

# **Evaluation of the Research and Professional Activity of the Institutes of the Czech Academy of Sciences (CAS) for the period 2010–2014**

## **Final Report on the Evaluation of the Institute**

**Name of the Institute:** Institute of Information Theory and Automation of the CAS, v. v. i.

**Fields, in which the Institute registered its teams:**

Computer and information sciences

Observer representing the Academy Council of the CAS: Jan Šafanda

Observer representing the Institute: Antonín Otáhal, substitute observer Milan Zajíček

### **Commission No. 2: Computer and information sciences**

Chair: Professor Edwin Hancock PhD, DSc.

Date(s) of the visit of the Institute: November 25, 2015

Programme of the visit of the Institute: see attached Minutes from the visit

Evaluated research teams:

*No. 1 - Department of Adaptive Systems;*

*No. 5 - Department of Image Processing;*

*No. 6 - Department of Pattern Recognition*

## **A. Evaluation of the Institute as a whole**

### **1. Introduction**

The Institute of information theory and automation performs fundamental and applied research in a large range of subjects related to information processing, such as Adaptive systems, Image processing and Pattern recognition. Although its roots are in traditional information theoretical approaches, and it has a long history - the institute has a youthful and vibrant research culture, and is keen to be seen as modern and innovative.

### **2. Strengths and Opportunities**

The Institute is well-managed and appears well supported by grants, even on the European level. Publishing the Kybernetika journal gives the institute an international prestige. Some of the research directions are timely and have good potential for future development. The Institute applies a very good strategy to engage students in their research activities both on the pregraduate and postgraduate levels. The age structure of the Institute is well balanced and they try to be an attractive employer - attracting researchers even from abroad.

### **3. Weaknesses and Threats**

The research directions are currently decided bottom up and thus a strategic coordination may not be easily possible. Too many smaller short-term projects result in a topical fragmentation together with high administrative and managerial costs. It may restrict the capacity of the research staff.

### **4. Recommendations**

A long-term Institutional funding is needed. The Institute has a capacity to apply for a ERC grants. Also involvement of senior foreign researchers would help to improve the quality of the Institute. Though applications are important, such projects should not hamper the quality of basic research activities. The institute should seek a healthy balance. A separation of the basic research and application activities is recommended. Continuity of activities is important, but the evolution process should respect the rapidly developing trends in the area of information technologies.

### **5. Detailed evaluations**

**Declaration on the quality of the results and share in their acquisition.** Three research teams were evaluated by the Commission. From the global point of view, the research topics pursued by these teams are up-to-date and relevant from both theoretical/fundamental and application oriented points of view. The productivity of the three groups is satisfactory and in a similar range, taking into consideration that the available personnel resources (FTE) are not equally distributed. The quality of publications has a median value of 3 (recognized internationally) in two cases and 2 (internationally excellent) in one case. It is thus fairly uniformly distributed over the three research groups and can be considered good. The institute members very significantly contributed to those publications that have co-authors from outside. Generally, the publications received a good degree of international recognition as evidenced by the number of citations.

**Declaration on the involvement of students in research.** The institute puts high emphasis on cooperation with universities by involving students in research activities of the institute. Both the number of courses and mainly the number of PhD students involved are impressive. Financial support of PhD students makes concentration on research possible and contributes to increase the quality of results. Direct involvement of the institute in jointly accredited PhD studies at different universities and in different fields of study are highly appreciated. It seems to be a good incentive for current

research, but also a wise investment towards recruiting future researchers. The institute also opens new courses on specialized topics at universities which are closely related to the research subjects of the institute. The extent of involved universities cover practically all most important universities in Czech Republic.

**Declaration on societal relevance.** Publication of the Kybernetika Journal gives the institute a long time credit not typical for many other institutes of even larger sizes. The research activities of the institute are very well supported by advanced computing center and a large library. Besides many hardcopy books, the emphasis is on the use of digital libraries from all major scientific literature providers. The institute consists from several, not always closely related or cooperating departments. UTIA is an equal opportunity employer and offers researchers several interesting non-financial benefits.

