The Importance of Clarifying the Classification of the Origin of Medical-Biological Signals When Teaching Biomedical Engineering Courses to Students

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A B S T R A C T

Biomedical engineering is the branch of medical science that studies the human body, its structure and function in normal and diseased states, and its diseases and treatments. Biomedical engineers design prosthetic limbs and artificial organs and the materials from which they are made. They develop software used to operate medical devices. Like those working in other engineering disciplines, they use their knowledge of science and mathematics, but combine it with their knowledge of medicine. This article discusses the importance of explaining the origin of medical and biological signals in teaching biomedical engineering courses to students.

A R T I C L E I N F O

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Introduction: Biomedical Engineering is a dynamic field that combines engineering principles with medical and biological sciences to create innovative healthcare solutions. This field explores the fundamental role of device and material manufacturing in the advancement of biomedical engineering, with a focus on adaptability, precision, materials selection, quality control, and innovation. It emphasizes the interdisciplinary knowledge required by a biomedical engineer, including an understanding of natural sciences, manufacturing technologies, and biological processes. In addition, the diverse applications of biomedical engineering in the medical field, from cardiovascular systems to cancer technologies, are particularly important, and the importance of biomedical devices for the diagnosis, treatment, and prevention of human diseases is significant.

Currently, one of the urgent tasks in the field of modern medicine, household appliances and electronics is to train specialists with the skills to distinguish and work with devices and technical means that require priority attention in the production, design and repair of equipment, devices and equipment. This is important for studying, researching, diagnosing and analyzing life-biological processes and obtaining accurate evidence. When creating various medical and biological devices, equipment and complexes, it is necessary to correctly process the signals and information entering them, visualize them, and bring them into a form that meets the necessary and world standards. Therefore, specialists working in this field must have modern scientific knowledge and skills. Specialists with a bachelor's degree working in various fields such as biomedical engineering, instrumentation, diagnostics must know the areas of analysis and processing of biomedical signals presented in this program and apply them in practice.

Discussion: Biomedical signal processing is a rapidly developing field. In particular, biomedical data processing plays an important role in biological research and medical practice. In the developed world, some imaging techniques are now widely used, which can be used to detect disease and provide diagnostic information.

The purpose of the course is to participate in the development and creation of new medical diagnostic systems, design and development of special medical measurement transducers, create software for automated primary processing of biomedical signals using algorithmic and mathematical methods, develop medical and technical requirements, develop new and existing medical devices and systems, projects, applications and develop methods for their testing. It is desirable that students develop skills and qualifications in the following areas of activity during the course of study:

- classification and physical nature of biomedical signals;
- computational methods and medical-technical justification for the selection of methods for analyzing biomedical signals;
- mathematical processing of signals from primary measurement transducers using modern methods of signal analysis and transformation;
- processing of large amounts of data using automated computers;
- digital spectral analysis;
- analysis and synthesis of digital filters and functional signal processing units;
- continuous transmission of primary signals to processing and analysis tools;
- General principles of automated analysis of medical and biological data;
- development of functional units and algorithmic tools of modern medical systems;
- calculation of the main characteristics of biomedical signals;
- rational coordination of the characteristics of biological objects with the parameters of technical communication;
- Develop key technical tasks for research, development, design and modeling of algorithms and medical devices.

General classification of signals: deterministic and random signals; analog, discrete, quantum and digital signals.

A signal (in information and communication theory) is a material information carrier used to transmit messages in a communication system. A signal can be generated, but unlike a message, which must be received by the receiver, it does not have to be received, otherwise it is not a message. A signal can be any physical process, the parameters of which change in accordance with the transmitted message.

A deterministic or random signal is characterized by a mathematical model, a function that describes the change in signal parameters. The mathematical model of representing a signal as a function of time is a fundamental concept in theoretical radio engineering, which has become effective for the analysis and synthesis of radio engineering devices and systems. In relay protection and automation tasks, a signal always means a dependence of current, voltage, power, frequency only on time.

Classification of signals

1. by the physical nature of the information carrier:

- electricity;
- electromagnetic;
- optical;
- acoustic;
- and so on.

2. by the method of setting the alarm:

- regular (deterministic) given by an analytic function;
- irregular (random) signals that take on arbitrary values at any time. The apparatus of probability

theory is used to describe such signals.

3. Depending on the function that describes the signal parameters, analog, discrete, quantized and digital signals are distinguished:

- continuous (analog), characterized by a continuous function;
- discrete, characterized by a function of samples taken at certain points in time;
- quantized by level;
- discrete signals quantized by level (digital).

In technical fields, it is very important to differentiate and understand signals depending on the function of the signal parameter.

Analog signal

Most signals are analog in nature, meaning they vary continuously over time and can take on any value within a given time interval. Analog signals are described by some mathematical function of time.

The sources of analog signals are, as a rule, physical processes and phenomena that are continuous in their dynamics of development over time, space, or any other independent variable, and the recorded signal resembles ("resembles") the process that generates it. The basic analog signal is a sine wave.

Analog signals are used in telephony, radio broadcasting, and television. Such a signal cannot be input into a computer and processed, because at any given time interval it has an infinite number of values, and an infinite number of bits is required to accurately (without error) represent its value. Therefore, an analog signal must be converted to represent a sequence of numbers with a certain number of bits.

