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THE CENTRAL COMPUTERIZED LABORATORY SYSTEM FOR THE ANALYSIS OF ANALOG BIOLOGICAL SIGNALS IN THE SEMMELWEIS MEDICAL UNIVERSITY

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To aid theoretical and clinical research work of the University we developed a general purpose laboratory system to process analog biological signals. Here are some of the topics solved within the system:

- analysis of EEG signals during oral glycerin therapy,
- quantitative analysis of the compound action potentials of the sympathetic efferent nerves,
- analysis of the spontaneous and evoked action potentials,
- Tensilon-effect on the tone and electrical activity of the outer eye muscles,
- spectral analysis of the airflow and oesophageal pressure signals,
- effect of the placental transfusion on the adaptation of newborns,
- evaluation of the intrauterine pressure and fetal heart rate signals.

The hardware configuration of our system is shown on Figure 1. For digitizing, storing, displaying and analysing analog signals the software was generally developed in assembly language. This is the basis for the solution of a number of specific problems. Particular problem can be solved with some supplementary programs which can be written in high level languages of TPAi or other computers (e.g. R20).

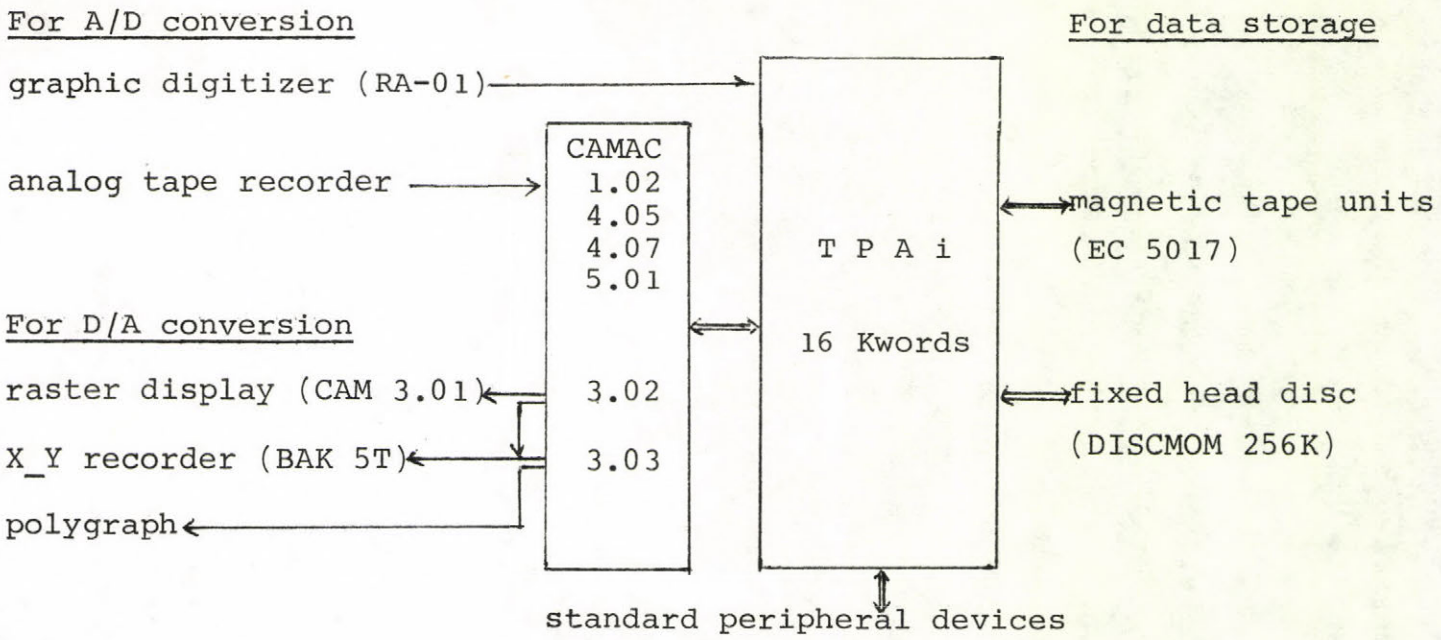

Figure 1.
The hardware configuration of the computerized laboratory system

THE MAIN CHARACTERISTICS OF THE SYSTEM ARE:

