

Joint Final Report

Institute of Cybernetics

Research fields Assessed

Information Systems and Automatic Control

Visit Dates

27-29 April 2000

Expert Team

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Part I

General Overview

The Higher Education Quality Assessment Center of Estonia has invited four experts from Germany, Finland, Latvia and Estonia to review and make accreditation recommendations for research on Information Technology and Automatic Control at the Institute of Cybernetic at Tallinn Technical University (hereinafter called "IoC").

The research fields which were assessed are: 1) Knowledge-based Control and Information Systems ("KBC"), 2) Compositional Specification and Verification of Hybrid Dynamical Systems("HDS"), 3) A Phonetic Research on the Sound System of the Estonian Language ("SS") and 4) Robust and Nonlinear Control Systems ("CS").

The expert team ("Team") visited IoC 27-29 April 2000, according to the prepared Agenda.

The Team was given the following materials:

- Self-assessment Report (61 pages)
- Development Plan for 1997-2002 (in Estonian, 15 pages)
- Materials about research programs (objectives, activities, staff, partners, results, grants, publications etc) of IoC.
- Additional materials (presentations slides etc)

The Team discussed presentations given by the following members:

- Prof. Dr. Jaan Penjam, the Director of IoC
- Dr. Ülle Kotta, the Vice Director of IoC
- researchers from working groups (more exactly described in Part II).

First of all, the Team will point out the following basic facts:

- IoC was established in 1960 as a research institute of Estonian Academy of Sciences, and is associated with Tallinn Technical University since 1997.
- IoC has three departments: 1) Mechanics and Applied Mathematics (containing the Laboratory of Photoelasticity), 2) Control Systems (containing the Laboratory of Phonetics and Speech Technology) and 3) Computer Science. IoC employs in total 82 people, with average age of academic staff about 47. Working conditions are very good (in average about 22,5 m² per person): most of the research staff have personal rooms equipped with modern technology.
- The budget for 2000 is expected to be about 11 MEEK, from which about 50% are for personnel costs.

What follows are the description of the working groups (Part II), general recommendations (Part III), accreditation conclusions (Part IV) and accreditation recommendation (Part V).

Part II

Working Groups

1. Knowledge-based Control and Information Systems

Presentations, Visits and Discussions

Jaan Penjam, the head of the research group gave a detailed presentation on the current research project **Knowledge-based Software Engineering for Information and Control Systems**. Then the evaluation team was given a demonstration, introduced by Ahto Kalja, of the following real working systems:

- Modeling of Estonian Radar Coverage
- CAD problem solving using the Artificial Intelligence programming environments
- Simulation of hydraulic chains using multi-pole models in NUT environment
- Development of ATM LAN and video-conferencing facilities.

The evaluation team had the opportunity to meet practically with all members of the research group (except Hele-Mai Haav) and discuss with them.

Activity

Knowledge-based systems form a research direction, where the Institute of Cybernetics has a longstanding tradition. Research in this area was started at the institute as early as in the seventies. In the nineties two leading researchers of this group, E. Tõugu and G. Minz, got full professorships in leading universities abroad (Royal Institute of Technology, Stockholm, Sweden, and Stanford University, USA). But despite losses in human resources, the research in this area has continued at the Institute of Cybernetics and new excellent results are obtained.

Currently the research group consists of 14 members; 8 of them with PhD degree. Group has a very active leader, professor Jaan Penjam. Leading researchers are taking part in the education process in Tallinn Technical University as well.

Research and Development

The main scientific result in the last years is the development of sophisticated knowledge-based programming environment, the system NUT. The NUT system combines object-oriented and structural synthesis methods, and it is based on deep theoretical results obtained by the research group in the fields of knowledge representation and deduction theory. The NUT system and other results obtained by the research group are used in several practical projects carried out within the framework of contracts with different national organizations. One of the most successful practical project has been the Modeling of the Estonian Radar Coverage. Research has good perspective - component based software design is one of directions where developed structural synthesis methods can be used.

Publications

The research group has an impressive publication record in high level international conference proceedings and journals, including the World Congress of Formal Methods in Development of Computing Systems, FM '99.

Competence of the Research Group

Competence of the research group is very high, more than half of the group members have PhD degree. Group has good international cooperation. Most of the publications are joint work with foreign researchers. Also the NUT system is developed in cooperation with the Royal Institute of Technology, Sweden.

2. Robust and Nonlinear Control

Presentations, Visits and Discussions

Ülle Kotta, the leader of the group, gave a first introduction on the activity of the research group and pointed out that the research carried out in Control Theory is totally restricted to basic research. It is a consequence of the recent changes in Estonia due to which the local industry has just a very limited capacity to support scientific research work. Then she explained the research activities carried out in the field of Nonlinear Control. Afterwards Maris Tõnso, MSc student, gave a demonstration of a nonlinear systems toolbox based on the computer algebra system Mathematica. Finally Ülo Nurges, PhD and senior researcher, explained his activities in the area of Robust Control.

Activity

Nonlinear Systems based on differential-geometric, and in particular, on differential-algebraic representations are rather new and find increased interest in the field of control theory. These new methods allow to deal with a much larger class of nonlinear systems that are in the future of growing importance for real applications.

In addition, a universal algebraic formulation has been developed by the group which allows the study of rather different problems in case of a discrete-time representation of nonlinear control systems. A single tool, based on a deep analysis, were developed for characterizing relevant dynamical properties. Efficient algorithmic procedures were developed which are well suited in solving concrete analysis and synthesis problems. In addition, it is an advantage that most of the algorithms can be implemented and realized in the computer algebra system Mathematica (Toolbox).

It is the intention of the group to explore these ideas further and to extend the toolbox.

