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MOTHER - An expert system in obstetrics and gynaecology

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Abstract

An experience in the building of an expert system in obstetrics and gynaecology is described in the paper. A corresponding technology has been developed for supporting physicians in the process of diagnosing and therapy.

We present the technology by describing an expert system, MOTHER, currently used in hospital practice. The technology comprises the substantial amount of routine interactions of the physicians with patients and other physicians in their practice.

On the AI side, the primary motivation of the investigation was to explore the extent to which production rules could be used to achieve expert-level problem solving in the domain discussed.

An information and expert parts successfully function together. A particular problem-oriented mechanism evaluates diagnosis and risk certainty degrees.

Like most of the medical expert systems, MOTHER can also be used for educational purposes.

1. INTRODUCTION

The development of medical applications in the field of informatics involves a broad spectrum of different systems. One class of them includes: administration systems, management systems and information systems for hospitals [1,2,3]. Medicine is one of the earliest and very large area where another class-expert systems were applied [4,5,6,7]. From the physicians' point of view, the main advantage of expert systems is the attempt to give consultation in "human-like" fashion connected with the ability not only to reach conclusions but also to explain their reasoning. In this way, expert systems are not black boxes for

physicians and their conclusions are better accepted in the routine medica practice.

Most of the existing medical expert systems are in medicine subareas, sucl as: internal medicine (CADUCEUS, ABEL, CAA, GALEN, MYCIN, SEEK MED1); psychology (ACT); pediatrics (BABY, BDD); anesthesia (ATTENDING psychiatry (HEADMED); oncology (ONCOCIN); X-ray (RADEX) [4,5]. There ex ists also a number of general purpose medical expert systems, such as: HELI ADS, SPHINX, etc. Of course this is only a part of the existing ones in thi field. The main topics of the developed systems are diagnosis, therapy, planin education, research, prognosis and control.

In this paper, we address the problem of building an expert system i obstetrics and gynaecology - MOTHER. It comprises: (1) information syste functions: collecting, storing and retrieving of clinical information and (2) expe system functions: diagnosing, risk evaluation and explanation. Our goal was create an expert system, which takes into account a medical description of: th woman general state, passed diseases, professional conditions and addition diseases, woman gynaecological state and current examination results. evaluates the risk rate for the woman and foetus during the current pregnanc receives a list of the most probable diagnoses with assigned certainty degre and helps the physician in the process of giving the appropriate prescription.

The paper is organized as follows: in Section 2 we discuss the gener structure of the MOTHER system. In Section 3, we give the MOTHE information subsystem, and in Section 4, the MOTHER expert subsystem. T realization is discussed in Section 5.

2. GENERAL DESCRIPTION OF THE SYSTEM

The MOTHER input is in the form of medical descriptions entered into t system database and includes: general information for the patient, medi history, information concerning previous pregnancies, additional diseases, clini state, medical test results, pregnancy outcome.

The main knowledge sources of MOTHER are clinicians, medical literatu and historical clinical information.

The main MOTHER components are: (1) expert subsystem includi Medical Knowledge Base and Inference Engine; (2) information subsyst including: Database Management System and Patient Database. They described in details in the next two sections.

The output of MOTHER allows: data review, report generati in-aid-physician functions and decision making. Using data from the Pati Data Base, rules from the Medical Knowledge Base and the Inference Engi

the system evaluates the appropriate diagnosis and several kinds of risk rates for the mother and foetus. According to the particular treatment the necessary prescriptions are automatically given.

3. THE MOTHER INFORMATION SUBSYSTEM

The MOTHER information subsystem consists of a Patient Database and a Database Management System. In what follows the data classes of the Patient Database and the functions of the Database Management System are described.

3.1. Data classes

On the basis of an information sheet with a standard format of questions and answers, it becomes possible detailed recording concerning not only standard history information, appropriate for the majority of the patients, but complicated pregnancy or additional medical disorders as well. The total question set (about 950 questions) was adapted from the standard history taking format, which had been satisfactorily used in the hospital for some time. The questions are divided into related groups, and are displayed one group at a time, including questions concerning particular complications, when such complications exist. The responses are either text or numerical values.

To assure the expert system functioning, there are several types of data, that are stored in the system database.

