Advances in Cognitive Neurodynamics

Yoko Yamaguchi
Editor

Advances in Cognitive Neurodynamics (III)

Proceedings of the Third International Conference on Cognitive Neurodynamics – 2011

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Preface

Five decades of brain research have led to the emergence of a new field, spanning the entire spectrum of cognition from synaptic dynamics to social interactions, and which integrates nonlinear neurodynamics operating simultaneously at and across various scales. A new kind of scientist is emerging, schooled in multiple academic disciplines, comfortable in working with data from different levels, and conversant with the mathematical and computational tools that are essential to cross the boundaries of these disciplines.

Cognition, in its essence, is dynamic and multilayered, and the pursuit of new clues inevitably leads us from one layer to the next, both reductionist and holistic. A new trend in the study of cognition from the point of view of neurodynamics has emerged as a result of the rapidly evolving developments of the activity within the field of Nonlinear Dynamics and Cognitive Science.

In order to promote the integration of Cognitive Science and Neurodynamics as a whole, the International Conference on Cognitive Neurodynamics has been held biannually since 2007 under the support of the editorial board meeting of Cognitive Neurodynamics (Springer). The first conference, ICCN2007, was held in Shanghai, and the second, ICCN2009, in Hangzhou, also in China.

And this was the third ICCN, at The Hilton Niseko Village, Hokkaido, Japan, from June 9–13, 2011. Due to the tragedies of the Great East Earthquake and ensuing tsunami in Japan, many people had difficulty in attending, so we are very grateful for the efforts of those who nonetheless helped to make ICCN2011 a success. There were 161 participants from 17 countries, 6 plenary talks by Prof. Leslie Kay, Prof. Robert Kozma, Prof. Soo-Young Lee, Prof. Hajime Mushiake, Prof. Noriko Osumi, and Prof. Peter Robinson, 130 papers, and invited lectures by 3 renowned researchers, Prof. Shun-ichi Amari, Prof. Minoru Tsukada, and Prof. Walter Freeman.

The conference ranged from a microscopic model of the neural impulse to a macroscopic model of the sleeping rhythm. Key sessions were: Neuronal Impulse, Patterns and Bifurcation, Integrative and Multi-level Approaches for Cognitive Neurodynamics, Model Complexity in Neural Network Phenomena, Toward Understanding of Intelligence: Collaboration between Neuroscience and Robotics, Spatiotemporal Network Dynamics, Shaping Embodied Neurodynamics through

Interaction, Mathematical and Statistical Aspects of Neurodynamics, Dynamic Patterns of Neural Activity in Human Information Processing, and Neural Basis of Biological Timing. We express our sincere appreciation to all the session organizers. We also appreciate the session presenters who maintained discussions throughout the sessions and at the poster presentations.

Another highlight was the young researcher session in which we asked young researchers to discuss and create a tentative collaboration plan which was then evaluated by the senior researchers. The young researchers learned much from the suggestions of the senior people. We also wish to acknowledge the Dynamic Brain Forum (DBF), co-organized with ICCN2011, and in particular, Prof. Jan Lauwerence for his organization of DBF sessions.

Historically, DBF was the "Origin of Brain Dynamics Study", the core research field of ICCN. DBF was initiated by the Japanese "Gang of Five" who were focused on nonlinear dynamics and their activity led to related work in Cognitive Neurodynamics in China which finally resulted in ICCN2007. So, ICCN owes much to DBF for their research field concept establishment, and ICCN2011 was happy to have coordinated with DBF2011. The next ICCN2013 will be held in Sigtuna, Sweden, by Prof. Hans Lijenstrom (Swedish Univ. of Agricultural Science). We look forward to sharing fresh topics and ideas both among the people who originally gathered at Niseko and with all other attendees.

We would also like to express our gratitude to the supporting organizations, Grant-in-Aid for Scientific Research on Innovative Areas "The study on the neural dynamics for understanding communication in terms of complex hetero systems (No.4103)" of MEXT Japan, RIKEN BSI, and Tamagawa University Global COE Program "Origins of the Mind"; for financial support from SCAT, sponsorship by Springer, FIRST project and Budapest Seminar, and co-sponsorship by JNNS, INNS and CNS. We hope all the supporting activity will continue to foment the development of this fast-moving and exciting scientific field.