**Declaration on the position in the international and national context.** The institute seems well positioned in the international and national research community. With its partly interdisciplinary research directions, gaining visibility is sometimes hampered by the lack of scientific outlets suitable for such kind of work. Nevertheless the institute has a good publication record and high international reputation, as it is also certified by a number of high level collaborations and international exchange.

**Declaration on the vitality and sustainability.** The institute appears healthy and well-managed. Scientific directions are determined in a bottom-up process originating from the individual departments and thus the institute puts emphasis on individual research rather than large-scale strategic research directions. While this can help to motivate individual top researchers and generate a high level of research by individuals or within ad-hoc self-organized collaborations, it may miss those opportunities where substantial research requires larger teams that can reach a critical mass. Relying on individual departments may also be dangerous where sustainability is nontrivial to achieve and when e.g. long term investments in software must be protected.

**Declaration on the strategy and plans for the future.** The institute is well positioned for the future through the strong research agendas of the individual departments. As coordinator of the AV21 strategy “Hopes and Threats of the Digital Era” the institute is one of the drivers of a CAS-wide strategic vision in information technology and computer science. The institute itself appears to be too heterogeneous so that a coherent strategic plan beyond that of the individual departments is missing.

## **B. Evaluation of the individual teams**

### **Evaluation of the Team No. 1: Department of Adaptive Systems**

#### **1. Introduction**

The Adaptive Systems (AS) department aims at fundamental research in the multidisciplinary area of Dynamic Decision Making under uncertainty and incomplete knowledge. The research results are published in book chapters, journal and conference papers. They are also transferred to diverse applications, which serve as a useful feedback for future research directions.

#### **2. Strengths and Opportunities**

The group has a long-term tradition of basic research in the area of Adaptive Systems, which has also proved useful for several quite diverse applications. The topic attracts the younger generation, which is important for the future of the group. The group has understood that a smooth modification of the main-stream is needed to open-up [new and ambitious topics of research](#)<sup>[1][2]</sup>.

#### **3. Weaknesses and Threats**

Interdisciplinarity opens new topics, but also requires high-level knowledge in several disciplines, which is not always in the group guaranteed. Also the age distribution is not optimal, but it is difficult in such small group to achieve. Many short-term projects prevent the group from achieving top-level results. A strong international project that would better stabilize the group is missing.

#### **4. Recommendations**

A smooth evolution of the group's objectives is important - it is not possible to build on tradition for ever. However, it should not be only an extension in the range or dimension of disciplines the new topics would include. Rather, the group should concentrate on less but better defined and focused objectives that would guarantee a stable and longer concentration on a problem under an umbrella of a (preferably international) grant.

#### **5. Detailed evaluations**

**Declaration on the quality of the results and share in their acquisition.** The work of this department concentrated on Bayesian dynamic decision making under uncertainty and incomplete knowledge. The main scientific achievements include advances in the fields of decision making strategies, Bayesian estimation, estimation in distributed networks, and linear, non-linear and decentralized control. The total number of outputs is 195 with 50 of them included in the WS. Given an average annual personal capacity of 14 FTE for researchers and 4.1 for other workers, the productivity of the department can be considered good. The quality of the publications, as assessed in Phase I, is good with a Quality Profile median value of 3 (recognized internationally) and an average of 2.6. Based on the AIS journal ranking, the quality of the publication venues is very good with 2 papers appearing in a journal ranked in the top decile and 21 papers appearing in a journal ranked in the upper half. The contribution of the team to these publications is very significant. The work of the department received a good degree of international recognition as evidenced by the number of citations.

**Declaration on the involvement of students in research.** The team successfully involves students at all levels into research. 29 Bachelor theses, 14 Master theses and 6 PhD theses have been completed, showing a good level of student involvement relative to the size of the team. 67 of 241 publications have been co-authored by students. Involving students already at Bachelor level proves

beneficial as many of the students doing a Bachelor thesis then also do their Master thesis with the team. Some of the Master and PhD theses have been awarded prizes, and three PhD students joined the team as members of research staff. The team will need to make an effort to maintain the level of student involvement as some of the team members who recruited students via teaching activities at universities have left the team.

