Physiol. Res. 40: 549–553, 1991

Computer-Aided Physiology (Teaching, Learning and Research)

O. KITTNAR, M. VÁVROVÁ, S. TROJAN

Institute of Physiology, First Faculty of Medicine, Charles University, Prague

Introduction

Experiments and demonstrations in physiology are mostly done when new knowledge is needed (demonstration of dynamic processes in the organism, modelling of certain situations, etc.). For these purposes we need a simple, effective, attractive and generally acceptable method which could extend them to a maximum. We believe that one of the ways could be to introduce of a uniform knowledge system for teaching, research and practical applications in physiology and medicine.

We have attempted to design such a system proceeding in our work from the following facts:

1. enough computers suitable for knowledge system applications are now available in schools, research and health care institutions;

2. in agreement with the world trends in manufacture and application of computers most suitable seems to be the use of IBM compatible personal computers, i.e. the PC and possibly the PS series;

3. for the time being there is no uniform structuralization of knowledge (there does exist, for instance, the SNOMED system for clinical practice, but it is not fully applicable in theoretical, especially physiological branches);

4. most of the information which has taken a lot of time and money to obtain is not being used sufficiently and is hard to obtain for further processing; a reasonable classification as well as any manipulation with knowledge remain nevertheless a great problem (Iliev 1984).

We have decided, therefore, to analyze the present state of work on the knowledge in biology and medicine and to design a knowledge system which could be generally applied in most of the natural sciences. For our work we have chosen a Prolog programming language which allows for a simple use of a knowledge base containing a declarative representation of laws related to the given problem expressed in symbols. A knowledge system would be built upon this base which would aid teaching, learning and research. It has been conceived in a way to make it easily accessible and applicable for these purposes.

Methods

The structure of knowledge in any science have been formed in its long historical development. Most of the knowledge is arranged hierarchically and exist in several forms, which we call the type of knowledge (see further).

For our purposes we have chosen knowledge in medical physiology and expressed it as a predicate: exist (Object, System, Functional part, Goal area, Goal term, Physiological parameter, Type of knowledge, Sex, State, Unit, Lower limit, Upper limit, [Connections], [References]).

Two communication modules have been designed for the work with the knowledge base which allow for storing into the base and consultations in a user-friendly and simple way. Pictographs (fonts), pictures and supporting commentaries have been added which make it easy to use the consultation module even by an uninstructed user.

Since the amount of knowledge in physiology is rather extensive, it has been decided to store it in the computer memory in files. At the beginning, the user selects the object, system and functional part he wishes to work with from a menu (see Fig. 1). Step by step he thus selects three letters of the English alphabet that describe the chosen area.

For each functional part there are several datafiles identified as B – knowledge base, F – pictographs, P – pictures, etc. This arrangement provides an almost unlimited capacity for storage and consultation in the given sphere of interest and an easy interrelation to information from other sciences (a maximum extent of a partial knowledge base for one file should be 64 kb).

Knowledge from a given field is stored in the base as predicate clauses is (Goal area, Goal term, Physiological parameter, Type of knowledge, Sex, State, Unit, Lower limit, Upper limit, [Connections], [References]) e.g. for the HCH functional part, where H (human) = man, C = circulation, H = heart, is (left ventricle, pump function, cardiac output, qn, b, n, l/min, 4.87, 6.50, [ii, chl, "pump function", "stroke volume", ii, chs, "sinoatrial node", "heart rate"], [Yang 1980]).

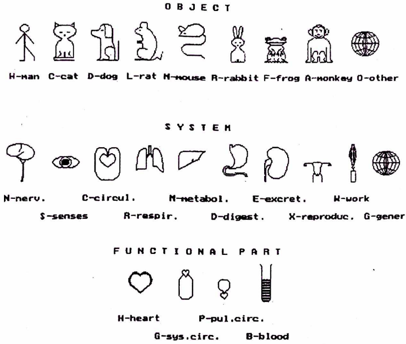
Goal area is selected from a menu at the functional part picture and it is indicated in the base by the given letter (in the above mentioned case: l – left ventricle, m – myocardium, s – conducting system, etc.).
Goal term and *Physiological parameter* are listed in words (we have tried to use the SNOMED system but it has proved inapplicable in physiology); in our case: pump function (e.g. "cavity", "wall", etc.) and cardiac output.
Type of knowledge – we have selected 8 basic types of knowledge in physiology: qn – quantitative, pi – picture, de – definition, gr – graph, fo – formula, ta – table, se – sentence, pr – programme. According to the type of knowledge the content of other variables is selected (see variables Unit and Connections).
Sex – (m – male, f – female, b – applicable for both).
State – physiological or pathophysiological conditions of the organism (e.g. n – normal, dm – diabetes mellitus, etc.).
Unit – for qn = name of unit, for se = the first sentence of the text, for fo = formula, etc. (for *qn, se, fo* see Type of knowledge).
Lower limit and *Upper limit* – quantitative limits of Physiological parameter (for *qn only, qn* see Type of knowledge).
Connections – for qn and de = sequence of variables describing connections to other physiological parameters which affect or are affected by the given parameter, for se = following sentences of the text, for fo = description of variables in the formula (for *qn, de, se, fo* see Type of knowledge).
References – list of authors of the publications, which were the source of information.

