Chapter 1: Organism and Machine

There are variety of interactions between organism and machine. Mechanical engineering makes a bridge between organism and machine. In this chapter, we study on interdisciplinary study fields between organism and machine, comparing organism and machine.

1.1 Character of Organism and Machine

In the history of technology, organism inspires machines, and comprehension of organism by mechanical engineering inspires prostheses (**Fig. 1.1**).

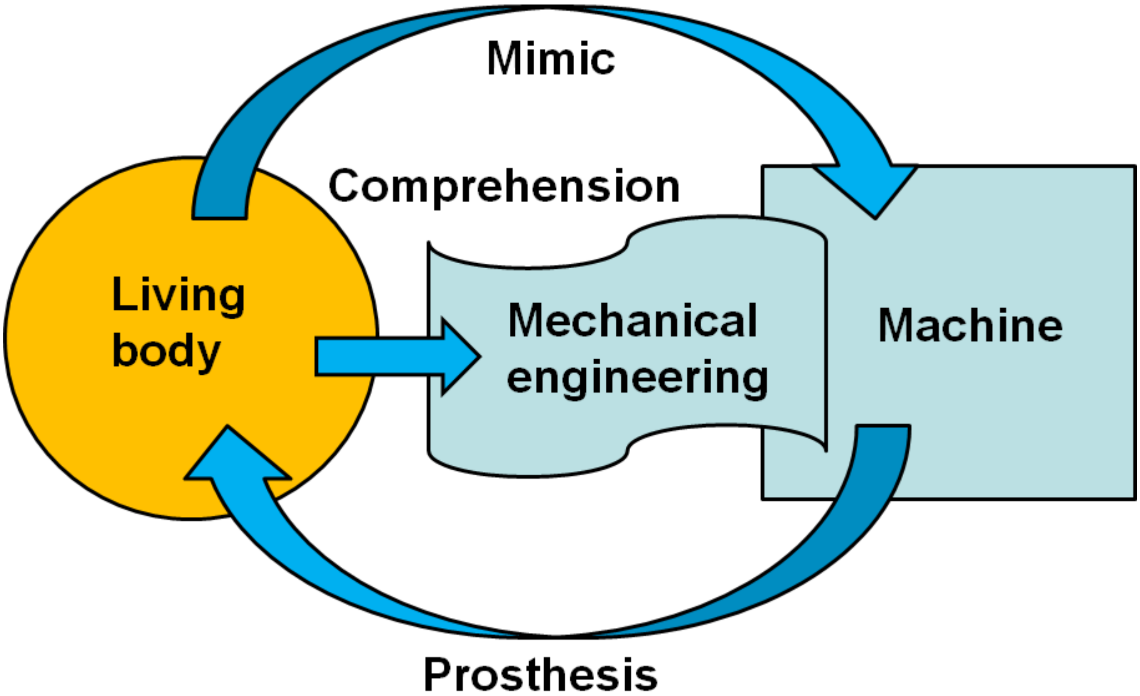

Fig. 1.1: Living body and machine.

A **machine** consists of multiple elements. Forms, materials, energy sources, methods for conversion and transmission of energy, and the way how to control its movement should be designed (**Fig. 1.2**).