Yoko Yamaguchi
Takashi Omori
Ichiro Tsuda

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Part I
Global Scope of Cognitive Neurodynamic Systems

Artificial Cognitive Systems with Active Learning and Situation Awareness Capabilities

Soo-Young Lee

1 Introduction

From 1998 to 2008 we had developed Artificial Brain inspired by brain information processing mechanism, which had successfully demonstrated lower-level secretarial functions [1]. From 2009 we are now extending this approach toward higher cognitive functions for intelligent agents, i.e., Artificial Cognitive System (ACS).

The essential functions of ACS for intelligent agents are proper *decision making* and following *action* (*behavior*). The decision making is based on *situation awareness*, which is also based on *knowledge representation and accumulation*. These five modules will be developed based on computational models of *proactive knowledge development* and *self identity*. Eventually both hardware and software will be developed.

The research will utilize relevant previous researches for audio-visual perception as well as cognitive science, and extend into computational models and HW/SW systems.

However, the cognitive scientific knowledge is not good enough due to poor temporal and spatial resolutions. Among available non-invasive techniques, fMRI provides about 1 mm^3 spatial resolution with 1 s temporal resolution, while EEG and MEG provide 1 ms temporal resolution with 1 cm resolution. Although there exist many attempts to combine fMRI and EEG/MEG for cognitive modeling, it is beyond current status-of-art technologies to measure brain signals with enough spatial and temporal resolutions.

In this position paper we propose to combine fMRI and EEG experiments, and the missing links will be filled-in from engineering knowledge, especially

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the information theory. In Sect. 2 we present the higher cognitive functions to be implemented for our intelligent agents, i.e., Artificial Cognitive System (ACS), and the multidisciplinary multimodal approach will be presented in Sect. 3.

2 Artificial Cognitive Systems

The ACS will be based on our previous works on *Artificial Brain* and its secretarial developments, called *OfficeMate*, and then further extended with additional functions.

The *Artificial Brain* was developed through Korean Brain Neuroinformatics Research Program from 1998 to 2008. It was a joint effort of researchers from many different disciplines including neuroscience, cognitive science, electrical engineering, and computer science, and about 35 professors and 70 professors from many Korean universities were involved in the program.

The Korean Brain Neuroinformatics Research Program had two goals, i.e., to understand information processing mechanisms in biological brains and to develop intelligent machines with human-like functions based on the mechanism. In 2008 we had developed an integrated hardware and software platform, i.e., *Artificial Brain*. With two microphones, two cameras (or retina chips), and one speaker, the *Artificial Brain* looks like a human head, and has the functions of vision, auditory, cognition, and behaviour. Also, with this platform, we had developed a testbed application, i.e., "artificial secretary" alias *OfficeMate*, which might reduce the working time of human secretary by a half.

As shown in Fig. 1, the information processing functions in the *Artificial Brain* consist of four modules. Among five human sensory processes the *vision* and

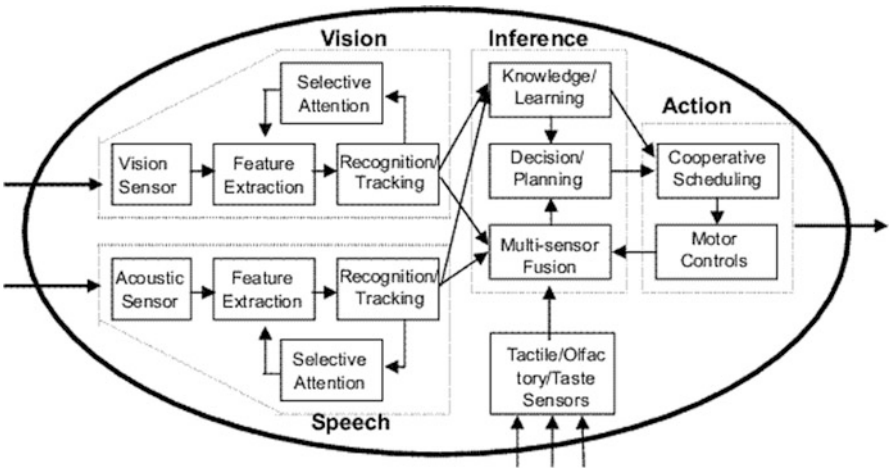

Fig. 1 Functional modules of Artificial Brain