performance solution methods for large scale systems arising after discretization of partial differential equations and image segmentation”**. One task was on developing techniques for analysis of Schur Complement based preconditioners for heterogeneous elliptic problems within the subspace correction methods framework. In this research Prof. Zikatanov collaborates with Prof. Margenov, Prof. Lazarov, and Prof. Kraus. The focus was on definition of appropriate subspaces and deriving stability estimate for which there are plenty of numerical evidences, confirming the stability. The new approach proposed by the collaborators is to consider piece-wise harmonic bases in the corresponding subspaces. Such bases minimize energy and usually lead to stable projections. This ongoing collaborative work will be continued in the future. Another task was on developing new methods for image segmentation with constraints. Prof. Zikatanov worked on this topic with Prof. Margenov and Dr. S. Harizanov. They have developed new paradigm for defining admissible intensity function, admissible segmentations as well as an algorithm for segmenting images. The algorithm is based on constructing optimal spanning trees in the graph defined by the pixel/voxel similarities in the image. A prototype computer code was written to test the proposed family of algorithms. One of the bottlenecks which is still under investigation is adding volume constraints for the segmentation. The collaborators have prepared a manuscript on this research which was submitted to the conference proceedings of LSSC’15 and, in extended version, to a peer reviewed journal. Third research direction is the development of scalable operator splitting methods and algorithms for time-dependent alternating directions (AD) methods. Prof. Zikatanov started collaboration with Prof. Margenov and Prof. Lirkov on this topic. While the

research is in its infancy, the collaborators were able to discuss a promising strategy to replace the AD methods with local relaxation methods which are computationally more efficient. The research planned for expanding this collaborative study will also include analysis of these alternative operator splitting algorithms.

- (ii) **Organisation of a Special Session at the 10-th Conference on Large Scale Scientific Computing** (LSSC'15), Sozopol, June 8–12, 2015. Prof. Zikatanov co-organized (with Prof. Vassilevski) a special session entitled “Multilevel Methods on Graphs” as part of the LSSC'15. The speakers in the special session included scientists from USA (University of Minnesota, Cornell University and Los Alamos National Laboratory) and Italy (Institute for High-Performance Computing and Networking). Prof. Zikatanov also participated in the Scientific Committee (SC), and was a SIAM representative in SC. In addition, Prof. L. Zikatanov was one of the six plenary invited speakers at LSSC'15 and presented a talk on “**Subspace Correction Methods: Theory, Practice, and Robustness**” which discussed the mathematical foundations of multilevel methods and their application in reservoir simulation.

3.5 PROF. ALEKSANDAR VENCL

In 2015, Prof. Vencl visited IICT as an incoming experienced researcher in AComIn in the period 1 September – 30 September 2015, and continues working as of 30.09.2015. His working program contained activities in the AComIn topic “Optimisation and Intelligent Control”, in the area “New Materials and Nano Technologies”. The local host was Prof. Dr. Dimitar Karastoyanov. The following interrelated activities were planned and accomplished during this visit:

- (i) **Peer reviewing of the joint paper “Tribology of metal matrix micro- and nanocomposites”**. The paper was a result of the joint research activities of the researchers from IICT-BAN, University of Belgrade and Technical University (TU) of Sofia. In this research Prof. Vencl collaborated with Prof. Karastoyanov from IICT-BAN and Prof. Kandeveva from TU-Sofia. The focus was on metal matrix composites with different matrix material, different reinforcing/alloying elements, and obtained by different processing techniques. The results were classified into three groups according to the matrix material. In the first group were the results for microcomposites with AlSi7Mg matrix alloy obtained by compocasting method. These results cover the influences of amount and size of reinforcement (Al_2O_3), and the influence of type of reinforcement (Al_2O_3 , SiC and SiC with graphite addition). In the second group were the results for nanocomposites with ZnAl25Si matrix alloy obtained by casting and compocasting method. These results cover the influences of silicon and strontium addition percentage, and the influences of strontium and/or Al_2O_3 nanoparticles addition. In the third group were the results for micro- and nanocomposites with Cu matrix obtained by powder metallurgy technology (preceded by mechanical alloying and/or internal oxidation). These results cover the influence of size of reinforcement (Al_2O_3) on the macroscale (composite properties), and the same influence on the nanoscale (only the matrix properties). The paper was presented by Prof. Vencl at the 11th International Conference on Tribology – BULTRIB '15 & International Scientific Conference “70 years FIT”, Sozopol (Bulgaria), 11-13.09.2015, as a Plenary Session paper. The paper is published in the Tribological Journal BULTRIB:
Vencl A., Bobić I., Kandeveva M., and D. Karastoyanov. *Tribology of metal matrix micro- and nanocomposites*, Tribological Journal BULTRIB, Vol. 5, 2015, pp. 10-19, ISSN: 1313-9878.

