

Outlines of the lectures delivered at the colloquium on "Cybernetical and Computing Methods in Medicine and Biology"*

Data acquisition and processing in the physiological laboratory by means of hibrid computing techniques

I. MADARÁSZ, L. SZEKERES

One of the characteristic features of the modern physiological, pharmacological, cardiological etc. laboratories consists of the appearing of a great quantity of output data produced by the ever growing number of different automatically working devices. In order to obtain the relevant informations needed for the solution of the given physiological problem, the question of adapting an adequate and optimized laboratory-level computing system arises. Taking into consideration the actual instrumentation possibilities (the relative low level of automatization in the laboratories, the lack of the universal desk computers in the market, etc.) — *a semi-automatized laboratory data acquisition, storing and computing system is described*, characterized by the use of different analog, hibrid and digital elements. The system has been developed in the electro-physiological laboratory of the Department.

The input elements of the system are: analog tape recorders, sampling unit and low-speed digital tape recorder. Informations from both type of the tape recorders can be read into the ferrit core of a multichannel amplitude analyser either by direct access to the memory, or by means of different wired-program peripheral devices. These are: averaging unit, multiscaler, amplitude- and intervall histogram measuring unit, digital period-analyser for the processing of electroencephalograms, ECG-curves, etc. Another access to the ferrit core memory consists of a low-speed punch-tape reader. The outputs are: printer, tape puncher, digital-to-analog converter with oscilloscope and $X-Y$ plotter. The punch tapes can be used for different data processing purposes either in the laboratory or in a remote computing center, if needed.

DEPARTMENT OF PHYSIOLOGY, MEDICAL UNIVERSITY OF SZEGED

Telemetric transfer and processing of electrophysiological data

L. KELLÉNYI

Abstract not received.

DEPARTMENT OF PHYSIOLOGY, MEDICAL UNIVERSITY, PÉCS

* Authors' abstracts.

Automatic evaluation of capnograms

I. SZEKERES, L. MURÁNYI, J. MATIEVICS

In the course of diagnostic and therapeutic procedures for the quantitative measurement of disturbance of the gas exchange, a new procedure was developed based on the formal analysis of the exhaled air-CO₂ curve (capnogram). The capnograms are characterized by the ratio of the frontal slope and the plateau slope. With the aim of automatizing the mass evaluation of the curves, the authors constructed a digital-operated apparatus controlled by an analogue-digital converter; this measures the capnogram amplitude at 0.04 sec intervals, transforms the obtained values to digital ones and controls the tape-punching apparatus. This records the data on punched tape in an 8-bit binary code. It is possible to use two types of coding procedure: by means of manual keying the examination daily serial number and a few notes, and automatic punching of the code combinations necessary for the machine programme. This information is recorded at the middle of the final stage of the capnogram. The information formed from the analogue signal can be recorded on magnetophone tape and can be pre-selected with the help of an oscilloscope. By means of a digital-analogue converter, it is also possible to record the results of other laboratory measurement series. Using a machine programme, mass curve-evaluation and data-processing can be carried out by computer.

DEPARTMENT OF PEDIATRICS, MEDICAL UNIVERSITY;
CLINICAL PHARMACOLOGICAL RESEARCH GROUP OF THE NATIONAL PHARMACOLOGICAL INSTITUTE;
COMPUTING CENTRE OF THE MEDICAL UNIVERSITY, SZEGED

Computer analysis of McFee-Parungao vectorcardiograms

M. CSANÁDY, P. HUNYA, T. GAÁL, M. HÓGYE, I. SZÁNTAI

The authors compare the data of heart catheterisation of 59 patients with QRS loops of vectorcardiograms (VCG) made about at the same time, processing by computer concerning right ventricular hypertrophy. Three haemodynamic parameters were examined: the pressure of the right ventricle, the total pulmonary resistance and the pulmonary blood flow. McFee-Parungao vectorcardiographic system was used.

The best correlations were found between *the pressure of the right ventricle* and the following VCG parameters: 1) the azimuth of 3/8 instantaneously vector (0.498), 2) the azimuth of max. QRS vector (0.495).

Comparing *the total pulmonary resistance* with the VCG data, 1) the quantity of forward position of the loop (0.510), 2) the ratio of the forward and backward positions of the loop (0.471), — proved to be the best ones.

In comparison with *the pulmonary blood flow* we got the best correlations with the quantity of forward position of the loop (0.310).

