

OVERVIEW OF BIOMEDICAL ENGINEERING

Biomedical Engineering (BME) is an engineering discipline which develops and applies methods and tools for further understanding of life processes and for providing better health care. It is a multidisciplinary activity which involves collaboration between engineers and life scientists from almost all specialties. It utilizes almost all areas of engineering expertise to solve problems of medicine and biology. However, it has now reached a stage of development in which it has its own unique concepts and methodologies, and it also has its own unique study areas.

BME activities may be overviewed with the following subdivisions:

- Bioengineering,
- Medical Engineering, and
- Clinical Engineering.

Bioengineering deals with the fundamentals of BME and comprises the activities undertaken in academic and research institutions. Medical Engineering is applied BME in the industrial world. Clinical engineering is BME as applied in hospitals and other health care facilities.

Bioengineering

Bioengineering aims at understanding life processes using methods and tools of modern engineering. In many situations it develops new engineering techniques and theory to tackle the specific problems of medicine and biology. It needs to do this because the peculiarities of the non-man-made processes of life often necessitate the development new novel approaches.

Out of the many concepts and methods of modern engineering, BME has most beneficially used System Theory as its core approach to the understanding of life processes. In this approach, life processes are viewed as made of sub-blocks each described by their inputs, outputs, and block properties. Mathematical models are used for the descriptions of the interior workings of the sub-blocks. Thus the dynamic interactions of the sub-blocks are analyzed and described using a mathematical (and of course quantitative) formalism. Computers are used to simulate these interactions. This quantitative systems approach to biology on the other hand has its own difficulties because life processes are often

- complex,
- non-linear,
- time-varying,
- adaptive,
- redundant,
- non-isotropic,
- non-homogeneous,
- non-Newtonian, and
- have statistical (inter-individual and inter-species) variation.

Mathematical models of life processes are not only used for further quantitative understanding and description, but they are also used for diagnosis. The techniques of parameter estimation, by which values of the parameters of a model are estimated from measured input-output data, may be used for diagnosis because each parameter of a model corresponds to a particular

property of the system. Thus parameter values out of the normal range indicate pathology and disease.

In order to quantitatively monitor the input-output signals of a life process, one needs sophisticated measurement methods. Often these methods, as applied to biological systems, are difficult to implement because a biological measurement method must be non-invasive and in-vivo. In vivo measurement means measuring a variable in the intact and live biological organism. Non-invasive means making the measurement without invading the intact organism because often invasion alters the variable to be measured in addition to possibly harming the organism.

Biomedical measurements may be in the form of the measurement of the time dependence of various variables, or they may be in the form of measuring the spatial distribution of a certain variable. The former is the area of biomedical signals and measurement, and the latter brings us to the field of medical imaging. Use of x-rays, ultrasound, infrared light, microwaves, magnetic resonance, and radioisotopes are only some of the approaches to medical imaging.

Again, one of the challenges of bioengineering is to deal with biological materials which are usually complex, composite, non-homogeneous, non-isotropic, etc. Study of bio-materials, as well as design and manufacturing of artificial bio-materials are fast growing areas of bioengineering.

Medical Engineering

Medical engineering develops methodology and technology to achieve advancement in the delivery of health care. Medical engineers' proper place to work is the industry. Medical engineers, unlike their counterparts in traditional disciplines, must be sensitive to concepts such as non-invasive sensing and testing with tolerances. They must realize that their designs must be within very strict safety standards. Medical engineers work in the areas of

- biomaterials,
- transducers,
- monitoring and measuring devices,
- diagnostic instruments,
- therapeutic instruments,
- artificial organs,
- aides for the disabled,
- medical imaging systems,
- and others.

Clinical Engineering

Application of BME tools, techniques, and devices in hospitals, other health care organizations, and at home often require dedication and expertise. Therefore we see increasingly more involvement of biomedical engineers at the sites of health delivery. Economic and efficient use of medical technology is the purpose. In particular biomedical engineers undertake the following duties in a hospital for example:

- Repair, maintenance, and calibration of medical devices and instruments
- Development of equipment inventory and documentation

- Development of a safety testing program and procedures
- Installation and planning of new technology, including information technology
- Development of standards and procedures for the use of medical technology
- Development of standards and procedures for the purchasing of medical technology
- Collaboration with health care personnel for the application of new technology
- Getting involved in collaborative research in hospitals where quantitative and mathematical procedures are needed

In major hospitals and health related regulatory government organizations, clinical engineering centers are established where biomedical engineers are employed.