- it is easy-to-learn; a conversational communication through a console display,
- it is easy-to-extend; modular construction (input, output, displaying and operating modules),
- serial measurement and evaluation,
- economic computation time,
- data from a maximum of 8 channels can be analysed simultaneously,
- special common data format in the core memory: single precision fixed point signed binary fraction with a variable scale factor (or exponent), the real and imaginary points having the same exponents,
- 4 to 4096 (by powers of 2) real or complex points can be processed at one (it is a block),
- data generally stroed on magnetic tapes (one volume comprises a number of files).

For digitizing the measured data the system has two analog input peripheral units:

- the CAMAC system is suitable for measuring voltages within the range of ± 5 V. The sampling frequencies can be deiscrete values provided by the CAMAC pulse generator. The maximal frequency that can be obtained in 10000/number of channels [Hz]. The sampled data are recorded on magnetic tapes.
- the RA-0= graphic digitizer can be used for digitizing data recorded on paper, e.g. with a compensograph.

Most often for the evaluation of the digitized signals the MATH program package written in assembly language is used. The most important operating subroutines (2) are the following: Fast Fourier Transform (FFT), inverse Fast Fourier Transform (IFFT), auto- and crosscorrelograms using FFT and IFFT. Generally the power-density spectra are calculated with the Fourier transformation method too. For FFT the Cooley-Tukey algorithm was applied (1). 1024 points may be transformed in 4.5 seconds, while 4096 points in about 10 seconds. The errors

caused by integral transformations are corrected with window--functions (by Bingham, Paresn, Hann, Hamming). There are some other operating subroutines e.g. for the selection of the evoked action potentials and other evoked signals. The MATH program package can be extended with new operating subroutines.

In addition, several programs in high level languages (TPAi BASIC, R20 FORTRAN) have been developed and/or adopted e.g.:

- Amplitude Analyser Program package (sampled mean, standard deviation, median, mean deviation, quantiles; empirical distribution function, central moment coefficients etc.),
- evaluation of the baseline and reference signals,
- calculation of the main points of positive and negative parts, latency time, zero-crossing, min. and max. values for the evoked action potentials,
- a special "peak-finding" program for locating fundamental and higher harmonics,
- the BMDP is the most important program package on R20,
- Time Series Analysis Program package on R20.

For displaying digitized signals three types of instruments are used:

- the CAMAC display: primarily for selecting and controlling. Signals from only 2 channels can be displayed at one time. Blocks are displayed one after the other. The user can stop, skip forward or backwards any of the displayed blcoks.
- an X-Y plotter: mainly for documentary purpose. Its disadvantage is that it is relatively slow and the paper must be changed after each plotted figure.
- a polygraph: also for selecting and control purposes. Figures from a maximum of 4 channels can be displayed at once.

The connection towards the high level languages is achieved by the "pseudo-handlers" of the MATH program package. Pseudo-handlers have been developed for TPAi BASIC, R20 FORTRAN. This is very important because this keeps the system open. The input pesudo-handlers receive the different data formats and

convert them into core memory format which can be evaluated. The output pseudo-handlers perform the opposite function. The pseudo-handlers generally use the OS/i handlers but we had to develope some new ones for the non-standard peripherals e.g. RA-01. The pseudo-handlers are the input/output modules of the MATH program package therefore they are flexibile and can be developed separately just as the operational and displaying modules.

SUMMARY

The central computerized laboratory system for the analysis of analog biological signals is based on a TPAi and a CAMAC hardware. The programs are generally written in assembly language. Due to the modular arrangement the system can easily be expanded. The OS/i operational system has been modified and expanded with new programs. Magnetic tapes provide the connection towards other computers.