These results show significant correlation between the haemodynamical data and the VCG parameters, though the correlation coefficients are not very fine. The electrocardiographic (ECG) data — which were thought to be the best ones among ECG parameters — did not show any significant correlation with the haemodynamical data.

1st MEDICAL CLINIC, MEDICAL UNIVERSITY;
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Investigation of the distribution of labeled phosphate in the course of the in vitro metabolism of erythrocytes by model analysis

L. LATZKOVITS, Cs. FAJSZI, I. SZENTISTVÁNYI

In the investigations presented the tracer kinetic model analysis of the in vitro phosphate metabolism of human erythrocytes has been performed. In the relatively short experiments applying Krebs-Ringer phosphate, only the acid-soluble phosphate compounds were labeled. Thus the closed system of the different phosphate pools could be represented by four compartments:

A: extracellular P_i

C: "acid-labile" phosphate

B: intracellular P_i

D: "acid-resistant" phosphate.

The amount of phosphate as well as the total- and specific activity were determined as functions of time in each of these compartments. For the model analysis the BRANSON equations were set up with the experimental data, according to each of the logically possible model variations including the four compartments, and were solved for rate values by applying a digital computer. Only one of the logically possible model variations proved to be able to provide real rate values. This model involves both P_i transport and exchange across the membrane as well as metabolic processes.

BRAIN RESEARCH INSTITUTE OF THE MEDICAL UNIVERSITY
BIOLOGICAL RESEARCH INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES, SZEGED

Application of cybernetical and computing methods for capillary circulation studies

Z. HANTÓŠ, P. HUNYA

Due to the structural features, the special flow relations in capillary systems can adequately be investigated by modelling procedures. Authors presented a theoretical model the construction of which is primarily directed towards the investigation of transmural fluid movements.

It is generally agreed that capillary filtration is determined by the hydrodynamic and oncotic pressure differences (Starling's theory). Transmural fluid movements produced by the pressure differences change the intravascular concentration and therefore the oncotic pressure of the plasma proteins. On the other hand, the hydrodynamic pressure is controlled by the changed viscosity.

A possible realization of the theoretical capillary model consists of non-linear differential equations the exact solutions of which are not known. Numerical methods were therefore applied to examine this model of distributed hydrodynamic parameters.

After constructing a lumped parameter model, the homogeneous units of the tube model can be considered as automata connected series to each other and parallel to the automaton representing the interstitial space.

Finally, a few results of the simulation and their possible physiological interpretation are presented.

LABORATORY OF CYBERNETICS, JÓZSEF ATTILA UNIVERSITY, SZEGED

**Application of correlation-functions in the analysis
of cardiovascular system**

E. MONOS, B. SZÜCS

The possibilities of application of correlation-functions in signal analysis and in dynamic system analysis were summarized. Using this techniques, the statistical features of some blood flow and pressure waves and their dynamic relationship were characterized quantitatively.

It was stated that pulsatile pressure changes can be regarded with a good approximation as stationary for a period of about 10 minutes. A well defined stochastic signal component could be detected on the pulsatile waves in most cases, the ratio of stochastic and periodic component however was much more smaller than in the case of the 3rd order pressure waves. By cross-correlation functions the velocity of pressure wave propagation was determined within a 1 msec limit. The dynamic relationship of arterial pressure changes and adrenal venous outflow could be well approximated with a transfer function of second order. The damping ratio of this system was always less than 1, which points to that oscillations could be manifested on the venous outflow.

EXPERIMENTAL RESEARCH DEPARTMENT, SEMMELWEIS MEDICAL UNIVERSITY;
DEPARTMENT OF AUTOMATION, UNIVERSITY OF TECHNOLOGY, BUDAPEST

**The use of the computers in medical diagnosis;
some practical guide for the clinicians**

R. SZABÓ

The physician's decisions in order to establish a diagnosis and to choose the optimal treatment can be easily simulated by a computer. But the computer can not substitute the physicians in collecting symptoms and signs, i.e. informations on the illness to be detected. The computer is unable also to check up the correctness of the diagnosis made by it.

The author discusses the conditions and pitfalls of collecting medical data, methodical problems of their feeding in the computer and in view of the physicians and patients enumerates some advantages resulting from the use of a computer.