- (ii) **Joint research activities in the topic “Wear under Vibration Conditions”**. This activities included improving of the testing rig and appropriate testing procedure for the study of abrasive

wear under normal vibration load. In addition, the influences of vibration speed on tested specimens wear characteristics were analysed. The kinematic pairs in machines and mechanisms always operate under lower or higher amount of vibration load caused by various reasons. The parameters of these vibrations undergo wide range of changes, especially in transitional non-stationary operation regimes. Vibrations have ambiguous effect on the tribological parameters of some tribosystem: static and kinetic coefficient of friction, wear, contact conductance, contact strength, noise, temperature rise, lubricant layer thickness, etc. Tribological parameters depend on the complex influence of a number of "input" parameters: vibrations, loading, sliding/rolling speed, working temperature, type of friction, shape and size of contact, working medium (lubricant, vacuum, air, abrasive particles, acid medium), chemical composition of the elements, surface physical-mechanical properties and microstructure, roughness, etc. Vibrations in most cases intensify the wear processes, which affects in turn the vibration parameters. The investigations were carried out at the Tribology Centre of the Faculty of Industrial Technologies at the TU-Sofia. The results of the research was later presented by Prof. Vencl at the 1st International Conference on Tribology – TURKEYTRIB '15, Istanbul (Turkey), 07-09.10.2015, in the Tribology in Manufacturing section. The paper is also accepted for publication in Journal JBTA:

Kandeva M., Grozdanova T., Karastoyanov D., Ivanova B., Jakimovska K., Vencl A., *Abrasive wear under vibrations of the spheroidal graphite cast iron microalloyed by tin*, Journal of the Balkan Tribological Association, 22, 2, 2016, Ref. No. 1394, ISSN: 1310-4772 (IF = 0.443).

(iii) Meetings and discussions with AComIn Team members. These meetings were connected with the researches and results conducted on the SmartLab equipment. In particular, discussions about the Laser Particle Sizer ANALYSETTE 22 NanoTec plus were carried out with Dr Jovana Ružić, and about Thermo Camera FLIR P640, with Dr Kristina Jakimovska.

4. ASSESSMENT OF THE ADDED VALUE OF THE EMPLOYMENTS TO THE IICT RESEARCH AND INNOVATION POTENTIAL

The added value of the AComIn-supported employments should be measured by the AComIn performance indicators; this is done in Deliverable D7.7 “Input for EC Review in month 36” where all project results are considered as a whole.

Here we list the papers that report results achieved by the incoming experienced researchers who are employed in AComIn during Reporting period 2. Some novel activities, skills and know-how that are brought to IICT by the recruited scientists are summarised in section 4.2.

4.1. PUBLICATIONS IN PEER REVIEWED SCIENTIFIC JOURNALS AND CONFERENCE PROCEEDINGS

Published:

1. P. Ribeiro, S. Stoykov, Forced periodic vibrations of cylindrical shells in laminated composites with curvilinear fibres, *Composite Structures*, Vol. 131 (2015), 462–478. **(IF 3.5)**
2. S. Stoykov, E. Manoach, S. Margenov, An efficient 3D numerical beam model based on cross sectional analysis and Ritz approximations, *ZAMM - Journal of Applied Mathematics and Mechanics* (2015), DOI: 10.1002/zamm.201400139. **(IF 1.162)**
3. S. Stoykov, G. Litak, E. Manoach, Vibration energy harvesting by a Timoshenko beam model and piezoelectric transducer, *European Physical Journal Special Topics*, Vol. 224 (2015), 2755-2770. **(IF 1.399)**
4. S. Stoykov, C. Hofreither, S. Margenov, Isogeometric Analysis for Nonlinear Dynamics of Timoshenko Beams, *Numerical Methods and Applications*, Springer LNCS, Vol. 8962 (2015), 138-146. **(SJR 0.339)**
5. S. Stoykov, S. Margenov, Scalability of Shooting Method for Nonlinear Dynamical Systems, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 9374 (2015), 401-408. **(SJR 0.339)**
6. S. Stoykov, S. Margenov, Nonlinear forced vibration analysis of elastic structures by using parallel solvers for Large-Scale Systems, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 8353 (2014), 381-388. **(SJR 0.339)**
7. S. Margenov, S. Stoykov, Y. Vutov, Numerical homogenization of heterogeneous anisotropic linear elastic materials, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 8353 (2014), 323-330. **(SJR 0.339)**.
8. S. Stoykov, The influence of geometrical nonlinearity on the dynamics of elastic structures, *Proceedings of the International Conference on Numerical Methods for Scientific Computations and Advanced Applications*, May 2014, Bansko, Bulgaria (2014), 103-106.
9. S. Stoykov, P. Ribeiro, Frequency response of cylindrical variable stiffness composite laminated shells, *Proceedings of 8th European Nonlinear Dynamics Conference*, Vienna, Austria (2014), Paper Id: 363.
10. P. Schwaha, M. Nedjalkov, S. Selberherr, J. M. Sellier, I. Dimov, R. Georgieva, Stochastic Formulation of Newton's Acceleration, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 8353 (2014), 186-193. **(SJR 0.34)**
11. J. M. Sellier, I. Dimov, The many-body Wigner Monte Carlo Method for time-dependent Abinitio quantum simulations, *Journal of Computational Physics*, Vol. 273 (2014), 589-597. **(IF 2.138)**