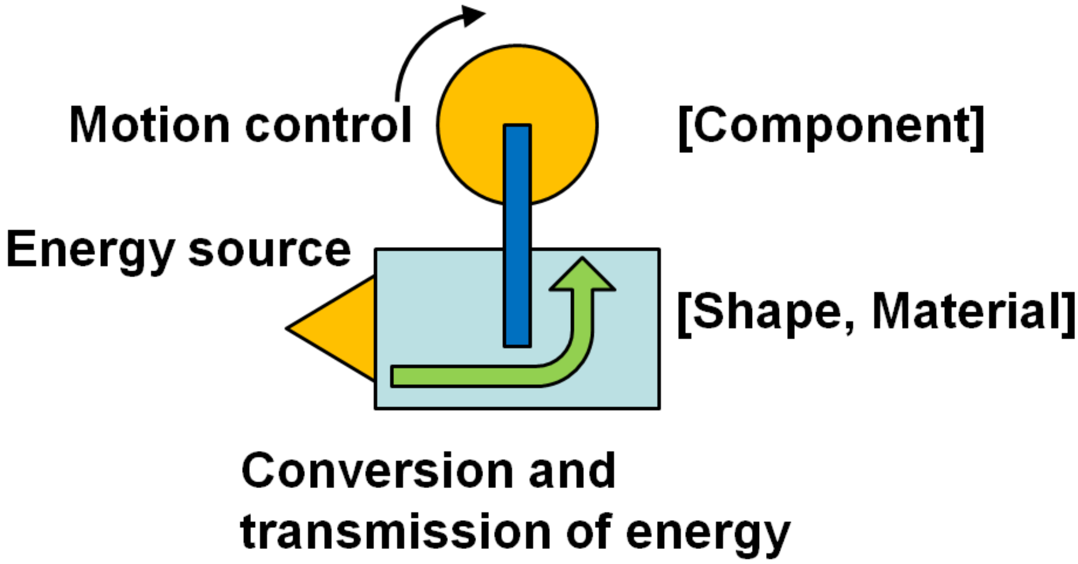

Fig. 1.2: Character of machine.

Think about a blood pump, for example. It consists of a casing, an impeller, and an electric motor. Each element is made of metal, plastics, or other materials. Electrical energy is converted into mechanical energy by an electric motor. An impeller rotates in a casing. A blood is drawn into the center of the impeller, and impelled to the circumference of the impeller by the centrifugal effect (**Fig. 1.3**).

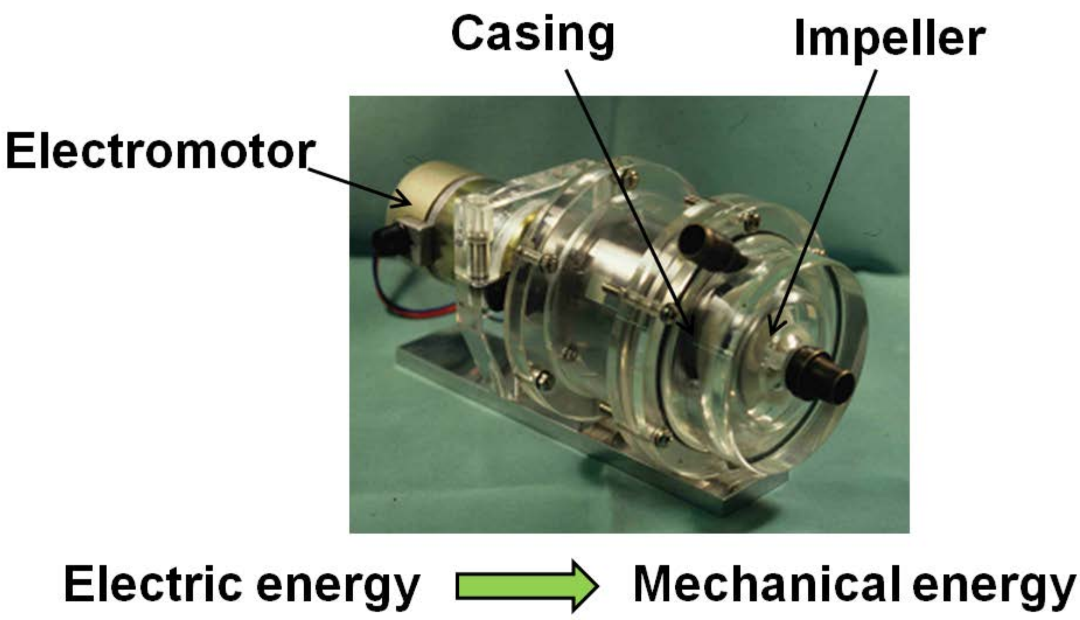

Fig. 1.3: Centrifugal pump.

Engineering is a discipline to design an object. The object is not limited to an artificial work, but is extended to natural circumferences or social systems. Engineering includes engineering for materials, chemical engineering, mechanical engineering, electric engineering, electronics, and civil engineering. Engineering includes architecture in Japan. Engineering includes a lot of new fields such as control engineering, systems engineering, information technology, social engineering, human engineering, environmental engineering, biotechnology, and design engineering.

