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IMPROVING THE QUALIFICATIONS OF DOCTORS ON THE BASE OF INTELLIGENT DECISION SUPPORT SYSTEMS

Abstract. Intelligent Decision Support Systems (IDSS) medical decisions is an effective tool for improving the qualifications of doctors. The use of IDSS medical solutions helps the doctor obtain additional knowledge and consolidate it on test tasks. The article proposes the structure and composition of the ISPPR of medical solutions, for which it is proposed to use a combined approach based on the frame structure of the knowledge representation model with the use of production rules that provide an explanation understandable to the doctor, including a list of signs, taking into account which the diagnostic hypothesis is formed. As an example, several production rules are given for determining possible diseases of patients based on the level of general blood analysis indicators.

Keywords: decision making, intelligent system, medical diagnosis, production rules, knowledge model, frame structure

Introduction

Currently, most medical IDSS based on expert knowledge or knowledge extracted from literary sources and repositories of medical records. They allow taking into account the specifics of the presentation of clinical information:

– unclear information or verbal characteristics of the patient's condition;

– ambiguous interpretation of clinical manifestations;

– multi-alternative diagnostic decision-making.

The use IDSS of medical decisions makes it possible to make correct diagnostic decisions that can be implemented by constructing an appropriate logical inference mechanism.

Knowledge about diseases (or syndromes) that are in certain relationships with the main diagnostic hypothesis allows IDSS of medical decisions to identify:

– cause-and-effect relationships indicating a possible cause of the disease;

– temporal relationships that allow both predicting the dynamics of the disease and reconstructing a possible anamnesis;

– associative links that make it possible to take into account the factors against which a given disease could develop now and to predict its development in the future.

The development the computer medical IDSS provides an opportunity not only for advisory assistance at various stages of the medical and diagnostic process (diagnostics, prognosis, selection of treatment), but also an opportunity to improve the qualifications of doctors when using IDSS. IDSS provide the doctor with answers to questions related to the decision-making process in the dialogue process [1]. It should be noted that the involvement of specialists in one or another subject-oriented area of medicine makes it possible to actively apply their knowledge and skills in the construction of the corresponding ISPPR. The use of ISPPR helps the doctor to obtain additional knowledge in the case of an incomplete manifestation of the clinical picture and in complex cases, in particular, in case of rare diseases.

Statement of the problem

Recently, the use of artificial neural networks for diagnosis and forecasting in ISPPR is quite common. However, it should be borne in mind that their decision-making is based on the calculation procedure, which is based on the transformation of the input coefficients of the features. Accordingly, they are a "black or gray box" that does not allow for clarification of the rendered decision. As a way out of this situation, it is proposed to use a combined approach based on a frame structure with the application of production rules that provide an explanation understandable to the doctor, which includes a list of signs, taking into account which the diagnostic hypothesis is formed. The method of presenting fuzzy knowledge in the form of fuzzy production rules is the most universal.

Analysis of existing IDSS

IDSS of medical solutions, if there are explanatory modules in the scope of the architecture, are characterized by an educational effect on specific examples in the process of use. Intelligent SPDs have this property to varying degrees. At the same time, a retrospective approach often allows the discovery of modules in previously created systems that are of great interest to new systems. This is appropriate to consider separate medical intelligent systems created in different years to support medical solutions, which are of particular interest for improving the doctor's qualifications when working with them. The very first medical expert system, MYCIN, was aimed at helping with diagnosis, in terms of identifying the microorganism that caused bacteremia and choosing the appropriate therapy [1,12]. The module for generating explanations was automatically called after the end of the consultation, which allowed the system to ask questions of a general and private nature that help to understand the logic of the proposed decision. The system also implemented a mode of taking into account the views of different scientific schools.

Educational medical IDSS are aimed at finding errors in the solution proposed by the student or doctor and offering an alternative option. As an example, that deserves attention, we can cite the IDSS of Yale University in the USA [2,3]. IDSS ATTENDING evaluates the preoperative preparation plan and the choice of anesthesia method, paying attention to the deficiencies that need to be corrected and the hazards that can be avoided. Knowledge is presented in the system in the form of a list of comments on certain actions of the doctor. Further development of this direction (FEOATTENDING, which evaluates the actions of a doctor when prescribing an additional examination for a patient) involves the use of knowledge that reflects the positions of two competing medical schools. This direction can provide an opportunity to use the best of various scientific approaches in practical medicine.

The Hunter Syndrome (Mucopolysaccharidosis Type II) EClinic Medical Education Program for use in IDSS is available from the Lysosomal Storage Research Group (http://www.lysosomalstorageresearch.ca). This program was developed using a multimedia platform in the form of an interactive virtual clinic and quick access to the literature, which provides support for decision-making in the IDSS of this disease profile. In an environment reminiscent of a real clinic, it is suggested to take a medical history, examine the patient and prescribe an appropriate study. The program provides real clinical data of patients. The user is offered questions intended for an immediate assessment of the effectiveness and efficiency of the training or professional development process [4].