12. J. M. Sellier, I. T. Dimov, The Wigner-Boltzmann Monte Carlo Method applied to electron transport in the presence of a single dopant, *Computer Physics Communications*, Vol. 185 (2014), 2427-2435. **(IF 3.078)**
13. J. M. Sellier, I. Dimov, A Wigner Approach to the Study of Wave Packets in Ordered and Disordered Arrays of Dopants, *Physica A: Statistical Mechanics and its Applications*, Vol. 406 (2014), 185–190. **(IF 1.676)**
14. J. M. Sellier, I. Dimov. A Wigner Monte Carlo Approach to Density Functional Theory, *Journal of Computational Physics*, Vol. 270 (2014), 265-277. **(IF 2.138)**
15. J. M. Sellier, S. Amoroso, M. Nedjalkov, S. Selberherr, A. Asenov, I. Dimov, Electron dynamics in nanoscale transistors by means of Wigner and Boltzmann approaches, *Physica A: Statistical Mechanics and its Applications*, Vol. 398 (2014), 194-198. **(IF 1.676)**
16. J. M. Sellier, M. Nedjalkov, I. Dimov, S. Selberherr. A benchmark study of the Wigner Monte-Carlo method, *Monte Carlo Methods and Applications*, Vol. 20(1), (2014), 43–51. **(SJR 0.224)**
17. J. M. Sellier, M. Nedjalkov, I. Dimov, S. Selberherr, The role of annihilation in a Wigner Monte Carlo approach, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 8353 (2014), 186-19. **(SJR 0.339)**
18. J. M. Sellier, I. Dimov, Towards solitonics design in the Wigner formalism, *Physica A: Statistical Mechanics and its Applications*, Vol. 417 (2015), 287–296. **(IF 1.722)**
19. J. M. Sellier, I. Dimov, A sensitivity study of the Wigner Monte Carlo method, *Journal of Computational and Applied Mathematics*, Vol. 277 (2015), 87-93. **(IF 2.266)**
20. J. M. Sellier, I. Dimov, On the simulation of indistinguishable fermions in the many-body Wigner formalism, *Journal of Computational Physics*, Vol. 280 (2015). **(IF 2.138)**
21. J. M. Sellier, M. Nedjalkov, I. Dimov, S. Selberherr. A Comparison of Approaches for the Solution of the Wigner Equation, *Mathematics and Computers in Simulations*, Vol. 107 (2015), 108-119. **(IF 0.836)**
22. J. M. Sellier, I. Dimov, Wigner functions, signed particles, and the harmonic oscillator, *Journal of Computational Electronics*, Vol. 14 (4) (2015), 907-915. **(IF 1.520)**
23. J. M. Sellier, D. Ivanova, I. Dimov, Molecular descriptors and quasi-distribution functions, *Computers and Mathematics with Applications* (2015), doi:10.1016/j.camwa.2015.06.037. **(IF 1,697)**
24. J. M. Sellier, M. Nedjalkov, I. Dimov, An introduction to applied quantum mechanics in the Wigner Monte Carlo formalism, *Physics Reports*, Vol. 577 (2015), 1-34. **(IF 22.91)**
25. J. M. Sellier, R. F. Sviercoski, I. Dimov, On the Wigner Monte Carlo Method Coupled to Pseudopotential Models, *Journal of Computational and Applied Mathematics*, Vol. 29 (2015). **(IF 1.266)**
26. I. Georgieva, C. Hofreither, R. Uluchev, Least Squares Fitting of Harmonic Functions Based on Radon Projections, *Mathematical Methods for Curves and Surfaces*, Springer LNCS, Vol. 8177 (2014), 158-171. **(SJR 0.339)**
27. C. Hofreither, U. Langer, C. Pechstein. FETI solvers for non-standard finite element equations based on boundary integral operators, *Lecture Notes in Computational Science and Engineering*, Vol. 98 (2014), 729-737. **(SJR 0.260)**
28. C. Hofreither, W. Zulehner, Spectral Analysis of Geometric Multigrid Methods for Isogeometric Analysis, *Numerical Methods and Applications*, Springer LNCS, Vol. 8962 (2015), 123-129. **(SJR 0.339)**
29. C. Hofreither, W. Zulehner, On full multigrid schemes for isogeometric analysis, *Domain Decomposition Methods in Science and Engineering XXII, Lecture Notes in Computational Science and Engineering*, Vol.104 (2015), 272-279. **(SJR 0.260)**
30. I. Georgieva, C. Hofreither. Interpolation of harmonic functions based on Radon projections, *Numerische Mathematik*, 127(3) (2014), 423-445. **(IF 1.608)**

