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AComIn:
Advanced Computing for Innovation

FP7 Capacity Programme
Research Potential of Convergence Regions

D1.1

Strengthening the Human Potential of the Institute of Information and Communication Technologies (IICT) - Month 18

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Prof. Galia Angelova, AComIn Coordinator

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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). 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.

Keywords	Recruitment of incoming experienced researchers, Assessment of the added value of employments to the IICT research capacity, Deviations from schedule and contingency plan

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Executive Summary

Deliverable D1.1 reports on the activities on Strengthening the IICT Human potential in AComIn Work Package 1 (WP1) during months 1-18 of the project. It describes the long-term employment of 6 incoming post-doctoral researchers and the short-term one-month employment of 6 incoming experienced seniors. D1.1 assesses the WP1 achievements in terms of publications (list of papers) as well as in terms of activities initiated with the participation of the employed incoming experienced researchers. Finally, D1.1 presents deviations from schedule and contingency plan.

D1.1 presents in details the procedure for searching and recruiting incoming candidates for the AComIn post-doctoral positions. The search for appropriate candidates is made by means of Job announcements at various EU job/mobility-portals and also by an active campaign to inform personally colleagues from good Universities and academic institutions on the Balkans and in the South-East European region. After eligibility check of the submitted application documents, a potential host professor is assigned to each candidate, discussing further with the candidate the directions of his/her eventual activity. The results of the eligibility check and the opinions of the host professor are fixed in a Candidate Evaluation Form, evaluating the candidate's research capacity in the context of the AcomIn project. The Project Executive Board, taking into consideration the Candidate Evaluation Form and the opinion of the supervising IICT senior, votes and either approves or rejects the candidate. In case of a positive decision the Executive Board recommends to the IICT Director to employ the candidate in IICT; the proposal for employment is accompanied by a personal Research Plan. The host professor monitors all organisational and administrative aspects of the employment.

The deliverable contains short CVs of the employed 6 incoming post-doctoral researchers, their Career Development Plans and concise information about the completed activities, current results, and plans for future work within AcomIn.

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

The deliverable contains Work plans and Reports about the completed activities of the 6 incoming seniors who were employed within AComIn for short terms (one month each).

The deliverable D1.1 deals with Assessment of the Added Value of the employments in IICT in months 1-18. 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.

D1.1 lists 30 papers, authored by researchers recruited via AComIn during project months 1-18 and published in peer reviewed scientific journals and conference proceedings (10 of the papers are under print at the D1.1 submission date). Some of the papers are published in top scientific journals within several moths only, which is an achievement by itself.

The recruited researchers have brought to IICT new topics of research, new skills, new connections and new horizons in many diverse and challenging research areas such as:

- computer simulation of dynamical behaviour of engineering structures with complex geometry;
- corpus linguistics and automatic processing of sublanguages;
- semi-classical and quantum transport simulations;
- finite elements analysis and non-standard FEM discretisations;
- mechatronic devices and bio-robotics;
- design and development of large repositories of digital educational objects;
- multimodal capture, semantic analysis and 3D representation of Cultural Heritage;
- 3D design etc.

The deliverable marks the deviations from the AComIn schedule, consisting in utilization of less man-months than the planned employments of incoming experienced researchers, both for the long-term and short-term recruitments. The delay is due to two main reasons:

- the equipment purchase and Smart Lab integration are delayed by about six months – and that prohibited employments in the related topics;
- it takes time to organise visits of incoming experienced researchers who usually plan their schedule some years in advance.

The Contingency plan states that 3 post-doctoral candidates for long-term employment are under serious consideration at the D1.1 submission date. There are also plans and schedule for the invitation of incoming experienced researchers with more than 10 years of research experience.

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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 1.1, as an input for the AComIn review in month 18, 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 1-18: Career Development Plans for incoming post-docs, 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 1-18;
- Deviations from Schedule and Contingency Plan.

2. Recruiting Incoming Experienced Researchers at Post-Doctoral Positions

Six incoming post-doctoral researchers have been employed in AComIn in months 1-18 (see Fig. 1). Recently, after purchasing the AComIn Smart Lab equipment in project months 12-18, four new applications have arrived (one is approved and the candidate awaits his working visa, three applications are under consideration at present). This section reports about the employments implemented in project months 1-18. Section 5 “Deviations from Schedule and Contingency Plan” considers the Applicants who expect approval and/or recruitment as of 31 March 2014.

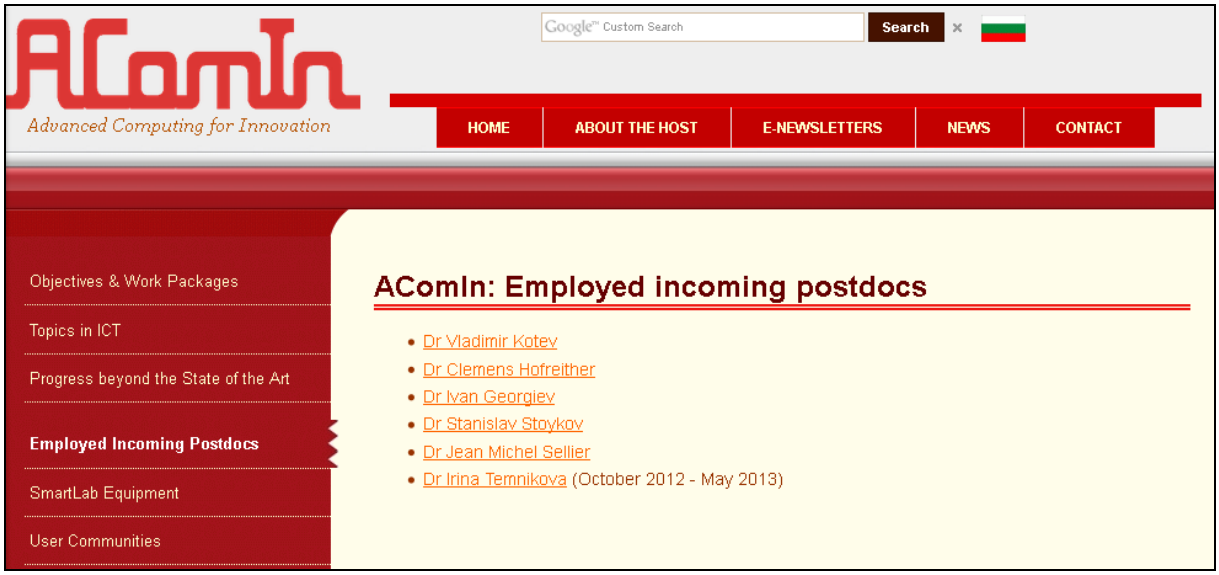


Figure 1. Listing the names and CVs of recruited incoming post doctoral researchers in the Public Area of the AComIn project site, see http://www.iict.bas.bg/acomin

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). 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).

2.1. APPLICATION DOCUMENTS AND PROCEDURES FOR RECRUITING INCOMING POST-DOCS

The AComIn team has been proactive in searching post-docs for long-term employment as incoming experienced researchers with less than 10 years of scientific experience. In the AComIn context, 'incoming researcher' is a scientist who has been working outside Bulgaria for more than 2 years during the last 3 years. The positions are announced for 12 months with option to extend them till the AComIn project end. The preliminary job announcements were launched at the time when AComIn was invited for negations (June 2012, 4 months before the actual project start).

Application Documents:

During the first project week, the AComIn Executive Board approved the set of application documents:

- 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 has 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.

Procedure for Selection of Incoming Post-Docs for Long-Term Employment:

In general the Application assessment procedure, approved by the AComIn Executive Board, consists of two phases. After eligibility check of the submitted application documents (phase 1), a potential host professor is assigned to each candidate. Phase 2 includes further personal contact and invitation to (skype) interview. To ensure careful evaluation and decision making about each application, the AComIn Exacutive Board has approved mandatory rules for project Personnel selection in four steps:

- the Job announcement, including the list of required application documents, is published at the AComIn site http://www.iict.bas.bg/acomin as well as at various EU job/mobility-portals like Euraxess, EURES etc., and the candidates are invited to submit applications to acomin@bas.bg;
- a Commission of 3 members, appointed by the Executive Board (the WP1 Leader, the Project Coordinator and the Project Manager), checks the eligibility of the submitted documents. In case of correct and full applications, the Commission redirects the contact to the potential future host professor of the respective post-doc candidate;
- the recommended IICT senior supervisor discusses further with the candidate the directions of his eventual activity and fills in the second part of the Candidate Evaluation Form which evaluates the candidate's research capacity (see Annex 1). After that the host professor reports his opinion regarding the candidate appointment to the Executive Board;
- the Executive Board, taking into consideration the Candidate Evaluation Form and the opinion of the supervising IICT senior, votes and either approves or rejects the candidate. In case of positive decision the Executive Board recommends to the IICT Director to employ the candidate in IICT according to the employment scheme fixed in the AComIn Technical Annex. The proposal for employment is accompanies by a personal **Research Plan** for the tasks to be performed that is agreed between the post-doc and his/her supervisor.

All Candidate Evaluation Forms (i.e. the templates in Annex 1 that are filled in for each applicant) are kept in the Executive Board archive. They are files named as follows:

AComIn-CAN-vnn-Evaluation form for <Name>.doc
where <*Name*> is the candidate name and *vnn* – version number.

This 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.

2.2. CAREER DEVELOPMENT PLANS OF YOUNG RESEARCHERS AND THEIR MONITORING

Career Development Plans:

The present section is a concise presentation of the principles, applied in the organisation and management of AComIn activities in order to support the personal development of the young experienced researchers (with less than 10 years of scientific experience, post-doctoral researchers), employed under AComIn long-term employment scheme.

i. 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 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:
According to the principles adopted in order to support the Career Development of post doctoral researchers, AComIn creates an atmosphere of open discussion of research ideas among the post docs, coming from various places allover the world, the project seniors and the IICT staff in general. The 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). Only the presentations at month 18 have been assessed by the IICT Scientific Council; the reports on intermediate results are stored at the site for references and internal monitoring. 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.

Figure 2. Monitoring postdoc performance via Reports in the Team Area of AComIn site:
- three intermediate reports for Dr Stanislav Stoykov and Dr Jean Michel Sellier;
- two intermediate reports for Dr Clemens Hofreither, Dr Ivan Georgiev and Dr Vladimir Kotev; and
- an intermediate and the final report for Dr Irina Temnikova.

2.3. JOB ANNOUNCEMENTS FOR RECRUITING INCOMING POST-DOCS

Several job announcements for open postdoctoral positions have been published in AComIn m. 1-18:

- in Euraxess, November-December 2012 (see Fig. 3) and February 2014;
- in the ELSNET site (http://www.elsnet.org, May 2013) and NLPeople.com (https://nlppeople.com/, February 2014);
- in the Image World mailing list (imageworld@diku.dk) which announces academic vacancies within the field of Computer Vision, Image Analysis, and Medical Image Analysis;
- in the Information Retrieval mailing list (sigir.org/sig-irlist) and Corpora mailing list (http://www.hit.uib.no/corpora);
- via the Ideal-ist project http://www.ideal-ist.eu an Announcement have been disseminated to the National Contact Persons in ICT in Eastern Europe and the Associated Countries;
- an Open Announcement is available most of the time at the AComIn Project site (see http://www.iict.bas.bg/acomin/opened_positions.html).

The analysis of the submitted applications shows that, via general sites like Euraxess, the announcement is visible to postdocs in Computer Science whose expertise might be relatively far from the topics of AComIn. Further personal discussions with the five candidates, who applied after seeing the job announcement in Euraxess, ended with the conclusion that their interests are only marginally convergent to the AComIn areas. Practically only one of the candidates who were potentially approved contacted the AComIn team after reading the announcement in Euraxess (see the discussions in Section 5). Moreover, to find candidates with expertise that matches the AComIn requirements, one needs to address organisations with specific expertise in e.g. signal processing or 3D image processing. Finally, the topics addressed by AComIn are among the hottest areas in advanced Computer Science and the competition for hiring good postdoc is very high.

Due to these reasons, the AComIn seniors decided to start an active campaign to inform personally colleagues from good Universities and academic institutions at the Balkans and the South-East European region. Announcements have been sent and colleagues invited from:

- Romania: University of Cluj-Napoka & Baia Mare, Polytechnical University in Bucharest, University in Craiova;
- Ukraine: National Aviation Academy (Kiev) and the Institute for Radiophysics and Electronics, National Academy of Sciences of Ukraine (Kharkov);
- Greece: University of Patras;
- Serbia: Nis University;
- FYROM: St. St. Cyril and Methodius University and American University College (Skopje),
- Turkey: Mersin University.

Colleagues from the abovementioned organisations arrived in Sofia to the AComIn Information Day, organised on 28-29 March 2014. The result was that one postdoc candidate from Ukraine submitted his application for appointment to the AComIn open positions. Further activities in spreading out the information about the opportunities, offered by AComIn, will follow in May and June 2014.

The AComIn seniors have also contacted the leading Departments of the Technical University of Sofia, who are interested in collaborating with IICT and performing joint research activities in the AComIn topics, and asked them for help to disseminate the job announcements to further Technical universities in the neighbouring countries. In fact this is important because the AComIn equipment has been already installed and the project needs postdocs who are particularly keen to work with the devices, i.e. IICT needs post-docs with a more engineering background. Partnering colleagues from Academic institutes at the Bulgarian Academy of Sciences have also disseminated the job

announcements. Further discussion regarding job announcements and searching for post-doctoral applicants is presented in Section 5.

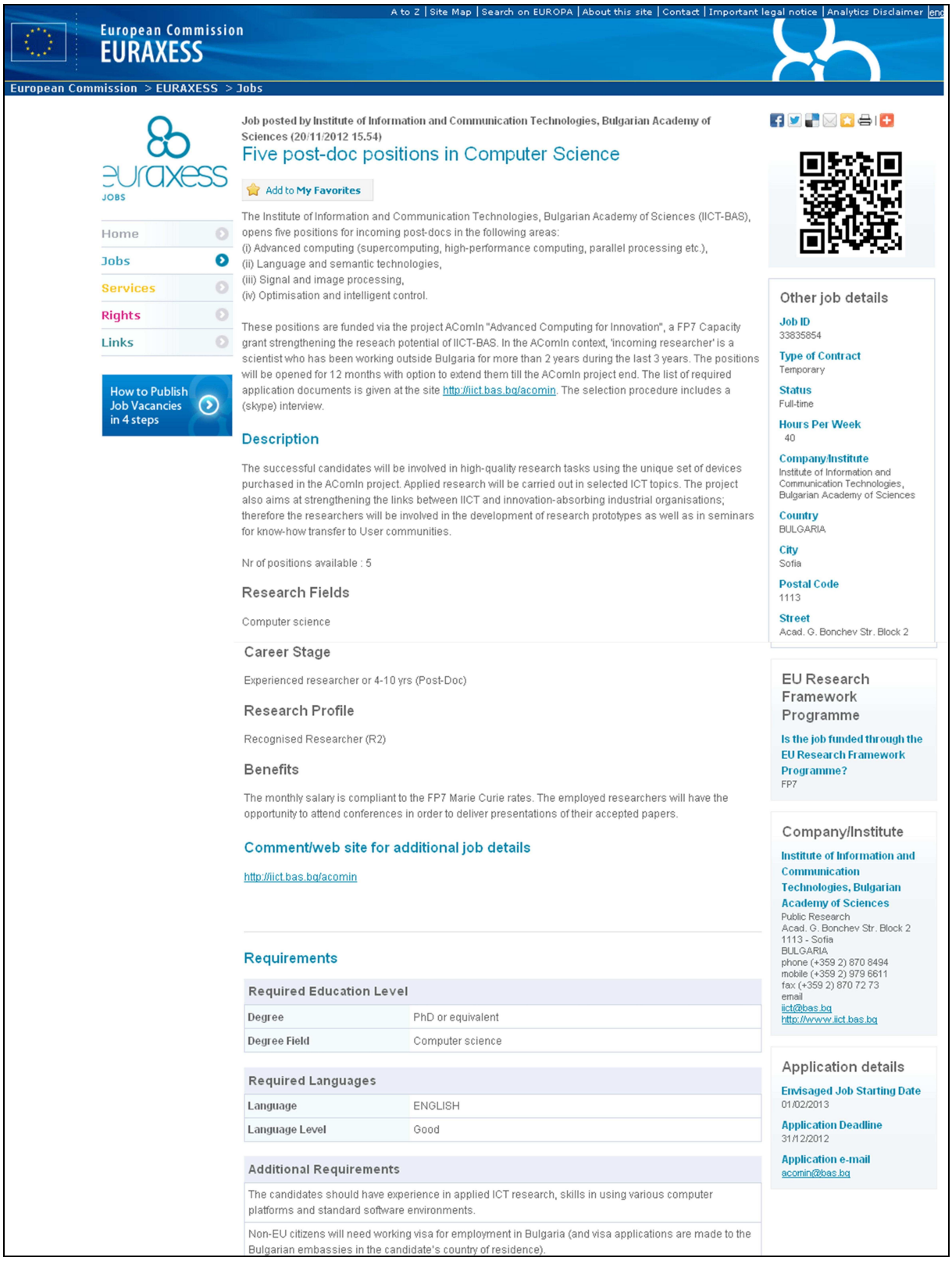


Figure 3. Announcement in Euraxess of five open AComIn positions for incoming post doctoral researchers at 20 November 2012, after the employment of Dr. Stanislav Stoykov, Dr. Irina Temnikova and Dr. Jean Michel Sellier (Job ID: 33835854)

2.4 RECRUITED INCOMING POST-DOCS IN MONTHS 1-18

When the project started on 1st October 2012, three candidates have been selected and employed within several weeks:

- Dr. Stanislav Stoykov (employed 16 October 2012, see Table 1),
- Dr. Irina Temnikova (employed 17 October 2012, see Table 1),
- Dr. Jean Michel Sellier (employed 19 November 2012, see Table 1).

Employing these post docs was a relatively easy and smooth process because the AComIn seniors had known the candidates for years. The young researchers had preliminary contacts with their respective host professors and managed to prepare quickly the necessary Research Plans for their activities in AComIn.

In total, six incoming post docs have been recruited in the First Reporting period of AComIn (project months 1-18, 1 October 2012 – 31 March 2014). The durations of their employments are summarised in Table 1.

