

Barbara JUROSZEK¹⁾
Ewa DZIUBAN²⁾

**MEASUREMENT OF PROPERTIES OF BIOMEDICAL SUBJECT
- COGNITIVE TARGETS
FOR STUDENTS AT TECHNICAL UNIVERSITIES
IN WROCLAW AND RZESZÓW**

Authors compared courses related to biomedical measurements at Wrocław University of Technology, where they are a base of speciality education and at Rzeszów University of Technology, where they are merely a supplement on measurements of living organism for students of Metrology. This comparison revealed that there is a "canon" of the necessary and common knowledge offered to students.

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1. GENERAL CHARACTERISTIC OF BIOMEDICAL OBJECT

Human organism presents a tree structure (Fig. 1.A). As a result of hierarchy the organism task is energy transformation on all levels of the organism structure (Fig. 1.B).

The information and signal transmission are realised by the close order. Their identification is a natural goal of cognitive process necessary for its full knowledge and plays fundamental role in its diagnosis and therapy. In this article a man is the biomedical object. It is characterised by many phenomena and wide range of different parameters and considerably differs from technical objects [1, 2, 3]:

¹⁾ Division of Measuring and Medical Electronic Instruments, Faculty of Basic Problems of Technology, Wrocław University of Technology, Smoluchowskiego 19, 50 - 370 Wrocław, Poland, e-mail: barbara@pwr.wroc.pl

²⁾ Faculty of Electrical and Computer Engineering, Rzeszów University of Technology, W. Pola 2, 35 - 959 Rzeszów, Poland, e-mail: edziuban@prz.rzeszow.pl

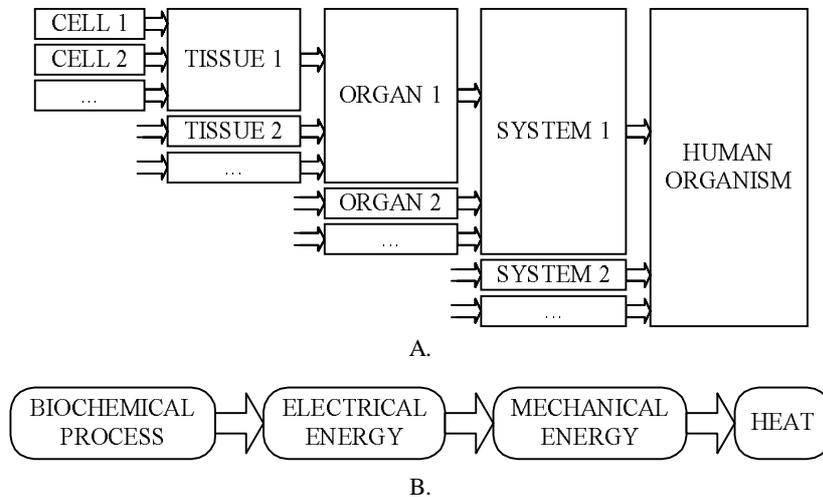


Fig. 1. A- anatomical tree structure of human organism. B- the stages of energy transformation during information transmission on different levels of organism structure

1. it is the system compound of many subsystems closely connected, where every steady-state disorder is compensated by other subsystem and for this reason it is inadmissible to disturb one subsystem functioning when the second is tested,
2. such complicated system makes it impossible to isolate anyone subsystem and testing it separately,
3. there exist many physical, chemical etc. Features which characterise every subsystem functioning which means that such an object is multiparameter,
4. it is impossible arbitrarily to make many tests during a very long time, because organism strongly changes its parameters and its features, depending on the measurable surrounding conditions and other unmeasurable influences (e.g. patient's disposition),
5. all biomedical signals are of low energy and their values are comparable to surrounding noises and disturbances, with almost the same frequency range. For this reason the object absolutely must be tested in isolation from such influences,
6. the time-constant component of a biomedical signal is very big, comparing to a very low level of the variable component, that gives the most substantial diagnostic information,
7. the man - the tested biomedical object - has a very important feature - intelligence, and for this reason he can generate himself a special state, where we can notice:
 - repeatable results,
 - special state of biological system, disclosing characteristic states of his organism and surprising organism changeability,
8. the natural biological changeability is characteristic of human organism,

9. during an object testing special requirements of electric safety must be strongly fulfilled.

2. THE WAY OF GENERATION BIOMEDICAL DIAGNOSTIC SIGNALS

Here, tested object is a biomedical object what means:

1. the PATIENT, as a **real existing material object**,
2. PHENOMENA COMPLEX bound with its existence.