Discrete signal

Nowadays, a discrete signal is often called digital. Many experts do not notice the difference between these two concepts and consider them synonymous, but it is worth clarifying what the difference is.

The process of converting an analog signal into a sequence of samples is called discretization, and the result of such a transformation is a discrete signal .

In signal processing in computing devices, its samples are represented in the form of binary numbers with a limited number of bits. As a result, the samples can only take on a limited number of values, and therefore, when the signal is represented, its rounding inevitably occurs .

The process of converting signal samples into numbers is called level quantization, and the resulting rounding errors are called quantization errors (or noise). A signal that is discrete in time and quantized in level is called a digital signal .

The combination of this concept with discrete can be explained by the fact that the bit depth of modern computer technologies is very large when it comes to working with decimal numbers in floating point format, so quantization errors are very small.

Comparison of analog and digital signals

When buying equipment, no one thinks about what types of signals are used in this or that device, and their environment and nature. But sometimes you still need to understand the concepts. It has long been clear that analog technologies are losing demand, because their use is irrational. In its place comes digital communication. You need to understand what it is about and what humanity is abandoning. In short, an analog signal is a method of transmitting information, which involves describing information by continuous functions of time. Basically, strictly speaking, the amplitude of oscillations can be equal to any value that lies within certain limits. Digital signal processing is characterized by discrete functions of time. In other words, the amplitude of oscillations of this method is equal to strictly defined values. Moving from theory to practice, it should be said that an analog signal is characterized by noise. There are no such problems with digital, since it successfully "smooths" them. Thanks to new technologies, this method of data transmission is able to independently restore all the original information without the intervention of a scientist. Speaking of television, we can say with confidence: analog transmission has long been obsolete. Most consumers are switching to a digital signal. The downside of the latter is that if any device can receive analog transmission, then a more modern method is only a special technique. Although the demand for the outdated method has long since fallen, nevertheless, such signals still cannot completely disappear from everyday life.

Noise and noise

For this type of measurement, when detecting signals carrying target information, signals that interfere simultaneously with the main signal - noise and interference of various natures - are recorded.

Noise also includes the distortion of useful signals under the influence of various destabilizing factors on measurement processes, for example, lightning discharges on electrical search measurement methods, etc. The separation of useful components from the total set of registered signals or the maximum suppression of noise and interference in the information signal while preserving its useful components is one of the main tasks of primary signal processing (results of observations).

The main sources of noise are:

1. magnetic field;
2. electric field;
3. radio waves;
4. combined voltage drop in a single conductor;
5. Microphone effect.

The magnetic field mainly affects inductive elements such as inductors, chokes or electrodynamic microphones. At high magnetic field intensities, it induces noise currents in the connecting wires, including in the power circuits of transistors and microcircuits.

By the nature of its effect on the elements of electronic equipment, the electric field is similar to the magnetic field, but unlike the magnetic field, it induces an electric voltage or noise potential.

Radio waves are inherently electromagnetic fields, so they can induce both currents and voltages in electronic circuits. This type of interference is the most difficult to combat, as high-frequency currents can penetrate deep into screening materials.

When current passes through an ohmic or inductive resistance, the voltage drops in it. In electronic devices, there are often powerful blocks or blocks with high noise and high sensitivity blocks at the same time. They usually operate from the same current source. However, the resistance of the case conductor, although small, has a resistance at which the voltage drop occurs. Since the same conductor is connected to a high-sensitivity block, noise can enter the output of this block. This means that the design of electrical circuits is usually subject to high requirements.

There are the following classes of medical electronic equipment:

1. Monitoring and diagnostic equipment. The purpose is to receive, transmit and record data reflecting the processes occurring in the human body (electrocardiographs, ultrasound diagnostic devices, X-ray machines), in the environment (gas air analyzers, aspirators, aerosol particle counters, fluorimeters).
2. Therapeutic (or physiotherapeutic) equipment. Purpose: for dosed exposure to the human body with various physical factors (electrosonography, myostimulation, cardiac stimulation) for therapeutic purposes.
3. Cybernetic electronic devices. Purpose: for processing, storage and automatic analysis of medical and biological data; for controlling human life processes; for automatic regulation of the state of the environment.

Summary: Biomedical signals and their properties Biomedical signals are physical manifestations of physiological processes of a living organism, which can be presented in a form convenient for measurement and processing by electronic means (for example, in the form of electrical voltage or current). Biosignal processing is carried out in order to identify biosignal characteristics that are informative from the point of view of medical diagnostics or to determine diagnostic indicators that can be calculated from biosignal parameters. According to the mechanism of formation, two main groups of biosignals can be distinguished:

Group 1 - biosignals associated with the formation of physical fields of biological origin in the body;

Group 2 - biosignals associated with changes in the physical properties of a biological tissue region under the influence of various physiological processes.

Biomedical signals are mainly used to diagnose or detect certain pathological or physiological conditions. In addition, these signals are used to analyze biological systems in healthcare.

Biomedical signals are the study of the physiological activity of organisms, from gene and protein sequences to nerve and heart rhythms to images of tissues and organs. Biomedical signal processing aims to extract important information from biomedical signals. Through biomedical signal processing, biologists can identify new information and doctors can monitor various diseases. Biomedical signals also carry information about the physical manifestations of physiological processes (events) of a living organism, making it possible to present them in a form convenient for processing using measurement and computational techniques.

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