Name of the Post Doc	Starting date of employment	End date of employment or end date of Reporting period
Dr. Stanislav Stoykov	16 October 2012	continues working as of 31/03/2014
Dr. Irina Temnikova	17 October 2012	31 May 2013
Dr. Jean Michel Sellier	19 November 2012	continues working as of 31/03/2014
Dr. Clemens Hofreither	1 August 2013	continues working as of 31/03/2014
Dr. Ivan Georgiev	2 September 2013	continues working as of 31/03/2014
Dr. Vladimir Kotev	3 December 2013	continues working as of 31/03/2014

Table 1. Employed post-docs with long-term contracts by 31 March 2014

Sections 2.4.1 - 2.4.6 consider the achievement of the six incoming experienced post-docs in project months 1-18.

2.4.1. 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 2012/2013,
host professor: Svetozar Margenov

The research work to be carried out is focused in the area of Advanced Computing and Finite Element Applications. The finite element method is a well established method for discretising partial differential equations which arise from different physical problems. The resulting discretised system of equations may consist of huge amount of degrees of freedom, especially in the cases when the finite element

method is applied to real life applications. The efficient solution of these systems requires advanced numerical methods, parallel algorithms and the usage of super computers. In addition to the techniques of discretisation and solution of the problem, the analysis of the dynamical behavior of the system is important and it requires additional numerical methods.

The modern engineering structures are of complex geometry and made from composite materials. Such structures are, for example, wind turbine blades, helicopter blades, aircraft wings, bridges, etc. These structures, even their complexity, still can be modeled as beams. Beams are one dimensional elements and inaccuracy might appear due to transforming the three dimensional structures into one dimensional problem. Thus, the validation and investigation of the range of validity of the beam models with three dimensional finite elements is essential.

One of the objectives of the research work in AComIn is to use three dimensional finite elements, with fine mesh and advanced numerical methods, to compare and validate beam models. This research work can be divided into three parts:

- Modeling and derivation of the equation of motion of complex beam structures. For that purpose, the model derived in Dr Stoykov's PhD thesis will be used and extended: it is adopted for tapered beams, initially twisted and constructed of composite materials. One p element is used and the accuracy of the results is improved by adding higher order shape functions.
- Modeling of equivalent beam structures by using three dimensional finite elements. Open source finite element software Elmer will be used and fine mesh are generated. The accuracy of the results is achieved by refining the mesh which significantly increases the degrees of freedom of the system, because the problem is three dimensional. Thus, the resulting system of equations can be solved on the Super Computer using parallel algorithms.
- Comparison of both models. Beams with open and closed thin-walled and solid cross sections are considered, constructed of isotropic and composite materials, and different boundary conditions are applied. The natural frequencies, static deformations due to point and distributed forces and moments, dynamic responses due to harmonic excitations and the distribution of stresses are compared for linear and geometrically nonlinear models. The cases of necessity of using three dimensional finite elements instead of using beam elements are emphasized and the difference between both models is to be shown on the Visual Wall for better interpretation.

In addition to this research, the nonlinear normal modes and bifurcation diagrams of the derived beam model are to be investigated in frequency domain by continuation and harmonic balance methods. The influence of the orientation of the layers, tapered ratio and the angle of twist on the dynamical behavior is to be investigated too. Coupling between modes, internal resonances and resulting multimodal oscillations should be presented.

A preparation for the usage of the Smart lab devices, particularly for the High Speed Camera and the Visual Wall, is considered for AComIn months 13-18. The High Speed Camera should be used for experimental identification of the nonlinear normal modes of structures. A literature review of the existing methods for identification of nonlinear mechanical systems is to be carried out, as well a review of the methods for processing the data from the High Speed Camera, i.e. the time response of the structure, and deriving the three-dimensional measurements from images.

The Visual Wall is to be used for post-processing, i.e. 3D visualization of the numerical results obtained from Elmer and from the beam model will be shown. Algorithms for transforming the data from the numerical experiments into format appropriate for 3D visualization on the Visual Wall will be developed.

The research results have to be presented and published in proceedings of two or three established international conferences. It is planned to present the results on two seminars held at the IICT. At least one journal paper is to be submitted during the AComIn period 1.

Individual Research Plan of Dr Stanislav Stoykov in AComIn for 2013/2014,
host professor: Svetozar Margenov

The research work, which will be carried out during the second year of the project AComIn, is divided in three parts: Continuation of the work from the first year; Application of the High Speed Camera; and New research directions.

Continuation of the work from the first year:

(i) In the first year, the equation of motion of beams with arbitrary cross sections was derived. TOBECS tool was developed, which computes numerically the cross sectional properties. The future continuation of the work consists of implementation of the model to composite beams, where the material of each layer can be orthotropic but arbitrary oriented with respect to the beam's axes, and to anisotropic materials.

(ii) The other main research direction, during the first year, was the numerical computation of periodic responses of three-dimensional structures. The numerical computation of the periodic solutions of nonlinear systems is computationally expensive, thus the continuation of this work will present parallel implementation of the shooting method and consequently numerical computation and comprehensive analysis of the bifurcation diagrams of complex three-dimensional structures.

(iii) 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 continue our collaboration on dynamics of shells with variable stiffness during the next year, and to submit a full conference paper plus a journal paper with the proposed work.

Applications of the High Speed Camera:

The camera will be used for detection of damage of structures. The response of the damaged structure is different than the response of the undamaged structure. Hence, the results measured by the camera of the damaged structure will be compared with the numerical results of the undamaged structure and from the differences of the responses, the damage will be localized.This work will be done in collaboration with prof. Emil Manoach from the Institute of Mechanics, BAS.

New research directions:

Several possibilities for new research directions, which are related with the current work, are also considered for the second year:

(i) Nonlinear dynamics of curved beams. The equation of motion of curved beam will be derived in cylindrical coordinate system, hence the geometry of the structure will be taken into account exactly. It was found that for a special curvature of the beam, the first two natural frequencies are equal, hence there are conditions for 1:1 internal resonance. 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.

(ii) The TOBECS tool will be modified, so it can 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.

(iii) The beam model, used in all these works, considers geometrical nonlinearity, it is suitable for large displacements, but it is not suitable for large rotations of the cross section, hence the nonlinear dynamics of cantilever beams cannot be investigated. The model can be extended to large rotations of 3D beams by several approaches: by using updated Lagrangian formulation, co-rotational formulation or geometrically exact beam model. This work can be done in collaboration with prof. Pedro Ribeiro from University of Porto.

Research Report of Dr. Stanislav Stoykov for research work done in AComIn months 1-18

Research Activities and Results

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

(i) Modeling and validation of complex beam structures;
(ii) Nonlinear dynamics of large-scale models;
(iii) Shell structures composed of advanced materials; and
(iv) working with the Smart Lab devices.

(i) Results in '*Modeling and validation of complex beam structures*'

A 3D beam model is derived for beams with arbitrary cross sections, tapered (i.e. beams with variable thickness and width) and initially twisted beams. By 3D beam it is assumed a beam which vibrates in the three-dimensional space and can execute torsional motion. The equation of motion is derived by the principle of virtual work and discretized into a system of ordinary differential equations (ODE) by the *p*-version finite element method (*p*-FEM). A geometrical type of nonlinearity, which is essential for large displacements, is included in the model. All cross sectional coefficients are computed preliminary. For that purpose, a tool called TOBECS (TOol for BEam Cross Sectional analysis) is developed. TOBECS computes the twist and the geometric centers of the cross section, it solves numerically a partial differential equation (PDE) for the warping function and then it computes all cross sectional coefficients by using Gauss integration points. TOBECS is validated with results obtained by several researches and tools, including VABS tool (Variational Asymptotical Beam Sectional Analysis). The results are shown to be in very good agreement with VABS. The tapered cross section and the initial twist of the beam are included in the equation of motion by expressing the cross sectional coefficients as function of the longitudinal local coordinate. After application of the *p*-FEM, a system of nonlinear second order ordinary differential equations is obtained. The complete beam model is validated by three-dimensional finite elements. A fine mesh of quadratic tetrahedrons is generated and the resulting large-scale system is solved on high-performance computing cluster using MUMPS (MUltifrontal Massively Parallel sparse direct Solver). The natural frequencies and the static deformations of the nonlinear models are compared. The validation confirmed that by TOBECS tool and by the *p*-FEM, complex beam structures can be modelled efficiently. The complete mathematical model, with the validations is submitted for publication at Finite Elements in Analysis and Design journal [Under Review, A].

Additionally, a model for 3D beams, which rotate about a fixed axis, is also implemented. A setting angle (i.e. angle which inclines the cross section to the plane of rotation) and hub radios are included in the model. The influence of the setting angle, the hub radios and the speed of rotation, on the natural frequencies is examined and forced vibrations in time domain are presented for various setting angles. The rotating beam model and the results are presented in [4].

The equation of motion of 3D laminated composite beams is also derived. The TOBECS tool is modified, in order to compute the warping function and all cross sectional properties for composite beams. Zigzag rotational functions are included in the model. It is shown that their usage is essential, for the cases of composite beams with significantly different material properties of the layers. Nonlinear normal modes and nonlinear forced responses in time domain are investigated. The mathematical models and the results are published in [2, 3].

(ii) Results in '*Nonlinear dynamics of large-scale models*'

The nonlinear frequency response function, of three-dimensional elastic structures, is obtained by numerical procedure that combines the shooting and the continuation methods. The equation of motion is derived by the conservation of linear momentum in Lagrangian coordinate system and it is discretised into a system of ordinary differential equations by the finite element method. The initial

value problem is transformed into two point boundary value problem by imposing the periodicity condition. The shooting method is used to solve the boundary value problem. The shooting method is derived for nonlinear systems of second order ordinary differential equations. This formulation, instead of the common one for systems of first order ODE, is preferred because of two reasons: first, it is demonstrated that the implementation of the shooting method for second order ODE reduces significantly the CPU time; and second, a transformation to first order ODE is not performed, hence additional computations, which result from avoiding the computation of the inverse of the mass matrix, are avoided. This implementation is essential for large-scale models, which usually result from space discretization of three-dimensional structures. Stability of the solution is investigated by Floquet's multipliers. For that purpose, a theorem which gives an explicit expression of the monodromy matrix is formulated and proven. It is shown that the monodromy matrix does not need any additional computations and that it results directly from the application of the shooting method. The sequential continuation method is used to define the prediction for the next point from the frequency response diagram. The numerical methods are implemented within Elmer software. They are validated with a beam model based on the Timoshenko's theory for bending, which uses the harmonic balance method for the periodic responses. It is demonstrated that the results are in agreement, a symmetry-breaking bifurcation point is found for both models, and the secondary branches, that start from the bifurcation point, present also the same periodic oscillations. The complete derivation of the shooting method for the system of second order ODE, with the expression of the monodromy matrix is published in [1]. Efficiency and parallel speed up of Elmer for nonlinear elastic problems is also investigated and presented in [5].

***(iii)* Results in '*Shell structures composed of advanced materials*'**

Variable stiffness materials are advanced materials which 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 fibers. A model of cylindrical composite laminated shells, composed of variable stiffness materials, is developed in collaboration with Prof. Pedro Ribeiro from University of Porto, Portugal. The usage of variable stiffness materials requires more shape functions in the model in comparison with non-variable stiffness materials, such as orthotropic. Additionally, shell structures require harmonics of higher order in the Fourier series. Hence, the computation of the nonlinear normal modes and the nonlinear frequency response function becomes cumbersome. The purpose of the collaboration is to implement the continuation method in parallel computing and to analyze the influence of the fiber orientation on the dynamics of cylindrical shells. This work is planned to be presented on the 8th European Nonlinear Dynamics Conference, 6–11 July 2014 in Vienna [In Preparation, A].

***(iv)* Results in '*Working with the Smart Lab devices*'**

The High Speed Camera is used for detection of damage of structures. The dynamical response of the damaged structure is different in comparison with the response of the undamaged structure. The difference of both responses is used for localization of the damage. Numerical algorithms for damage detection, which use the Poincaré maps, have been developed. At this stage their efficiency is analyzed between numerical models of damaged and undamaged structures. The final objective is to compare the response of damaged structure, recorded by the High Speed Camera, with the numerically computed response of undamaged structure and to localize the damage. The work is accomplished in collaboration with Prof. Emil Manoach from the Institute of Mechanics, Bulgarian Academy of Sciences.

The 3D Visualization Wall is used for presenting the response the three-dimensional beam structure, obtained by the shooting method, discussed in point *(ii)*. A solution from the secondary branch is chosen, because in this branch the vibration of the beam is in space, due to the symmetry-

breaking bifurcation point. The animation is generated with ParaView (Parallel Visualisation Application) by using stereo mode settings, for creating left and right eye movies.

Participations and presentations at scientific events:

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

- 9th International Conference on "Large-Scale Scientific Computations", 3-7 June, 2013, Sozopol, Bulgaria, talk: “Nonlinear forced vibration analysis of elastic structures by using parallel solvers for Large-Scale Systems”;
- 4th International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, 12-14 June 2013, Kos, Greece, talk: “Nonlinear vibrations of rotating 3D tapered beams with arbitrary cross sections”;
- 11th International Conference on Vibration Problems, 9-12 September 2013, Lisbon, Portugal, talk: “Nonlinear free vibrations of 3D composite beams”.

Attendances to conferences with corresponding presentations of results are planned for 2014 as follows:

- International Conference on "Numerical Methods for Scientific Computations and Advanced Applications", 19-22 May 2014, Bansko, Bulgaria, talk: “The influence of geometrical nonlinearity on the dynamics of elastic structures”.
- 8th European Nonlinear Dynamics Conference, 6 – 11 July 2014, Vienna, Austria, talk: “Frequency response of cylindrical variable stiffness composite laminated shells”.
- 8th International Conference on Numerical Methods and Applications, 20 – 24 August 2014, Borovets, Bulgaria, talk: “Isogeometric analysis for nonlinear dynamics of Timoshenko beams”.

Publications, published:

[1] S. Stoykov, S. Margenov. *Numerical computation of periodic responses of nonlinear large-scale systems by shooting method*, Computers & Mathematics with Applications (IF 2,07), DOI: 10.1016/j.camwa.2014.01.023

[2] S. Stoykov, S. Margenov, Nonlinear Vibrations of 3D Laminated Composite Beams, Mathematical Problems in Engineering, Vol. 2014, pp. 1-14, DOI: 10.1155/2014/892782.

[3] Stoykov S., S. Margenov, Nonlinear free vibrations of 3D composite beams, In: Z. Dimitrovová, J. Almeida, R. Gonçalves (Eds.), Proceedings of the 11th International Conference on Vibration Problems, 9 - 12 September 2013, Lisbon, Portugal, ISBN: 978-989-96264-4-7, Paper id: 164, 10 pages. Available http://www.icovp.com/components/com_breezingforms/uploads/164_paper0.pdf

[4] Stoykov S., S. Margenov, Nonlinear vibrations of rotating 3D tapered beams with arbitrary cross sections, In: M. Papadrakakis, V. Papadopoulos, V. Plevris (Eds.), Proceedings of the 4th ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, 12 - 14 June 2013, Kos, Greece, Paper id: 1479, 15 pages. Available at http://eccomasproceedings.org/cs2013/pdf/1479.pdf

Publications, accepted:

[5] S. Stoykov, S. Margenov, Nonlinear forced vibration analysis of elastic structures by using parallel solvers for Large-Scale Systems, In: I. Lirkov, S. Margenov, J. Waśniewski (Eds.), Large-Scale Scientific Computing, Lecture Notes in Computer Sciences Vol. 8353, Springer 2014.

[6] S. Margenov, S. Stoykov, Y. Vutov, Numerical homogenization of heterogeneous anisotropic linear elastic materials, In: I. Lirkov, S. Margenov, J. Waśniewski (Eds.), Large-Scale Scientific Computing, Lecture Notes in Computer Sciences Vol. 8353, Springer 2014.

Publications, Under Review at 31 March 2014:

[A] S. Stoykov, E. Manoach, S. Margenov, An efficient beam model based on the p-version finite element method and preliminary cross sectional design, Finite Element in Analysis and Design, manuscript number: D3301.

[B] S. Stoykov, 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.

Publications, In Preparation at 31 March 2014:

[A] S. Stoykov, P. Ribeiro, Frequency response of cylindrical variable stiffness composite laminated shells, 8th European Nonlinear Dynamics Conference, 6-11 July 2014, Vienna, Austria.

[B] S. Stoykov, C. Hofreither, S. Margenov, Isogeometric analysis for nonlinear dynamics of Timoshenko beams, 8th International Conference on Numerical Methods and Applications, 20-24 August 2014, Borovets, Bulgaria.

Plans for future work within AComIn

It has been demonstrated that the spectra obtained by isogeometric space discretization has higher accuracy than the spectra obtained by space discretization by the finite element method. In nonlinear dynamics the higher frequencies of vibration are essential for correct results. Thus, it is expected that the isogeometric analysis will perform better for the computation of the nonlinear normal modes and the nonlinear frequency response function. The implementation of the isogeometric analysis to the beam equation of motion has been started in collaboration with Dr. Clemens Hofreither. The nonlinear model will be derived and comparison with the *p*-FEM will be analyzed in the frequency domain. It is planned to present this work on the 8th International Conference on Numerical Methods and Applications, 20-24 August 2014, Borovets, Bulgaria [In preparation, B].

Functionally-graded materials (FGM) are another type of advanced materials, which are becoming important in engineering applications. The major advantage over the composite materials is that there is no risk of delamination. It is planned to derive the equation of motion of 3D beams composed of FGM. The TOBECS tool will be adopted for such materials and the cross sectional coefficients will be computed preliminary. The model will be validated by three-dimensional finite elements.

The beam model, discussed above in *Results section (i)*, considers geometrical type of nonlinearity, but it is not suitable for large rotations of the cross section. Such rotations appear in cantilever beam structures. It is planned to adapt the beam model for analysis of large rotations. There are several approaches which can be used for this problem, by using updated Lagrangian formulation, co-rotational formulation, geometrically exact beam model or by separating the displacement field into a rigid body motion and elastic deformation. This work might be realized in collaboration with prof. Pedro Ribeiro from University of Porto, Portugal.

Curved beams have been used in many engineering application because they increase the resistance of the materials. By increasing the curvature, the natural frequencies change, and there exist a curvature, for which the first two linear frequencies become equal. Thus, 1:1 internal resonance is possible, which can significantly change the response of the beam. The equation of motion of curved beam will be derived in cylindrical coordinate system. The bifurcation diagrams will be obtained and the existence of a bifurcation point, due to 1:1 internal resonance will be investigated. Stability will be examined and the shapes of vibration related with the main and the secondary branches will be presented.