The biomedical value is the measurable value. This is only one characteristic feature or complex of features. Sometimes they are important (measured values) for the object from measuring point of view, the other time - conditioning the state of measured value (i.e. influencing values).

Most of them change in time and are registered in a form of signals, important for medical diagnosis. These signals are of four types (Fig. 3):

1. spontaneous, existing independently of patient's will (e.g. ECG signal),
2. specially modified by the patient (e.g. forced expiration),
3. modified by an observer (ed. evoked brain potentials),
4. caused by an artificial factor (e.g. roentgenographic signal in densitometry).

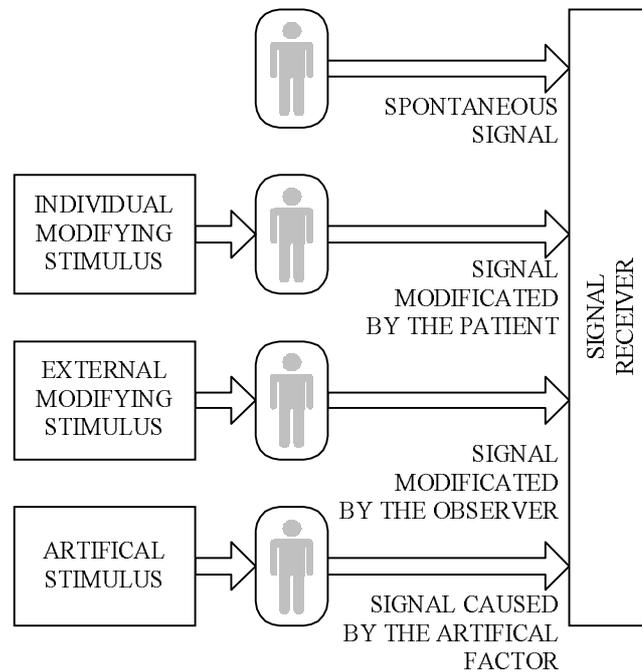


Fig. 3. The fundamental way of generation diagnostic signals in human organism

The signal is the answer of the object' properties changes and for this reason the measuring results interpretation is sometimes very difficult. The standardisation of this signal is possible only in some cases (see point 3 and 4, above).

3. THE STRUCTURE OF THE COGNITIVE PROCESS OF BIOMEDICAL OBJECT

The diagnostic medical instrument must compare the unknown measured value with a standard value. This operation is performed twice (Fig. 4).

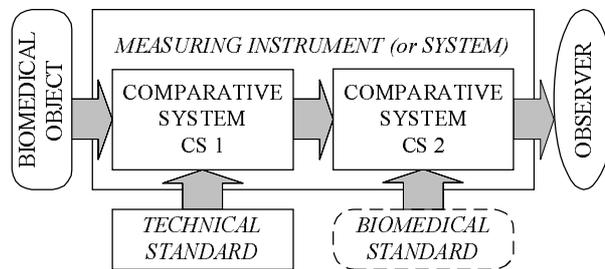


Fig. 4. Measuring structure for biomedical object

The first time with using a technical (reference) standard (e.g. of voltage, pressure) and the second - with a biological standard existing as a predicted value (e.g. predicted ECG signal parameters (Δt , ΔV)).

The quality of technical standard is usually known with a high precision. The definition of biomedical standard causes many problems

4. TECHNICAL REQUIREMENTS ON MEDICAL EQUIPMENT

The measuring instruments used in biomedical object diagnosis must fulfill special requirements that are the result of its characteristic features. They are:

1. minimal power consumption from a tested object,
2. necessity of isolation of the useful signal from the environment which gives a very big level of noises and disturbances,
3. a non-invasive method of the object's features registration,
4. undisturbing one biomedical system operation while testing of another one,
5. absolute assurance of electrical safety,
6. necessity of referring all results to standard, that is medical predicted value.

We don't need such requirements during the technical object' testing.

5. SOURCES OF ERRORS

During measurement of parameters, properties and appearances of biomedical subject the following causes of uncertainties and errors may occur:

1. indirect method of measurement, where resulting error depends on the definition preciseness of other component quantities,
2. sensor of biomedical quantity,
3. natural biological changeability of subject which shows that single measurement is only the realisation of a random variable,
4. rejection of interfering frequency may eliminate this frequency from useful biomedical too, hence distortion and loss of information may result,
5. insufficient collaboration of patient during tests,
6. medical standards with their uncertainty,
7. instruments calibration method basing on simulation of a patient' features and properties,
8. biomedical signal processing, but these procedures have appropriate precision and errors are negligible in comparison with errors mentioned above.