31. I. Georgieva, C. Hofreither. Interpolating solutions of the Poisson equation in the disk based on Radon projections, *Journal of Mathematical Analysis and Applications*, 423(1) (2015), 305-317. **(IF 1.12)**
32. I. Georgieva, C. Hofreither. Cubature Rules for Harmonic Functions Based on Radon Projections, *Calcolo*, 52, (2015), 153-166. **(IF 0.808)**
33. S. Stoykov, C. Hofreither, S. Margenov, *Isogeometric Analysis for Nonlinear Dynamics of Timoshenko Beams, Numerical Methods and Applications*, Springer LNCS, Vol. 8962 (2015), 138-146. **(SJR 0.339)**
34. I. Georgiev, S. Margenov, Semi-coarsening AMLI preconditioning of anisotropic trilinear FEM Systems, *Computers and Mathematics with Applications*, Vol.68(12) (2014), 2103-2111 **(IF 1.697)**
35. I. Georgiev, E. Ivanov, S. Margenov, Y. Vutov, Numerical Homogenization of Composite Materials, *Numerical Methods and Applications*, Springer LNCS, Vol. 8962 (2015), 130-137. **(SJR 0.339)**
36. Ang. Liolios, A. Elenas, Ast. Liolios, St. Radev, K. Georgiev, I. Georgiev, Tall RC buildings environmentally degraded and strengthened by cables under multiple earthquakes: A numerical approach, *Numerical Methods and Applications*, Springer LNCS, Vol. 8962 (2014), 187-195. **(SJR 0.339)**
37. M. Mironova, M. Ivanova, V. Naidenov, I. Georgiev, J. Stary, Advance study of fiber-reinforced self-compacting concrete, *Applications of Mathematics in Techniques and Natural Sciences*, AIP Conference Proceedings, Vol. 1684 (2015), <http://dx.doi.org/10.1063/1.4934293>. **(SJR 0.15)**
38. D. Karastoyanov, V. Kotev, T. Penchev, Forging Process Control by Additional Rocket Force, *International Journal of Emerging Technology and Advanced Engineering*, Vol. 4 (8) (2014), 297-306
39. D. Karastoyanov, V. Kotev, I. Yatchev, Development of a Braille Tactile Device Driven by Linear Magnet Actuators, *International Journal of Engineering and Innovative Technology*, Vol. 4 (2) (2014), 35-43
40. D. Karastoyanov, V. Kotev, T. Penchev, Forging by Rocket Driven Hammer: Dynamics and Experiments, *Advanced in Engineering Mechanics and Materials* (2014), 174-177
41. D. Karastoyanov, V. Kotev, Electromagnetic Microdrives for Braille Screen: Control and Circuit Testing, *International Journal of Materials Science and Engineering*, Vol. 3 (1) (2015), 1-6
42. K. Kostadinov, V. Kotev, D. Penchev, Force Sensing of Teleoperated Robotized Cell Injection, *Advances in Robotics, Mechatronics and Circuits* (2014), 160-163
43. V. Kotev, D. Karastoyanov, P. Genova, Application of the Spatial Mechanisms in Bioreactors: Design Concept., *International Journal of Materials Science and Engineering*, vol. 3, (1) (2015), 82-85
44. V. Kudriashov, K. Alexiev, Non-stationary random Wiener signal detection rule for case of monostatic reception, *Acoustics, Sofia, Bulgaria*, 28-29 November 2014, Year XVI(16) (2014), 61-63
45. V. Kudriashov, K. Alexiev, Acoustic camera – how to see the sounds, *Acoustics, Sofia, Bulgaria*, 28-29 November 2014, Year XVI(16) (2014), 64-67
46. K. Lukin, V. Kudriashov, P. Vyplavin, V. Palamarchuk, S. Lukin, Coherent radiometric imaging using antennas with beam synthesizing, *International Journal of Microwave and Wireless Technologies*, Vol. 7 (3-4) (2015), 453-458. **(IF 0.348)**.
47. V. Kudriashov, A Modified Maximum Likelihood Method for Estimation of Mutual Delay and Power of Noise Signals by Bistatic Radiometer, *Comptes rendus de l'Académie bulgare des Sciences*, Vol. 68 (5) (2015), 631-640. **(IF 0.284)**
48. V. Kudriashov, Non-stationary Random Wiener Signal Detection Criterion Variants for Case of Monostatic Reception, 7th Balkan Conference in Informatics, Craiova, Romania, 2-4 September 2015, Proceedings, DOI: 10.1145/2801081.2801089.