2.4.2. DR IRINA TEMNIKOVA

Dr Irina Temnikova (http://pers-www.wlv.ac.uk/~in0290/Home.htm, currently in Qatar Computing Research Institute http://qcri.org.qa/our-people/bio?pid=164&name=Irina_Temnikova) received her PhD in Computational linguistics from the Research Institute in Information and Language Processing, University of Wolverhampton, UK in 2012. The topic of her PhD thesis is "Text Complexity and Text Simplification in the Crisis Management domain" (interdisciplinary research between Computational Linguistics, Linguistics and Psycholinguistics). Her research interests are in the area of Terminology Extraction, Application of Natural Language Processing (NLP) to the Crisis Management field, Automatic Text Simplification, Controlled Languages, Text Simplification Evaluation, Human Comprehension in Emergency Situations, Corpus Linguistics, Bio-Medical NLP, Cross-lingual NLP, Translation Studies, Paraverbal Role of the Punctuation.

Individual Research Plan of Dr Irina Temnikova in AComIn, 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 DoW Part B, page 9. The main aim of this research is to extract multilingual terminology from publicly available sites and produce a dynamic terminological resource that might be offered as an enhancement of other applications of public use. One such application would be to integrate the dynamically produced terminology resource with the Semantic Web Linked Open Data (LOD[1]) cloud. Another application is to use the terminological resource for enhanced multilingual search of European patents.

One of the motivations for this research is that although the Linked Open Data project provides accessibility to a large number of interlinked resources, their terms search is still very restricted and not employing any advanced linguistic processing. The second motivation is that, in the present state-of-the-art approaches to linguistic processing of patents by the present moment there is no approach to address the extensive and quickly increasing collections of patents. Applying a rich and dynamically generated terminological resource to patterns' search would solve this problem.

The research work employs computational NLP techniques to terminology extraction from the publicly available Wikipedia pages. Due to the interdisciplinarity of the task, the study mixes NLP techniques for term extraction, Semantic Web LOD techniques well as ontologies.

In order to achieve the aforementioned solutions, the study needs to complete the following milestones in its first six months:

(i) The state-of-the-art literature, relevant to the aforementioned fields should be analysed. The literature has to be examined for existing previous approaches similar to the proposed one. Systematic classification of relevant approaches should be made, along with criticisms of which the proposed approach can aim to address;

(ii) The Wikipedia dumps for English and at least Bulgarian has to be downloaded to IICT servers;

(iii) The Wikipedia articles have to be analysed for terms' appearance;

(iv) An algorithm regarding how to recognise and extract terms in one language and how to extract terms in the parallel Wikipedia articles with different linguistic versions, has to be designed;

(v) Experiments with multilingual terms extraction from Wikipedia should be done;

(vi) Experiments aiming to determine the applicability of the multilingual terms extracted from Wikipedia to collections of patents has to be completed.

After completing the feasibility study and the design of the algorithm in milestone *(iii)*, the following further steps are to be performed:

[1] http://www.w3.org/wiki/SweoIG/TaskForces/CommunityProjects/LinkingOpenData

(vii) Investigation of how to split patent documents into sub-sections treating different invention topics should be performed. This includes a study of patents structure, and where the terms relative to patents' search are situated;

(viii) An experiment on identifying the closest match between sub-sections of patent documents and Wikipedia articles has to be done in order to test if this can improve the "Wikipedia to patents" match.

In order to keep in step with the present state-of-the-art of the related disciplines, active discussion with representative scientists from the aforementioned fields needs be conducted, including a visit to the Information Retrieval Workshop, organised by the COST action MUMIA (http://www.mumia-network.eu/) with focus on patents extraction (December 13th, 2012, Thessaloniki, Greece). The research results, produced in eight months, should be also presented at the International conference Recent Advances in Natural Language Processing (RANLP 2013, http://www.lml.bas.bg/ranlp2013/) and its satellite workshops. An article describing the experiments comparing different approaches to identify the closest match of patent documents with Wikipedia articles is to be submitted to RANLP 2013 (one of the most important conferences in the NLP field).

Research Report of Dr. Irina Temnikova for research work done in AComIn months 1-8

Research Activities and Results

The conducted research has completed all planned tasks in the Individual Workplan, plus additional tasks which emerged on the way. The research plan was motivated by the fact that the search technologies in two important ICT fields -- Semantic Linked Open Data (LOD) and patent search -- had limited capabilities, despite being widely used. For example, it is known that among users, conducting patent search, full-text search (rather than bibliography search, patentee search, etc.) is preferred. However, it is also known that in its current state, full-text patent search is based on manually built queries, which makes it inadequate to the vague language of patents[2].

The hypothesis of the feasibility study, conducted in AComIn, was that that adding synonyms and translation equivalents to the index terms of LOD and patent documents would improve their retrievability. More concretely, the hypothesis was that it would be possible to enhance documents search by enriching index terms with their synonyms and translation equivalents, extracted from related Wikipedia articles. The aim of Dr Temnikova has been to study whether it is possible and how to apply the abovementioned methodology to patent search. Specifically, the following research activities were performed:

(i) Critical examination of the large existing state-of-the-art literature relevant to NLP for Wikipedia, patent search and NLP approaches to patents and patent search. Result: A structured table with summary of the approaches.

(ii) Retrieving and pre-processing the current version of Wikipedia articles. Result: Wikipedia dump file for English, version October-November 2013 downloaded.

(iii) Analysis of Wikipedia articles. Result: Insights into Wikipedia articles's structure, where the terms appear and how to recognize them automatically.

(iv) Visit to a Working Group Meeting of the European Cooperation in Science and Technology (COST) action Multilingual and Multifaceted Interactive Information Access (MUMIA), which was focused on patent search (December 13th, 2012, Thessaloniki, Greece). Result: Given a presentation about the approach taken by AComIn, collected feedback from patent search specialists, made contacts with Dr. Barrou Diallo, Head of Research at the European Patent Office (EPO), received information about available patent datasets.

(v) Patent data collection. Result: MAREC400k patents corpus downloaded and pre-processed. MAREC400k is a subset of 400 000 documents of the MAREC patent corpus. MAREC's documents

[2] Adams, Stephen. The text, the full text and nothing but the text: Part 1 Standards *for creating textual information in patent documents and general search implications*. World Pat. Inf. 2010, Vol. 32, pp. 22-29.

are written in 19 languages and come from the four main world patent authorities (European Patent Office, World Intellectual Property Organisation, United States Patent and Trademark Office, and the Japan Patent Office). In matter of pre-processing, MAREC400k has been stripped from XML tags and enriched with part-of-speech tags.

(vi) Patent structure investigation. Result: The structure of the patents in the MAREC400k dataset was studied, the parts which contain most terms were identified.

(vii) Initial experiments on linking disambiguated Wikipedia articles to patent documents main topic. Result: Manual annotation of links between whole Wikipedia articles and whole patent document. Scripts to automatically find similarity between Wikipedia articles and patents. The results were not enough satisfactory and for this reason, improvements to the approach were proposed.

(viii) Advanced experiments on disambiguating the links between patent documents and Wikipedia articles. Result: Tested approaches: cosine similarity between whole Wikipedia articles and patent documents description parts; similarity between patent categories titles and Wikipedia articles; similarity between patent claims and whole Wikipedia articles; and similarity between patent paragraphs and whole Wikipedia articles [10]).

(ix) Patents language analysis to determine if patents are really written in a specific language, and thus specific processing tools are needed. Results:

- Sublanguage analysis method chosen[3]. Method tested on an obvious case of sublanguages, to see if such an old method (even if well-known and no other new methods existing) can really recognise that a text is written in a sublanguage. The published paper contains an extensive compared to previous work [7].
- The method has been tested for Bulgarian, to test if it applies to languages other than English and the findings are positive [8]);
- Finally, the method has been applied to patent documents to see if they behave as if written in a sublanguage/sublanguages [9].

(x) Research results update presentation at the next MUMIA COST Working Group (WG) meeting. Informal Summary presentation of the research done so far at the WG Meeting "Usage and development of computing infrastructures and language resources for MUMIA" (co-organised with the Workshop "Adaptation of language resources and tools for closely related languages and language variants" at RANLP-2013), on September 13th, 2013. Useful feedback collected.

Participations and presentations at scientific events

In total, six presentations were given by Dr Temnikova at scientific events, including two Working Group Meetings of the MUMIA COST action and four presentations of accepted papers at international conferences in the NLP domain. Two international conferences were attended: 51st Annual Meeting of the Association for Computational Linguistics (ACL 2013, ~1500 participants, the main conference in the NLP field), and the 9th Recent Advances in Natural Language Processing conference (RANLP-2013, ~160 participants, 4-5th in the NLP area), specialised in presenting new, cutting-edge research. Both conferences are between the 5 most influential events in the field. The presentations were as follows:

- Angelova, Galia and Irina Temnikova. *Towards Employing Multilingual Term Resources for Intelligent Patents Search* (position paper). MUMIA COST action working group, Thessaloniki, Greece, 13 December 2012. The aim of this report was to present to patent specialists the initial ideas of the AComIn research. Essential feedback was collected, including about existing datasets in this domain, and useful contacts were established.

[3] Tony McEnery and Andrew Wilson. 2001. *Corpus Linguistics*. Edinburgh University Press, 2nd edition.

- Irina Temnikova and K. Bretonnel Cohen. *Recognizing Sublanguages in Scientific Journal Articles through Closure Properties*. The 12th Workshop on Biomedical Natural Language Processing (BioNLP 2013), held in conjunction with ACL 2013, August 8th-9th, 2013, Sofia, Bulgaria.
- Irina Temnikova, Ivelina Nikolova, William A. Baumgarther, Galia Angelova, and K. Bretonnel Cohen. *Closure Properties of Bulgarian Clinical Text*. International Conference Recent Advances in Natural Language Processing (RANLP 2013), September 7-13, 2013, Hissar, Bulgaria.
- Irina Temnikova, Negacy D. Hailu, Galia Angelova, and K. Bretonnel Cohen. *Measuring Closure Properties of Patent Sublanguages*. International Conference Recent Advances in Natural Language Processing (RANLP 2013), September 7-13, 2013, Hissar, Bulgaria.
- Ivelina Nikolova, Irina Temnikova, and Galia Angelova. *Can Patents Search be Enriched with Wikipedia Articles keywords?* International Conference Recent Advances in Natural Language Processing (RANLP 2013), September 7-13, 2013, Hissar, Bulgaria
- Presentation at the MUMIA COST Action Working Group Meeting "Usage and development of computing infrastructures and language resources for MUMIA" (co-organised with the Workshop "Adaptation of language resources and tools for closely related languages and language variants" at RANLP-2013, September 13th, 2013, see http://lml.bas.bg/ranlp2013/docs/LingVar-Program+MUMIA-WG2_subsession-13Sept2013.pdf

Publications, published:

[7] Temnikova, I. and K. Bretonnel Cohen. *Recognizing Sublanguages in Scientific Journal Articles through Closure Properties*. In: Proceedings of the 2013 Workshop on Biomedical Natural Language Processing (BioNLP 2013), associated to the International conference ACL 2013, Sofia, Bulgaria, August 4-9 2013, pp. 72–79. Uploaded in the ACL Anthology http://aclweb.org/anthology/W/W13/W13-1909.pdf

[8] Temnikova, I., I. Nikolova, W. A. Baumgarther, G. Angelova, and K. Bretonnel Cohen. *Closure Properties of Bulgarian Clinical Text*. In: Angelova, G., K, Bontcheva, and R. Mitkov (Eds.), Proc. of the Int. Conf. on Recent Advances in Natural Language Processing (RANLP 2013), September 07-13, 2013, Hissar, Bulgaria, published by Incoma Ltd., Shoumen, Bulgaria, ISSN 1313-8502, 2013, pp. 667-675. Uploaded in the ACL Anthology https://aclweb.org/anthology/R/R13/R13-1087.pdf RANLP-2013 has SJR (SCOPUS) impact rank.

[9] Temnikova, I., N. D. Hailu, G. Angelova, and K. Bretonnel Cohen. *Measuring Closure Properties of Patent Sublanguages*. In: Angelova, G., K, Bontcheva, and R. Mitkov (Eds.), Proc. of the Int. Conf. on Recent Advances in Natural Language Processing (RANLP 2013), September 07-13, 2013, Hissar, Bulgaria, published by Incoma Ltd., Shoumen, Bulgaria, ISSN 1313-8502, 2013, pp. 659-666. Uploaded in the ACL Anthology https://aclweb.org/anthology/R/R13/R13-1086.pdf RANLP-2013 has SJR (SCOPUS) impact rank.

[10] Nikolova, I., I. Temnikova, and G. Angelova. *Enriching Patent Search with External Keywords: a Feasibility Study.* In: Angelova, G., K, Bontcheva, and R. Mitkov, Proceedings of the International Conference Recent Advances in Natural Language Processing (RANLP 2013), September 7-13, 2013, Hissar, Bulgaria, published by Incoma Ltd., Shoumen, Bulgaria, ISSN 1313-8502, 2013, pp. 525-531. Uploaded in the ACL Anthology https://aclweb.org/anthology/R/R13/R13-1069.pdf RANLP-2013 has SJR (SCOPUS) impact rank.

Publications, accepted:

[11] Irina P. Temnikova, William A. Baumgartner Jr., Negacy D. Hailu, Ivelina Nikolova, Tony McEnery, Adam Kilgarriff, Galia Angelova, and K. Bretonnel Cohen. Sublanguage Corpus Analysis Toolkit: A tool for assessing the representativeness and sublanguage characteristics of corpora. To appear in

the Proceedings of LREC-2014, the 9th International Conference on Language Resources and Evaluation, 26-31 May 2014, Reykjavik, Iceland.

2.4.3. 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 en 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 Schroedinger Poisson simulator for heterostructures) and RTDNEGF (a RTD simulator based on the NEGF formalism).

Individual Research Plan of Dr Jean Michel Sellier in AComIn 2012/2013,
host professor: Ivan Dimov

Motivation of the research: The semiconductor industry is going through an important crisis today due, principally, to the fact that miniaturisation of devices did bring the developers in the realm of quantum transport. While those quantum effects were only seen as perturbations/disturbs in the past, today they are so relevant that some groups even think of exploiting them as principal effects to make new innovative devices work.

In order to overcome this crisis it is of extreme importance to have electron transport models that are able not only to cope all the quantum effects (at a fundamental scale and not at a first-order perturbation level) but also important semi-classical effects happening at room temperature such as, for instance, photon scattering.

Today these problems are resolved by two co-existing communities of researchers. The first one is the semi-classical transport community able to simulate very accurately the effects of photon scattering. The Monte Carlo (MC) method has been extremely successful in the description of such devices and effects in the past but only a little has been done to include quantum effects due to the miniaturisation of the devices. The second community deals with the fully quantum transport, able to simulate the transport of electrons in the full quantum regime with no approximation at all, even including atomistic effects etc. The transport model widely used here is the Non-Equilibrium Green Functions (NEGF) formalism. The method is incredibly accurate for quantum transport at very low temperatures but it is virtually incapable of including the scattering effects in a serious, reliable and predictive way due to the enormous numerical constraints.

It would be of extreme interest to have the two methods combined in one method able to take the best of the two worlds: quantum transport described by NEGF and scattering described by MC. In this context, Prof. Dimov and Prof. Nedjalkov from IICT have shown the path on how to integrate/merge the two worlds. Several papers on the Wigner equation and its possible numerical integration by means of MC methods (i.e. numerical particles) have shown the way. The research plan of Dr Sellier addresses the integration of the two methods.

The outcomes could be of great impact in the semiconductor community giving the creation of the first fully quantum simulator able to take into account also scattering effects. That could lead to the simulation of 3D devices like FinFETs, nanowires, multi-gate FETs, i.e. devices that are the most likely to be the candidates to substitute the MOSFET technology that is suffering from the miniaturisation effects. Those devices are already taken into account by industries such as Intel and AMD, as publicly advertised.

Development of the Simulator, validation and applications: The development of a simulator that exploit our knowledge of Wigner-Boltzmann model will be implemented and validated against benchmark semiconductor devices, sub-micron and mesoscopic, to show the feasibility, reliability and applicability of the method to real life cases. The code will be written using the C language in order to use all the computational power of the CPU/cores. Despite the new fashion of using languages such as C++ and Python in the numerical community, C remains the only language that fully allows affordable low-level optimization coding, computationally fast and portable code, very important since the code has to run both on single CPU machines and clusters such as the IBM Blue-Gene available at IICT. C codes can easily reach the speed of FORTRAN codes with almost no effort today. Not to mention the fact that C language has the great advantage of total absence of run-time burden, as it happens in languages such as Java and C++. The code will be parallelized using the standard MPI library. This is a feasible task since Monte Carlo techniques are pretty much straightforward to be parallelized due to their intrinsic mathematical structure. This will allow us to maintain the portability among different operating systems and/or architectures.

Visualisation techniques: The output of the newly developed code will be a well-known standard one, i.e. the VTK format. This is a very general format internationally recognized. Data in one, two or three dimensions can be described easily and interpreted by advanced parallel scientific visualization packages such as VisIt and Paraview. This will allow us to use parallel tools for the visualization of millions of particles along with the possibility of using intelligent visualization peripheries. In this way, it will be possible to explore the data interactively.

*Proposed Planning for 2012-2013***:** The whole project is expected to span a period of 1 year. We propose the implementation of the following plan to reach the potential results described above: studies of the already existing techniques; research and development of a Unification of the two Wigner-Boltzmann methods known so far; developing the simulator from scratch, with coding and numerical optimizations, and parallelization to run local multi-core CPUs and clusters such as the IBM Blue-Gene available at IICT; application of the newly developed simulator to benchmark devices to show the feasibility and reliability of the method.

The results will also be presented in least in two seminars at IICT, at the Conference on large-scale scientific computation, Sozopol, Bulgaria, June 2013.

