

Chapter 11

Cognitive Systems Research

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11.1 Introduction

Computational Cognitive Systems group conducts research on artificial systems that combine *perception, action, reasoning, learning and communication*. This area of research draws upon biological, cognitive and social system approaches to understanding cognition. Cognitive systems research is *multidisciplinary and interdisciplinary*. It benefits from sharing and leveraging expertise and resources between disciplines. Methodologically, *statistical machine learning, pattern recognition and signal processing* are central tools within computational cognitive systems research. Our research focuses on modeling and applying methods of unsupervised and semisupervised learning for *conceptual modeling, machine translation and multilingual processing, and socio-cognitive modeling*. The general aim is to provide a methodological framework for theories of *conceptual development, symbol grounding and embodiment, communication among autonomous agents, situational activity analysis, social simulation, and constructive and expansive learning*.

11.2 Summary of collaboration

We have worked in close collaboration with other groups in Adaptive Informatics Research Centre, lead by Prof. Erkki Oja and Prof. Samuel Kaski, in particular natural language processing and multimodal interfaces (Dr. Mikko Kurimo and Dr. Jorma Laaksonen). We have also collaborated with the representatives of *Helsinki School of Economics* and *University of Art and Design Helsinki*. The collaboration with Helsinki School of Economics and *National Consumer Research Centre* has mainly taken place within Tekes-funded Kulta project that focuses on *modeling and simulation of changing consumer needs*. The project will be described in more detail in the subsequent sections. After 2009, these universities and Helsinki University of Technology, operate within the merged Aalto University. Helsinki University of Technology will operate as *Aalto University School of Science and Technology*. In Tekes-funded ContentFactory project, we have collaborated with *University of Helsinki* and in particular with Dr. Roman Yangarber and Prof. Lauri Carlson and their groups. Our specific topic related to multilingual terminology and ontology learning is described in some detail elsewhere in this report.

An important collaboration arena in the future will be the *EIT ICT Labs* that is built upon five co-location centres in Berlin, Eindhoven, Helsinki, Paris, and Stockholm. *European Institute of Innovation and Technology* (EIT) has nominated the EIT ICT Labs as one of its three first Knowledge and Innovation Communities (KIC). In the preparation of the EIT ICT Labs, Prof. Martti Mäntylä and Prof. Heikki Saikonen from Helsinki University of Technology have had a central role. We foresee that this institution will be an important platform for research collaboration within our research area. With one of the partners, *Deutsche Forschungszentrum für Künstliche Intelligenz* (DFKI), we already share common interest in promoting efficient European communication through the joint EU-funded *Network of Excellence in Technologies for a Multilingual Europe* (T4ME). DFKI will serve as the coordinator of the NoE, lead by Prof. Hans Uszkoreit. The network will start its work in early 2010. The core consortium consists of twelve partners from Germany, France, Spain, Italy, Greece, Czech Republic, Finland, Ireland, the Netherlands and Slovenia, and is coordinated by DFKI, Germany. TKK (Aalto University) is the only Nordic partner in the consortium.

The group has been active in conducting and developing further international collaboration. In September 2008, the group was centrally responsible for organizing the International and Interdisciplinary Conference on Adaptive Knowledge Representation and Reasoning, AKRR'08 [1]. Timo Honkela has given keynote talks “From quantification

of information to quantification of meaning using socio-cognitive computing" at the 2008 IAPR Workshop on Cognitive Information Processing in Santorini, Greece, and "Conceptual Autonomy of Agents" at the International Conference on Agents and Artificial Intelligence, ICAART 2009 in Porto, Portugal. As a member of European Neural Network Society executive committee, Timo Honkela will serve as the programme co-chair of International Conference on Artificial Neural Networks 2011 (ICANN'11) and as the general chair of Workshop on Self-Organizing Maps 2011 (WSOM'11).

Year 2008 was the final year for the multi-national Project *MedIEQ* in which our group was actively involved. The project was co-funded by the European Commission under the Public Health programme. The project was set to pave the way towards the automation of quality labeling process of medical web sites. Matti Pöllä was our key representative in the project. Close collaboration with Prof. Eero Hyvönen's *Semantic Computing Research Group* at TKK was also conducted.

In 2009, two researchers and graduate students in our group, Tiina Lindh-Knuutila and Mari-Sanna Paukkeri, conducted a research visit abroad that lasted half a year. Tiina Lindh-Knuutila visited the International Computer Science Institute (ICS) at *University of California Berkeley*, USA. Mari-Sanna Paukkeri visited the School of Informatics at the *University of Edinburgh*, United Kingdom

The group has collaborated with Academician Teuvo Kohonen, for instance, to study the performance of the *Self-Organizing Map* (SOM) algorithm in vector quantization [2]. Moreover, we have helped in updating the large SOM bibliography [3].

11.3 Summary of cognitive systems research areas

Our main research areas are *conceptual modeling*, *machine translation* and *multilingual processing*, and *socio-cognitive modeling*. We approach conceptual modeling as a dynamic phenomenon. Among humans, conceptual processing takes place as an individual and social process. We attempt to model this dynamic and constructive aspect of conceptual modeling by using statistical machine learning methods. We also wish to respect the overall complexity of the theme, for instance, not relying on explicit symbolic representations are the only means relevant in conceptual modeling. Our machine translation research builds on the conceptual modeling research as well as on the research on adaptive language technology.

Socio-cognitive modeling is our newest research area which builds on 1) the experience and expertise in modeling complex phenomena related to language learning and use at cognitive and social levels and 2) strong national and international collaboration especially with the representatives of social sciences and humanities. Socio-cognitive modeling mainly merges aspects of computer science, social sciences and cognitive science. The basic idea is to model interlinked social and cognitive phenomena.

References

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