6. COGNITIVE TARGETS

Taking into account the properties of the biomedical subject, origin of both diagnostic and test signals, sources of errors and hazard of electrical shock and microshock it is possible to term the objectives of the teaching program. They should build a pattern program of lectures on biomedical measurements. The objectives are:

1. electrical safety of medical devices,
2. collection of effective and reliable information of patient's state of health in presence of disturbances and interference signals,
3. generation of testing signals,
4. calibration,
5. quality control of medical devices,
6. computerisation.

7. COMPARISON OF PROGRAMS

The didactic program comparison was made on the basis of two programs presented of two universities: Wrocław University of Technology (WUT) and Rzeszów University of Technology (RUT). In the first „the medical instrumentation” subject is the basis lecture for students of Fundamental Problems of Technology Faculty, specialisation:

Biomedical Engineering. In the second - this is only a supplement of general education in the measuring field.

7.1. SITUATION AT WROCLAW TECHNICAL UNIVERSITY

At Wroclaw University of Technology “Electromedical instrumentation” takes place in the VII (Lecture 45 hours and Seminar 15 hours) and VIII (Laboratory Practice 60 hours) semester. It should direct students of Biomedical Engineering to applying their knowledge to the problems of diagnosis instrumentation.

Particular problems consider:

1. the metrological models of the biomedical object,
2. metrological parameters choosing and preciseness evaluation methods of electromedical instruments for multidimensional diagnostic signal,
3. the role of population tests in evaluation of metrological quality of electromedical diagnostic instrument.,
4. biomedical transducers: their metrological special operating conditions,
5. the conditions of biomedical object test, likelihood of its state evaluation and their influence on the medical diagnosis,
6. the types of naturally and artificially generated biomedical diagnostic signals, their repeatability,
7. biomedical diagnostic signals: parameters, randomness, spectrum,
8. biomedical signals in relation to noises and disturbances, the methods of their minimalization,
9. the instrument influence of the object quality evaluation - identification of patient - diagnostic instrument interaction.

7.2. SITUATION AT RZESZÓW UNIVERSITY OF TECHNOLOGY

At Rzeszów University of Technology lectures on “Medical Measurements” take place in the IX semester of speciality Metrology and Measurement Systems, faculty of Electrotechnics and Computer Science. They should direct students of electrical engineering to applying their knowledge to the problems of measurement and treatment in modern medical practice [4]. Actually biomedical oriented engineers first of all will provide the technical support for testing and overhaul existing measurement methods and procedures, safe use of medical equipment in the clinical environment and evaluation of new equipment. Apart from that engineers would educate the medical staff to help them understand new technologies and function of new equipment (for example ultrasound dopplers or nuclear magnetic resonance equipment actually in use) because it is being introduced despite increasing problems with the economy of health care in

Poland. In Rzeszów the subject named “Medical Measurements” consists of 30 h of lectures and 15 h of classes, that means it is merely a supplement for students of Metrology.

7.3. HOW COGNITIVE TARGETS ARE FULFILLED AT BOTH TECHNICAL UNIVERSITIES?

All metrological problems that arise during biomedical object testing are presented in different didactic forms - they interlace each other. Comparison of themes realised at both universities is presented in Table 1.

Table 1. Fulfillment of cognitive targets at both technical universities (L - lecture, S - seminar, C - class, LP - laboratory practice)

Objectives	1	2	3	4	5	6	7	8	9
WUT	L	L	L	L	L	L	L	L	L
				S	S			S	S
	LP	LP	LP		LP	LP	LP	LP	LP
RUT	L		L			L	L		
			C			C			C
1- electrical safety, 2- interferences, 3- collection of information, 4- new measuring methods in medicine, 5- budget of uncertainties in medical measurements, 6- testing signals, 7- calibration, 8- quality control, 9- computerisation.									

8. CONCLUSION

Wrocław Technical University offers a speciality in biomedical education for students while at Rzeszów University of Technology it is merely a supplement. The authors established the pattern of crucial themes in biomedical education and drew comparison resulting from it. It occurred, that more than a few similarities can be found between two programs existing in separate conditions and that the most significant difference lies in the number of hours dedicated to several themes. This comparison revealed that there is a “canon” of the necessary and common knowledge offered to students of Biomedical Engineering.

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