MOTHER - An expert system in obstetrics and gynaecology

Peter Stanchev, Valery Vutov, Alexander Grigorov and Ellen Stancheva

Institute of Mathematics, Bulgarian Academy of Sciences, G. Bonchev Str., 8, 1113 Sofia, Bulgaria, Telex 22628 BANMAT BG, Fax. (359) 275 2078

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 medical practice.

Most of the existing medical expert systems are in medicine subareas, such as: internal medicine (CADUCEUS, ABEL, CAA, GALLEN, MYCIN, SEEK MED1); psychology (ACT); pediatrics (BABY, BDD); anesthesia (ATTENDING); psychiatry (HEADMED); oncology (ONCOCIN); X-ray (RADEX) [4,5]. There exists 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 the field. The main topics of the developed systems are diagnosis, therapy, planning, education, research, prognosis and control.

In this paper, we address the problem of building an expert system in obstetrics and gynaecology - MOTHER. It comprises: (1) information system functions: collecting, storing and retrieving of clinical information and (2) expert system functions: diagnosing, risk evaluation and explanation. Our goal was to create an expert system, which takes into account a medical description of: the 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 pregnancy and receives a list of the most probable diagnoses with assigned certainty degree and helps the physician in the process of giving the appropriate prescription.

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

2. GENERAL DESCRIPTION OF THE SYSTEM

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

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

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

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

3.2. Database Management System functions

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

- data collection. Data are collected using menu forms. The data classes are independent from each other and can be entered at different stages. Each data item there is a help row at the bottom of the screen, to facilitate the correct answer of the user. The system can use data collected by other specialized systems, for instance ultrasound system;
- data manipulation. The system allows data update, deletion, insertion and retrieval;
- report generation. There exist two kinds of standard reports, generated by the system. The first one includes statistical data for a given time period e.g., total number of women in childbirth, cases distribution according to 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 a medical history report for the each pregnant woman, which includes general data such as: blood pressure, RH factor, entrance date, initial diagnosis; discharge date, discharge diagnosis; probable term of birth; gynaecologic state; information for previous pregnancies; number of births; number of abortions; data from the last examination; pregnancy outcome, etc;
- in aid-of physician functions. Using the stored data, the system performs the 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, the physician can read the corresponding
behaviour prescription on 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 imminus, Abortus incipiens,
Placenta praevia, Abl. placenta, Nephropathia, Praeclampsia, Eclampsia,
Ismunisation, 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.

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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
(noteexisting) 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-praeivia
IF: (gestation-week > 20 and bleeding-exutero = true and contractions =
false)
THEN: diagnosis = placenta-praeivia with certainty degree 4
REASON: The diagnosis is placenta-praeivia 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 one fired 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
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 Systems, 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 an 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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7. ACKNOWLEDGEMENTS

The authors thank the medical experts, participating in the project, and especially Prof. Radonov and Prof. Madjarov, for their active collaboration in the knowledge acquisition process and for providing permanent consultations, organizing the experiments process, and the real system application.

8. REFERENCES

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