Chapter 1

Introduction

The Centre of Excellence called the Adaptive Informatics Research Centre (AIRC) started in January 2006 in the Laboratory of Computer and Information Science at Helsinki University of Technology. It followed the tradition of the Neural Networks Research Centre (NNRC), operative for two six-year periods from 1994 to 2005, also under the national Centre of Excellence status. AIRC finished in December 2011 at the Department of Information and Computer Science, School of Science, Aalto University, to be directly followed by a new Centre of Excellence in Computational Inference (2012 - 2017).

The core function and strength of our Centres of Excellence is the ability to analyze and process extensive data sets coming from a number of various application fields using our own innovative and generic methods. Our research has concentrated on neurocomputing and statistical machine learning algorithms, with a number of applications. In the algorithmic research, we have attained a world class status over the years, especially in such unsupervised machine learning methods as the Self-Organizing Map and Independent Component Analysis.

Building on this solid methodological foundation, we apply the knowledge, expertise and tools to advance knowledge in other domains and disciplines. In the AIRC, we took a goal-oriented and interdisciplinary approach in targeting at the adaptive informatics problem. By adaptive informatics we mean a field of research where automated learning algorithms are used to discover the relevant informative concepts, components, and their mutual relations from large amounts of data. Access to the ever-increasing amounts of available data and its transformation to forms intelligible for the human user is one of the grand challenges in the near future.

The AIRC Centre of Excellence focussed on several adaptive informatics problems. One is the efficient retrieval and processing techniques for text, digital audio and video, and numerical data such as biological and medical measurements, which create valuable information sources. Another problem area are advanced multimodal natural interfaces. We are building systems that process multimodal contextual information including spoken and written language, images, videos, and explicit and implicit user feedback. Automated semantic processing of such information facilitates cost-effective knowledge acquisition and knowledge translation without the need to build the descriptions manually. Yet another problem, which we approach together with experts in brain science and molecular biology, is to develop and apply our algorithmic methods to problems in neuroinformatics and bioinformatics.

The Adaptive Informatics methodology that we focus on is to build empirical models of the data by using automated machine learning techniques, in order to make the information usable. The deep expertise on the algorithmic methods, gained over the years, is used to build realistic solutions, starting from the problem requirements. The application domains have been chosen because of our acquired knowledge in some of their core problems, because of their strategic importance in the near future, and because of their mutual interrelations. The algorithms are based on our own core expertise. Future research, which largely takes place in the new Center of Excellence in Computational Inference (COIN; 2012 - 2017), will continue to be novel, innovative, as well as inter- and multi-disciplinary, with a specific focus on shared research activities that will have a significant societal impact.

The AIRC Centre of Excellence consisted of five interrelated research groups: Algorithms and Methods, Bioinformatics and Neuroinformatics, Multimodal Interfaces, Computational Cognitive Systems, and Adaptive Informatics Applications (see Figure 1.1).

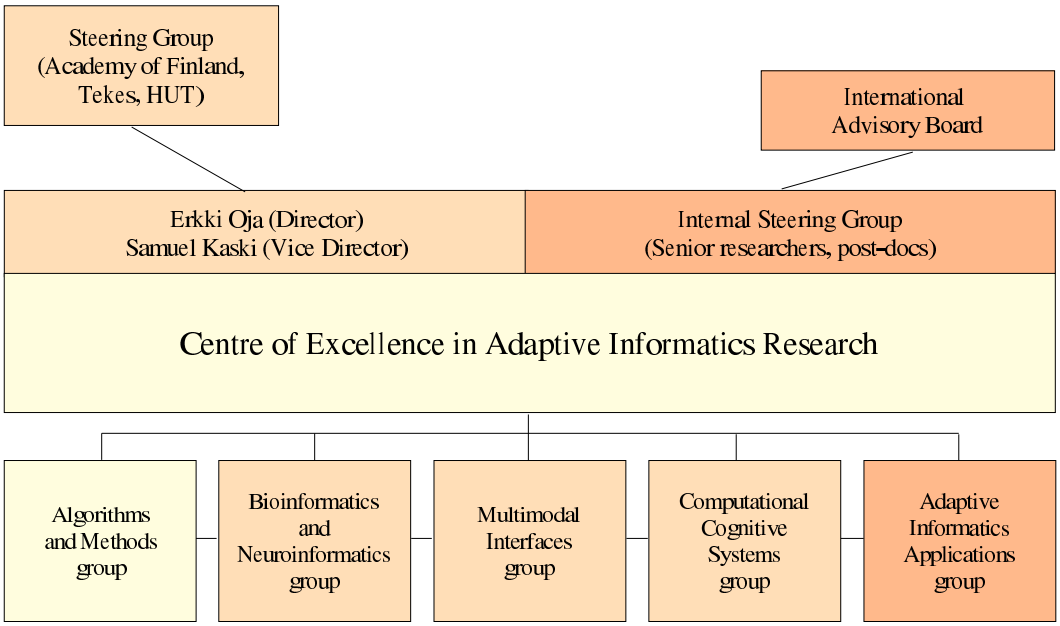

Figure 1.1: *The organization of the AIRC Centre of Excellence*

The Algorithms and Methods group conducted basic algorithmic research in adaptive informatics that relies heavily on computer science, mathematics and statistics, and was partly motivated by the research problems of other groups. In contrast, the groups of Bioinformatics and Neuroinformatics, Multimodal Interfaces and Computational Cognitive Systems formed an interdisciplinary research network with shared research interests in life and human sciences. The group of Adaptive Informatics Applications brought the research results into practice together with collaborating enterprises. This inter- and multi-disciplinary diversity facilitated a rich exchange of ideas, knowledge and expertise both within and between research groups. The ideas generated in one research group spark innovative ideas and research methods in other groups. This kind of ability to pool knowledge and resources between groups reduces duplication, saves time, and generates more powerful research methods and results. Altogether, it makes the Centre of Excellence a coherent whole. One proof of the success was that the core group of senior researchers, complemented by some other PI's, won already the fourth consequent Center of Excellence, COIN (Computational Inference).

Each group in AIRC and COIN has a wide range of national and international collaborators both in Academia and industry. Researcher training, graduate studies, and promotion of creative research is strongly emphasized, following the successful existing traditions.

The present Biennial Report 2010 - 2011 details the individual research projects of the five groups during the final two years of the six-year period of the AIRC. Additional information including demos etc. is available from our Web pages, `www.cis.hut.fi/research`.