49. V. Kudriashov, Non-stationary Random Wiener Signal Detection with Multistatic Acoustic System, 4th International Conference on Telecommunications and Remote Sensing, Rhodes, Greece, 17-18 September 2015, 1-5
50. S. Stoykov, S. Harizanov, S. Margenov, Space discretization by B-Splines on discontinuous problems in structural mechanics, Proceedings of the 7th Balkan Conference on Informatics (2015), Paper Id: 31, DOI: 10.1145/2801081.2801113.
51. E. Abadjieva, V. Abadjiev, On the Synthesis of Spatial Rack Mechanisms: Mathematical Modelling-Analytical and 3D Software Creating of the Face Rack Drive Teeth, Machine Design, Vol. 7 (2) (2015), Faculty of Technical Science, University of Novi Sad, pp. 47-54, ISSN 1821- 1259. Presented at The International Workshop KOD 2015, Machine and Industrial Design in Mechanical Engineering, 11-14 June, 2015, Balatonfüred, Hungary), **ICV**: 4.43
52. V. Abadjiev, E. Abadjieva, D. Karastoyanov., Gravity Dress Device, Bulgarian Patent Application, No 111918, February 3, 2015
53. M. Savov, S. Wang, Fluctuation limits of a locally regulated population and generalized Langevin equations, Infinite Dimensional Analysis, Quantum Probability and Related Topics, Vol. 18 (2) (2015), DOI: 10.1142/S0219025715500095. (**IF** 0.65)
54. Jakimovska K., Duboka, C., Application of fuzzy AHP method for vehicle roadworthiness evaluation, In: Proceedings of the 25th International Automotive Conference „Science and Motor Vehicles 2015“, 14-15 April 2015, Belgrade, Serbia, ISBN 80941-39-4, pp 241-251
55. Jakimovska, K., Duboka, C., Karastoyanov, D., An AHP/DEA method for measurement of the vehicle roadworthiness performance index – VRWPI, In: G. Kartnig, N. Zrnica, S. Boshnjak (Eds.), Proceedings of the 21th International Conference „Material Handling, Constructions and Logistics 2015“, 23-25 September 2015, Vienna, Austria, ISBN: 978-86-7083-863-5., pp 217-220
56. Iu. Chyrka, A Narrowband Sound Signal Frequency Estimation with Impulsive Noise Filtering, Proceedings of the Balkan Conference on Informatics: Advances in ICT, Craiova, Romania (2015), pp. 40–44, CEUR Workshop Proceedings series Vol. 1427, 2015, <http://ceur-ws.org/Vol-1427/paper6.pdf>
57. Iu. Chyrka, Fast Direction-of-Arrival Estimation for Single Source, International Conference on Telecommunications and Remote Sensing, ICTRS-2015, Rhodes, Greece (2015), 54-58
58. O. Kanishcheva, G. Angelova, About Emotion Identification in Visual Sentiment Analysis, In Proceedings of the 10th International Conference on "Recent Advances in Natural Language Processing" RANLP 2015, 7-9 September 2015, Hissar, Bulgaria, 258-265, ISSN 1313-8502.
59. Kanishcheva, O. and G. Angelova. A Pipeline Approach to Image Auto-Tagging Refinement, Proceedings of the 7th Balkan Conference on Informatics Conference, Craiova, Romania, 2015, ACM Proceedings Series, ACM New York, ISBN: 978-1-4503-3335-1, doi>[10.1145/2801081.2801108](https://doi.org/10.1145/2801081.2801108)
60. Balabanov, A. Fast decentralized optimal control algorithm on the basis of Bass' relation for vehicles in a platoon, In BCI'15 Proceedings of the 7th Balkan Conference on Informatics(2015), ACM Digital Library, ACM NY, [Doi:10.1145/2801081.2801106](https://doi.org/10.1145/2801081.2801106)
61. A. Balabanov, E. Soldatenko, Application procedures of the resolvent method for the checking of the matrix stability, Intelligent Systems, Control and Mechatronics. May 13-15, 2015, Sevastopol, Proceedings, 70–74.
62. A. Balabanov, Solutions construction of some particular types of matrix algebraic Riccati equations, Intelligent Systems, Control and Mechatronics, May 13-15, 2015, Sevastopol, Proceedings, 62–69.
63. A. Balabanov, I. Slobodyanyuk, An H infinity optimization of neighbour vehicles in the platoon, Intelligent Systems, Control and Mechatronics, May 13-15, 2015. Sevastopol, Proceedings, 53–56.

64. Dicheva D., Dichev Ch., Agre G., and G. Angelova. Gamification in Education: A Systematic Mapping Study. *Educational Technology & Society*, 18 (3), 2015, 75-88, ISSN 1176-3647 (**IF 1.34**)
65. Christo Dichev, Darina Dicheva, Galia Angelova, Gennady Agre – From Gamification to Gameful Design and Gameful Experience in Learning, *Cybernetics and Information Technologies* 2014, Vol. 14, No 4, pp. 80-100. DOI: 10.1515/cait-2014-0007 (**SJR 0.212**)
66. Christo Dichev, Darina Dicheva, Gennady Agre, Galia Angelova. Trends and Opportunities in Computer Science OER Development. *Cybernetics and Information Technologies* 2015, Volume 15, No 3, pp. 114-126, DOI: 10.1515/cait-2015-0045 (**SJR 0.17**)
67. Milena Dobрева, Galia Angelova, Gennady Agre. Bridging the Gap between Digital Libraries and e-Learning. *Cybernetics and Information Technologies* 2015, Volume 15, No 4, pp. 92-110. DOI: 10.1515/cait-2015-0057 (**SJR 0.17**)
68. Vencl A., Bobić I., Kandeва M., and D. Karastoyanov. *Tribology of metal matrix micro- and nanocomposites*, Tribological Journal BULTRIB, Vol. 5, 2015, pp. 10-19, ISSN: 1313-9878.