Mechanical engineering designs machines. You study how to **design** a machine, how to make a machine, and how to move a machine. You create a new way to move a machine. You create a new machine.

You define a **force**, which makes deformation or movement. You study **dynamics of machinery**, **strength of materials**, **thermodynamics**, and **fluid dynamics**. A force also works between objects. A force is categorized to several groups: an electrical force between electric charges, a magnetic force between magnetic charges, a universal gravitation, a Van der Waals force, and a nuclear force.

Instead of a counter object, you can define a force **field**, such as a gravitational field, an electrical field, and a magnetic field. An object falls from the high level to the low level at the surface of the earth. You can define a gravitational force along the gravitational field without definition of the counter object “the earth”.

An **organism** is analogous to a machine, from the perspective that it consists of multiple elements, and moves with consumption of the energy. The organism takes and evacuates materials in the environment. The organism moves, converting a chemical energy to electrical and mechanical types of energy (**Fig. 1.4**).

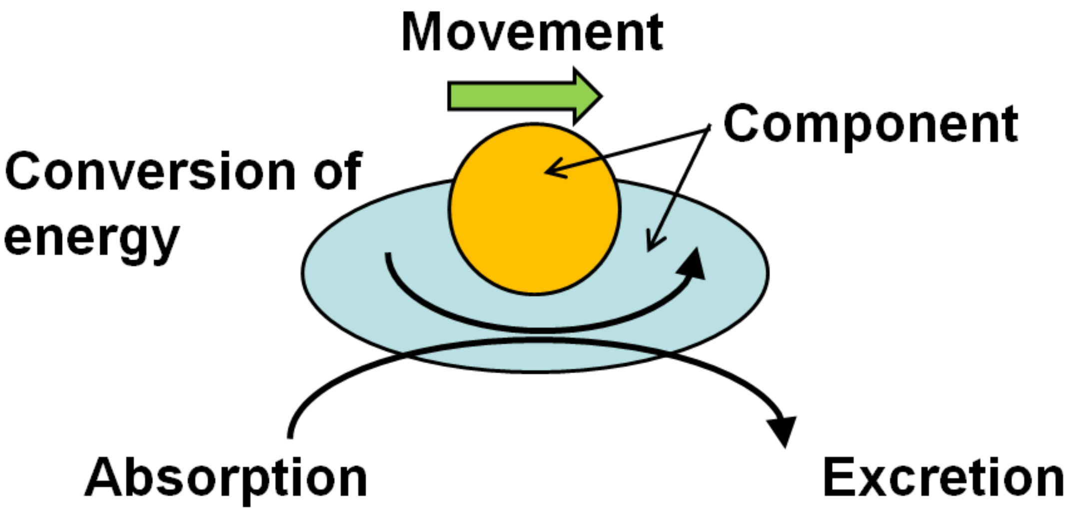

Fig. 1.4: Character of organism.

The movement of the machine has been designed beforehand. The movement of the organism, on the other hand, is the results of learning. The machine is designed to realize stability. The organism, on the other hand, keeps variation, and adapts to the environment (**Fig. 1.5**).

