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

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1. Introduction

The *Mobiligence* program is a five-year program 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). This paper introduces the concept of the *mobiligence*, and presents the overview, objectives, and approaches of the program.

2. Objective of the *Mobiligence* program

Human, animals, or even insects have function to behave adaptively even in diverse and complex environment, 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.

The objective of the *mobiligence* program is to understand the mechanism on how the adaptive behaviors of the biological systems are generated.

3. Concept of the *Mobiligence*

Such an adaptive function is considered to emerge from the interaction of the body, brain, and environment, which is caused by motion or action of the subject. The environmental information which the subject can obtain is quite limited in the static condition. However, once the subject starts to move or act, the signals to move its body are transmitted from the brain to the body, and the interaction between the body and environment is generated due to the motion or action, and the rich environmental information can be acquired dynamically. From this consideration, we suggest a working hypothesis that the adaptive function is considered to emerge from the interaction among the body, brain and environment, which requires motions or actions of the subject, and name this concept *mobiligece*, which stands for intelligence emerged from mobility.

The information which can be acquired by motions or actions are;

1. diverse information by existing in various locations
2. dynamical information, and
3. experience.

4. Research Approach in the *Mobiligence* program

A large amount of knowledge and findings on function and mechanisms of various neural networks and neural modulator has been obtained so far by the biological research represented by neurophysiology. However, the most of such knowledge was obtained based on animal experiments. The animal experiments can be made in the condition that the body is fixed. In such conventional analytical approach in the biology, the observation is quite limited to the measurement of the simple brain function in stationary state, and function on interaction between brain, body, and environment in dynamic state is difficult to observe.

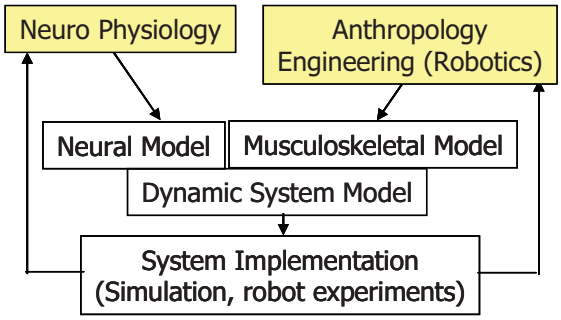
To overcome the problem, a new approach was adopted in the *mobiligence* research. The physiological models or hypotheses can be made from the knowledge obtained by biological studies such as clinical medicine and animal experiments. With the physiological models or hypotheses, the biological models can be derived by integrating engineering technologies and methodologies, such as dynamical system modeling. The biological models or hypotheses can be implemented on a simulator and actual robot systems, and can be verified by realizing the adaptive functions. The biological models can also be constructed by integrating biological elements and mechatronic elements to construct bio-machine hybrid systems.

Such a research approach to understand the mechanisms of emergence of adaptive behaviors can be called a constructive approach by close collaborative research of biology and engineering.

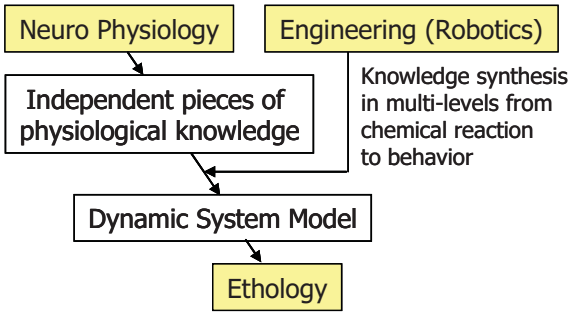
In the *mobiligence* program, three types of methodologies of collaborative research of biology and engineering;

1. system Biomechanics
2. synthetic Neuroethology, and
3. brain machine integrated system.

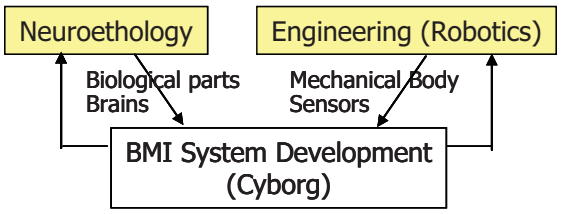
The schematic concept of the methodologies is shown in figure 1.



(a) System Biomechanics



(b) Synthetic Neuroethology



(c) Brain Machine Integrated System

Fig. 1 Methodologies for collaborative research

5. Research Groups of the *Mobiligence* program

The *mobiligence* program focuses on three aspects of the mechanisms generating adaptive behaviors:

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.

Group A: Adaptation to environmental change
discusses investigation of mechanism to generate the information based on cognition of the environmental change

Group B: Physical adaptation
discusses investigation of mechanism to change and control the body according to the environment

Group C: Social adaptation
discusses investigation of mechanism to select the behaviors adaptively to other agents and society

While the three groups investigate the specific adaptive behaviors of various biological systems, it is required to seek for the common principle, which underlies the mechanisms to generate the various types of specific adaptive behaviors. The fourth group was organized to investigate the common principle of the *mobiligence*:

Group D: Social adaptation
discusses investigation of common principle on dynamics in generating adaptive behaviors

6. Expected Impact of the *Mobiligence* Program

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.

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References

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