Individual Research Plan of Dr Jean Michel Sellier in AComIn 2013/2014,
host professor: Ivan Dimov

The Wigner-Boltzmann equation is a very promising model to simulate the next generation of semiconductor devices (post-CMOS). In particular it would be extremely interesting to provide a methodical study of the dynamics of electron wave packets in the so-called single-dopants transistors which exploit one, two or an array of dopants burried in a Silicon substrate. The model could eventually provide working conditions at temperature lower than room temperature but relatively high (higher than 20 mK which is considered to be in ballistic regime). The electrostatic potential created by an applied voltage on the leads needs to be calculated by means of the Poisson equation. This is an important point that needs to be addressed and implemented in the code. Furthermore, the calculation of the Wigner potential is still a weak point and needs to be speed up. We propose here to calculate it by means of integration Monte Carlo techniques. Also, the Wigner-Boltzmann equation represents one of the most promising theoretical model for the simulation of full quantum transport of charged particles such as electrons.

Development of efficient Monte Carlo methods for linear algebraic systems: We want to apply Monte Carlo techniques to the resolution of the Poisson equation;

Monte Carlo techniques for the calculation of the Wigner Potential: In this year, we want to apply a Monte Carlo integration technique to speed up this calculation. Some time needs to be spent to understand how eventually this technique would affect the accuracy of the results. Validation tests also need to be performed;

Simulation of Devices candidate to Quantum Computing: Preliminary calculations have been performed showing that our Wigner-Boltzmann Monte Carlo approach have the potential to simulate such devices in a time dependent, full quantum fashion, including phonon scatterings (first time to the best of our knowledge). We want to carry on with these calculations and eventually simulate realistic devices such as single electron transistors (SET), double-dopant transistors and arrays of dopants;

Applications to Chemical systems: We want to introduce the use of the Wigner Monte Carlo method in ab-initio calculations. In particular, this novel approach could allow the simulation of chemical systems from a time-dependent perspective and with open boundary conditions. We could eventually apply this method to study molecules and study their time dependent dynamics paving the way towards the simulation of chemical reactions.

Sensitivity Analysis: It is our aim to spend some time of this project in the study of the Wigner-Boltzmann model by means of sensitivity analysis techniques. In particular, we would like to study the dependence of the model on the coherence length parameter which could be seen as a weak point of the model.

Anticipated results and innovations: The application we aim to achieve this year will produce advancements of three species: Development of physical insights in the field of Silicon based quantum computing devices; Development of a completely new numerical technique for the time dependent simulation of chemical systems; Development of mathematical advancements and insights in the theories of quantum transport.

Proposed Planning for 2013/2014: The whole project is expected to span a period of 1 year. We propose the implementation of the following plan to reach the potential results described above: studies of the dependence of the Wigner-Boltzmann model over the coherence length (sensitivity analysis calculations); studies of the application Monte Carlo integration techniques to the calculation of the Wigner potential; studies of the application and improvement of Monte Carlo linear system solvers to the Poisson equation; research and simulation of Quantum Computing Devices based on Silicon and single dopants (by applying our Wigner-Boltzmann Monte Carlo method); research and simulation of Chemical systems using the modified Kohn-Sham system including the corresponding Wigner equations.

The results will also be presented in: two seminars at IICT, one seminar at Sofia University, to several Conferences including MCQMC (Leuwen, Belgium, April 2014) and IWCE (Paris, France, June 2014).

Research Report of Dr. Jean Michel Sellier for research work done in AComIn months 1-18

Research Activities and Results

The following research activities were performed:

(i) The initial part of the project has been focused on the development of a time-dependent Monte Carlo algorithm to solve the Wigner equation. This equation is an intuitive formulation of quantum mechanics based on the concept of distribution function and phase-space which is equivalent to the Schrödinger equation. While, this model is very intuitive and can even include inelastic effects such as phonon scattering, the Wigner equation represents a formidable mathematical problem even from a numerical perspective. Indeed, its unknown (in the case of the single-body model), is a (quasi-) distribution function defined over a 7-dimensional space. Many attempts to solve this equation by means of finite difference and finite element methods have been made without success due to the impossibility of reliably calculating the so-called diffusion term (a derivative of a very rapidly varying function). **Our Monte Carlo method represents the first successful attempt in the world to simulate the Wigner equation time-dependently and multi-dimensionally.** Indeed, this method

based on the concept of signed particles, exploiting the Iterative Monte Carlo method, is the only one in the world able to achieve time-dependent and three-dimensional simulations of the Wigner formalism. This, eventually, has raised a big interest in several communities around the world (Physicists, Chemists and Engineers). Indeed groups at the University of Antwerp (Belgium) and in TU-Wien (Austria) are now using this new method on a daily basis.

(ii) A profound investigation of the Wigner Monte Carlo method has been performed in the first year of the project after the development of the method. First of all, thorough validations have been carried out in spatial and wave spaces (see publications below).

In particular, in the wave space we performed a test involving the time evolution of a delta-function, where the exact solution is known and can be used to check the validity of our approach. We, then, proceeded with the evolution of a wave packet in proximity of a potential barrier and compared with the Schrödinger solution. A very good quantitative agreement has been reached despite the very different numerical approaches utilized for the simulations. **This is the first Wigner Monte Carlo method able to obtain a quantitative agreement with the Schrodinger model.**

(iii) The Wigner Monte Carlo method for the one-body problem has been applied to a plethora of different important situations (see publications below). We have been able to explain the origin of the appearance of quantum decoherence in two-dimensional systems due to inelastic external processes. **For the first time we have shown how even elastic processes can trigger decoherence as soon as they include some level of randomness in their implementation.** We also applied the Wigner Monte Carlo method to explain the dynamics of an electron in a MOSFET channel in proximity of traps and scattering centers. This has been presented at the SISPAD 2013 conference where a great deal of interest was shown by the audience (many invitations followed right after this conference).

(iv) We then focused on the development of a three-dimensional Wigner-Boltzmann simulator – development of an algorithm that includes the Boltzmann scattering term in the context of the Wigner Monte Carlo method. This new method has been applied to the study of the dynamics of electron wave packets in the presence of single dopants such as Phosphorus and/or Boron atoms in Silicon substrate at different lattice temperatures, which are considered the building blocks to realistically exploit quantum effects in Silicon based technology. **This is the first simulation in the world that is time-dependent, full quantum and can include the Boltzmann scattering term.** The results have been recently submitted to Computer Physics Communications, Elsevier, and are under review. They also have been partially presented at the MCQMC conference in Leuven, Belgium, where interest has been shown by a number of physicists present at the talk.

(v) The two-dimensional Wigner Monte Carlo method (ballistic regime) has been applied to the study of ordered and disordered arrays of dopants in order to explain the experimental results of various groups (in particular the Shinada's group from ASMeW, Japan). **The results are able to explain the experimentally observed enhanced transport characteristics obtained by ordered arrays.** The paper explaining our simulation results has been recently accepted on Physica A, Elsevier.

(vi) A Walk on Equation Monte Carlo method has been recently developed. **This method has shown to be more efficient and accurate than the Preconditioned Conjugate Gradient method despite its Monte Carlo nature.** The results have been recently submitted for publication on Applied Mathematical Modelling and are under review. They also have been partially presented at the MCQMC in Leuven, Belgium, where a great deal of interest has been shown by the mathematical community.

(vii) A sensitivity analysis of the coherence length in the Wigner Monte Carlo method has been carried with success using the concepts of L1, L2 norms and the cosine similarity. **In this work we are able to show that the Wigner Monte Carlo method is stable, robust and results do not sensibly depend on the choice of the momenta space discretization**. This work has been submitted recently in the Journal of Computational and Applied Mathematics, Elsevier, and is under review.

(viii) A sensitivity analysis of design parameters for diodes has been carried, exploiting the Boltzmann Monte Carlo method. The aim of this work is to show the efficiency of sensitivity studies of the design of semiconductor devices. It has been recently submitted and is under review.

(ix) A modification to Density Functional Theory to include the one-body Wigner MC method has been developed and validated in the case of Hydrogen molecules in different geometrical configurations, Boron and Lithium. The results have been recently published on the Journal of Computational Physics (see below). **This is a very important achievement since the use of single-body Wigner Monte Carlo method allows for the first time the use of the intuitive Wigner formalism in the study of chemical systems. It has also the important advantage of being highly scalable allowing the simulation of extremely complex molecules on relatively small clusters.** This work has been received with great enthusiasm by the community of chemists.

(x) Finally, we have been able to generalize our single-body Wigner Monte Carlo approach to the simulation of the many-body, time-dependent, quantum problem. This is the first time such an achievement is possible in Science. This represents a very important scientific result which has been submitted on the Journal of Computational Physics. Thanks to such achievement, **it is now possible to simulate (in a ab-initio, time-dependent context) the many-body quantum problem for strongly correlated systems, a very important problem for chemists and physicists**. The formalism is still the Wigner one which allows intuitive physical interpretations of the quantum system.

Furthermore, being the method intrinsically Monte Carlo, it scales very well on parallel machines paving the way towards the time-dependent simulations of chemical reactions.

Participations and presentations at scientific events:

- Talk "*The Role of Annihilation in a Wigner Monte Carlo Approach*" at the 9th International Conference on "Large-Scale Scientific Computations" LSSC-2013, Sozopol, Bulgaria, 3-7 June 2013;
- Invited lecture *"A Monte Carlo Technique For The Wigner-Boltzmann Equation Challenges and Perspectives"* at a seminar in the Institute for Microelectronics, Technical University of Vienna, Austria, 2 May 2013;
- Talk "*A benchmark study of the Wigner Monte-Carlo method*" at the 9th IMACS Seminar on Monte Carlo Methods, Annecy, France, 14-20 July 2013;
- Two talks ("*Two-Dimensional Transient Wigner Particle Model*" and "*Quantum Insights in Gate Oxide Charge-Trapping Dynamics in Nanoscale MOSFETS*" at the International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), Glasgow, UK, 2-6 September 2013;
- Invited lecture "*The Wigner Monte Carlo Approach: From Theory to Applications*" delivered twice at 18 and 19 November 2013 to different auditoria: to
    - the Group of Semiconductor device modeling, IMEC (Leuwen, Belgium) and
    - the Group of Theoretical physics (University of Antwerp, Belgium);
- Invited Keynote "*Advanced Quantum Simulations for Next-Generation Nanoelectronic Devices*" at the Lab Surfing Event of EYE Future and Emerging Technologies project, Thessaloniki, Greece, 25 March 2014;
- Recently invited as plenary speaker to the 17th International Workshop on Computational Electronics IWCE-2014, 3 – 6 June 2014, Paris, France.

Publications, published:

[12] Nedjalkov, M., P. Schwaha, S. Selberherr , J. M. Sellier, D. Vasileska. Wigner Quasi-Particle Attributes: An Asymptotic Perspective. Applied Physics Letters, AIP Publishing, Vol. 102 (16), 2013, id. 163113 (4 pages). ISSN: 0003-6951. E-ISSN: 1077-3118. DOI: 10.1063/1.4802931
Five-Year IF: 3.817, IF (2013): 3.794, SJR indicator (2012): 1.938

[13] Sellier, J.M., M. Nedjalkov, I. Dimov, S. Selberherr. Decoherence and Time Reversibility: The Role of Randomness at Interfaces. Journal of Applied Physics, AIP Publishing, 2013, p. 174902 (7 pages). ISSN: 0021-8979. E-ISSN: 1089-7550, DOI: 10.1063/1.4828736
Five-year IF: 2.220, IF (2013): 2.210, SJR indicator (2012): 0.99

[14] J.M. Sellier, I. Dimov. *A Wigner approach to the study of wave packets in ordered and disordered arrays of doJ.M.pants*. Physica A: Statistical Mechanics and its Applications, doi: http://dx.doi.org/10.1016/j.physa.2014.03.065, 2014. Five-Year IF: 1.651, IF (2012): 1.676, SJR indicator (2012): 0.634

[15] Sellier, J.M. and I. Dimov. *A Wigner Monte Carlo Approach to Density Functional Theory*. Journal of Computational Physics, Elsevier, 2014. http://dx.doi.org/10.1016/j.jcp.2014.03.065, ISSN: 0021-9991, Five-Year IF: 2.851, IF (2013): 2.138, SJR indicator (2012): 1.921

[16] Sellier, J.M., S. Amoroso, M. Nedjalkov, S. Selberherr, A. Asenov, I. Dimov. *Electron Dynamics in Nanoscale Transistors by Means of Wigner and Boltzmann Approaches*. Physica A, Elsevier, 2013. DOI: 10.1016/j.physa.2004.04.121. Five-Year IF: 1.651, IF (2012): 1.676, SJR indicator (2012): 0.634

[17] Amoroso, S., L. Gerrer, A. Asenov, J. M. Sellier, I. Dimov, M. Nedjalkov, S. Selberherr. *Quantum Insights in Gate Oxide Charge-Trapping Dynamics in Nanoscale MOSFETs*. Proceedings of the 18th International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), IEEE, 2013, pp.25 – 28. ISBN: 978-1-4673-5733-3. DOI: 10.1109/SISPAD.2013.6650565

[18] Sellier, J.M., M. Nedjalkov, I. Dimov, S. Selberherr. *Two-dimensional Transient Wigner Particle Model*. Proceedings of the 18th International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), IEEE, 2013, pp. 404 – 407. ISBN: 978-1-4673-5733-3. DOI: 10.1109/SISPAD.2013.6650660

Publications, accepted:

[19] Sellier, J.M., M. Nedjalkov, I. Dimov, S. Selberherr. *A benchmark study of the Wigner Monte-Carlo method*. Monte Carlo Methods and Applications, De Gruyter, 2014. Accepted for publication. Mathematical Citation Quotient: 0.12, SJR indicator (2012): 0.224.

[20] Sellier, J. M., M. Nedjalkov, I. Dimov, S. Selberherr. *The Role of Annihilation in a Wigner Monte Carlo Approach*. In: I. Lirkov, S. Margenov, J. Waśniewski (Eds.), Large-Scale Scientific Computing, Lecture Notes in Computer Sciences Vol. 8353, Springer 2014, (8 pages).

[21] Schwaha, P., M. Nedjalkov, S. Selberherr, J.M. Sellier, I. Dimov, R. Georgieva. *Stochastic Alternative to Newton's Acceleration*. In: I. Lirkov, S. Margenov, J. Waśniewski (Eds.), Large-Scale Scientific Computing, Lecture Notes in Computer Sciences Vol. 8353, Springer 2014, (8 pages).

Plans for future work

One bottleneck of the Wigner equation is represented by the calculation of the Wigner potential (a function defined over the phase-space). We plan to utilize a Monte Carlo integration technique and/or a-priori analytical knowledge to speed the calculations up. A systematic study needs to be performed in order to understand the validity of this new approach.

Having being able to successfully implement a Wigner Monte Carlo - Density Functional Theory method, the next natural step seems to us to apply it to practical problems issued by the physicists and chemists community.

We also plan to apply the many-body Wigner Monte Carlo method to the study of real strongly correlated quantum systems to explain effects that cannot be interpreted otherwise.

2.4.4. 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,
host professor: Svetozar Margenov

Dr Hofreither's research in the AComIn topic 'Advanced Computing' has to be focused on working with high-resolution three-dimensional models of porous media as can be obtained from the industrial computed tomography (CT) devices to be made available in the 3D Input Lab of the AComIn project. In particular, Dr Hofreither proposes to develop discretisation schemes and solvers for convection-diffusion problems on such large-scale three-dimensional geometries with inhomogeneous densities. Dr Hofreither plans to consider first problems with constant or piecewise constant convection vector. These problems align well with his previous research interests as his PhD thesis contained results on a particular discretisation scheme for 3D convection-diffusion problems using Trefftz-type trial functions. Therefore, as a first milestone, Dr Hofreither proposes to adapt these results to the situation of porous materials and to create a highly parallel implementation of the underlying solver. The discretisation scheme has been demonstrated to yield stable results for moderately high mesh Peclet numbers without any further stabilisation for a model problem, and Dr Hofreither is interested to investigate these properties in a more complex situation. The solver developed in his PhD thesis for this discretiszation scheme was based on the ideas of the Finite Element Tearing/Interconnecting (FETI) approach and is thus very well suited for implementation on modern supercomputing hardware.

A recent research topic of Dr Hofreither's work are isogeometric discretisations and, more generally, spline-based discretisation schemes. There are results in the literature which indicate surprisingly good performance of spline-based discretisations for convection-dominated problems. Therefore it is proposed to investigate also methods of this type for the described problem. An experimental comparison of the performance of different discretisation schemes for the problem at hand would certainly be interesting. Furthermore, Dr Hofreither has recently developed efficient multigrid solvers for isogeometric discretisations of elliptic problems. It is his plan to generalise these to the situation of convection-diffusion problems such that they may serve as highly performant local solvers in, e.g., a domain decomposition solver for large-scale problems.

The format of the data, namely in voxel structure, presents additional interesting opportunities for efficient methods. First, multiscale and multigrid methods are particularly easily constructed for such uniform hexahedral meshes. The homogeneous shape of the elements also allows for a larger amount of work to be done offline as a preprocessing step, possibly enabling a discretisation of higher quality. Finally, the voxel structure lends itself very well to the use of efficient data structures on the side of software development. Here Dr Hofreither plans to use his experience in developing computational software in order to construct code which makes efficient use of the existing computing infrastructure.

Another long-standing area of research for me is in surface approximation and image reconstruction based on Radon projections. This is just the type of data which is used in X-ray and computed tomography (CT) in order to obtain density information about an object of interest. Dr Hofreither's recent work in this field has been focused on efficient reconstruction methods for harmonic functions which converge fast with respect to the number of X-ray measurements and are robust with respect to noise in the input data. An additional topic is best-fit reconstruction using very large sets of partially redundant data. The underlying algorithms can benefit from Fast Fourier

Transforms in order to solve the reconstruction problems in almost linear time. The current implementations do not take advantage of parallel computing facilities, and it is Dr Hofreither's plan to create parallel algorithms and implementations for some of these problems. A further interesting prospect is the comparison of the performance of the reconstruction algorithms developed in his work with the ones used in industrial devices. Achievements from this line of research should result in further possible publications during Dr Hofreither's post-doc employment within the AComIn project.