2nd MEDICAL CLINIC, MEDICAL UNIVERSITY, SZEGED

**Use of computers in solving the diagnostic problems
of scintigraphic procedures**

L. CSERNAY, J. CSIRIK

Abstract not received.

1st MEDICAL CLINIC, MEDICAL UNIVERSITY, SZEGED

Computer simulation of the cerebellar cortex

A. PELLIONISZ

A computer simulation method is applied to the cerebellar neuronal circuit, giving an opportunity to study the activity of many neurons simultaneously. As a morphological basis a schematic connection chart is deduced from the original neural net. As a next step the network is additionally simplified by placing all the five types of cerebellar neurons into two-dimensional fields. The patterns of excited neurons at a particular instant are handled as matrices. The excitation-matrices are consecutively transformed and displayed by the computer. Two simulations are discussed in the paper; the first one contains about 60 000 neurons, giving an opportunity to get an insight into the possible activities of large neuronal fields and to test structuro-functional hypotheses of the cerebellar cortex. The second model aims at analyzing experimental field-potential recordings by simulating the possible excitation-patterns set up on the neuronal fields under experimental circumstances. In this manner the "pattern sensitive" feature of Golgi-inhibition, which seems electrophysiologically ununderstandable, can easily be explained. At the end software- and hardware problems of the neuronal simulation are discussed.

INSTITUTE OF ANATOMY, MEDICAL UNIVERSITY, BUDAPEST

An iterative method in the computer-aided scintigraphy

J. CSIRIK, L. CSERNAY

A method of processing the data of a home-made scintigraph (Scintikart-Numerik) by digital computerization is described. Technical possibilities of data processing are surveyed. Outline of the mathematical program is presented and the time needed for data processing is indicated. Results of the control phantom examinations are reported. This procedure improved the diagnostic possibilities of cold nodules with the size of 2—4 cm by 60—80 per cent.

1st MEDICAL CLINIC, MEDICAL UNIVERSITY, SZEGED

The modelling of human motor process

M. NEMESSURI, O. BIHARI, J. GALAMBOS, T. SZÁNTÓ, M. VADAY

Authors carried out the analysis of different motor actions as going, running, throwing, shooting and catching the ball, weight lifting and others. They used photokynography with normal, rapid and ultrarapid registration and EMG. They were searching for basic motor mechanisms respectively their reflections on EMG and photokynograms. The investigations suggest that the motor pattern of goal-directed movements is constructed from two elements: pulsion and traction. They are building the simple and complex movement patterns in extremely combined manner connected with each other parallel and in series.

HUNGARIAN INSTITUTE OF PHYSICAL EDUCATION, BUDAPEST

Some remarks on the mathematical modelling of diagnostic methods

I. GYÓRI

These notes give a mathematical formulation of the problems of diagnosis and differential diagnosis in medicine. The formulation of the problem is followed by descriptions of well-known diagnostic methods, one based on Bayes's theorem and another, invented by Bykovskii, based on an information theoretical model. If the symptoms considered are not independent, then the application of both methods becomes very cumbersome. Hence the author also describes a method that can conveniently be applied even in the case of interdependence of the symptoms, and which goes over into Bykovskii's method if the symptoms are independent.

COMPUTING CENTRE OF THE MEDICAL UNIVERSITY, SZEGED

Examination of the distribution of synaptical vesicles in the motor end-plate of striated muscle by mathematical methods

P. HUNYA, S. BENSE, P. NAGY, B. CSILLIK

A mathematical method for characterizing the distribution of synaptical vesicles in the ending of an axon is given. It is used to make a comparison between two classes of electron microscope pictures of the neuromuscular junction:

In the mathematical model a picture is given by an ordered group $A = A(G, g_1, g_2, f)$, where G is a region corresponding to the axon on the picture, g_1 and g_2 are curves representing two parts of the boundary of G (presynaptical membrane and the remainder part of the boundary). f is a real function of two variables which describes the distribution of the synaptical vesicles in G . The picture A is transformed into the point $M = (R, Q)$ of a two-dimensional space E^2 . The first component is defined as the ratio

$$R = \frac{c_1}{c_2},$$

where

$$c_i = \frac{\int_{g_i} \int_G \frac{f(p)}{d(p, q)} dp dq}{\int_G dx dy} \quad (i=1, 2)$$

expresses the accumulation of vesicles, at the membrane represented by g_i . (One can generalize the "measure" c_i based upon physical analogy in two directions, namely concerning the regions G , g_i and the dimensions of the pictures.) The second component shows the mean number of vesicles in G :

$$Q = \frac{\int_G f(x, y) dx dy}{\int_G dx dy}$$

Using the transformation given above, the two classes (stimulated and control classes) form two well separated regions in E^2 . The physiological interpretation of this result is finally discussed and the possibility of the wide-range application of the method is explained.