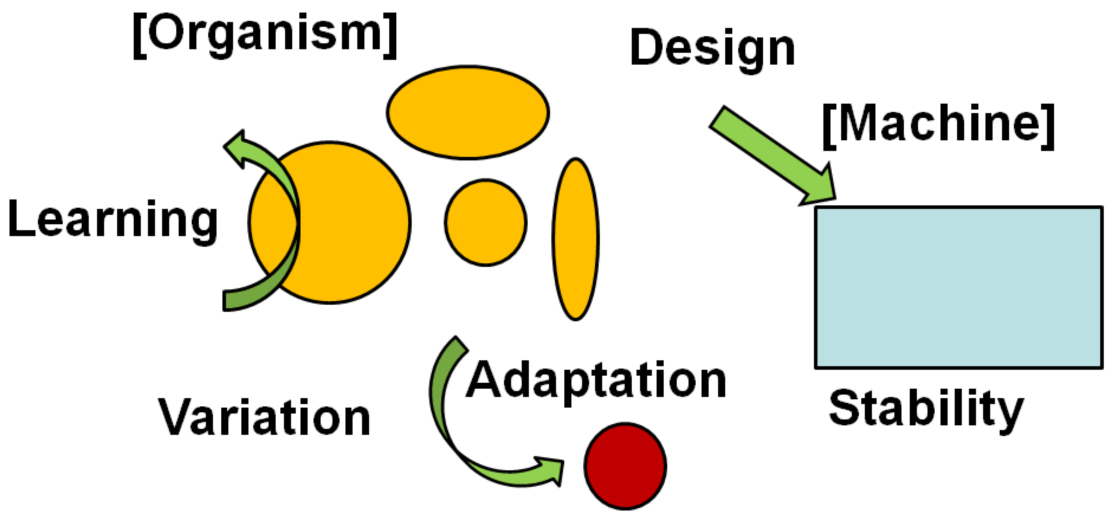

Fig. 1.5: Difference between organism and machine.

A new machine is designed as an imitation of an organism: biomimetics. A **robot** is designed to imitate the movement of a human: humanoid. A machine realizes a super movement beyond a human.

A **surgical robot** realizes the super movement beyond the human operator, and new way for the surgical operation. A continuous rotation, a fine movement, and a stable movement for a long time are applied to the robotic operation. It is possible for the robot to go behind the tissue, and suture continuously.

Some machines are designed to assist movement or function of the organism. The machine compensates the defect of the organism, or substitutes the function of the organism.

A **powered exoskeleton** helps human to enlarge the power to sustain a heavy load. It also supports the movement of the handicapped muscle. A nursing robot helps not only a nurse, but also a handicapped. Machines help the daily activity for the human.

A **membrane oxygenator** takes oxygen and evacuates carbon dioxide. It assists the gas exchange of the lung (see 5.3.1). A circulatory assist pump conveys the blood from the vein to the artery to help the heart.

1.2 Interdisciplinary field of study

The conventional machine deals macroscopic materials, so that it is designed to be homogeneous and uniform. The homogeneous material and the steady temperature are applied during the experiment on the machine.

The organism, on the other hand, has **individuality**. The organism can change every time such as growing or aging. Thus, **statistics** is useful to describe the behavior of organism (**Fig. 1.6**). The mean value is calculated, after the same protocol is repeatedly applied to collect enough number of samples in the study on the organism.

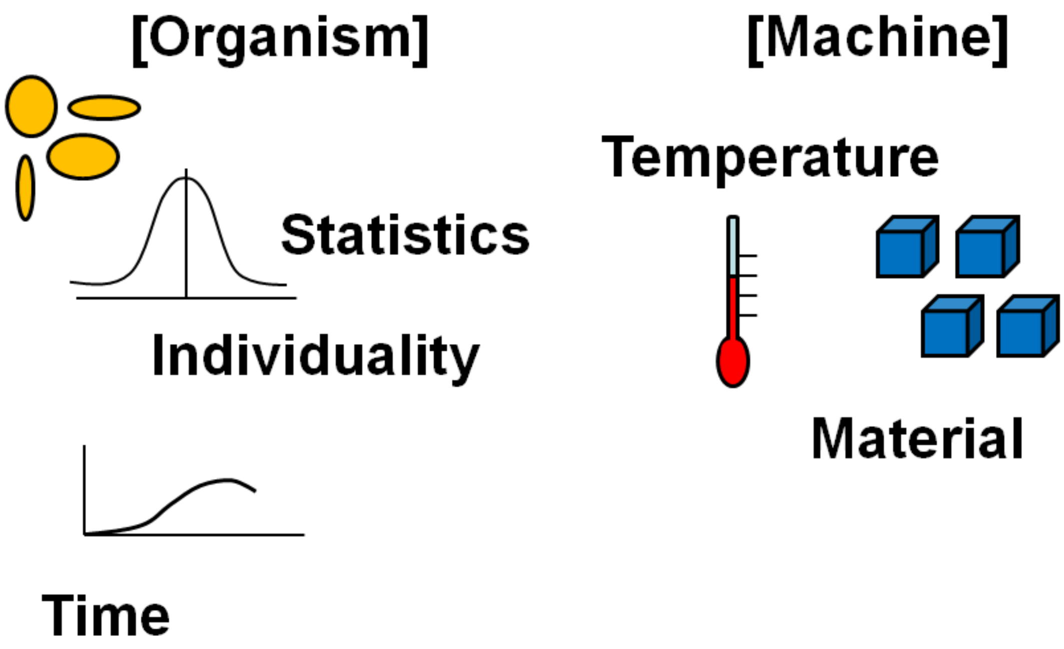

Fig. 1.6: Individuality and homogenization.