Research Report of Dr. Clemens Hofreither for research work done in AComIn in August 2013 - March 2014

Research Activities and Results

Clemens Hofreither has worked on four major topics during his employment in AComIn and received research results as follows:

(i) ***Geometric multigrid methods for Isogeometric Analysis***

Clemens has investigated geometric multigrid methods for solving the large, sparse linear systems which arise in isogeometric discretisations of elliptic partial differential equations. A main observation is that the performance of standard V-cycle iteration is highly dependent on the spatial dimension as well as the spline degree of the discretisation space. It was determined that conjugate gradient iteration preconditioned with one V-cycle mitigates this dependence, but does not eliminate it. In order to better understand the difficulties arising in the solution process, he has performed both classical local Fourier analysis as well as a numerical spectral analysis of the two-grid method. This has led to several new insights, notably the influence that boundary effects have on the efficiency of multigrid solvers for IGA, and the crucial observation that classical multigrid smoothers do often not perform well in the isogeometric setting as spline degree is increased.

Furthermore, as an alternative approach, he has investigated a geometric full multigrid method for solving the resulting linear systems. It can be observed that the full multigrid approach performs much better than the V-cycle multigrid method in many cases, in particular in higher dimensions with increased spline degrees. Often, only a single cycle of the full multigrid process is sufficient to obtain a quasi-optimal solution in the L2-norm. A modest increase in the number of smoothing steps is sufficient to restore optimality for more difficult problems. The perceived advantage of full multigrid methods in this setting is not fully understood yet and is the subject of ongoing investigations.

(ii) ***Efficient implementation of Isogeometric analysis on modern manycore hardware***

In order to take advantage of modern advances in supercomputing hardware, it is often necessary to adopt new programming models. In particular, the massive multiprocessing capabilities inherent in modern GPU computing devices require implementations directed specifically at these infrastructures. As part of his work, Clemens has implemented assembling routines for isogeometric analysis which take advantage of GPU computing via the CUDA framework. Initial comparisons have yielded a speedup factor of about ten times on one- and two-dimensional model problems on commodity hardware. Extension of this code to handle more general cases, as well as benchmarks on high-end hardware, are topics of further work.

(iii) ***Interpolation and cubature of harmonic functions based on Radon projections***

Radon projections type of data are a crucial component of many problems in science and technology, most notably all forms of Computed Tomography (CT) imaging. As part of an ongoing cooperation, it is studied how such type of data can be used as the input for interpolation and cubature problems. In particular, the efforts were focused on the PDE-constrained case where the functions to be

reconstructed are harmonic. Recent advances in this topic include precise error estimates for interpolation and cubature problems, as well as generalizing a cubature rule to more general settings.

Finally the study was also extended to functions which are constrained by a Poisson equation instead of being harmonic and have resulted in initial error estimates for interpolation in this case.

(iv) ***Stabilisation of isogeometric methods for advection-dominated problems***

Stabilised methods are a necessity for solving singularly perturbed numerical problems, like advection-dominated advection-diffusion models. In stabilised methods following the SUPG (streamline upwind Petrov-Galerkin) approach there is a crucial stabilisation parameter which has to be chosen in accordance both with the problem and the concrete numerical method. Previous choices of this parameter for isogeometric analysis have been purely heuristic. Clemens has derived formulas for the optimal choice of this parameter in IGA which is based on inspection of discretisation stencils. The results agree well with the previously chosen parameters in the literature.

Participations and presentations at scientific events:

- A presentation "On full multigrid schemes for isogeometric analysis" at a minisymposium at the 22nd International Conference on Domain Decomposition Methods, Università della Svizzera italiana - Lugano, Switzerland, 16-20 September 2013, http://dd22.ics.usi.ch/
- Invited talk "Fast Solution Methods for Isogeometric Analysis" at the scientific workshop "Supercomputing applications" SuperCA++ 2013, Hotel Strimon, Kyustendil, 13-15 October 2013, http://parallel.bas.bg/SuperCA++/seminarKustendil/ScientificPrigram_Kyustendil.html
- Poster presentation (with Irina Georgieva): "Interpolation and Cubature for Harmonic Functions in the Unit Disk Based on Radon Projections" at the scientific workshop "Supercomputing applications" SuperCA++ 2013, Hotel Strimon, Kyustendil, 13-15 October 2013, http://parallel.bas.bg/SuperCA++/seminarKustendil/ScientificPrigram_Kyustendil.html
- A presentation "Cubature Rules for Harmonic Functions Based on Radon Projections" (with Irina Georgieva) at the Workshop on Approximation Theory, CAGD, Numerical Analysis, and Symbolic Computation, Sozopol, Bulgaria, 25-30 August, 2013, http://emagm.vtu.bg/workshop/
- A presentation "Cubature Rules for Harmonic Functions on the Disk Using Line Integrals over Two Sets of Equispaced Chords" (with Irina Georgieva) at the Eighth Annual Meeting of the Bulgarian Section of SIAM (BGSIAM'13), Sofia, Bulgaria, 18-19 December 2013, http://www.math.bas.bg/IMIdocs/BGSIAM/news.html
- Participation in the 95th European Study Group with Industry (ESGI'95), Sofia, Bulgaria, 23-27 September 2013, http://esgi95.fmi.uni-sofia.bg/. Group work on the scientific problem "Laboratory calibration of a MEMS accelerometer sensor" posed by Angel Ivanov, MM Solutions AD. The work included week-long group study of the problem, presentation of two talks on intermediate and final results, and publication of a final report in the booklet "Problems and Final Reports" available online and in print, published by Demetra 2013, ISBN 978-954-9526-84-4.

Publications, published:

[22] Georgieva, I. and C. Hofreither. *Interpolation of harmonic functions based on Radon projections*. Numerische Mathematik, November 2013. DOI: 10.1007/s00211-013-0592-y. IF: 1.329

[23] Georgieva, I. and C. Hofreither. *Cubature Rules for Harmonic Functions Based on Radon Projections*. Calcolo, March 2014. Springer Milan, DOI: 10.1007/s10092-014-0111-2. IF: 0.8

[24] Georgieva, I., C. Hofreither and R. Uluchev. Least Squares Fitting of Harmonic Functions Based on Radon Projections. In: Morten Daehlen, Michael Floater, Tom Lyche, Marie-Laurence Mazure, Knut Morken, and Larry L. Schumaker (Eds.) Mathematical Methods for Curves and Surfaces, Lecture Notes in Computer Science Volume 8177, 2014, pp. 158-171, DOI 10.1007/978-3-642-54382-1_9 (SJR: 0.332)

Publications, accepted:

[25] Hofreither, Clemens and Walter Zulehner. On full multigrid schemes for isogeometric analysis. In: Proceedings of the 22nd International Conference on Domain Decomposition Methods, Springer Lecture Notes in Computational Science and Engineering, 2014.

[26] Georgieva, I. and Clemens Hofreither. Cubature Rules for Harmonic Functions on the Disk Using Line Integrals over Two Sets of Equispaced Chords. In: K. Ivanov, G. Nikolov and R. Uluchev (Eds.) Proceedings of Constructive Theory of Functions 2013, Sozopol, Bulgaria, Prof. Marin Drinov Academic Publishing House, Sofia, 2014.

Plans for future work

A recently started cooperation with Stanislav Stoykov concerns the application of isogeometric methods to structural analysis of linear and nonlinear beam models. 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.

2.4.5. DR IVAN GEORGIEV

Dr Ivan Georgiev (http://parallel.bas.bg/~john/index.html) holds a PhD in Computational Mathematics from the Bulgarian Academy of Sciences. He spent about 3 years (2011-2013) as a post-doctoral scientist at the Johann Radon Institute for Computational and Applied Mathematics of the Austrian Academy of Sciences. His research interests are mostly related to efficient numerical solution methods for partial differential equations, solvers for systems resulting from non-stardard finite element discretisations, robust with respect to anisotropy and coefficient heterogogeneity.

Individual Research Plan of Dr Ivan Georgiev in AComIn,
host professor: Svetozar Margenov

The work of Dr. Georgiev in the framework of AComIn project is related mostly to Area 1 of the project: *Advanced computing and Finite Elements applications*. The existing high performance computing infrastructure in IICT together with the purchased Smart Lab equipment has to be used intensively. The following problems are the focus of Dr Georgiev's research:

(i) Robust multilevel preconditioners for anisotropic problems with discontinous coefficients

Semi-coarsening approach is a proper choice for construction of efficient preconditioners for anisotropic problems discretized with bilinear finite elements. One of the advantages of this method is that using the proper ordering the system related to the first block, in the two-by-two block factorization of the matrix, can be solved directly.

Based on the expertise and previous results the plan is to extend this approach to 3D problems discretised by trilinear finite elements. The goal is to construct robust preconditioner with respect to mesh and coefficient anisotropy.

Additive Schur Complement Approximation (ASCA) is a newly developed technique for construction of efficient multilevel preconditioners based on approximate block factorisation of finite element matrices. The local construction and the sparse structure of ASCA make the method suitable for parallel realisation. It is planned to extend this technique for non-conforming finite element discretizations of anisotropic second order elliptic problems with highly varying coefficients.

(ii) Numerical simulations for coupled problems

Fluid-structure interaction is a challenging problem with many important applications. One such application is a simulation of a flow through 3D structures and especially the blood flow through intracranial aneurysms. This is a hard problem due to complicated computational domains, different and only approximately known elasticity properties of blood vessels affected by aneurysms.

The plan is to make a series of tests on different parallel machines with real angiography data. The obtained results will be important for verification of the simulation data and for prediction of rupture risk for a given geometry. This research work needs to be done in close collaboration with medical doctors and specialists in fluid mechanics.

(iii) Numerical homogenisation of composite materials

Composite materials like Wood Plastic Composites (WPC) significantly enlarge the possibilities of design and functionality of wood and plastic materials. The homogenised properties of the composite material can be determined by numerical upscaling based on the known characteristics of wood and plastic.

Using the available Smart Lab equipment - industrial CT scanner one can obtain the geometrical structure of different reference volume elements to be used as computational domains for solving a sequence of cell problems.

Knowing the geometry of the domain, the plan is to run a series of experiments varying for different types of wood and plastic. The goal is to obtain a representative collection of upscaled mechanical properties of WPC specimens which is also interesting and important for the industrial partners who provides the test specimens.

The research results from the work on the above problems will be presented at the scientific seminar “Parallel algorithms and scientific computations” of the IICT, at the Information days of the AComIn project, and at the specialised international conferences and workshops. The obtained results will be submitted for publication in the refereed journals and book series. The expectation is to submit at least one journal and two proceedings papers.

Research Report of Dr Ivan Georgiev for research work done in AComIn in September 2013 - March 2014

Research Activities and Results

Ivan Georgiev worked on four major topics during his employment in AComIn and received research results as follows:

(i) Robust multilevel preconditioners for anisotropic problems with discontinous coefficients

Optimal order algebraic multilevel iteration (AMLI) preconditioners based on recursive application of two-level finite element (FE) methods and polynomial stabilization have been introduced and analysed from O. Axelsson and P. S. Vassilevski in the nineties.

The construction follows the natural hierarchical splitting using the fact that the finite element spaces corresponding to two successive mesh refinements are nested. Uniform estimates for the constant γ in the strengthened Cauchy-Bunyakowski-Schwarz (CBS) inequality are very important for the derivation of optimal order methods. The value of the upper bound for $\gamma \in (0,1)$ is a part of the construction of the multilevel extension of the related two-level method.

Composite algebraic two-level and multilevel preconditioning algorithms for second order anisotropic elliptic boundary value problems are constructed. Here we allow big jumps in the coefficients and varying the direction of dominating anisotropy from one element to another in the coarse triangulation. The discretisation is done by trilinear conforming finite elements where the semi-coarsening mesh refinement strategy is applied. A new uniform estimates for the related CBS constants are derived. The additive preconditioning strategy for the system with the pivot block in the hierarchical two-level splitting is proposed, where the related sub-problems have a two dimensional structure.

(ii) Numerical simulations for coupled problems

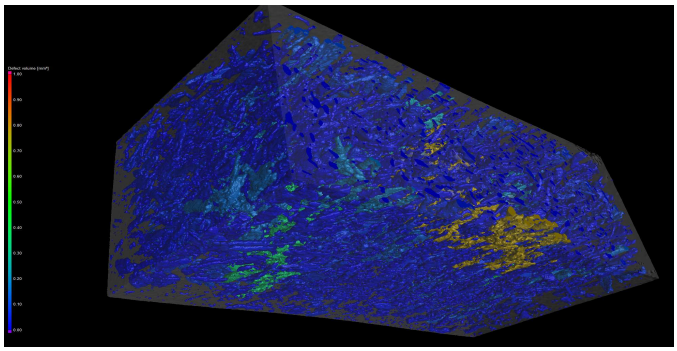
Fluid-structure interaction has many important applications including the simulation of a flow through 3D structures and especially the blood flow through intracranial aneurysms.

For better understanding of the nature of the problem Dr Georgiev is working on finite element solution of axisymmetric flow problem arising in blood flow simulation. His research in this topic is done together with a master student from Sofia University.

Specialised software for computer modeling of the fluid structure interaction problems has been installed on the available IICT high performance cluster and a series of experiments are run. The first tests of the performance are encouraging.

(iii) Numerical homogenisation of composite materials

Composite materials significantly enlarge the possibilities of design and functionality of the single component materials. The homogenised properties of the composite material can be determined by numerical upscaling. Then the extensive computer simulations can be performed on the macro scale i.e. the whole detail can be simulated using the upscaled material parameters.



Dr Georgiev did series of CT scans of different composite materials provided from colleagues in academia and from industrial partners. This is a first step of the study which will be followed by extraction and segmentation of proper reference volume elements to perform the numerical homogenisation.

Left: A Wood Plastic Composite

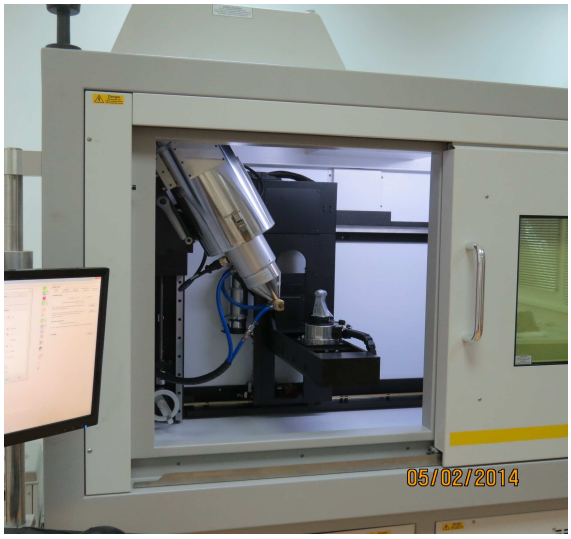
(iv) Working with the Smart Lab Equipment

The main focus was to learn how to work with the industrial Computer Tomograph. To produce a reasonable data that can be used for analysis and simulations one has to practice with different materials and with different scanning regimes. The next step is the reconstruction of 3D volume from the obtained series of “raw” 2D radiograph images. To produce a “good” reconstruction, different parameters/options in the software have to be set for the different objects/materials. The third step of the study is to perform the analysis with the specialised software. Here again different algorithms for segmentation, smoothing, and defect detection are available.

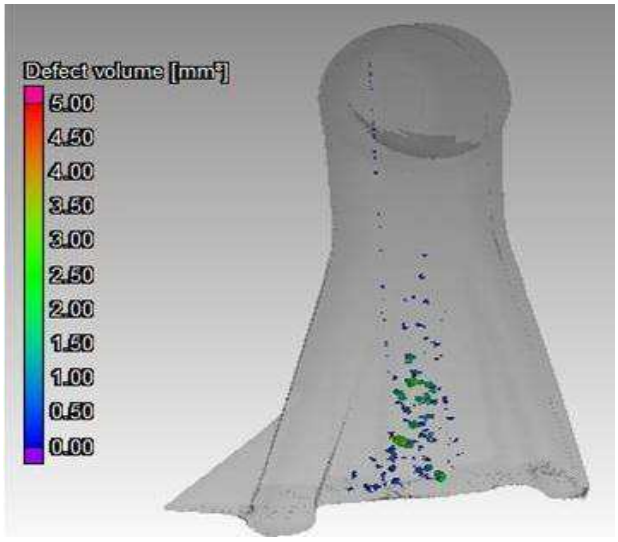
Dr Geirgiev is working on pilot projects with various industrial and academic partners. The companies from casting industry are interested in non-destructive testing and defect detection of their castings in order to adjust and develop the casting process and to increase the quality of their

production. Machine engineering companies are interested in controlling the quality of the parts delivered from their subcontractors in order to guarantee the quality of the final product.

Dr Georgiev has also established connections and started projects with academic partners working in the areas of composite materials, geo-materials, and metal alloys study.



Computer Tomograph



Detection of internal structural defects

Participations and presentations at scientific events:

- Participation in the 95th European Study Group with Industry, 23-27 September 2013, Sofia, Bulgaria, http://esgi95.fmi.uni-sofia.bg/
- Talk: "*Optimal order multilevel methods for numerical solution of anisotropic scalar elliptic problems in polyhedral domains*" at the Seminar on Computational Mathematics, Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, 12 December 2013,
- Talk "*Computer simulation of Wood Polymer Composite matherials*" at the Seminar on Industrial Mathematics, IICT-BAS, 19 December 2013, Sofia, Bulgaria, http://iict.bas.bg/acomin/events/19-Dec-2013/Industrial_Math_report.pdf
- Participation at the 8th Annual Meeting of the Bulgarian Section of SIAM, 18-19 December 2013, Sofia, Bulgaria, http://www.math.bas.bg/IMIdocs/BGSIAM/news.html.
- Talk "*Non-destructive testing and microstructure of materials*" at the Seminar on Mathematical modeling and Numerical Analysis, Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", 19 March 2014
- Demonstrations of CT scanning at the AComIn Doors Open Days in IICT-BAS, Sofia, 28-29 March, 2014. Programme at http://www.iict.bas.bg/acomin/news/28-29-March-2014.pdf and TV Channel 1 News Emission about CT scanning (after 9th minute) at http://bnt.bg/predavanyia/po-sveta-i-u-nas/po-sveta-i-u-nas-emisiya-12-00-29-mart-2014

Publications under review:

Georgiev, I. and S. Margenov, Semi-coarsening AMLI preconditioning of anisotropic trilinear FEM Systems, Computers and Mathematics with Applications (under review at 31 March 2014)

Plans for future work:

Dr. Georgiev plans to continue further with the development of multilevel algorithms based on a hierarchical basis splitting and recursively stabilized two-level additive or multiplicative preconditioners. Both, conforming and non-conforming FEM approximations will be considered. We are mostly interested in the construction and analysis of robust methods when the coefficient jumps are aligned with the interfaces of the initial mesh. In this case the focus will be on locking-free algorithms for parameter dependent problems including strong mesh and/or coefficient anisotropy.