On one hand, the MOTHER database consists of: (1) long-term abstracts of demographic and clinical information useful for readmission and statistical calculation; and (2) short term comprehensive collection of data gathered during the current hospital admission.

On the other hand, from medical point of view, we can group the information in the following classes:

- general information. This class includes the woman name, age, address, blood group, profession, medical state of the husband, etc.;
- patient medical history. This class includes the information about passed diseases like hypertension, diabetes, alcoholism, nephritis, tuberculosis, etc.;
- previous pregnancy information. This is the information for the more characteristic stages, during the previous pregnancies, if any. It includes pregnancy time period, details, outcome, etc.;
- additional and professional diseases. In this class of data we include the professional conditions of the patient and additional and professional diseases. They are grouped in subclasses such as: internal, neurological, skin diseases, etc. For the chosen disease subclass we select the corresponding disease and the degree to which the woman is affected, i.e., the main disease symptoms during the treatment. This information plays an importa role to determine the risk rate for the woman and child in the curre pregnancy;
- clinical state. This information includes woman's general state, e.g., heigl weight, skin state, gynaecological state (pelvis size, hydramnio olygohydramnion, presentatio sacralis, situs transversus et oblique disclosure size, consistency, etc.), etc.;
- medical test results. This class includes the results from the medical tes such as: pulse, temperature, blood pressure, hemoglobin, erythrocyte indirect Coombs, etc., starting from the first examination of the woman by physician until the current pregnancy state. One of the important tests is tl ultrasound examination. There is a special system, developed to manag only the information obtained from the ultrasound examination. The expe system has the possibility to use the necessary part of it for its purposes;
- pregnancy outcome. In this class of data we include information abou pregnancy outcome type (birth, abortion or saved pregnancy), abortion typ birth complications, type of delivery (forceps, V. E. LSCS, breech, etc information for the new-born.

3.2. Database Management System functions

Using the above data classes the Database Management System allows th following functions:

- data collection. Data are collected using menu forms. The data classes ar independent from each other and can be entered at different stages. Fc each data item there is a help row at the bottom of the screen, to facilitat the correct answer of the user. The system can use data collected by othe specialized systems, for instance ultrasound system;
- data manipulation. The system allows data update, deletion, insertion an retrieval;
- report generation. There exist two kinds of standard reports, generated b the system. The first one includes statistical data for a given time perioc e.g., total number of women in childbirth, cases distribution according to th type of delivery, number of new-born children, number of born alive number of born dead, number of dead infants, etc. The second one is medical history report for the each pregnant woman, which includes genera data such as: blood pressure, RH factor, entrance date, initial diagnosis discharge date, discharge diagnosis; probable term of birth; gynaecologica state; information for previous pregnancies; number of births; number c abortions; data from the last examination; pregnancy outcome, etc.;
- in-aid-of physician functions. Using the stored data, the system performs th following functions:

- calculation of the probable term and gestation week. The probable birth term is calculated in several different ways. This allows the physician to determine the probable date of birth with a high degree of certainty. The gestation week is calculated in five different ways on the basis of: (1) last term date; (2) first antenatal movement date; (3) ultrasound examinations; (4) objective examinations; and (5) conception date.
- behaviour prescription on the bases of the evaluated diagnosis. Depending on the calculated diagnosis, thephysician can read the corresponding behaviour prescriptionon the screen or receive outprints. There are about 250 different prescriptions, included in the system.

4. THE MOTHER EXPERT SUBSYSTEM

The main task that can be performed by the expert part of the system are diagnosing, evaluation of the risk factors for the mother and foetus and evaluation of the risk factors additional and professional diseases. The expert system can also give explanation of the obtained results and can suggest an appropriate treatment of the patient.

The Medical Knowledge Base is the essential part of the expert system. The knowledge sources are the following:

- experts (physicians). A team of 19 high skilled experts in different areas of obstetrics and gynaecology were contributing to the knowledge acquisition process;
- medical literature. The main sources are the contemporary textbooks and articles in the field of obstetrics and gynaecology;
- historical clinical data. A statistical processing of a patient data archive is used for knowledge acquisition and new production rule formulation [8].