**Declaration on societal relevance.** A significant part of the research activities in the team is application-oriented. Significant contractual research amounting to 305K Euros was carried out, and the team collaborated with a number of further businesses. This indicates a good level of impact on the economy. Research results by the team also appear to have impact in the medical domain (JodWeb system for cancer treatment, blind source separation for kidney diagnostics) and nuclear disaster response planning (training provided to fire service, presentations given to various expert audiences and Ministry of the Interior). The team is also involved to a significant level in educational activities (specialised courses based on the team's know-how as well as broader BSc and MSc level courses taken by a large number of students) at several universities in the Czech Republic and internationally (Ukraine, Austria). The involvement in outreach and popularization activities is also good, with a number of presentations and seminars being organized in addition to standard Open House Day activities.

**Declaration on the position in the international and national context.** Starting in the 60s, the group has a long-term tradition in fundamental research devoted to Bayesian Dynamic Decision Making under uncertainty and incomplete knowledge. However current specific activities result in numerous research topics starting from fundamental basic research problems and ending with the transfer of theoretical solutions to industry. The scientific activities have been mainly supported by grants from Czech Grant Agency. The international projects concern Czech-Norwegian Program and the Eurostars Program, which however is mainly devoted to the support of SMEs. Other international contacts, resulting in joint publications, are certainly useful, but with a limited impact. A significant international strictly research oriented project of a larger impact is missing. It might be caused by the large spectrum of specific activities – concentrating on fewer topics with higher devoted capacity might help in the future. Though the position of the team on national level is strong, it should still struggle more to better establish itself on the high international level.

**Declaration on the vitality and sustainability.** The group seems to be sustainable and the age structure is suitable for the future development. PhD students are involved in research activities and what is even more important, the best of them become members of the institute. That means that the topics are attractive for the young generation. The cooperation with practice is appreciated as an important feedback to theoretical research. It is regrettable that the cooperation with SKODA AUTO has terminated. Though significant improvements have been reported, more effort should be spent towards better positioning in international structures considering both the partners and research streams. The group is sufficiently small and does not require additional complicated management policies.

**Declaration on the strategy and plans for the future.** The basic principle of future direction is reasonable. On one side, it is a continuation of previous directions and at the same time it aims at new multi-disciplinary objectives. Though the continuation seems to be a safe way of achieving results, the second will have to be processed more carefully. The bottleneck is proper funding, because multidisciplinary research without funding is practically impossible. An international partner will be more suitable, but at the same time probably also more difficult to find. In any case, a smooth and gradual modification of the group's objectives is recommended.

## **Evaluation of the Team No. 5: Department of Image Processing (ZOI)**

### **1. Introduction**

The research of the department focused on various topics in image processing, including moment theory, image restoration, image forensics, cultural heritage applications, and medical imaging. Particular research highlights include novel procedures and algorithms in all these areas.

## **2. Strengths and Opportunities**

The group has some highly cited work in image registration and moments analysis, which is well known both for its originality and as a standard source of state-of-the-art review and comparative study. This represents a relatively diverse and high quality set of methods that can be applied to a wide range of image processing applications, and offers ample scope for future fundamental work. The work has hence provided, and should continue to provide, a good potential source of funding for applied, commercial and fundamental projects. The area is topical and should offer an attractive source of projects for young researchers. This is reflected in a good age balance in the group. There is a good set of new areas that could be opened up including medical imaging and super-resolution microscopy.

## **3. Weaknesses and Threats**

The main problem is overload. The group finds it hard to keep publication abreast of developments, and to sustain commitments to commercial projects.

## **4. Recommendations**

Group should apply for ERC funding, both for individuals and projects, to increase international visibility. The group should also consider recruiting staff capable of project leadership in new areas.

## **5. Detailed evaluations**

**Declaration on the quality of the results and share in their acquisition.** The total number of outputs is 145 with 52 of them included in the WS. Given an average annual personal capacity of 12 FTE for researchers and 4 for other workers, the productivity of the department can be considered satisfactory. The quality of the publications, as assessed in Phase I, is good with a Quality Profile median value of 3 (recognized internationally) and an average of 2.62. Based on the AIS journal ranking, the quality of the publication venues is excellent with 4 papers appearing in a journal ranked in the top decile and 17 papers in a journal ranked in the upper half. The contribution of the team to these publications is very significant. The work of the department received a good degree of international recognition as evidenced by the number of citations.