Dr Georgiev will continue his research in the area of numerical homogenisation of composite and porous materials. We observe serious interest for collaboration in our colleagues from the field of material sciences who are ready to produce for us different test specimens that we will study and will compare and validate results with other methods when it's possible.

Further plans of Dr Georgiev include work with 3D scanning, digitalisation, and visualisation of archaeological artefacts.

Collaboration with colleagues from fluid dynamics is planned as well as use of other Smart Lab devices (High speed camera and Laser particle sizer). The research will be focused on the area of practical studies of capillary jet instability for jets containing micro and nano particles.

Finally, it is necessary to continue establishing connections with industry as a basis for future collaboration. Dr. I. Georgiev is a contact person for the newly announced 104th European Study Group with Industry, 23-27 September 2014, http://parallel.bas.bg/ESGI104/.

2.4.6. DR VLADIMIR KOTEV

Dr Vlaidmir Kotev (http://www.iict.bas.bg/acomin/CV_Vl_Kotev.pdf) holds a PhD degree in Biomechanics from the Bulgarian Academy of Sciences. His fields of research are 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,
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 Smart Lab project equipment. Dr. Kotev is working on the following problems:

(i) **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 analysed.

(ii) **Medical and micro robotics**

- *Cell injection robot*

Cell bio-manipulation technologies include the following base procedures such us 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 *Nac Memrecam HX6*, and industrial computed tomography (CT) device will be used for the experimental research.

(iii) **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.

(iv) **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.

(v) **Industrial technological process 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 has 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 Report of Dr Vladimir Kotev for research work done in AComIn from December 2013 to March 2014

Research Activities and Results:

Dr. Kotev was appointed to a post-doc position in AComIn at 3rd December 2013. Since then he and his host supervisor Prof. Karastoyanov have been conducting a theoretical and experimental research on image processing and intelligent control of micro, mobile robots and mechatronic systems for biomedical application. Also, they carry out research on metal forming processes such as forging, die forging, and pile drives. In particular, Dr. Kotev has been working on several problems related to design, dynamics, simulations, and control of a robot for cell manipulations and micro fluidic devices, a bioreactor, an orthopedic bone cutting robot, medical micro robots, mobile robots, and mathematical modeling and experiments of forging achieved by a rocket driven hammer. Also, Dr. Kotev has been studying how to use some devices of the Smart Lab equipment such as the infrared thermo camera *FLIR P640*, the high speed camera *Nac Memrecam HX6* and the Laser Particle Sizer *ANALYSETTE 22 NanoTec plus*. Within AComIn and its thematic priorities, Dr. Kotev has been working on the following five problems listed below:

(i) Mechatronic systems for medical applications

- ***Design, dynamics and control of spatial motion bioreactors***

Dr. Kotev has been working on the dynamical modeling and design of mechanisms for a rotation bioreactor in accordance with the motion law of cell culture. Bioreactors are used in a lot of biological processes. The bioreactor systems have controllable motors and monitoring sensors to control the processes in the bioreactor chamber. Dr. Kotev and his colleagues suggest and study a mechanism with spatial motion for bioreactors. Spatial mechanisms with closed kinematic chain (CKC) are most often used for transmission. In traditional literature on the theory of mechanisms and machines, the kinematic and dynamic analysis of spatial motions of coupler links is poorly covered or not mentioned at all. The team analyzes the possibilities of implementation of spatial mechanisms with one or two degrees of freedom (DoF) with CKC, i.e a coupler, in bioreactor devices, which requires the extensive analysis of coupler's spatial motion. Furthermore, the possibility is studied of using the coupler's rotation around its own axis when both of the kinematic pairs, to which it is linked, are spherical ones of the 3rd class.

The main advantage of this research is that mechanisms for spatial motion bioreactors only with one degree of freedom are designed; i.e only one motor will be used to drive the bioreactor.

- ***Research on a novel Braille Screen tactile display***

Dr. Kotev and his host professor Karastoyanov are conducting a study on the development of a new type of graphical Braiile screen. Permanent magnet linear actuator intended for driving a needle in Braille screen has been optimized. They obtained the following results: increasing the height of the coil has important influence on the force-displacement characteristics and the holding force; above a certain value, thought, any further increase does not lead to significant change; the maximal stroke influences more significantly the initial force than the holding one and its minimal value could be recommended; higher outer diameter of the actuator leads to significant increase of both holding and initial force; current density of 15 A/mm^2 could ensure enough initial force at lower starting position of the mover. Moreover, Dr. Kotev and prof. Karastoyanov proposed and studied mechanisms for development of planar and spatial motion tactile display. They suggest plastic mechanisms with linear magnetic actuators incorporated into their links.

(ii) Medical and micro robotics

- ***Concept design, mathematical modeling, integration and vision-based control of a cell manipulation robot system***

Dr. Kotev investigates the design of robotic systems for cell micro injection integrated with a microfluidic cell-holding device for single-cell immobilization. He is focused on a robot for cell injection which has been recently developed at the Bulgarian Academy of Sciences. Dr. Kotev is working on dynamics and vision control of the system consisting of a micro fluid feeding device and a robot. Therefore, cameras to track the position of the pipette during the cell injection operations are used. He is making a microfluidic device from transparent polymer material. It is composed of a stationary dish, with attached to it immobilization station, cell-providing station, cell-extraction station, cell-removable station and sperm immobilization station. A drivable unit provides connection between the stations by linear movement of a movable plate on the surface of the dish. Several options for cell holding micro-cavities of the immobilization station are developed. The process of cell immobilization is achieved by applying negative pressure to the cell micro-cavities via a micro pump.

The benefit of this task will be to develop a design concept for integration of a microfluidic cell feeding device with a cell injection manipulator and to develop software for vision based control for robotized systems consisting of cell injection manipulator and cell feeding device. Dr. Kotev is involved in the preparation of a project proposal on that topic. The team is going to use a 3D printer in order to develop a microfluidic device for cell separation and transport.

- ***Research on bone cutting process performed by a bone cutting robot***

It is well known that orthopedic robots enhance both surgical procedures and patient overcome. The aim of this research is to study the influence of the cutting conditions such as cutting speed and thrust force, on bone structure as well as time and temperature of the cutting process performs by a hand-held bone cutting robot. Therefore, in addition to theoretical research on bone cutting process, it is necessary to conduct experiments in order to develop a proper control of the hand-held cutting robot. Three SmartLab devices will be employed in such experiments: the infrared thermo camera FLIR P640, the high speed camera Nac Memrecam HX6 and the CT Scan. Dr. Kotev's research task in this activity is to define the influence of cutting conditions on bone structure during the cutting procedure in order to control the cutting robot properly as well as to provide experimental data on bone cutting processes with different set of cutting conditions.

- ***Design and dynamics of a micro-nano medical robot***

Surgical robotics offers enhanced dexterity and increased accuracy directed towards reducing patient trauma and improving clinical results. Minimally invasive procedures exist in the fields of

gastroenterology and cardiology. The aim of this research is to provide a design, computational and control framework for developing a micro-nanorobot for microsurgery into human's body. This robot will be injected into patients' bloodstreams to carry out potentially life-saving operations. A novel design concept for the development of a micro- nanorobot, based on the nanoelecromechanical technologies, including sensors, actuators, power supply, etc. and nanomaterials, will be elaborated. Therefore, novel parallel computational algorithms must be developed for sensors data acquisition, signal and image processing, in order to solve the inverse dynamics to control the robot. This new generation of medical in vivo micro-nanorobots will improve patient's recovery and enhance medicine.

As AComIn-related post-doctoral research, Dr. Kotev has made a design concept of the micro-nano medical robot, which was presented in Thessaloniki, in the EYE Lab Surfing Event (25-26 March, 2014), which was aimed at assisting young researchers in realizing their potential in writing FET (Future and Emerging Technologies) projects and to accomplish new scientific achievements. He gave a presentation titled: Dynamics and Control of Micro-Nano robot for Medical Application.

(iii) Forging by a rocket driven hammer: dynamics and experiments

Technological processes such as forging, die forging, and pile driving are realized as a result of a collision between two bodies. The bodies' rebound after the collision takes place due to the use of part of the energy of the hit for their elastic deformation. Dr. Kotev and his supervisor Prof. Karastoyanov study the influence of impact parameters such as forces, accelerations, velocities, time and energy on shape forming of parts achieved by a rocket driven hammer. A laboratory set up for control of impact utilizing a cold rocket engine working with compressed air has been developed. This experimental set up allows for the generation of an additional force on a body during the impact period. In order to control the working conditions in forging the dynamics of the impact process is analyzed. Moreover, a mathematical model describing the relation between impact and part deformation has been derived. Also, experiments on plastic deformation of specimens were conducted on this set up, using a high-speed camera. The obtained results show that controlled impact enhanced forging process.

The team is using devices from the Smart Lab equipment to test and verify their theoretical approaches and results. Also, the Smart Lab equipment is being utilized to get experimental information for the research.

Participations and presentations at scientific events and meetings:

- At 9-10 January 2014, Dr. Kotev and his supervisor Prof. Karastoyanov organised a scientific meeting with Prof. Ken'ichi Yano, the head of the Mechatronics laboratory at MIE University in Japan. Prof. Ken'ichi Yano and his laboratory carry out advanced research in various areas of robotics and mechatronics, for e.g. humanoid, medical, mobile and industrial robotics. Prof. Yano visited BAS to discuss possibilities for collaboration, future cooperation and joint research as well as staff exchange within the framework of joint projects. Prof. Yano will visit IICT in September 2014 together with some of his students;
- In February 2014 Dr. Kotev attended a 3-days training course in termography and got some hands-on experience in using the infrared thermo camera *FLIR P640*, a device from the AComIn SmartLab;
- On 25-26 March 2014 Dr. Kotev presented a research project proposal for the Lab Surfing event of the new P7/FET project Empowering Young Explorers (EYE), held in Thessaloniki. At the Brainstorming sessions of the Lab Surfing event, Dr. Kotev and his team of researchers from Greece, Serbia and Romania elaborated a proposal entitled: *"Symbiosis of bio-systems and cognitive agricultural robots"*. They are going to submit this project proposal *Symbiosis of bio-systems and cognitive agricultural robots* to the Blue Sky Conference in Budapest that will be held within the framework of the EYE project.
- On the event Open Days 28-29 March 2014 at the AComIn Doors Open Days Dr. Kotev presented his activities to Prof. Panteliou from the University of Patras, Greece and they discussed possibilities for future research in the area of bio-medical engineering.

- Dr. Kotev was elected in the Technical committee of International Conference on Robotics and Mechatronics (ICROM 2014), July 6-7, 2014, Nottingham, UK
  http://www.iccss.org/committee.htm

Publications, accepted:

[25] Kotev, Vl., D. Karastoyanov and P. Genova. *Application of the Spatial Mechanisms in Bioreactors: Design Concept*. Accepted for the International Conference on Robotics and Mechatronics (ICROM 2014), July 6-7, 2014, Nottingham, UK. To be published in a volume of the International Journal of Materials Science and Engineering (IJMSE), ISSN: 2315-4527.

[26] Karastoyanov, D. and V. Kotev. Electromagnetic Linear Microdrivers for Braille Screen: Control and Curcuit Testing. Accepted for the International Conference on Robotics and Mechatronics (ICROM 2014), July 6-7, 2014, Nottingham, UK. To be published in a volume of the International Journal of Materials Science and Engineering (IJMSE), ISSN: 2315-4527.

Plans for future work

Their future plans are to keep doing the abovementioned research on dynamics, simulations, and control of a robot for cell manipulations and micro fluidic devices, a bioreactor, an orthopedic bone cutting robot, medical micro robots, and mobile robots. Also, Dr. Kotev and his host researcher Prof. Karastoyanov are preparing project proposals in the area of robotics using some devices from the Smart Lab equipment. They are going to use the Smart Lab equipment to perform the following activities:

- To measure the size and weight of biological cells using the ANALYSETTE 22 NanoTec plus system;
- To measure the speed and temperature of a bone cutting operation performed by a hand - held bone cutting robot. They are going to use the infrared thermo camera FLIR P640, and high speed camera Nac Memrecam HX6. Also, to study bone structure after cutting with different sets of the cutting conditions, a Tomograph XTH 225 Compact industrial CT scanning could be used;
- To test their theoretical results of design and dynamics of robots they are going to use infrared thermo camera FLIR P640, and high speed camera Nac Memrecam HX;
- To use the hand-held color 3D laser scanner Handyscan 3D VIUscan Creaform and 3D printer in order to design and develop parts for their prototypes of robots and devices;
- To study in more depth techniques for intelligent and vision based control of robots.
- To investigate the qualitative and quantitative behaviour of nonlinear dynamical models describing gene-regulation systems in biological cells.

3. Recruited Incoming Experienced Researchers with Short-Term Contracts, months 1-18

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 2 lists the employments of six incoming experienced scientists during the first Reporting period of AComIn. Figure 4 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	Affiliation	Starting date of employment	End date of employment
Prof. Raytcho Lazarov	Department of Mathematics, Texas A&M University, College Station, TX, USA	10/04/2013	10/05/2013
Prof. Darina Dicheva	Department of Computer Science, Winston-Salem State University, NC, USA	03/06/2013	02/07/2013
Prof. Hristo Dichev	Department of Computer Science, Winston-Salem State University, NC, USA	03/06/2013	03/07/2013
Prof. Milena Dobreva	Faculty of Media and Knowledge Sciences, University of Malta, Malta	18/06/2013	17/07/2013
Dr. Petar Goulev	Digital Fashion Studio, London College of Fashion, University of the Arts, London, UK	15/08/2013	15/09/2013
Prof. Johannes Kraus	Johann Radon Institute for Computational and Applied Mathematics (RICAM), Austrian Academy of Sciences, Linz, Austria	01/10/2013	31/10/2013

Table 2. Employed incoming experienced researchers with short-term contracts by 31 March 2014

Figure 4. Research Plans and Reports of Visiting Experienced Researchers in the Team Area of AComIn site

3.1. PROF. RAYTCHO LAZAROV

The working program of Prof. Lazarov's 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 behavior as well as high-performance computing in engineering and environmental problems". The local host was Prof. Svetozar Margenov. Three inter-related activities were planned:

- Joint research in the topic "*Preconditioning Techniques for Processes in Heterogeneous Media"* – this is the area of development, study, analysis and implementation of preconditioners for systems arising in finite elements (FEM) approximation of second order elliptic problems, describing processes in highly heterogeneous media. The theoretical study includes both mixed and least-squares finite element methods for self-adjoin second order problems. The robustness is achieved through special overlapping Schwarz procedure that also utilizes some newly developed estimates for the Raviart-Thomas projection in weighted norms.
- Delivering Intensive Course of Lectures in *Advanced Numerical Methods for PDEs*. The lectures present six advanced topics in the area of numerical solution of partial differential equations. They are based on the concept of the contemporary numerical methods, namely, inf-sup condition. The first part of the course contains lectures presenting the basic tools of the analysis and the finite element constructions. The second part of the lectures address advanced topics related to Stokes equations and the third part - the latest development of the theory and practice of finite elements methods, namely, discontinuous Galerkin method.
- Organisation of a Special Session on "*Modeling and Numerical Simulation of Processes in Highly Heterogeneous Media*" at the 9-th Conference on Large Scale Scientific Computing (LSSC'13), Sozopol, June 3–7, 2013, to bring together researchers working in the area of large scale simulation and computations of various processes in highly heterogeneous media.

The reported results fully meet the planned activities of the Work program. In addition some contribution to the organisation of ESGI'95 has been made.

- The approach "*Preconditioning Techniques for Processes in Heterogeneous Media"* was developed and studied using the recently proposed preconditioning technique based on additive Schur complement approximation. A generalisation for robust algebraic multilevel preconditioning of weighted norms is under further investigation. The goal is to present the completed results in a joint journal paper authored by J. Kraus, R. Lazarov, M. Limbery and S. Margenov;
- The course in *Advanced Numerical Methods for PDEs* contained 12 lectures oriented to experienced researchers. It is in fact world-level training in recent developments in the field. All lectures were available in advance via internet. The list of participants in the course is available in the Team Area of the AComIn site, under the menu "Reports", WP5. This course was a very important event for the project, having in mind that AComIn is focused on Advanced Computing and prof. Lazarov is a world-famous expert in this area;
- The Special Session at LSSC'13 was co-organised by Oleg Iliev, Raytcho Lazarov and Jörg Willems. Prof. Oleg Iliev (Department of Flow and Material Simulation at the Fraunhofer Institute for Industrial Mathematics (ITWM), Kaiserslautern) is one of the AComIn partners. Dr. Jörg Willems represents the Radon Institute of Computational and Applied Mathematics (RICAM), Austrian Academy of Sciences, which is another strategic international partner of IICT.

During his visit to IICT, Prof. Raycho Lazarov took part in several working meetings dedicated to the organisation of ESGI'95, the 95th event of the European Study Group with Industry, driven by the Oxford Centre for Applied Mathematics (OCAM) according to the policies of the European Consortium for Mathematics in Industry (ECMI). For the first time, ESGI runs an event in Bulgaria, and IICT was a co-organiser of this activity. Prof. Lazarov's experience in collaboration with high tech industrial partners provided a valuable contribution to the efforts of the local organising committee to meet the requirements and high international standards of OCAM and ECMI.

3.2. PROF. DARINA DICHEVA

The working program of Prof. Darina Dicheva contained activities in the AComIn topic “Language and Semantic Technologies”, Area 6 “Digital preservation of cultural heritage for research and education by integration of facilities provided by Smart Lab devices and advanced computing solutions”. The work activity was focused on the IT challenges in developing and using educational digital repositories as well as semantic techniques for supporting educational systems. The local hosts were Prof. Gennady Agre and Prof. Galia Angelova. The following tasks were planned:

- *Reviewing the state of the art and the trends in K12 e-learning developments and practices around the world*. The review has to shed a light on the current developments, practices and trends in e-learning around the world with an emphasis on the K-12 virtual education. A special attention should be given to the presentation of the main policies, supportive tools and research activities driving the steady progress in online learning in the US. This task is motivated by the slow and late introduction of K-12 e-learning in Bulgaria;
- *Presenting the prepared review of the state of the art in K12 e-learning practices at an AComIn seminar*. This activity is relevant to the AComIn objective to transfer innovations to Bulgaria, in this case in the area of e-learning to the Bulgarian K-12 education. The plan is to familiarise a user group including representatives from relevant academic, administrative and educational communities with the state of the art and future trends in the e-learning at schools;
- *Delivering a lecture on improving content findability and search in educational digital repositories with a focus on using language and semantic technologies*, in order to share the experience of the Intelligent Information Systems Group (IIS Group) at Winston-Salem State University on how to increase the value of educational repositories to end users by applying language and semantic technologies for improving the findability of the stored content;
- *Initiating joint research* in the area of semantic annotation, targeting large educational repositories. Special focus of the investigation is the use of semantic web technologies for knowledge reuse in distributed learning and the use of educational ontologies for semantic annotation.

