

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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Abstract: The *Mobiligence* project is a five-year project started from 2005. All the life forms such as humans, animals, and insects, can behave adaptively even in diverse and complex environment. Such an adaptive function is considered to emerge from the interaction of the body, brain, and environment, which is induced by the active mobility of the cognitive subject. The objective of the project is to understand the mechanisms for the generation of intelligent adaptive behaviors based on constructive approach by collaborative research among biological and engineering research scientists. This paper presents the abstract of the project.

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. The first international symposium on *mobiligence* was held in December of 2005[2], in which we discussed mainly the research plan and primary research results obtained in the planned research groups of the *mobiligence* project. This is the second international symposium to discuss and evaluate the research results so far in both planned research groups and applied research groups for 2006-2007.

This paper presents the abstract of the project.

2. Objective of the *Mobiligence* Project

All the life forms such as humans, animals, and insects, can behave adaptively even in diverse and complex environment in various types of behaviors, such as locomotive behaviors in the form of swimming, flying, and walking, manipulation behaviors such as reaching, capturing, and grasping by using hands and arms, social behaviors 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 is induced by the active mobility of the cognitive subject. Base on the consideration, we call the intelligence for generating adaptive motor function *mobiligence*. Namely, the *mobiligence* can be defined as intelligence for generating adaptive motor function which is emerged by mobility. The objective of the project is to understand the mechanisms for the generation of intelligent adaptive behaviors.

3. Research Approach of the *Mobiligence* Project

The conventional analytical approach based on animal experiments in biology is not effective for this problem, because it reveals only the simple brain function in a stationary state, not the complex system function emerged from interaction among brain, body, and environment in a dynamic state. In the *mobiligence* project, we tackle this problem based on constructive and systematic approach by tight collaboration among biological and engineering research scientists as shown in figure 1.

In the course of this collaborative project, the following processes will be carried out:

1. Biological and physiological examinations on biological systems;
2. Introduction of physiological models based on the biological knowledge and findings on adaptive behaviors of various life forms;
3. Modeling of the mechanisms on adaptive behaviors of various life forms by introducing dynamical

system models utilizing robotic and system methodologies biological systems;

4. Construction and experiments on artificial systems by implementing biological system models; and
5. Creation of a hypothesis and its verification.

4. Research Subjects and Groups

In the *mobiligence* project, we focus on following three subjects on various types of life forms such as humans, animals, and insects, by organizing research groups on each subject:

Group A: Mechanism whereby a cognitive subject adapt to recognize environmental changes;

Group B: Mechanism whereby a cognitive subject adapt physically to environmental changes; and

Group C: Mechanism whereby a cognitive subject adapt to other cognitive subjects or its society.

The three groups conduct their respective research. However, the final goal of this project is to clarify the universal, common principle underlying the mechanism of *mobiligence*, and establish the design principle for adaptive systems. We organized a fourth group to elucidate the common principle:

Group D: Common principle on mechanisms to generate adaptive behaviors.

The planned research groups are responsible to create the new research area *mobiligence* to show the enormous potentials of constructive and systematic approach by tight collaboration among biological and engineering research scientists. The planned research groups studies the following specific subjects:

Group A: Understanding the mechanism on adaptive cognition for environmental change, especially in such as reaching movements of a human;

Group B: Understanding the mechanism on physical adaptation of the body motion to the

indefinite environment, especially in such as locomotion of a monkey;

Group C: Understanding the mechanism on socially adaptive behaviors, especially in such as fighting behaviors between male crickets; and

Group D: Elucidating the common principle from the viewpoint of balance dynamics, especially in passive walking of a human, and modular collective behaviors of amoeba.

In addition to the 10 research themes of the planned research groups, we accepted 29 research themes for applied research groups in the term of 2006-2007. In the *mobiligence* project, various types of collaborations have been emerged among researchers in the planned and applied research groups.

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
- [2] Proceedings of 1st international symposium on mobiligence, Sapporo, Japan, Dec. 2005.

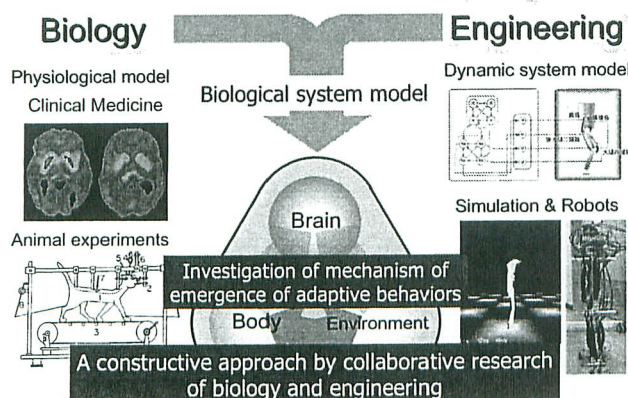


Fig. 1 Framework of the *Mobiligence* Project

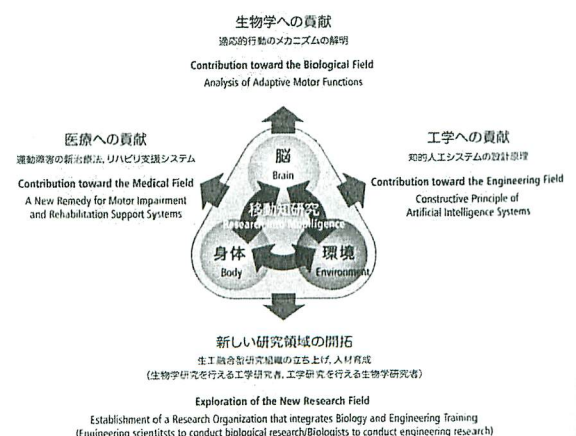


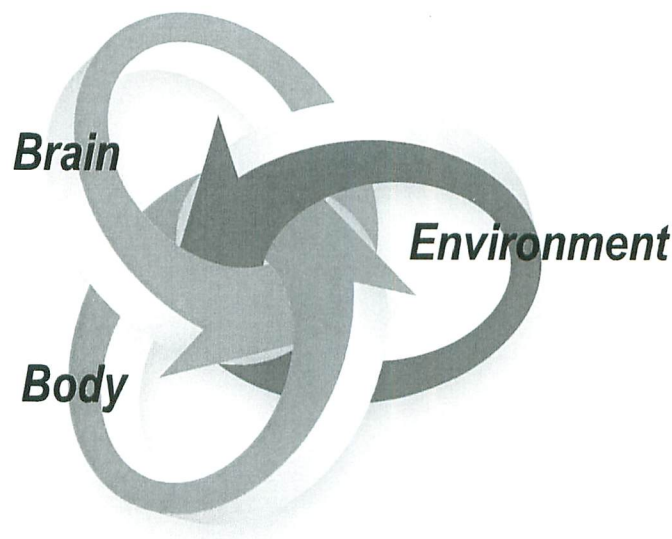
Fig. 2 Expected Impact of the *Mobiligence* Project

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