In our above mentioned case the selected knowledge is:

Object	Man	H
System	Circulation	C
Functional part	Heart	H
Goal area	Left ventricle	
Goal term	Pump function	
Physiological parameter	Cardiac output	
Type of knowledge	qn	
Sex	b	
State	n	
Unit	l/min	
Lower limit	4.87	
Upper limit	6.50	

Connections are increased by (ii): stroke volume (physiological parameter of the goal term "pump functions") and heart rate (physiological parameter of the goal term "sinoatrial node")

References	Yang (1980)



Results

Since it is very difficult to build such a broadly-based knowledge system we have chosen a modular arrangement. All modules can be selected from the main menu or they can be used separately. The modular arrangement allows easy expansion or narrowing of the system possibilities and facilitates its continuous dynamic development.

The following modules have been completed so far: 1. Introduction – informs the user about the knowledge base structure, how to use the knowledge system and what are its potentials; 2. Selection of object, system, functional part and goal area – realized using a graphic support as described in the above listed figure; 3. Storage into the knowledge base – serves for the formation or expansion of knowledge in the selected area; in order to optimize the use of the system two original programs were implemented: PENCIL, a user friendly designed picture editor and FONTER, a pictograph (font) designer enabling to design the user's own font sets in a simple way. 4. Consultation – allows for obtaining a review of knowledge in the selected area. The knowledge base is at present completed in two systems: circulation (C) for following functional parts: blood (B), heart (H), systemic

(G) and pulmonary (S) circulation; nervous system (N) for functional parts nerve cell (N), motor system (M), autonomic system (A) and integrative functions (I).

The whole system is equipped with HELPs and is run from a computer keyboard in a way clearly indicated in the bottom of the screen which allows an uninstructed person to use it.

For educational purposes the system was enriched by the special program for examination. This program enables fully automatic computer aided testing and automatic tests generating from designed questions sets. The program consists from 3 parts: A) QUESTIONS GENERATOR enables generating of four questions types: 1) Multiple choice – multiple answer test questions 2) Picture questions with area choice 3) Picture questions with color choice 4) Choice from several pictures. B) TEST GENERATOR The editor created questions set can be subdivided into some subsets, by the topics, that the user wishes to examine on them. (respiration, circulation, nervous system, ...). Up to 99 tests with the same name (RESPIR1, RESPIR2, RESPIR3, ...) can be generated in the same step. In every test the user can determine, how much graphic and text questions – from which topic – is to be included in the test. If required, it is possible to determine the time limit for answering. Tests can be generated for printer or it is designed for computer aided examination using the last part of the program – TESTER. C) TESTER – for computer-aided testing The person tested writes the test number, given by the instructor, its own Id. No., forename and surname. Than the questions from the test given, the time elapsed and the current question number are continuously displayed. The instructor determines, if it is allowed to return to the previous questions and to correct the answers previously given. In the log file there is present Id.No., forename and surname of the student, total score and the total time for test finishing. At wrong answered questions the wrong answers of the examined student are written together with correct answers. All three parts are activated from shell which enables user-friendly review of tests, sets of questions and tests results. The graphic knowledge is created using the picture editor and font editor.

Discussion

We wish to underline that the present knowledge system is only the first – elementary part of an envisaged system which should make it possible to use a possibly universal and easily accessible work with data and knowledge. At present, work is going on using a module for an automated scanning of connections, comparisons of individual objects, input of the results of experimental data analysis into the knowledge base, etc.

An introduction of the pr (programme) type of knowledge is a problem which will require considerable effort. It is assumed that the name of the appropriate programme (demonstrative, complementary, etc.) will be listed in the base – in case of interest the user can obtain it or retrieve it directly from the knowledge system.

We wish to stress that the whole system is designed as a universal one and can be, upon request, easily adapted for application in any other field while preserving the possibility for an interdisciplinary transfer of information. The knowledge base involved in the designed system represents the information about functions and processes in healthy organism. Thus it presents an important basic input for clinical sciences.

The use of knowledge systems and other methods of artificial intelligence in medical sciences can help in the problem of classification and manipulation with knowledge. In spite of successful development of many expert systems for medical applications their use in clinical practice is still very rare. Perhaps they are not able to represent the physician's knowledge about physiological processes in the human body. According to our experience and in agreement with new possibilities of artificial intelligence (Bratko *et al.* 1988) we believe that the future development of artificial intelligence in medicine will use the methods of knowledge systems and qualitative simulations more extensively.

References

BRATKO I., MOZETIC I., LAVRAC N.: *Kardio: a Study in Deep and Qualitative Knowledge for Expert Systems*. MIT Press, Cambridge, Ma., 1988, 257 pp.

ILIEV L.: *Theory of Modelling*. Publishing House of the Bulgarian Academy of Sciences, Sofia, 1984, 75 pp.

YANG S.S., BENTIVOGLIO L.G., MARANHAO V., GOLDBERG H.: From cardiac catheterization data to hemodynamic parameters. FA Davis Co., Philadelphia, 1980, pp. 136–146.

Reprints requests

Dr. O. Kittnar, Institute of Physiology, First Faculty of Medicine, Charles University, CS-128 00 Prague 2, Albertov 5.