The reported results fully met the planned activities of the Work program:

- The *Review of the state of the a*rt in K12 e-learning developments and practices has been prepared. It overviews (in addition to the US) the situation in other countries including Mexico, Canada, Australia, New Zealand, India, Hong Kong, South Korea, China, and Singapore. E-learning in the EU and its place in the Digital Agenda for Europe were considered as well as the current state of the introduction of K-12 e-learning in Bulgaria. The trends in the next generation of e-learning and virtual learning environments were the basis for outlining the research areas and technologies that need further development and advancing. This review has been published in the article: Dichev, C., D. Dicheva, G. Agre, and G. Angelova. *Current Practices, Trends and Challenges in K-12 Online Learning. Cybernetics and Information Technology*, Vol. 13 No. 3, ISSN 1311-9702, pp. 91-110, DOI 10.2478/cait-2013-0028;
- A *lecture entitled "On-line and blended learning in K-12: an international overview"* was held on 26 June 2013 at IICT-BAS. This list of participants is available in the Team Area of the AComIn site, under the menu “Reports”, WP2;
- A *lecture entitled "Finding open educational resources in computer science"* was held on 26 June 2013 at IICT-BAS. This list of participants is available in the Team Area of the AComIn site, under the menu “Reports”, WP2;
- *Joint research was initiated in the area of semantic annotation*, targeting large educational repositories. The first step was reviewing of the existing metadata standards and semantic annotation approaches used in educational repositories and applications. This step paves the way for a proposal concerning a Bulgarian ‘standard’ for educational metadata. This activity will be running within AComIn in years 2 and 3 of the project.

3.3. PROF. HRISTO DICHEV

The working program of Prof. Hristo Dichev contained activities in the AComIn topic "Language and Semantic Technologies", Area 6 "Digital preservation of cultural heritage for research and education by integration of facilities provided by Smart Lab devices and advanced computing solutions". The local hosts were Prof. Gennady Agre and Prof. Galia Angelova. The following tasks were planned in his Program:

- *Developing methods for assessing and analysing the local needs and readiness for online K-12 education*. The goal of this activity includes developing methodology and framework for studying, analysing and assessment of the needs and readiness for online learning in Bulgarian K-12 education system. The first objective is to identify barriers and facilitators as well as other potential forces accompanying the introduction of online learning which in turn can help to select implementation strategies to deal with the identified barriers and utilize facilitators. The second objective of the planned evaluation framework is to generate a collective picture of the attitudes, skills and knowledge of the teachers, their motivation for change, combined with the perceived technological level and infrastructure in the country;
- *Delivering lecture on the critical aspects for successful start of K-12 online learning* and the role of community of active supporters in the initial stage for advocating, promoting, sharing common experiences and providing feedback. The key objective of this lecture is to serve as a starting meeting for initiating a user group of K-12 online learning supporters. The lecture is planned after a series of individual meetings with potential active members of the projected user group. The intended audience includes K-12 teachers, academic and administrative staff;
- *Critical analysis of the impact of K-12 online learning*: emerging forms, best practices and examples. The aim of this activity is to survey, analyse and evaluate jointly with the IICT hosts the established models of online learning and investigate the existing alternatives in terms of the common repository types. The focus of the work is on examining the practical aspects of online learning in different contexts.

The reported results fully met the planned activities of the Work program:

- *Assessing and analysing the local needs and readiness for online K-12 education*. A key goal of this activity was to propose a methodology for studying, analysing and assessing of the needs and readiness for online learning in Bulgarian K-12 education system based on large scale data. The methodology and the evaluation framework were developed iteratively over the visiting period. Based on the proposed methodology a survey questionnaire was developed covering questions on the knowledge and skills of potential teachers, perceived barriers and facilitators, training needs as well as questions on the current state of information and communication technology in schools and its use (http://iict.bas.bg/acomin/bg/news.html). The content of the questionnaire was discussed with representatives from all stakeholders and aimed at collecting information from a diverse and representative sample;
- A *lecture entitled* "On-line and blended learning in schools: how to apply it in Bulgaria" was held on 26 June 2013 at IICT-BAS, discussing a broad range of relevant topics with focus on advantages, disadvantages, benefits and obstacles in K-12 online implementation. It was attended mainly by K-12 teachers, members of the academic, education and administrative communities. This list of participants is available in the Team Area of the AComIn site, under the menu "Reports", WP2;
- The results of the *Critical analysis of the impact of K-12 online learning: emerging forms, best practices and examples* have been published in: Dichev, C., D. Dicheva, G. Agre, and G. Angelova. *Current Practices, Trends and Challenges in K-12 Online Learning. Cybernetics and Information Technology*, Vol. 13 No. 3, ISSN 1311-9702, pp. 91-110, DOI 10.2478/cait-2013-0028. The *Analysis* examined the practical aspects of online learning in different contexts.

The joint work with Prof. Dichev will continue within AComIn in years 2 and 3 of the project.

3.4. PROF. MILENA DOBREVA

The working program of Prof. Milena Dobreva contained activities in the AComIn Area 6 "Digital preservation of cultural heritage for research and education by integration of facilities provided by Smart Lab devices". The local hosts were Prof. Gennady Agre and Prof. Galia Angelova. The emphasis of her work was on application approaches for digitalisation 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 following tasks were planned:

- *Research* on using linked data technologies in digital cultural heritage repositories;
- *Research* on improving the user experiences in digital cultural heritage environments;
- *Research* on potential synergies between access methods to digitalised cultural content and educational resources;
- *Delivering lectures* open to the wider research and practitioner community, especially related practical aspects of digital libraries and access to digitalised cultural content.

The reported results fully met the planned activities of the Work program:

- *Research on using linked data technologies in digital cultural heritage repositories* was carried out. During the first project year, the aim was to outline the scope of a theoretical study and to start the work on a state-of-the-art review which would *(i)* outline the advantages of linked data in the cultural heritage domain; *(ii)* scope current use with good practice examples; *(iii)* analyse the spread of current applications of linked data and identify gaps in provision. This study involves desk research; the visit to Bulgaria gave a chance also to work on a case study of Research Space, which is currently under development under the guidance of the British Museum. The company OntoText (Bulgaria), an AComIn user, is technological partner in Research Space. The final outcome would be presented in a joint journal paper. The team of this project includes Milena Dobreva, Galia Angelova, Gennady Agre, possibly with the participation of Darina Dicheva and Hristo Dichev;
- *Research on improving the user experiences in digital cultural heritage environments*. This task aimed to advance in the understanding of user needs, with a focus on the scenario of use of 3D models in a mixed environment where the user can not only work with a 3D model but also obtain a 3-printed replica. For the first project year the emphasis was on outlining the general issues in user modeling relevant to cultural heritage, addressing two domains-scoping requirements and needs, related to long term preservation. A further joint research paper which will address in depth the requirements and the possible solutions for user studies related to 3D cultural heritage objects will be developed into a research paper, to be submitted to a journal;
- *Two lectures* were held respectively on the 1st and 8th of July 2013: "Methods for investigation of the digital libraries users" and "End Users and Digital Preservation: Challenges and Perspectives". The list of participants is available in the Team Area of the AComIn site, under the menu "Reports", WP2.
- *Research on potential synergies between access methods to digitalized cultural content and educational resources*. This task aimed to scope what innovative applications of digital cultural heritage repositories could be aimed at an educational outreach. Meetings with the Director of Bansko Museum Complex and PhD students from the Department of Library and Information Studies of the Philosophical Faculty of Sofia University, working on wider outreach for museum information and the use of mobile applications and QR codes, were held on 14 and 16 July 2013 in order to establish an initial AComIn end-user community.

3.5. DR PETAR GOULEV

Dr Goulev visited IICT in order to organise and give a special cource entitled “Using advanced computer technologies in the fashion and textile industry”. This activity fits to the WP2 objectives “Purchasing Smart Labs and building User Communities”. The aim was to teach participants how to apply the latest modern technological developments in fashion (e.g. intelligent databases, 3D design) to the industrial needs of this sector, from the supply chain right through to the retail environment. The duration of the full-time course was one week. The course with its hands-on training was oriented to about 20 participants. The Program of the course and its lectures was as follows:

- Day 1, 2.9.2013: Button game or how to study the customer;
- Day 2, 3.9.2013: Scanning and creating 3-D models of a customer;
- Day 3, 4.9.2013: 3D design of clothes and accessories;
- Day 4, 5.9.2013: E-commerce in the fashion industry.

The Programme of work of Dr Goulev has been divided by weeks as follows:

- Week 1, 19.08 - 23.08 2013: Preparation of material for the course;
- Week 2, 26.08 - 30.08 2013: Installation of computer hardware and software;
- Week 3, 2.09 - 6.09 2013: Course;
- Week 4, 9.09 - 13.09 2013: Analysing of results of the course.

The Course was held successfully with 26 participants (the list of participants is available in the Team Area of the AComIn site, under the menu “Reports”, WP2). Due to fact that the AComIn 3D scanner had not been delivered by 2nd September 2013, a manual 3D scanner was provided by the Bulgarian Ministry of Education and Science. The scanning software was ensured by the Team Ltd. (http://www.team.bg). The company 3d Print – Bulgaria (http://www.3dprint-bg. com) demonstrated the creation of 3D objects in real time using MakerBotReplicator2. The software for 3D modelling of the human body and 3D clothes design was provided by the Digital Studio of the London College of Fashion together with dozens of human body models (the installations was free of charge).

The analysis of the feedback, collected from the attendees, shows that they participated in the lectures with great enthusiasm. In Bulgaria, 3D technology is unknown in textile industry and fashion due to absence of 3D scanners in the public domain. Additional prohibiting factor is the relatively low level usage of E-commerce services in Bulgaria, as only half of the population has Internet access. Furthermore the customisation is perceived as too expensive by Bulgarian customers. Generally speaking, in Bulgaria the clothing customisation is made through the traditional tailor method; people go in the shop and the clothing is fitted for them without using any 3D technology. The expectation for the future penetration of 3D scanning in Bulgaria is quite high, as the price of these (3D scanning) devices decreases and customers are able to obtain more information about the existing technology.

The participants in the course were from different backgrounds; college Teachers, lecturers from the University, researchers, designers, constructors, engineers as well as business managers. They weren’t very well informed of the 3D scanning technologies. The printing of 3D shapes was a new experience for all and follow-up demonstrations were arranged in New Bulgarian University.

As a result of the course the people who participated will inform their working groups or academic peers about the big opportunities that the E-commerce and 3D customisations offers to the fashion industry and how the 3D design of clothes and accessories could be utilised to benefit the Bulgarian industry. The benefit is not only in increasing the comfortability of the clothes but also in decreasing the price of manufacturing. Furthermore the participants are looking forward to a pilot Bulgarian anthropometric study and are willing to expand it in the area of South Eastern Europe, where they already have commercial and/or academic partners.

Six months after this course, in March 2014, Dr Goulev has already teaching agreements with the New Bulgarian University (Sofia) and the Academy of Music, Danse and Fine Arts (Plovdiv). This is evidence that the AComIn initiative to organise the course was timely and successful.

3.6. PROF. JOHANNES KRAUS

The working program of Prof. Kraus 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 behavior as well as high-performance computing in engineering and environmental problems". The local host was Prof. Svetozar Margenov. Four main activities were included in his Work Programme:

- *Research on Preconditioning Techniques for Processes in Heterogeneous Media*. The planned joint research is in the area of development, study, analysis and implementation of preconditioners for systems arising in finite elements (FEM) approximation of second order elliptic problems, describing processes in highly heterogeneous media. It is based on previous results, published in prestigious volumes, including a paper reporting results that were achieved with the partial support of AComIn[4];
- *Development of a novel non-variational multigrid algorithm for general symmetric positive definite problems*;
- *Delivering an Invited Lecture* at the Annual Seminar on Supercomputing Applications, 13-15 October 2013, Kyustendil;
- *Taking part in the PhD defense* of Maria Lymbery (a PhD student of Prof. Svetozar Margenov), as one of Maria's Consultants.

The reported results fully met the planned activities of the Work program:

- The *Research on Preconditioning Techniques for Processes in Heterogeneous Media* continued the collaboration of the team including J.Kraus, R. Lazarov, M. Lymbery and S. Margenov. The study is aimed at a design, theoretical and numerical justification of iterative methods for such problems that are robust with respect to the contrast of the media, defined as the ratio between the maximum and minimum eigenvalues of the coefficient tensor (related to the permeability/conductivity). The question of inf-sup stability of the mixed finite element discretizations under investigation has been addressed and the next steps in the design and analysis of robust algebraic multilevel preconditioners of weighted H(div)-norms have been discussed. The goal is to present the completed results in a joint journal paper in 2014;
- The *Development of a novel non-variational multigrid algorithm for general symmetric positive definite problems* has been successful. The resulting novel non-variational MG algorithm is referred to as auxiliary space multigrid (ASMG) method. The theoretical results are supported by a representative collection of numerical tests which demonstrate the efficiency of the new method and indicate its high robustness for multiscale problems. A manuscript entitled "Auxiliary space multigrid method based on additive Schur complement approximation" has been prepared and submitted for publication in a special issue of "Numerical Linear Algebra with Applications (NLAA)" related to the "Preconditioning of Iterative Methods (PIM) 2013" Conference in Honor of Ivo Marek;
- A plenary talk on "AMLI-cycle auxiliary space multigrid method for multiscale problems" was presented at the Supercomputing Applications (SuperCA++) workshop, held in Kyustendil, October 13-15, 2013. The list of participants is available in the Team Area of the AComIn site, under the menu "Reports", WP5.
- Prof. Kraus has acted as a consultant of Maria Lymbery, a PhD student of Prof. Svetozar Margenov, and in October 2013 took part in the successful defense of her thesis. This was an important step in her personal professional career but also, a contribution to forming a strong team of experienced researchers in IICT in order to strengthen its research potential.

The fruitful collaboration with Prof. Kraus which had been established a decade ago will continue in AComin years 2 and 3.

[4] J. Kraus, M. Lymbery, S. Margenov, Robust multilevel methods for quadratic finite element anisotropic elliptic problems, Numerical Linear Algebra with Applications Vol. 2 (2013), March 2013, DOI 10.1002/nla.1876

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 D7.4 “Input for EC Review in month 18” where all project results are considered as a whole.

Here we only list the papers that report results achieved within the employments. We also summarise the novel activities, skills and know-how that are brought to IICT by the recruited young researchers.

4.1. Publications in Peer Reviewed Scientific Journals and Conference Proceedings

Some 30 papers are authored by researchers recruited via AComIn and have been published in project months 1-18 (below we keep the enumeration introduced in sections 2.4.1-2.4.6):

[1] S. Stoykov, S. Margenov. *Numerical computation of periodic responses of nonlinear large-scale systems by shooting method*, Computers & Mathematics with Applications (IF 2,07), DOI: 10.1016/j.camwa.2014.01.023

[2] S. Stoykov, S. Margenov, Nonlinear Vibrations of 3D Laminated Composite Beams, Mathematical Problems in Engineering, Vol. 2014, pp. 1-14, DOI: 10.1155/2014/892782

[3] Stoykov S., S. Margenov, Nonlinear free vibrations of 3D composite beams, In: Z. Dimitrovová, J. Almeida, R. Gonçalves (Eds.), Proceedings of the 11th International Conference on Vibration Problems, 9 - 12 September 2013, Lisbon, Portugal, ISBN: 978-989-96264-4-7, Paper id: 164, 10 pages. Available http://www.icovp.com/components/com_breezingforms/uploads/164_paper0.pdf

[4] Stoykov S., S. Margenov, Nonlinear vibrations of rotating 3D tapered beams with arbitrary cross sections, In: M. Papadrakakis, V. Papadopoulos, V. Plevris (Eds.), Proceedings of the 4th ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, 12 - 14 June 2013, Kos, Greece, Paper id: 1479, 15 pages. Available at http://eccomasproceedings.org/cs2013/pdf/1479.pdf

[7] Temnikova, I. and K. Bretonnel Cohen. *Recognizing Sublanguages in Scientific Journal Articles through Closure Properties*. In: Proceedings of the 2013 Workshop on Biomedical Natural Language Processing (BioNLP 2013), associated to the International conference ACL 2013, Sofia, Bulgaria, August 4-9 2013, pp. 72–79. Uploaded in the ACL Anthology http://aclweb.org/anthology/W/W13/W13-1909.pdf

[8] Temnikova, I., I. Nikolova, W. A. Baumgarther, G. Angelova, and K. Bretonnel Cohen. *Closure Properties of Bulgarian Clinical Text*. In: Angelova, G., K, Bontcheva, and R. Mitkov (Eds.), Proc. of the Int. Conf. on Recent Advances in Natural Language Processing (RANLP 2013), September 07-13, 2013, Hissar, Bulgaria, published by Incoma Ltd., Shoumen, Bulgaria, ISSN 1313-8502, 2013, pp. 667-675. Uploaded in the ACL Anthology https://aclweb.org/anthology/R/R13/R13-1087.pdf RANLP-2013 has SJR (SCOPUS) impact rank.

[9] Temnikova, I., N. D. Hailu, G. Angelova, and K. Bretonnel Cohen. *Measuring Closure Properties of Patent Sublanguages*. In: Angelova, G., K, Bontcheva, and R. Mitkov (Eds.), Proc. of the Int. Conf. on Recent Advances in Natural Language Processing (RANLP 2013), September 07-13, 2013, Hissar, Bulgaria, published by Incoma Ltd., Shoumen, Bulgaria, ISSN 1313-8502, 2013, pp. 659-666. Uploaded in the ACL Anthology https://aclweb.org/anthology/R/R13/R13-1086.pdf RANLP-2013 has SJR (SCOPUS) impact rank.