LABORATORY OF CYBERNETICS, JÓZSEF ATTILA UNIVERSITY;
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Computer analysis of evoked potentials

I. MÉSZÁRÓS, GY. IVÁNYI, Z. ZÁMORI

The mathematical analysis of evoked potentials is widely used in neurophysiological research. A new method, elaborated by the authors, makes possible data reduction by fitting Gauss-distribution curves upon measured data. Digitized responses are fed into the computer; the program fits the mathematical functions of positive and negative peaks through a defined number of iterations. The necessity of further iterations is controlled by the least-squares method. Results are printed and plotted as well, on the line-printer.

A second program enables the averaging of distinctly digitized evoked responses. Distribution of digitized values is displayed graphically and numerically upon each measured point of the averaged signal.

DEPARTMENT OF COMPARATIVE PHYSIOLOGY, EÖTVÖS LÓRÁND UNIVERSITY;
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A cybernetical program used for diagnostic purposes differentiating between various human colon diseases and those due to *Entameba histolytica*

G. PRÓNAY, P. HUNYA

Authors used for their investigations the experiences and data of 480 patients having a positive stool-sample concerning *Entameba histolytica*. With the help of probability methods using the Bayes-formula, as proposed by Ledley and Lusted, later modified by Wishnevsky and actually by one of the authors concerning the problems of their case-histories, authors tried to find differential diagnostic signs and syndromes with the help of which it would be more easy to differentiate between simple carrier-states and such clinical entities as irritable colon syndrome and idiopathic ulcerative proctocolitis combined with *Entameba histolytica* carrier-state and without it.

In their differential diagnostic program they made use of 13 diagnoses and 76 anamnestic data and physical signs, further on laboratory investigations. Authors suppose to have worked out — with the help of mathematical statistical methods — a better diagnostic procedure in detecting special syndrome-entities due to *Entameba histolytica*.

MUNICIPAL HOSPITAL, MISKOLC;
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Computing methods in medicine

A. GAÁL

In this paper the mathematical problems of medicine and biology, as well as the importance and possibility of development of biomathematics were shown.

Those parts of medicine are briefly described, in which the computers — being very useful technical instruments of our age — can help very much both the hospital attention and research.

We have demonstrated the most suitable group (team) for solving the problems in biology and medicine by an example.

We have mentioned some error and the work to do in our country; in organization.

MEDICAL UNIVERSITY, PÉCS

A model of receptors and receptor fields and their simulation by computer

A. TÖRÖK, P. HUNYA, CS. FAJSZI

Receptors transmitting the environmental changes may be examined like black boxes, at the input of which the stimulus, at the output the spike-series can be measured. The physical or chemical change of the environment is called the stimulus. The examinations were directed towards the problem of coding intensity of the information in the receptor as a function of the stimulus intensity.

Sense organs can be generally interpreted as sets of elementary microreceptors. A characteristic threshold-value called resting threshold is attributed to each microreceptor. These threshold-values follow a probability distribution pattern. It is known that a microreceptor reacts with firing only to an adequate external stimulus corresponding to, or exceeding the threshold value. This provides the sense organ i.e. the microreceptor with varying amounts of information depending on the intensity of the stimulus and the length of time.

The firing frequency depends on the intensity of the external stimulus and on the length of time. Mathematically one can approximately describe how the stimulus-threshold changes in time from the beginning of firing. This is called instantaneous threshold. With the help of this function we can explain the experimental fact that by changing the stimulus intensity also the frequency of the excitatory impulse burst is changed, i.e. according to which mathematical regularity is to be found in the change of the amount of information coded into an excitatory impulse burst by the instantaneous threshold of the microreceptors.

The functioning of the receptor was programmed on a computer at the Laboratory of Cybernetics, József Attila University. At the stimulation of the field the computer produced the distribution of stimulus-thresholds and examined the spike-series of each receptor.

