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EKG.PRO: An Expert System for ECG Analysis

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Abstract - **The paper presents an expert system (EKG.PRO) which helps the doctor in the ECG (Electrocardiogram). The expert system was implemented in Turbo Prolog 2.0 and in IBM-compatible Personal Computer. A description of the EKG.PRO as well as an example of its usage is also included.**

1. INTRODUCTION

Many complex and ill-structured problems in engineering are not suitable to algorithmic solutions. Design, diagnosis, interpretation and classification, monitoring, etc. are such problems. Expert Systems provide a sophistication approach towards the solution of such problems. An Expert System (ES) is a computer program that perform a task normally done by an expert or consultant and which, in so doing, uses captured, heuristic knowledge. Some of the main characteristics of an ES are the Representation and use of Knowledge, the Separation of Knowledge and Control, the Inferential Processing, the Manipulation of large Knowledge bases, the Relaxation of uniqueness, completeness, the desirable Run-time explanation and the Symbolic processing. The components of an ES are: a) Input-Output facilities b) a Working Memory c) an Inference Engine d) a Knowledge base.

Expert Systems theory and Practice have received during the recent years much attention by doctors and biomedical engineers working in several branches of clinic medicine. The treatment in some cases is very complicated because of multiple causality and the large number of evaluated parameters.

EKG.PRO helps doctors to overcome various difficulties in the special domain of ECG analysis. EKG.PRO is implemented in Turbo.Prolog 2.0. The dialogues with the system can be saved. So, there is no need to re-answer the same question (for another run) for the same patient.

2. SYSTEM ARCHITECTURE.

1. The Input/Output facilities has been implemented such that allow the user to communicate with the system and to create and use a database for the specific case at hand.
2. A working memory that contains the ECG analysis data and intermediate to final results produced by the system.
3. An Inference Engine that contains the strategy which "governs" the knowledge. It also produces an explanation for the solution.
4. A Knowledge base that contains the basic knowledge and the domain rules.

More specifically: The Input/Output facilities allow the user to communicate with the system in a friendly manner. This achieved by proper interconnections between the user and the system. By these interconnections a full work environment can be offered to the user. Message use is a part of the interconnection. The Turbo Prolog input attribute *write* is mainly used for screen presentation of a message. The user reads the message on the screen and replies. User's answers are read by the program which uses some proper input attributes: readln, readchar, readint, readreal. Turbo Prolog offers tools for windows creation and usage. The attribute clearwindow cleans the current window. The attribute removewindow deletes the current window, while the attribute makewindow makes a new window. Each attribute is accompanied by some arguments which determine the details for the created window (coordinates, colours, titles, etc.).

In the EKG.PRO, windows are widely used for message presentation. Users are facilitated by these messages. A special case of these messages are the so called Help Texts. User, if he wants, can see the Help Texts on the screen and be informed about the medical terms. The attribute file_str( ) is used. This contains two arguments. The first argument is a file name and the second is a string variable. The attribute file_str reads a text ≤ 64 from the file and gives this text to the second argument. After that the attribute display is used for text presentation in a window. In the text, user motion is available. However, user cannot make any change in the text.

Input/Output facilities also include *menus* for a more friendly usage. EKG.PRO uses the menu2.Pro file of Turbo Pascal for menu construction. The attribute menu includes the following arguments *Row, Col, Windowattr, Frameattr, String, List, Header, Startchoice, Selection*. The Row, Col arguments define the menu position inside the window. Wattr, Fattr define the window colour as well as the colour of its frame. Stringlist define a list with the possible menu selections. Header is a headline that appears in the top of the window of the menu. Startchoise defines the bar position which is used for the selection. Selection is a variable in which the user's selection is stored up. A main system possibility is the possibility of answering to the question "why the particular diagnosis was resulted?". If the user ask the question "why", a window will be appeared on the screen containing the answers for the particular diagnosis, i.e. the symptoms with the corresponding certainty degrees. The user can check if some error exist.

The inference engine includes the *backtracking technique, the recursion process* and the *fussy logic*. *Fail* and *Cut* attributes are used in conjunction with the backtracking technique. In the recursion a function calls itself as a subfunction. The *repeat* attribute is used. Fuzzy logic is used because the medical information may not be reliable or since we assume a certain fuzziness in our description. In order to build the knowledge base, knowledge and rules diseases (as they appeared in the ECG) should be collected. Afterwards, we eliminate the subjective methods which may exist and we schedule the logic structures of the particular medical knowledge field in a way that Turbo Prolog can process them. A logic language as Turbo Pascal is limited to deduction with formal logic. It is a mathematically precise language and allow us to deduce logically consistent new facts from the given database of facts by the application of logical inferences.