In developing the system Lóránt Ormai, Éva Keszthelyi, Zoltán BYdeskuty and László Szekeres helped the authors.

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ЦЕНТРАЛЬНАЯ ЛАБОРАТОРИЯ ОБРАБОТКИ АНАЛОГОВЫХ БИОСИГНАЛОВ МЕДИЦИНСКОГО УНИВЕРСИТЕТА ИМ. И. СЕММЕЛЬВЕЙСА

На базе ЭВМ типа ТРА/1 Группы Вычислительной Техники Мед. Унив. им. И. Семмельвейса с целью поддержки теоретической и клинической исследовательской работы университета создана лаборатория обработки аналоговых сигналов. Различные операции над сигналами производятся с помощью системы КАМАК, а для хранения информации установлены накопители на магнитных лентах. Ввод информации осуществляется с аналоговых магнитографов или с графического материала с помощью аналого-цифрового преобразователя РА-01. Устройствами вывода служат графопостроитель, дисплей системы КАМАК и 4-х-канальное самопишущее устройство.

Существующая в настоящее время система математического обеспечения, созданная с учетом самых различных требований использователей имеет модулярную структуру, позволяет серийные измерения с последующей обработкой. Возможности:

- сбор данных с А/Ц преобразованием на нескольких каналах одновременно с различной частотой дискретизации;
- собственная система обработки /быстрое преобразование Фурье, обратное преобразование Фурье, автокоррелограммы, взаимные коррелограммы, различные спектральные весовые функции, и т.д./;
- вывод данных /т.е. построение кривых/ после А/Ц преобразования, а также результатов обработки;
- переход к программам, выполненным на алгоритмических языках высокого уровня /на ЭВМ ТРА/1 и ЕС-1020/.

Прогарммы системы мат. обеспечения написаны на языке Ассембли, благодаря чему продолжительность их прогона весьма

удовлетворительна. Разделение операций ввода и вывода от операций собственно обработки позволяет дальнейщее развитие системы без особенных сложностей. Система доступна использователям, не располагающим специальными знаниями и навыками в области вычислительной техники.

ÖSSZEFOGLALÁS

BIOLÓGIAI ANALÓG JELFELDOLGOZÓ LABORATÓRIUM TPA/I KISSZÁMÍTÓGÉPRE A SOTE SZÁMÍTÁSTECHNIKAI CSOPORTBAN

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A SOTE Számitástechnikai Csoport TPA/i kisszámitógépére alapozva - az Egyetemen folyó elméleti és klinikai kutató munka segitésére - analóg jelfeldolgozó laboratóriumot hoztunk létre. A jelekkel kapcsolatos különböző feladatok elvégzésére CAMAC rendszert, adattárolásra mágnesszalagos egységet használunk. Adatainkat analóg magnetonfonról és RA-01 rajzdigitalizálóval regisztrátumról visszük be. Megjelenitésre CAMAC display, X-Y rajzoló és négy csatornás gyorsregisztráló használható.

A sokrétü felhasználói igényeket figyelembe véve alakitottuk ki programrendszerünket, mely moduláris felépitésü, sorozatmérésre és értékelésre alkalmas. Szolgáltatásai:

- több csatornás mérés-adatgyüjtés változtatható mintavételi frekvenciával,
- saját értékelő rendszer /FFT, IFFT, autó- és keresztkorrelogram, ablakfüggvények, marker szerinti válogató stb./,
- digitalizált és értékelt jelek megjelenitése,
- csatlakozási lehetőség a TPA/i és R20 -s számitógépek magasszintü programnyelvei felé.

A softwaret assembler nyelven irtuk, igy a gutási idők kedvezőek. Az input, output és müveleti részek szétválasztásával a rendszer könnyen továbbfejleszthető. Használata számitógépes ismeretekkel nem rendelkezők számára is elég könnyen elsajátitható.