Accepted for publication:

69. S. Stoykov, S. Margenov, Scalable parallel implementation of shooting method for large-scale dynamical systems. Application to bridge components, *Journal of Computational and Applied Mathematics*, DOI: 10.1016/j.cam.2015.04.015. (**IF 1.365**)
70. Ang. Liolios, At. Karabinis, Ast. Liolios, St. Radev, K. Georgiev, I. Georgiev, A computational approach for the seismic damage response under multiple earthquakes excitations of adjacent RC structures strengthened by ties, *Computers and Mathematics with Applications* (accepted). (**IF 1.697**)
71. I. Georgiev, S. Harizanov, Y. Vutov, Supervised 2-phase Segmentation of Porous Media with Known Porosity, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 9374 (accepted). (**SJR 0.339**)
72. V. Kudriashov, K. Lukin, V. Palamarchuk, S. Lukin, A. Garbar, Mapping of Acoustic Noise and Microwave Radiation, *Cybernetics and Information Technologies*. (**SJR 0.212**)
73. V. Kudriashov, Experimental evaluation of opportunity to improve the resolution of the acoustic maps. *New Approaches in Image Analysis - Techniques, Methodologies and Applications*, Springer Intelligent Systems Reference Library. (**SJR 0.186**)
74. I. Georgiev, S. Harizanov, Y. Vutov, Supervised 2-phase Segmentation of Porous Media with Known Porosity, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 9374, accepted. (**SJR 0.339**)
75. S. Harizanov, S. Margenov, L. Zikatanov, Fast Constrained Image Segmentation Using Optimal Spanning Trees, *Large-Scale Scientific Computing*, Springer LNCS, Vol. 9374, accepted. (**SJR 0.339**)
76. Jakimovska K., Vasilev V., Stoimenov N., Gyoshev S., Karastoyanov D., Train control system for railway vehicles running at operational speed, 22nd International Scientific Conference on Achievements in Mechanical and Materials Engineering (AMME'2015), Zakopane (Poland), 06-09/12/2015, Abstracts Proceedings, ISBN: 978-83-63553-39-5, pp. 68, Accepted for Publication
77. Ruzic J., Jakimovska K., Stoimenov N., Gyoshev S., Karastoyanov D., Influence of mechanical alloying time on particle size of copper matrix composite, 22nd International Scientific Conference on Achievements in Mechanical and Materials Engineering (AMME'2015), Zakopane (Poland), 06-09/12/2015, Abstracts Proceedings, ISBN: 978-83-63553-39-5, pp. 96, Accepted for Publication
78. Van-Hieu Vu, Hai-Son Le, O. Kanishcheva, and G. Angelova. Fine-tuning SIMPLE based Content Based Image Retrieval system, *Proceedings of the Sixth International Symposium on Information and Communication Technology (SolCT 2015)*, 3-4 December 2015, Hue,

- Vietnam, ACM Proceedings Series, ACM, (accepted).
79. V. Abadjiev, G. Dimchev, E. Abadjieva, D. Karastoyanov., One Application of the International Terminological Standard BDS ISO 10825 for the Damage Identification on the Teeth of Gear Transmissions., 6th Int. Conf. on Mechanics and Material Design M2D'2015, July 26-30 2015, Ponta Delgada, Portugal, PAPER REF: No 5691pp. 509-516 (published on CD), International Journal of Mechanics and Material Design, ISSN 1569-1713, (in print),
 80. E. Abadjieva., Spatial Face Rack Drives: Mathematical Models for Synthesis and Software Illustrations, 6th Int. Conf. on Mechanics and Material Design M2D'2015, July 26-30 2015, Ponta Delgada, Portugal, PAPER REF: No 5760, pp. 601- 612 (published on CD), International Journal of Mechanics and Material Design, ISSN 1569-1713, (in print),
 81. Jakimovska, K., Duboka, C., Karastoyanov, D., Application of fuzzy TOPSIS and AHP method in evaluating vehicle roadworthiness performance, In: C. Andreescu, A. Clenci (Eds.), Proceedings of the 14th European Automotive Congress "EAEC-ESFA 2015" 25-27 November 2015, Bucharest, Romania, will be published in a Springer Journal (in print)
 82. Kandeve M., Grozdanova T., Karastoyanov D., Ivanova B., Jakimovska K., Vencl A., Abrasive wear under vibrations of the spheroidal graphite cast iron microalloyed by tin, Accepted in the Journal of the Balkan Tribological Association, 22, 2, 2016, Ref. No. 1394, ISSN: 1310-4772 (IF = 0.443).