The statistic description is also useful to a non-organic objective. To describe the behavior of the material in the atomic level in the material, statistics is applied. The radiation intensity released from radioactive material per unit time distributes around the mean value.

Idea beyond the barrier is necessary in the multidisciplinary study. You had better leave the internal way of thinking in a discipline. The traditional law disturbs the innovation.

Technical terms and **law**s have different definition in each special field of study. “**Control**” means adjustment or regulation in engineering. “Control” means, on the other hand, reference for comparison in biology (**Fig. 1.7**).

You should observe everything carefully without prejudice, when you learn a new special field of study. Learning a new special field of study is similar to learning a foreign language [1]. You need to learn the background of culture, communicate with the new field.

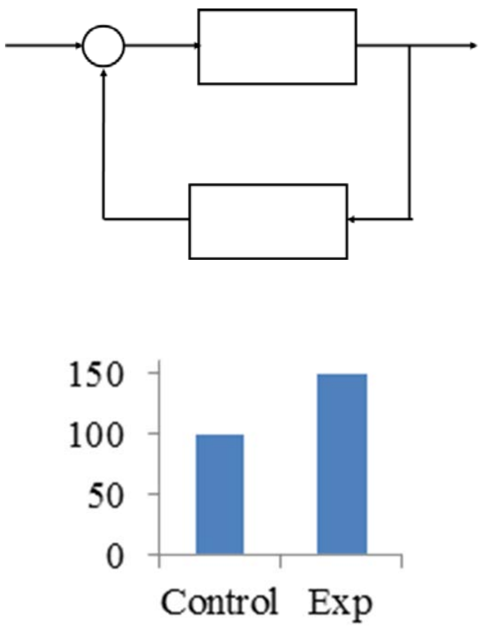

Fig. 1.7: Control?

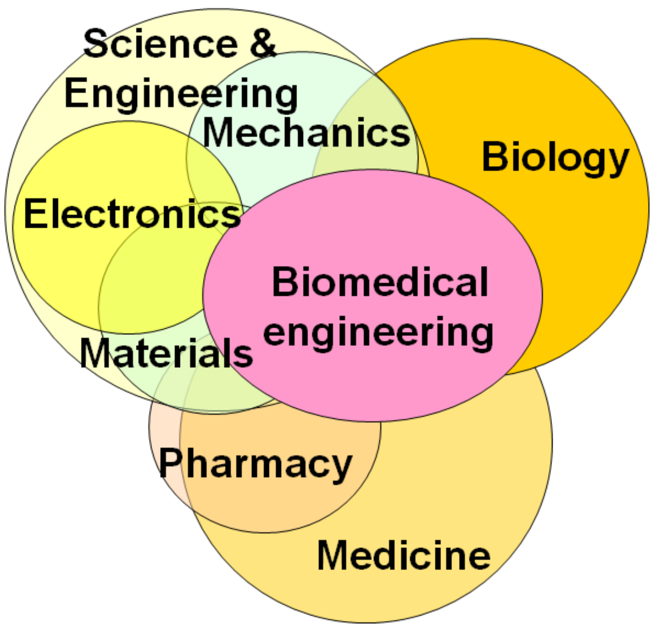

Fig. 1.8: Biomedical engineering field.

Biomechanical Engineering is multidisciplinary area, which is connected with Mechanical Engineering, Electronics, Materials, Biology, Medicine, Pharmacology (**Fig. 1.8**). You should learn directly each new field, when you challenge to make new bridging field of study.

Think about an **artificial heart**. When you focus on the pumping action of the heart, you will design a blood pump. You apply electric engineering to design the electric driving system. Materials are useful to design durability of the parts. Medicine gives you knowledge of the function of the heart.