DEPARTMENT OF PHYSIOLOGY, MEDICAL UNIVERSITY;
LABORATORY OF CYBERNETICS, JÓZSEF ATTILA UNIVERSITY;
BIOLOGICAL RESEARCH INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES, SZEGED

Computer aided EEG analysis by pattern recognition based on the auditive system

F. SEBESTYÉN

The subject of this paper is the simulation of the activity of the electroencephalographer, that is the computer-aided analysis of the EEG by pattern recognition. The EEG is unduely treated as a two-dimensional pattern by an algorithm based on visual perception. It seems to be more promising to apply algorithms based on the auditive system.

The sound pressure changing in time, impinging the auditive system shows, on an abstract context, close analogy to the biopotentials of EEG. Both of them are physical quantities changing in time.

It has a meaning to speak about pattern recognition in relation both of hearing and vision, though the latter is more familiar to us. The prominent difference between the two is that pattern recognition by the auditive system does not need any background of the curve as does need the visual system. The advances of this are the followings:

- a) The steps of the algorithm are much less compared to the visual case for the lack of background;
- b) there are no difficulties with the variation of position, orientation and size.

It is quite natural to check the basic supposition by actual hearing of the EEG. For this reason the EEG potentials have to be speeded up. A 1 to 40 ratio can be easily made by the tape recorder Type 7001 of the Brüel et Kjaer Comp. The original rates of the components are saved by this procedure. But the cardinal thing is the overall sensation. The centre of the "alpha"-rhythm, for example is a sound of 400 cps. According to Békésy's results two cycles of a signal are enough to give a pitch sensation.

Hopefully the analysis by hearing will give us some useful informations with diagnostical value in itself. By using a stereo system it seems to be possible to detect asymmetries between the two hemispheres by differences in amplitude, frequency and phase. Further direct advance of the speeding up process would be that the acoustical measuring equipments are at hand for wide analysis. The work will be promoted in each of the directions mentioned.

COMPUTING CENTRE OF THE HUNGARIAN ACADEMY OF SCIENCES, BUDAPEST

On the frequency dependence of acoustically evoked potentials and its modelling

O. FEHÉR, P. HUNYA

Click evoked potentials were off from the acoustic cortex of anaesthetized cats. On increasing the frequency of stimulation the amplitude of these potentials shows a characteristic diminution. As an explanation for this frequency dependence the authors presume that in consequence of each impulse always the same proportion of the transmitter substance is liberated from the thalamocortical terminals. In case of repetitive stimulation the released quantity of transmitter at each impulse

approaches a limit characteristic for the given frequency and so do the amplitudes of the evoked potentials. As a model for these events the functioning of a condenser is supposed to be adequate. This condenser is charged from a battery (U_0) through a resistance R_1 on voltage U_0 and discharged by momentary short-circuiting through resistance R_2 . At appropriate values of the time constants of the charging and discharging circuits and those of the durations of short-circuiting, the model produced curves of frequency dependence very like to those obtained in physiological experiments on the cat's acoustic cortex. The functioning of the model was simulated by a Minsk 22 computer. The authors assume that their model reflects adequately the dynamics of transmitter synthesis and liberation playing role in the production of the acoustically evoked potentials.

DEPARTMENT OF ANIMAL PHYSIOLOGY;
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The approach of the transfer functions of the retina

GY. BENEDEK, I. GYÓRI, I. MADARÁSZ

Averaged responses obtained in different points of the visual system: retina, optic nerve and visual cortex, evoked by short flashes of light, have been analysed on the basis of methods known from the control theory. The experiments were carried out on cats after pretrigeminal transection. For the analysis of evoked responses, amplitude-phase-frequency characteristics, figuring the relation of Fourier integrals of output and input signals in a complex plane, has been taken. The investigations were made in the region of linear responses. After calculating the characteristics of physiological evoked potentials, led from different points, transfer functions were determined, also after giving toxic doses of ouabain.

DEPARTMENT OF PHYSIOLOGY, MEDICAL UNIVERSITY, SZEGED

Computers now and in the future for clinical purposes

M. HORVÁTH

The pattern-analysis of bioelectrical signals, the cycleanalysis of flow parameters, the automatic computation of the cardiac output and circulating blood volume, the computerized testing of the respiratory function were discussed on the basis of home works. Within the scope of the pattern-recognizing methods the computerized nuclear scintigraphy was dealt with, stressed its great diagnostic advantage.

Finally a review on the medical adaptation of computers till now was presented and in connection with the matter, the organisation problems of software programs in the future were discussed.

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