Emergence of Adaptive Motor Function through Interaction among the Body, Brain and Environment

- A Constructive Approach to the Understanding of *Mobiligence* -

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1. Introduction

The *Mobiligence* project is a five-year project started from 2005[1], which was accepted as a program of Scientific Research on Priority Areas of Grant-in-Aid Scientific Research from the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT). In addition to the planned research groups which started in 2005, new two-years-research groups (applied research groups) will be selected and start from 2006. This paper presents the abstract of the project.

2. Objective of the *Mobiligence* Project

Human can behave adaptively even in diverse and complex environment. All the animals can perform various types of adaptive behaviors, such as a locomotive behavior in the form of swimming, flying walking, a manipulation behaviors such as reaching, capturing, grasping by using hands and arms, a social behavior to the other subjects, etc. Such adaptive behaviors are the intelligent sensory-motor functions, and most essential and indispensable ones for animals to survive.

It is known that the function of such adaptive behaviors is disturbed in patients with neurological disorders. Parkinson disease is a typical example of disorders on adaptive motor function, and autism or depression can also be considered as a disorder on social adaptive function.

Recently, due to aging or environmental change of society, the population of people who are suffering from these diseases is growing rapidly, and it is urgent to cope with this problem. However, the mechanisms for the generation of intelligent adaptive behaviors are not thoroughly understood. Such an adaptive function is considered to emerge from the interaction of the body, brain, and environment, which requires that a subject acts or moves. Base on the consideration, we call the intelligence for generating adaptive motor function *mobiligence*.

The present project is designed to investigate the mechanisms of *mobiligence* by closely collaborative research of biology and engineering. In the course of this collaborative project, the following processes will be carried out:

1. Biological and physiological examinations of animals;
2. Modeling of biological systems;
3. Construction and experiments on artificial systems by utilizing robotic technologies; and
4. Creation of a hypothesis and its verification.

The final goal of this project is to establish the common principle underlying the emergence of *mobiligence*.

3. Research Approach of the *Mobiligence* Project

In this project, the *mobiligence* mechanism is to be elucidated by the constructive and systematic approaches, through the collaboration of biologists and engineering scientists who developed biological models by integrating physiological data and kinetic modeling technologies as shown in figure 1. In other words, the *Mobiligence* Project is pursued by integrating biology and engineering, i.e., physiological analysis (biology), modeling and experiments on artificial systems (engineering), verification of models (biology), and discovery and application of principles (engineering).

In the following discussion, the focus is on three adaptive mechanisms:

1. Mechanism whereby animals adapt to recognize environmental changes;
2. Mechanism whereby animals adapt physically to environmental changes; and
3. Mechanism whereby animals adapt to society.

Research groups for each of the categories listed above are organized. The three groups conduct their respective research and clarify the universal, common principle underlying the mechanism of *mobiligence*. The Planned Research Team studies the following specific subjects: analysis of the environmental cognition and the adaptive mechanism in reaching movements; analysis of the physical adaptive mechanism in walking; and analysis of the adaptive mechanism observed in the social behaviors of insects. In addition, the Planned Research Team clarifies the common principle underlying *mobiligence* from a dynamic viewpoint. Furthermore, we study adaptive mechanisms relating to various objects by publicly inviting proposed topics and clarify the universal, common principle therein.

4. Research Activities till the *Mobiligence* Project

The *Mobiligence* project is highly motivated by the previous project on emergent systems, which was carried out from 1995 to 1997 and directed by Prof. Shinzo Kitamura of Kobe University. Although the system theory on emergent function formation was actively discussed in the project, the principle it couldn't be revealed enough how to design the emergent systems. After the project on emergent systems, a special interest group on System Principle on Emergence of *Mobiligence* and Its Engineering Realization was organized in the System and Information Division of the Society of Instrument and Control Engineers (SICE) in 2003, and the research activities have been continued.

We held a workshop sponsored by the Tohoku University Nation-wide Cooperative Research Project from 2001, and a workshop on the development of the emergence system of *mobiligence* and its control system under the sponsorship of the Nissan Science Foundation.

Before starting the *mobiligence* project, we planned and held organized sessions in international conferences and in lecture meetings of academic societies

- IFAC Intelligent Autonomous Vehicles (IAV)
- International Symposium on Distributed Autonomous Robotic Systems (DARS)
- International Symposium on Adaptive Motion of Animals and Machines (AMAM)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
- SICE Annual Conference
- SICE System and Information Division Annual Conference (SSI)
- SICE System Integration Division Annual Conference (SI)
- SICE Symposium on Decentralized Autonomous Systems

5. Expected Impact of the *Mobiligence* Project

Various types of adaptive motor function mechanisms performed by animals are expected to be elucidates. In the medical field, the results of our research will contribute to the discovery of a method to improve motor impairment and develop rehabilitation systems. In addition, in the engineering field, the results of our research will contribute to the derivation of the design principles of artificial intelligence systems. Furthermore, we will explore the new research field, *mobiligence*, establish a research organization that integrates biology and engineering, and implement programs to foster young engineering scientists and biologists to conduct collaborative and interdisciplinary research between biological and engineering research, respectively.

References

[1] http://www.arai.pe.u-tokyo.ac.jp/mobiligence/index_e.html

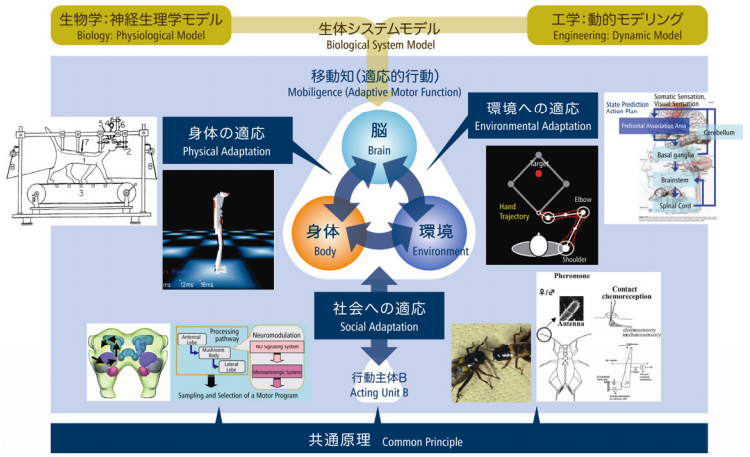

Fig. 1 Framework of the *Mobiligence* Project

Fig. 2 Expected Impact of the *Mobiligence* Project