The Knowledge Base consists of production rules that are divided into three groups:

(1) rules for diagnosing. This group includes rules for diagnosing of 24 diseases in obstetrics and gynaecology, such as: Abortus immineus, Abortus incipiens, Placenta praevia, Abl. placentae, Nephropathia, Praeeclampsia, Eclampsia, Isoimunisation, etc.;
(2) rules for evaluation of risk factors for the mother and foetus. The group includes sets of rules for evaluation of the risk factors for each of the above mentioned diseases, in case of occurrence;
(3) rules for evaluation of the risk from additional diseases. These rules serve for estimation of the additional risk for the mother and foetus, if symptoms of additional and professional diseases are present.

The general form of the rules is:

RULE: <rule name> IF: <condition> THEN: <conclusion>
REASON: <explanation text>.

The <rule name> is an identifier of the name of the rule.

The <condition> is a boolean expression containing tests of existing (notexisting) different medical symptoms. Most of the data that are used in the <condition> of the rules are extracted from the Patient Database. For diagnosing and risk evaluation of some diseases, the data used in the rules are gathered interactively through asking questions.

The <conclusion> gives a diagnosis or a risk for the mother and foetus with assigned degrees of certainty.

The <explanation text> explains the reasons for firing the rule. The text is displayed on the screen when an explanation from the user is required.

An example of a production rule for establishing of diagnosis is:

RULE: r3-placenta-praevia
IF: (gestation-week > 20 and bleeding-exutero = true and contractions = false)
THEN: diagnosis = placenta-praevia with certainty degree 4
REASON: The diagnosis is placenta-praevia with certainty degree 4, because the pregnancy is after the 20-th gestation week and there is bleeding exutero and there are no contractions.

We have developed a specific mechanism for evaluating the risk and diagnosis degrees on the basis of the following approaches:

- every rule that describes a disease or disease risk has an appropriate degree of certainty; we have chosen a four-degree scale (1, 2, 4, and 8) to measure this certainty.
- the total degree (R) of a particular disease or risk in the range of 0 to 100 is calculated as follows:

R =min (S, 15), if all the rules fired have degree value 1,
min (S, 25), if all the fired rules have degree values 1 or 2, but there is at least one rule with degree value 2 among them,
min (S, 45), if all the fired rules have degree values 1, 2 or 4, but there is at least one rule with degree value 4 among them,
min (S, 95), if there exists at least onefired rules with degree value 8,

where S is the number of fired rules with degree value 1, plus 2 multiplied
- by the number of fired rules with degree value 2 plus 4 multiplied by the number of fired rules with degree value 4 plus 8 multiplied by the number

of fired rules with degree value 8.

This mechanism provides the possibility to range the diagnosis and risk rates in order to distinguish the most probable diagnosis decisions.

The Inference Engine applies the rules from the Knowledge Base to the patient data in order to produce diagnoses or to evaluate the risks for the mother and the foetus. For this purpose we used the standard forward chaining procedure available in GURU system [9].

The MOTHER expert system provides also explanation facilities based on a back-way-tracing mechanism. The user can follow through the process of decision making and risk factor evaluation receiving information about each fired rule, as well as the values of the involved variables.

5. REALIZATION

We have developed the expert system MOTHER for the purpose of decision making and data handling in obstetrics and gynaecology. It supports the recognition of pathological medical cases on the bases of expert knowledge, provided by a team of 19 obstetricians, the most highly qualified ones in Bulgaria. The system is realized using the expert system shell GURU (a product of Micro Database System, Inc.) [9] on IBM/PC. The knowledge base includes about 2000 rules. A data record for a particular patient includes about 950 fields. The user interface is realized using a hierarchical menu-driven method. The system is used as a consulting system in a hospital (Sofia-city hospital 3) and as a obstetrics-and-gynaecology learning system in the Academy medical faculty. It is commercially available.

6. CONCLUSIONS

Considering the results of our investigation and experience, we can conclude that: (1) an effective and useful expert system in the domain of medicine can be built only by taking into account the specific characteristics of the particular subdomain; (2) the methodology proposed for evaluating the disease and risk degree values have proved out to be sufficiently efficient for consulting and learning purposes; (3) a crucial stage in the work is the intensive collaboration between expert physicians and system designers for the purpose of knowledge acquisition; (4) the experience with the system development and application has shown that a better efficiency can be achieved by separate realization (using appropriate software tools) of the information and expert parts, providing the

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