4.2. ENABLING NEW RESEARCH ACTIVITIES AND TECHNOLOGY TRANSFER TASKS

Dr Volodymyr Kudriashov came from the O. Ya. Usikov Institute for Radiophysics and Electronics, National Academy of Sciences of Ukraine, as an expert in radar signal processing. Working with the SmartLab Acoustic Camera, he transferred some ideas and techniques that are applied in the area of passive radars. He proposed new methods for spatial resolution improvement and showed an opportunity to detect lubrication loss in rolling ball bearings. He also developed rules for non-stationary Wiener signal detection with monostatic and multistatic acoustic systems. Experimental simulations of the above-mentioned methods with the Acoustic Camera showed significant improvement of device functionality.

Dr Stanislav Harizanov comes from TU Kaiserslautern/Fraunhofer ITWM with expertise in advanced computing and image processing. In AComIn he proposed a couple of volume-constrained 2-phase segmentation algorithms that have been parallelised and efficiently implemented and now are applicable to large images of high resolution. Such constrained mathematical models have not been previously considered for segmentation. They incorporate knowledge in the fields of Graph Theory and Convex Analysis. The conducted numerical experiments on 3D image reconstructions scanned by the SmartLab Tomograph XTH 225 showed significant improvement in the image quality, compared to standard non-supervised segmentation methods.

Dr Emilia Abadjieva spent 2 years as a post-doctoral scientist in the Department of Human and Information Systems, Faculty of Engineering at Gifu University – Japan. Her research interests include the mathematical modelling of the processes of spatial motion transformations. An AComIn, using the new 3D printer purchased in AComIn Smart Lab, she raised awareness about 3D prototyping in industrial engineering, and demonstrated successful analytical and software synthesizing of hyperboloid gears through 3D software technology.

Dr Mladen Savov has PhD in probability theory from the School of Mathematics, University of Manchester. He has a strong mathematical background in analysis of stochastic processes. For the relatively short period he spent as a postdoc of AComIn he has achieved great scientific results on

probabilistic analysis and convergence studies of the Monte Carlo method developed to study the Wigner equation. In this way the developed numerical scheme was improved and the understanding behind it is advanced. This has the potential to save computer time and thus make efficient usage of expensive resources.

Dr Kristina Jakimovska is expert in transport systems maintenance, safety and diagnostics. She conducts theoretical and simulation research on vehicle safety and vehicle roadworthiness of used cars using MCDM (Multi - criteria decision methods). Using the Smart Lab Thermo camera, she established a very fruitful cooperation with the Technical University of Sofia and T. Kableshkov University of Transport and developed a scientific approach to prevent emergency events in transport by continuous monitoring on railway vehicles in motion. Also, she collaborates with colleagues from the Academy in the area of 3D scanning, 3D modelling and digitization of cultural objects and archaeological artefacts.

Dr Iurii Chyrka is expert in algorithms for radar signal parameter estimation. In AComIn he developed new methods that improve the quality of the near-field acoustic holography images captured by the SmartLab Acoustic Camera. Their application enhances the resolution of holography in high frequency range and decreases errors during sound source localisation, particularly of a single source. A MATLAB implementation of known holography methods along with the new ones overcomes some limitations of the built-in Acoustic Camera software: cutted upper frequency, limited distance to the object, comparatively small reconstruction area etc. Some multichannel single frequency estimation methods, helpful in sound sources tracking and direction-of-arrival estimation, were developed too.

Dr Olga Kanishcheva works in the Vision and Language area, which is a challenging field aiming to bridge image recognition techniques and human views to image semantics. Her research includes sentiment analysis of images, image clusterisation and tag sense disambiguation. She proposed an approach for post-editing of keywords which are assigned to images by an auto-tagging program. For sentiment analysis of images she suggested a combined perspective formula, which uses an external lexicon that defines the emotional component of English keywords. Her investigations also include research on the colors and positive/negative annotations - a novel direction that helps to understand better the connection between image meaning and the associated keywords.

Dr Aleksey Balabanov studies fundamental problems of control theory as well as the application of optimisation in the transportation domain. His research was focused on large scale, complex systems optimisation problems including analytical optimisation solutions in terms of the linear-quadratic and H infinity criteria, and their use in searching stabilizing solution of algebraic Riccati equation by developed Bass' and resolving method equations. These methods were applied to a control problem of cooperative movement in a platoon of intelligent vehicles, and to the estimation of vehicles amount in queues, which appeared in front of controlled junctions in under saturated urban transportation network. The SmartLab AIMSUN microscopic traffic flow simulator is used in the latter developments.