The curriculum has not been established for the multidisciplinary field of study. In the curriculum of the interdisciplinary study, the relation between subjects is hard to be understood for the students. The learning story is not easy as a traditional curriculum of a discipline. A new idea, on the other hand, can be created in the trial to connect disciplines.

In a **bridge curriculum**, a guide, who experienced multi-disciplines, introduces the relation between subjects (**Fig. 1.9**) [2]. For example, the principle of the measurement of the electrocardiogram is lectured in the measurement engineering, and the physiological and clinical aspects are lectured in the introduction of medicine. The guide applies the learning experience in the multidisciplinary special fields of study to the bridge curriculum.

"**Biomechanics**" is interdisciplinary field of study located between biology and mechanics. Several multidisciplinary fields of study have been developed. "**Biorheology**" is interdisciplinary field of study located between biology and flow. "**Biomaterials**" is interdisciplinary field of study located between biology and materials. "**Bioelectronics**" is interdisciplinary field of study located between biology and electronics.

When you are touching another discipline with a curiosity and with a deep insight, you are going to break through the shell of the traditional field, and to open a new field.

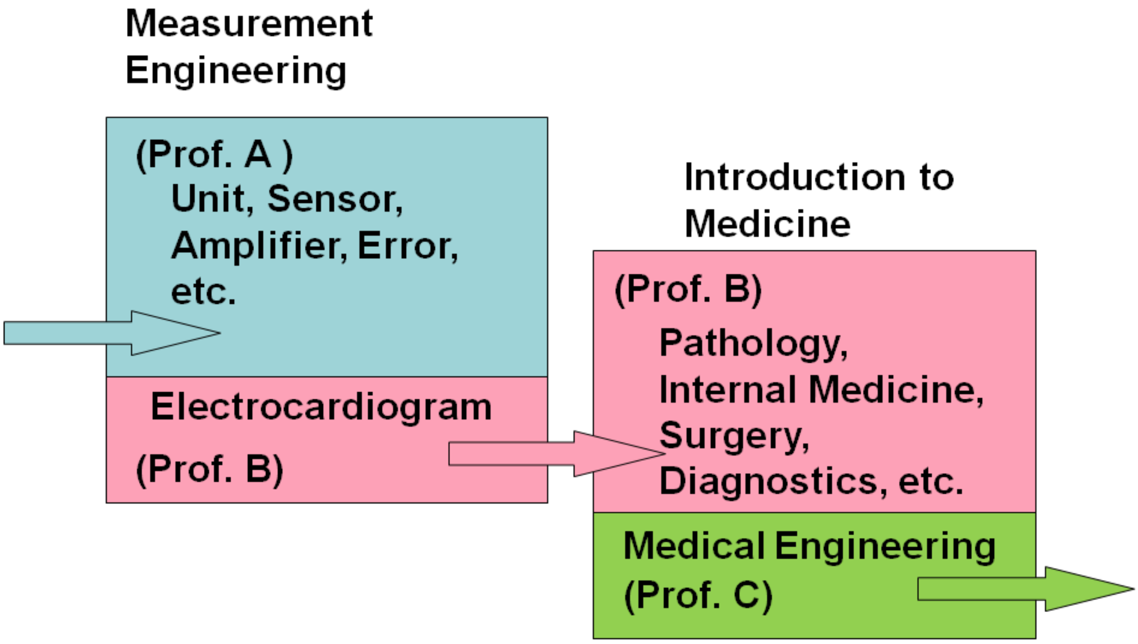

Fig. 1.9: Bridge Curriculum.

Questions

Q 1.1: Classify following into machine and non-machine. Explain the reason.

Paper Airplane, Computer, Optical Microscope, Electron Microscope, Earphones, A Walking Stick, A Leg Prosthesis, A Bicycle, Stairs, An Escalator, An Illumination, Sensor Light, Printer, Shape Memory Alloy, Biological Cell, Human with an Artificial Organ.

Q 1.2: Explain about relation between mechanical engineering and surrounding field. Explain about interdisciplinary technology with examples.

Q 1.3: Explain about a technical term, which has different meaning.