**Declaration on the involvement of students in research.** Involvement of both undergraduate and doctoral students in research of the ZOI department is rich and successful. The direct involvement of doctoral students in research activities is primarily reflected in five PhD theses that were defended in the evaluated period, all concerning the main directions of the image processing field treated in the ZOI. The doctoral students are directly involved in the solved problems as research assistants, employed by the Institute. In the evaluated period, the number of involved doctoral students varied between 7 and 12 in individual years. The members of the ZOI dept. supervised 12 doctoral students. It is planned to accept a new PhD student in the near future. Besides that, partial topics of the research, namely in medical imaging field and superresolution project, became themes of diploma and bachelor theses (altogether 21 MSc and 13 BSc thesis were supervised); two of these MSc theses were awarded special recognition.

**Declaration on societal relevance.** The impacts of the ZOI results may be considered as corresponding to the high level scientific department – they concern the internationally recognised both theoretical and applied science results as well as university teaching activities and important practical applications in contractual cooperation with industrial enterprises and governmental institutions. Many senior researchers are directly participating in the university (BSc, MSc and PhD) teaching, mostly in specialised courses. This also enables a good scheme of recruitment for PhD study thus leading to a very

satisfactory share of young researchers in the staff of the institute. The ZOI dept. has a regular continuously innovated teaching program for three main Czech universities (UK, CVUT, ZCU) encompassing one BSc course and 9 MSc courses, oriented mainly to the area of image processing and analysis. Two consulted courses are offered for PhD students. The ZOI dept. in cooperation with the MFF UK succeeded in accreditation of a new PhD study program devoted to computer graphics and image analysis (2012). The chairman and three members of the respective Study Programme Board are ZOI team members. In the evaluation period, collaboration with the application sphere amounts six items of contractual research for business (4) and governmental (2) sectors. Considering the relatively high amount (113 k EUR) involved, the practical value of this research is obvious. The public policy decisions may be positively influenced by the forensic expertise in image and video authentication. Members of ZOI dept. are involved in many different research community serving activities: 2 memberships in editorial boards of scientific journals, 1 representation in an international scientific union, 26 memberships in scientific boards and committees at main Czech universities, co-chairing of a scientific conference, reviewing papers for important journals and conferences in the field, and reviews of PhD dissertations incl. international ones.

The popularization activities of the ZOI dept. are multiform, including organization of Summer schools and a Winter schools on image processing problems, organizing special lectures and discussions concerning the IP field for wider public, including experts from other fields and the respective associations, university departments (eg. medical) and students, and workshops and conference contributions devoted to the developed specialised software (e.g. in forensic), and also popularizing the IP field at differently or more widely oriented expert conferences. The dept. participates at the generic popularization activities of the Czech Academy of Sciences; also the popularization activities of the image processing science in high schools deserve a positive note.

**Declaration on the position in the international and national context.** The group has an international reputation in the area of image analysis, and this is intermediate between low level image processing and higher level computer vision. It hence complements activities elsewhere in CAS and also at CTU. There is a good set of both national and international collaborations. There are a good number of national, and some international prizes.

**Declaration on the vitality and sustainability.** The age profile of the group is good, and there are also a good number of PhD students in the group. Funding, especially for applied and commercial work, seems plentiful. There is some evidence that additional staff members, especially at the more senior level would increase the viability of the group and its ability to manage its funding portfolio.

**Declaration on the strategy and plans for the future.** Some new areas of work are planned on topics such as super-resolution microscopy and medical image analysis. Otherwise plans are to strengthen current activities. The group should be encouraged to look towards synergistic work with other groups within CAS.

## **Evaluation of the Team No. 6: Department of Pattern Recognition**

### **1. Introduction**

The team works in the fields of statistical pattern recognition and texture modelling.

### **2. Strengths and Opportunities**

The group appears well supported financially, with a good distribution of age. It is exceptionally well equipped with access to a unique gonio-reflectometer. There appears to be a good stream of national funding, with plenty of potential work through forensic image analysis.