Dr Konstantinos Liolios is expert in Environmental Engineering. His research is focused on a computational investigation of selecting the optimal reaction type, concerning the Biochemical Oxygen Demand (BOD) removal in constructed wetlands (CW). A simulation by using on one hand the first-order and on the other hand the Monod reaction type has been realised. The numerical simulation of the BOD removal in CW was presented under temperature variability. Besides the groundwater flow and the solute concentration fields, the temperature distribution and the temperature dependent decay coefficients were computed. The SmartLab software provides a convenient simulation framework for his work, especially for 3-dimensional numerical simulation of flow through porous media.

Dr Jovana Ružić is expert in the field of synthesis and characterization of advanced metal matrix composites (MMCs) obtained by powder metallurgy. Her research in AComIn is focused on optimisation of techniques for characterisation of powder materials, such as laser diffraction method, by using the laser nanoparticle sizer ANALYSETTE 22 and the Tomograph XTH 225 in order to generate 3D particle shape. Using CT scanning for analysing the particle morphology is an innovative approach in powder characterisation. She cooperates with the Tribology centre, TU Sofia to determine tribological properties of composite materials. SmartLab provides advanced knowledge of particle size/shape which implies better understanding of the influence of particle size/shape on MMCs production.

Prof. Ludmil Zikatanov, who came from the University of Pennsylvania, is a renowned expert in Finite Elements applications and high-performance computing for engineering and environmental problems. Jointly with Prof. Svetozar Margenov and Dr Stanislav Harizanov - post-doc in AComIn, he developed of a new paradigm for defining admissible intensity function, admissible segmentations as well as an algorithm for segmenting images. The algorithm is based on constructing optimal spanning trees in the graph defined by the pixel/voxel similarities in the image. Related programming code was written to test the proposed family of algorithms. This implementation is directly related to the improvement of image quality for the industrial tomograph XTH 225 – a device in AComIn SmartLab.

Prof. Dr Aleksandar Venci is an expert in Tribology, a science and engineering discipline of mechanical engineering which studies phenomena and processes on the interacting surfaces in relative motion, including the study and application of the principles of friction, wear and lubrication as well as phenomena connected with these processes. His knowledge about composite materials and its application was transferred to the AComIn post-docs through the intensive cooperation and discussions. He conducts experiments with the SmartLab Thermocamera and applies it as a diagnostic and monitoring tool for the plain bearings. It was shown that, by continuous measuring of the plain bearings contact temperature, it is possible to predict the value of friction in the plain bearing, an important parameter connected with the dissipation of energy in systems. He also established firmer connections with the Faculty of Industrial Technology at TU - Sofia, through this research and some previous contacts.

5. DEVIATIONS FROM SCHEDULE AND CONTINGENCY PLAN

In AComIn period 1 there was a considerable delay in employment of incoming experienced researchers, both for the long-term and short-term recruitments. By 31 March 2014 (end of Reporting period 1) only

- 44.25 person months in total were utilised for the recruitment of incoming post-docs with long-term contracts, out of 84 person month planned for recruitment in Reporting period 1;
- 6 person months were utilised for the short-term employment of incoming seniors with more than 10 years of experience, out of 17 person months planned for Reporting period 1.

In Reporting period 2, however, incoming post-docs were employed for 105.39 person months, exceeding the plan of 84 person month for the period (see Table 1, page 7). In this way in AComIn months 1-36 the utilized person months for post-doc recruitment are 150 in total (out of 168 planned for post-docs).

Regarding the budget for short-term employment of incoming seniors with more than 10 years of experience, there is still delay in Reporting period 2: only 8.25 person months are used, out of 17 person months planned.

Contingency plan: the activity in WP1 will continue by 31 January 2016. It is expected that 11 of the 12 post-docs, working currently in the project, and one incoming guest professor will be employed in AComIn by the end of January 2016 and will fully utilize the remaining resources for recruitment of incoming experienced researchers.

6. CONCLUSION

The long-term employments of post-docs in AComIn Period 2 have been successful, given that very strong and experienced candidates were hired, and the delay in recruitments in Project period 1 has been compensated. The incoming post-docs were essentially involved in activities related to the deeper understanding, deployment and exploitation of the SmartLab equipment. Several issues of fundamental nature were raised (e.g. quality of tomographic images, resolution of the acoustic camera and others) and implied further theoretical studies and proposal of new methods that were tested practically by prototypical implementations.

The contribution of the guest professors, employed with short-term contracts, also becomes visible after project year 3. Most of them contributed to the achievements of the AComIn post-docs and IICT young researchers. Some of them strongly supported the development of User Communities. For instance, Prof. Darina Dicheva and Prof. Christo Dichev helped to establish partnership between UCHA.SE (the most popular eLearning portal in Bulgaria) and IICT in the modern area in educational data mining. For the first time an exercise in educational analytics took place and was demonstrated as a showcase and advanced applications of data mining in the area of K-12 learning.

The results, achieved by the incoming experienced researchers, clearly contribute to the objective to strengthen the IICT research and innovation capacity. We note once again that some of the papers, acknowledging AComIn and listed above in section 4.1, are published in top scientific journals within several months only, which is an achievement by itself.