[10] Nikolova, I., I. Temnikova, and G. Angelova. *Enriching Patent Search with External Keywords: a Feasibility Study.* In: Angelova, G., K, Bontcheva, and R. Mitkov, Proceedings of the International Conference Recent Advances in Natural Language Processing (RANLP 2013), September 7-13,

2013, Hissar, Bulgaria, published by Incoma Ltd., Shoumen, Bulgaria, ISSN 1313-8502, 2013, pp. 525-531. Uploaded in the ACL Anthology https://aclweb.org/anthology/R/R13/R13-1069.pdf RANLP-2013 has SJR (SCOPUS) impact rank.

[12] Nedjalkov, M., P. Schwaha, S. Selberherr , J. M. Sellier, D. Vasileska. Wigner Quasi-Particle Attributes: An Asymptotic Perspective. Applied Physics Letters, AIP Publishing, Vol. 102 (16), 2013, id. 163113 (4 pages). ISSN: 0003-6951. E-ISSN: 1077-3118. DOI: 10.1063/1.4802931
Five-Year IF: 3.817, IF (2013): 3.794, SJR indicator (2012): 1.938

[13] Sellier, J.M., M. Nedjalkov, I. Dimov, S. Selberherr. Decoherence and Time Reversibility: The Role of Randomness at Interfaces. Journal of Applied Physics, AIP Publishing, 2013, p. 174902 (7 pages). ISSN: 0021-8979. E-ISSN: 1089-7550, DOI: 10.1063/1.4828736
Five-year IF: 2.220, IF (2013): 2.210, SJR indicator (2012): 0.99

[14] J.M. Sellier, I. Dimov. *A Wigner approach to the study of wave packets in ordered and disordered arrays of doJ.M.pants*. Physica A: Statistical Mechanics and its Applications, doi: http://dx.doi.org/10.1016/j.physa.2014.03.065, 2014. Five-Year IF: 1.651, IF (2012): 1.676, SJR indicator (2012): 0.634

[15] Sellier, J.M. and I. Dimov. *A Wigner Monte Carlo Approach to Density Functional Theory*. Journal of Computational Physics, Elsevier, 2014. http://dx.doi.org/10.1016/j.jcp.2014.03.065, ISSN: 0021-9991, Five-Year IF: 2.851, IF (2013): 2.138, SJR indicator (2012): 1.921

[16] Sellier, J.M., S. Amoroso, M. Nedjalkov, S. Selberherr, A. Asenov, I. Dimov. *Electron Dynamics in Nanoscale Transistors by Means of Wigner and Boltzmann Approaches*. Physica A, Elsevier, 2013. DOI: 10.1016/j.physa.2004.04.121. Five-Year IF: 1.651, IF (2012): 1.676, SJR indicator (2012): 0.634

[17] Amoroso, S., L. Gerrer, A. Asenov, J. M. Sellier, I. Dimov, M. Nedjalkov, S. Selberherr. *Quantum Insights in Gate Oxide Charge-Trapping Dynamics in Nanoscale MOSFETs*. Proceedings of the 18th International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), IEEE, 2013, pp.25 – 28. ISBN: 978-1-4673-5733-3. DOI: 10.1109/SISPAD.2013.6650565

[18] Sellier, J.M., M. Nedjalkov, I. Dimov, S. Selberherr. *Two-dimensional Transient Wigner Particle Model*. Proceedings of the 18th International Conference on Simulation of Semiconductor Processes and Devices (SISPAD), IEEE, 2013, pp. 404 – 407. ISBN: 978-1-4673-5733-3. DOI: 10.1109/SISPAD.2013.6650660

[22] Georgieva, I. and C. Hofreither. *Interpolation of harmonic functions based on Radon projections*. Numerische Mathematik, November 2013. DOI: 10.1007/s00211-013-0592-y. IF: 1.329

[23] Georgieva, I. and C. Hofreither. *Cubature Rules for Harmonic Functions Based on Radon Projections*. Calcolo, March 2014. Springer Milan, DOI: 10.1007/s10092-014-0111-2. IF: 0.8

[24] Georgieva, I., C. Hofreither and R. Uluchev. Least Squares Fitting of Harmonic Functions Based on Radon Projections. In: Morten Daehlen, Michael Floater, Tom Lyche, Marie-Laurence Mazure, Knut Morken, and Larry L. Schumaker (Eds.) Mathematical Methods for Curves and Surfaces, Lecture Notes in Computer Science Volume 8177, 2014, pp. 158-171, DOI 10.1007/978-3-642-54382-1_9 (SJR: 0.332)

[29] Dichev, C., D. Dicheva, G. Agre, and G. Angelova. *Current Practices, Trends and Challenges in K-12 Online Learning. Cybernetics and Information Technology*, Vol. 13 No. 3, ISSN 1311-9702, pp. 91-110, DOI 10.2478/cait-2013-0028.

[30] J. Kraus, M. Lymbery, S. Margenov, Robust multilevel methods for quadratic finite element anisotropic elliptic problems, Numerical Linear Algebra with Applications Vol. 2 (2013), March 2013, DOI 10.1002/nla.1876

Accepted for publication:

[5] S. Stoykov, S. Margenov, Nonlinear forced vibration analysis of elastic structures by using parallel solvers for Large-Scale Systems, In: I. Lirkov, S. Margenov, J. Waśniewski (Eds.), Large-Scale Scientific Computing, Lecture Notes in Computer Sciences Vol. 8353, Springer 2014.

[6] S. Margenov, S. Stoykov, Y. Vutov, Numerical homogenization of heterogeneous anisotropic linear elastic materials, In: I. Lirkov, S. Margenov, J. Waśniewski (Eds.), Large-Scale Scientific Computing, Lecture Notes in Computer Sciences Vol. 8353, Springer 2014.

[11] Irina P. Temnikova, William A. Baumgartner Jr., Negacy D. Hailu, Ivelina Nikolova, Tony McEnery, Adam Kilgarriff, Galia Angelova, and K. Bretonnel Cohen. Sublanguage Corpus Analysis Toolkit: A tool for assessing the representativeness and sublanguage characteristics of corpora. To appear in the Proceedings of LREC-2014, the 9th International Conference on Language Resources and Evaluation, 26-31 May 2014, Reykjavik, Iceland.

[19] Sellier, J.M., M. Nedjalkov, I. Dimov, S. Selberherr. *A benchmark study of the Wigner Monte-Carlo method*. Monte Carlo Methods and Applications, De Gruyter, 2014. Accepted for publication. Mathematical Citation Quotient: 0.12, SJR indicator (2012): 0.224.

[20] Sellier, J. M., M. Nedjalkov, I. Dimov, S. Selberherr. *The Role of Annihilation in a Wigner Monte Carlo Approach*. In: I. Lirkov, S. Margenov, J. Waśniewski (Eds.), Large-Scale Scientific Computing, Lecture Notes in Computer Sciences Vol. 8353, Springer 2014, (8 pages).

[21] Schwaha, P., M. Nedjalkov, S. Selberherr, J.M. Sellier, I. Dimov, R. Georgieva. *Stochastic Alternative to Newton's Acceleration*. In: I. Lirkov, S. Margenov, J. Waśniewski (Eds.), Large-Scale Scientific Computing, Lecture Notes in Computer Sciences Vol. 8353, Springer 2014, (8 pages).

[25] Hofreither, Clemens and Walter Zulehner. On full multigrid schemes for isogeometric analysis. In: Proceedings of the 22nd International Conference on Domain Decomposition Methods, Springer Lecture Notes in Computational Science and Engineering, 2014.

[26] Georgieva, I. and Clemens Hofreither. Cubature Rules for Harmonic Functions on the Disk Using Line Integrals over Two Sets of Equispaced Chords. In: K. Ivanov, G. Nikolov and R. Uluchev (Eds.) Proceedings of Constructive Theory of Functions 2013, Sozopol, Bulgaria, Prof. Marin Drinov Academic Publishing House, Sofia, 2014.

[27] Kotev, V., D. Karastoyanov and P. Genova. *Application of the Spatial Mechanisms in Bioreactors: Design Concept*. Accepted for the International Conference on Robotics and Mechatronics (ICROM 2014), July 6-7, 2014, Nottingham, UK. To be published in a volume of the International Journal of Materials Science and Engineering (IJMSE), ISSN: 2315-4527.

[28] Karastoyanov, D. and V. Kotev. Electromagnetic Linear Microdrivers for Braille Screen: Control and Curcuit Testing. Accepted for the International Conference on Robotics and Mechatronics (ICROM 2014), July 6-7, 2014, Nottingham, UK. To be published in a volume of the International Journal of Materials Science and Engineering (IJMSE), ISSN: 2315-4527.

4.2. ENABLING NEW RESEARCH ACTIVITIES AND TECHNOLOGY TRANSFER TASKS

Beyond the number of papers, presenting results in the Work Plans of the recruited researchers, they have brought to IICT new topics of research, new skills, new connections and new horizons as follows:

Dr Stanislav Stoykov came from University of Porto bringing new research topics related to beam models and their application to computer simulation of dynamical behaviour engineering structures with complex geometry. The developed supercomputing simulations based on 3D FEM models and MUMPS (new for IICT team) solvers is an innovative approach for verification of beam models. A new thematic network has been established including the host Prof. Svetozar Margenov, Prof. Pedro Ribeiro (University of Porto, Portugal), Prof. Jerzy Warminski (TU-Lublin, Poland), and Prof. Emil Manoah (Institute of Mechanics, Bulgarian Academy of Sciences).

Dr Irina Temnikova brought from the UK experience in corpus linguistics and automatic processing of sublanguages, especially in English. Her works in sublanguage study and identification help to understand the linguistic particularities of sublanguage texts and the specific features which facilitate

or prohibit the automatic processing of such texts. The experiments with terminology extraction from Wikipedia and Patent texts (a new application domain for IICT) shed light on approaches for improving the patent search systems, given that efforst are invested in the development of dynamically-collected, multilingual terminological collections.

Dr. Jean Michel Sellier is already a well-known young researcher who joined the AComIn project after being a Research Assistant Professor at Purdue University, Indiana, USA; a post doc at Imperial Collage, London, UK and IREM France, Vitrolles (Provence), France. Dealing with semi-classical and quantum transport simulations he was very successful in developing efficient algorithms and performing very complex numerical simulators. Dr. Sellier contributed to obtaining an added value to IICT research and innovation potential by focussing on very important applied aspects by studying some possibilities of having quantum computing. Because of his research, now we are much closer than before to the understanding that quantum computing is not feasible for normal room temperatures of about 300 K (26,85°Celsius).

Dr. Clemens Hofreither came to IICT from a world reknown group in Numerical Methods (lead by Prof. Ulrich Langer) at Johannes Kepler University, Linz. The added value of his recruitment for IICT is related (but not limited) to the transfer of knowledge in finite elements based on piece-wise harmonic test functions. The second innovative (not only for IICT) research topic is the so called "isogeometric analysis". What is to be especially noted in this respect is the started research project on application of isogeometric analysis in beam models bringing together the experience of Dr Stanislav Stoykov, Dr Clemens Hofreither and their host Prof. Margenov.

Dr. Ivan Georgiev returned to Bulgaria after a post-doctoral study in Radon Institute of Applied Mathematics (RICAM), Linz. He came back with a new level of expertise in robust preconditioning methods for non-standard FEM discretisations like the Discontinuous Galerkin Methods. At the same time, he had been enriched with a new understanding and skills in interdisciplinary research activities and industrial applications. This was very important for his contribution to start the real work with the new equipment in the SmartLab (Computed Tomography and 3D Scanning) as well as for establishing new user communities.

Dr Kotev returned from Japan, after a post-doctoral study in one of the most dynamic groups in Biorobotics. He brought a new vision about the developments in research Labs, their experimental testing and the transfer of mechatronic devices to industrial application. After his return Prof. Ken'ichi Yano, the head of the Mechatronics laboratory at MIE University, visited IICT with a proposal to establish joint collaboration so he can send his doctoral students for short visits to Bulgaria (and Europe). The next visit of Prof. Ken'ichi Yano is scheduled for September 2014.

Prof. Raycho Lazarov is an internationally recognised leader in the field of computational mathematics. His intensive course in Finite Element Methods gave unique opportunities to the attendees for introduction to some of the most advanced topics in this area. At the same time he contributed a lot to a deeper interpretation of some of the new joint research results, providing test data form the SPE10 collection.

Prof. Darina Dicheva is a world-reknown expert in eLearning. The motivation of AComIn seniors to invite her actually stems from the slow and delayed adoption of eLearning in Bulgarian schools. The main idea is to plan some developments that have research value (and can be perfomed in academic setting) to be further used in future applications. Thus AComIn tasks might catalyze e2020 activities in Bulgaria, by raising the awareness about K-12 eLearning in the educational Public Bodies.

Prof. Dichev is a leading researcher in Articifical Intelligence and related technologies, user modelling, semantic technologies and their application in eLearning. He brings to IICT his expertise in the design

and development of large repositories of digital objects as well as his practical skills in exploitation of educational content in real applications. During his stay in Bulgaria he met numerous potential active members of the projected user group in order to establish a community of K-12 online learning supporters.

Prof. Milena Dobreva is an internationally recognised expert in Digital Libraries, Digital Humanities and User experience studies. Currently she is the Head of the Department “Library Information & Archive Sciences”, Faculty of Media & Knowledge Sciences, University of Malta. She came to IICT to study the user needs in environments where 3D models (scanning and replica) are implemented. The collaboration with Prof. Dobreva paved the way for the organisation of the Workshop “ICT Technologies for the Multimodal Capture, Semantic Analysis and 3D Representation of Cultural Heritage” (10 September 2014 in Varna, Bulgaria) with PC Chairs who are leading EU experts in the field.

The Technology Transfer Course of Dr. Petar Goulev "Applying Advanced 3D Technologies in the Textile Industry and Fashion” has been organised in order to present recent developments of computer technologies for 3D customisation of clothing and fashion accessories. The motivation of the AComIn seniors, who planned the course, is that the 3D technology is relatively unknown in Bulgaria, especially in the public domain, and it can be advertised via applications in the popular domain of clothing design and fashion in general. To the best of our knowledge, this was the first systematic course in 3D design in Bulgaria at all.

With the short recruitment of Prof. Johannes Kraus, AComIn helped IICT to strengthen additionally the working collaboration between Prof. Kraus and the IICT hosts. In this joint work, Prof. Kraus brings new approaches to the construction of robust multilevel methods. The long time collaboration with Prof. Margenov has been extended to the young experienced researcher Maria Limbery form IICT. Prof. Kraus was also an external advisor of the PhD thesis of Dr. Lymbery, successfully defended in 2013, which was also a contribution to the development of IICT’s human potential.

5. DEVIATIONS FROM SCHEDULE AND CONTINGENCY PLAN

In AComIn period 1 there are some deviations from the planned employments of incoming experienced researchers, both for the long-term and short-term recruitments. By 31 March 2014

- 44,25 person months in total are used for the employed incoming post-docs with long-term contracts, out of 84 person month planned for recruitment in Reporting period 1;
- 6 person months are used 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.

This delay is due to two main reasons:

- the equipment purchase and Smart Lab integration are delayed by about six months (see the section “Deviations from Schedule and Contingency Plan” in Deliverable D2.2);
- it takes time to organise visits of incoming experienced researchers who usually plan their schedule several years in advance.

Because of the delay in equipment installation, it was impossible to start earlier the whole range of activities and research tasks related to the application of Smart Lab devices. However, the AComIn seniors actively explore all options to search for post-doctoral candidates. At the present moment there are 3 post-doctoral candidates for long-term employment: one approved from Ukraine (who is

currently applying for a EU working visa in order to come to Bulgaria); another candidate from Ukraine and one from India whose applications are under consideration. In this way the AComIn team is optimistic that the planned post-doctoral recruitments will be fully implemented. There are also plans and schedule for the invitation of incoming experienced researchers with more than 10 years of research experience, in order to catch up with the planned short-term employments.

6. CONCLUSION

The long-term employments of post-docs in AComIn Period 1 have been successful, given that 3 positions were occupied in the first project weeks – and, what is more important – very strong and experienced candidates were hired. The project now accelerates its activities including new initiatives related to the running SmartLab equipment. This will bring new applications for long-term appointments and new incoming experts for short-term employments. The latter might participate in technology transfer activities following the successful events held in Period 1.

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.

The AComIn seniors are determined to keep the high standards of the project achievements in Period 2 as well, accelerating the employment process.

ANNEX 1: Evaluation form for post doc applicant

Advanced Computing for Innovation

Form for evaluation a POST-DOC for long-term employment in AComIn

APPLICANT NAME: .....

I. ELIGIBILITY CHECK

REQUIRED APPLICATION DOCUMENTS	**Available** *(yes/no)*
(Copy of the) PhD certificate awarded in the AComIn topics	
Abstract of achievements in PhD thesis	
List of publications and citations	
Recommendation letters from three internationally recognized seniors in the AcomIn topics	
Evidence of experience in applied ICT research	
Curriculum Vitae containing information about skills in working with computer platforms and software environments	
Evidence of spoken and written English language competence (for applicants, whose native language is not English)	
Motivation letter stating preferences of project areas and particular SmartLab devices	
Earlier possible date to begin work in IICT	
Less than 7 years after the defence of PhD thesis	

Conclusion regarding the eligibility check (application completeness and comprehensiveness):

/date/ /Signature of Commission members/

……..

……..

……

II. EXPERT QUALITIES OF THE CANDIDATE

REPORTING IICT SENIOR: .....

1. Qualification (in certain AComIn area)

2. Number and evaluation of papers and citations

3. Assessment of the recommendations

4. Evaluation of the candidate's experience in applied ICT research and the computer/programming skills

5. Language proficiency

6. Evaluation of the candidate's research capacity in the context of AComIn scientific objectives

7. Assessment of the candidate's motivation after taking into account the discussions of future work and impressions of direct (scype) contact

REPORTER'S OPINION:

REPORTER:

/date/ /signature/

EXECUTIVE BOARD DECISION:

The AComIn Executive Board with protocol № /

APPROVES/DOES NOT APPROVE */delete the unnecessary/*

the employment of .....

as a post-doc in AcomIn.

AcomIn COORDINATOR:

/date/ /signature/