Knowledge is hierarchically organised in a context tree. In the root, the symptom with the greater value (i.e. the most common symptom with the greater value (i.e. the most common symptom in all diseases) is written down. Proceeding towards leaves, the symptom value decrease. If one replies to every node that one meets, one terminates to the diseases written down as the leaves of the tree. The symptoms are declared as attributes (therefore they are logical functions with only two possible values: true, false) with two arguments. Diagnosis is ruled-based and the hypothesis that a disease exists is true if the rules symptoms are obtained. First the hypothesis (the disease) is written. Then the symptoms are examined one by one. If a symptom is considered "false", we don't proceed on the examination of the rest symptoms but the next disease will be considered. User's answers are stored up in a dynamic data base in order to avoid to require the same questions.

3. THE PROGRAM FILES

The files that consist the program are:

a. EKG.PRO. It is the main file of the program. It queries the user for the symptoms and the corresponding certainty coefficients. It makes the diagnosis of the disease and it presents the reason for the particular diagnosis.

b. MENU2.PRO. In order to construct the usual menu in the program, the file MENU2.PRO is used. The user is moved across the possible selections by using the keyboard and select the proper answer.

c. TDOMS.PRO. It contains universal declarations of objects and attributes that are used by more than one files. TDOMS.PRO contains only the common definitions of the domains and predicates segments. TDOMS.PRO is used from all the parts of the program in which it is included with the include command.

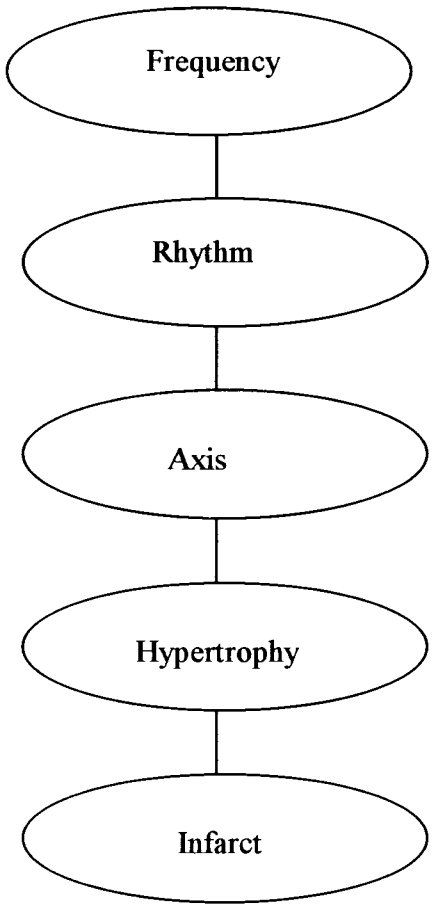
d. TPREDS.PRO. It contains the principal attributes that are used in the EKG.PRO files.

e. PRINCIP.PRO, FREQUEN.PRO, RHYTHM.PRO, HYPERTR.PRO, EMFRAGM.PRO. These are help files containing fundamental medical knowledge and information for the user.

The program EKG.PRO is executable in a Turbo Prolog 2.0 environment.

Example: An anterolateral infarct from [8] is examined. Inchemia causes inversion of **T** waves. Muscle injury causes elevation of **S-T** segment. Death (infarction) of muscle causes **Q** or **QS** waves.

The EKG.PRO passes through the following "levels"



and finally finds in the level of the Infarct the following

Inversion of T waves

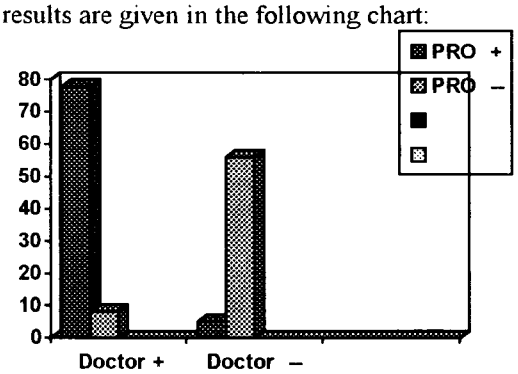
Elevation of S-T segment

Q wave

This is an Example of our Expert System. Other cases were also tested and we found a very strong relation with a "real" doctor's diagnosis. More specifically we obtained the following results: The patients are various cases from the medical literature:

	Pro +	Pro -
Doctor +	78	8
Doctor -	5	56

Our results are given in the following chart:



CONCLUSION:

A new program in medicine is the expert system (EKG.PRO) which helps the doctor in the ECG. The expert system was implemented in Turbo Prolog 2.0 and in IBM-compatible Personal Computer. In this note, a description of the EKG.PRO as well as an example of its usage is given. Some statistics is also made.

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