### **3. Weaknesses and Threats**

Failure to continue to recruit and retain a sufficient number of young researchers. Perhaps the group should also critically reexamine the publication strategy for their work.

#### 4. Recommendations

Consider diversifying into physically based texture and reflectance models by recruiting graphics specialist. Consider how to better exploit gonioreflectometer both commercially and scientifically. To keep high standards may require concentration on less, most important, objectives.

#### 5. Detailed evaluations

**Declaration on the quality of the results and share in their acquisition.** The research of this department covered statistical pattern recognition and visual data modeling, with an emphasis on finite mixture modelling, Markov random fields for scene interpretation, physically correct visualization, and visual data restoration. Major accomplishments include the development of a number of novel and enhanced algorithms in all of these fields. The total number of outputs is 80 with 21 of them included in the WS. Given an average annual personal capacity of 7.1 FTE for researchers and 1.5 for other workers, the productivity of the department can be considered satisfactory. The quality of the publications, as assessed in Phase I, is very good with a Quality Profile median value of 2 (internationally excellent) and an average of 2.36. Based on the AIS journal ranking, the quality of the publication venues is acceptable with 2 papers appearing in a journal ranked in the top decile and 5 papers appearing in a journal ranked in the upper half. The contribution of the team to these publications is very significant. The work of the department received a satisfactory degree of international recognition as evidenced by the number of citations.

**Declaration on the involvement of students in research.** Three bachelor theses, two master theses and three doctoral dissertations is not many, considering the size and actual research activities of the group. The reason might be that there is only one PhD supervisor and that the majority of the team members are quite young. The positive thing is that the quality of resulted dissertations is high, which can be demonstrated by the Antonin Svoboda Award granted to one of the dissertations. Another important thing is that all the PhD topics are contributing to the research program of the group.

**Declaration on societal relevance.** The educational activities of the group are high. The group has developed two Pattern Recognition courses in both the Czech and English versions. But the teaching activities also concern other subjects, such as Artificial Intelligence and Decision Making, which are regularly taught at the Czech Technical University and the University of Economics in Prague. Though the primary objective of the group is academic research with the main emphases on publication, the studied subject of statistical pattern recognition and visual data modelling automatically have a high effect on the application sphere. Unfortunately, no direct cooperation is reported – this might provide the group with additional financial support. Group members have also presented tutorials on high level conferences, such as CVPR or ICPR. They are also members of many PCs of important conferences. Popularization of research results through the ERCIM News is also valuable.

**Declaration on the position in the international and national context.** Department *compares well with international leading teams in the field as far as the results and their impact on the field are concerned.* They are well known for their work on classifier design, Markov models, mixture models, and physical texture modelling. In the past they have worked with leading international teams on classifier design producing seminal work with the groups lead by Kittler at Surrey and Duin at TU-Delft, and also on texture modelling with groups at CWI in the Netherlands. *The breadth/completeness of the research activity is good compared to world leading teams of comparable size,* with potentially good and relatively unique synergy between statistical pattern recognition and physical texture modelling. Recent work on accurate texture distribution models is



potentially of very high international impact – provided its dissemination is managed skillfully. Based on this, the *ability of the group to attract foreign researchers* is potentially good. *Possible missing research directions include the* grounding of the texture work more strongly in the graphics area, and physically based modelling would be a good addition to the group's set of approaches. If the group could recruit someone from the SIGGRAPH community the work could fly. Group seems very well regarded nationally, with a good set of international collaborations.

**Declaration on the vitality and sustainability.** The composition of the team is good, with a good spread of ages, with some promising early career researchers. The areas of research are potentially attractive for young people, despite difficulties recruiting and retaining. Funding seems adequate to sustain the team and equip them.

**Declaration on the strategy and plans for the future:** There are good plans to more tightly integrate physical texture modeling and statistical pattern recognition to reduce dimensionality of distributions and better classify material. Available means and human resources for realization of the plans seem ok. The team is encouraged to consider recruiting a graphics expert since this would allow them to exploit their equipment and expertise in mainstream appearance modeling.

**Date:** January 29, 2016

**Commission Chair:** Professor Edwin Hancock PhD, DSc.