Ülo Nurges reported about his activities in robust control. In contrast to the above mentioned work, this is a classical way for designing a linear time-invariant controller using a special approach.

Research and Development

The work in the field of Nonlinear Control done by the group of Ü. Kotta is novel and of a high scientific level. It is restricted to basic research. In general there exist at the moment almost no activities which are concerned with applications.

To our knowledge there are no comparable research activities going on at this moment in Estonia. Nevertheless, on a longer time horizon this topic will be very important even in applied areas. Therefore the activities in nonlinear systems should go on at the Institute of Cybernetics.

Publications

The self-assessment report lists 17 publications which were partly published in well recognized Journals and one English monograph by Ü. Kotta entitled: Inversion Method in the Discrete-Time Nonlinear Control Systems. This work is strongly related to the above mentioned results.

Competence of the Research Group

The competence in nonlinear control is very good and of an international standard. There exists a number of international contacts with well known schools. Ü.Kotta had also visiting appointments at several foreign research centres including the well known group in Twente, Holland.

The work in robust control has a not so high international standard.

3. A Phonetic Research on the Sound System of the Estonian Language

Presentations, Visits and Discussions

The Team visited the Laboratory of Phonetics and Speech Technology where the principal investigator Einar Meister gave an overview of their activities and achievements. He also demonstrated the text-to-speech converter. The whole staff of the laboratory took part on the presentation.

Activity

IoC has relatively long traditions in doing research and developmental work in the area and is the leading institution in Estonia in speech technology. The character of the work has been changed in last years: if in previous years some work has to be done for development devices for speech synthesizing, then in recent years standard hardware can be used.

Both international and domestic co-operation is relatively broad. Main partners in Estonia are Institute of Estonian Language, Tartu University and FiloSoft Ltd; main foreign partners are universities in Finland, Sweden and USA. The group also took part on the COPERNICUS project No. 1304 "BABEL -a Multi-Language Database".

Research and Development

Main research areas are speaker recognition, speech analysis and text-to-speech synthesis, as well as word prosody and Estonian language sound patterns. The research include acoustics and perception of Estonian vowels, stop consonants and fricatives. A considerable phonetic database has been created. In co-operation with Institute of Estonian Language and FiloSoft Ltd, the Estonian text-to-speech synthesizer has been developed.

Publications

The number of research papers in internationally refereed journals is relatively modest, big part of the results has been published in different conference proceedings. At the moment the group is working on a composition of a monographic issue "Estonian Phonetics". There is a positive tendency in last years: joint publication with researchers from other institutions.

Competence and Education

The research group is very small (three researchers), but it is very competent in its field. Two students are taking part on research as well.

4. Compositional Specification and Verification of Hybrid Dynamical Systems

Presentations, Visits and Discussions

Jüri Vain, the head of the research group gave a detailed presentation on the current research done in this research area. Then the evaluation team was given a demonstration of the system for model checking and deductive verification. The evaluation team had the opportunity to meet with the leading members of the research group and discussed with them their work.

Activity

Currently the research group consists of 6 members, 3 of them with PhD degrees. Some researchers are taking part in the education process in the Tallinn Technical University as well.

Research and Development

The main objective of the research is to study formal theories and tools for development of dynamical systems with main focus on compositional techniques. It is well known that specification and verification of dynamical systems is a very hard task. This problem is currently studied by this group basically on a theoretical level. From this point of view results obtained by the research group are a good contribution in this area. For example, a transformation technique with formally verifiable refinement steps is developed. This technique allows to transform conceptual metamodels to a real-time specifications of the system. Verification methods based on this technique are developed and implemented in the Stanford verification system PVS. A lot of other theoretical results are obtained.

Perspective of this research direction in the Institute of Cybernetics is not clear because it is very theoretical. One possibility would be to combine this research direction with the knowledge-based research direction to form one very powerful research direction in the Institute of Cybernetics. Also, it would be desirable to pay more attention to applications.

Publications

The self-assessment report lists 12 publications. Most of them are conference papers. There are no papers which appeared in international recognized journals.

Competence of the Research Group

The researchers of the group are well aware of the latest state of the art. However, one would expect that more attention should be given to real problems in different areas. Nevertheless, the group has been successful and received during the period 1993 - 2000 five grants from the ESF and one grant from the Estonian Innovation Foundation.

Part III

General Recommendations

The Team offers the following recommendation to IoC and to other related bodies. The parties should view these recommendations as suggestions from colleagues. The Team has not given these recommendations in any order of priority and all concerning bodies may consider them for general improvements.

- The leading researchers are working only part-time at IoC (and full-time mainly at the Tallinn Technical University). Such situation may have some advantages (e.g. it may tighten the research relations with the University), but in general it means double work load in management. Therefore they can not fully devote their energy to the research and development work at IoC. The Team strongly suggests the leading researchers to reconsider the division of work between the university and IoC.
- The research tasks of the institute requires solid bases of different areas of Mathematics. However, Tallinn Technical University is not preparing mathematicians and therefore the institute should make more use of training possibilities offered by the universities with comprehensive Mathematical programs. This would also have a positive reaction to attract younger people to join the research staff.
- There is a lack of publications in internationally well-recognized journals.
- The research groups should put more effort to the development of their skills for coping with practical problems which would lead to a more active co-operation with the industry.

Part IV

Accreditation Conclusions

The Team got an impression that a part of the staff is not fully devoted to perform the research tasks within the institute.

Part V

Recommendations

Evaluation judgement of research fields Information Technology and Automatic Control

Good to Satisfactory

The Team has based its decision on the information received, the outcome of the accreditation visit, and the findings reported in Part II.