Have a certain interest in the field of medicine of the IDSS, which have problem solvers. Such ISPPR carry out a synthesis of cognitive procedures [5], which include modules explaining the proposed solutions. A comfortable interactive dialogue should increase the doctor's knowledge in the process of differential diagnosis, contribute to the formation and understanding of hypotheses. In a number of IDSS, the knowledge bases contain both linguistic rules and images [6], which are presented to user doctors. These can be phenotypic manifestations of the clinical picture of diseases, which is especially important in rare diseases, and even images obtained during instrumental studies (Echo-CG, CT, MRT, etc.). Their presentation to doctors in the decision-making process by intelligent systems will contribute to increasing the effectiveness of the formation of diagnostic hypotheses, as well as the knowledge of doctors.

Decision of the problem

Making a rational medical decision in conditions of uncertainty requires a weighted expert assessment taking into account the maximum number of factors possible for the given task, which is due to the possibility of their formalization in the presence of specialists in the relevant subject area. medicine. As already mentioned above, in this article it is proposed to build the ISPPR of professional development of doctors on the basis of a scheme of fuzzy logical derivation [7]. Hence, the following generalized structure of ISPPR is proposed (Fig. 1). This IDSS is focused on the use of specialized information warehouses (Data Warehouse) and OLAP (On-Line Analytical Processing) technologies – dynamic multidimensional data analysis using an effective tool for intelligent data analysis, modeling and forecasting [8].

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The analysis of indicators of the effective functioning of such a service-oriented ISPPR is given in work [9].

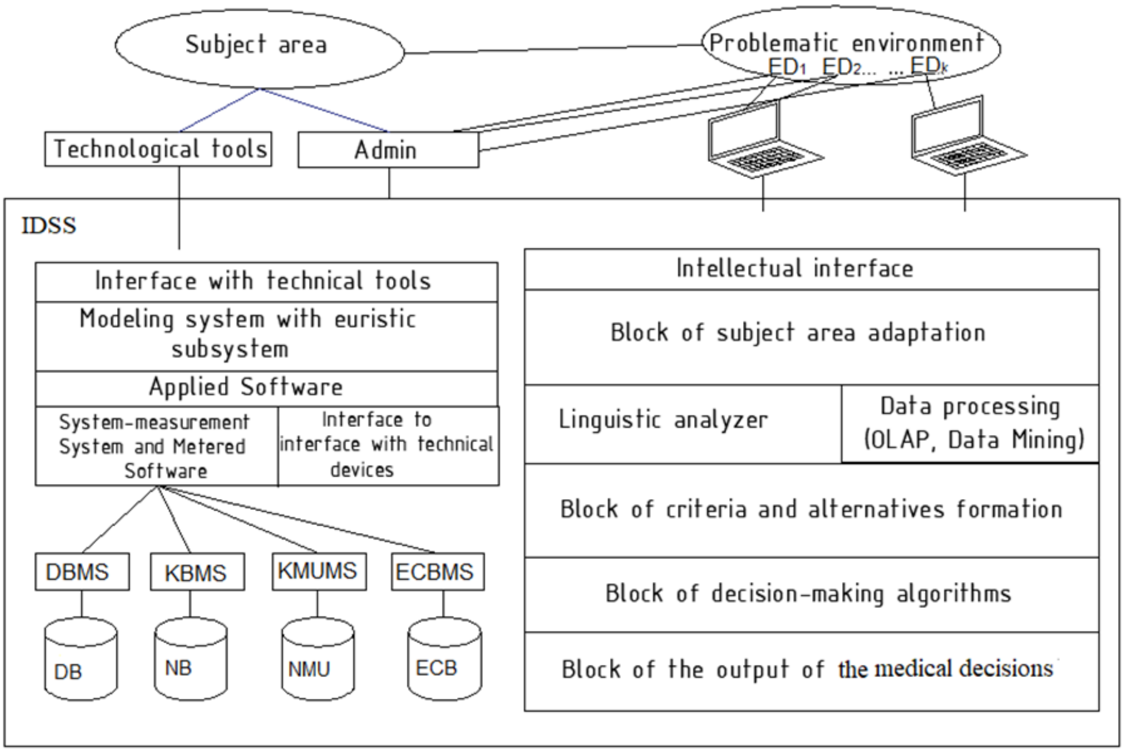

Figure 1. Generalized structure of the educational medical IDSS (DBMS, KBMS, KMUMS, ECBMS – management systems of database, knowledge base, knowledge model update, evaluation criteria base, respectively; ED1, ED2 ... EDK–- expert designers)

The IDSS structure shown in Fig. 1 ensures, in dialogue with design experts, an automated setting for the selected subject area of medicine by entering into the system the main concepts, attributes, their possible meanings, connections between them, as well as types of possible situations characteristic of this subject area region A knowledge base (KB) is defined as a knowledge representation model (KRM). The development of the KRM is the most difficult stage, the «bottleneck» of the creation of any intelligent systems, in particular medical IDSS [10].

According to the above proposed combined approach to the construction of the MPZ for the ISPPR of improving the qualifications of doctors (Fig. 1), we will consider the scheme of the mechanism of fuzzy logical derivation. The scheme of the mechanism of fuzzy logical derivation, the basis of which is the compositional rule of Zade, is presented in Fig. 2. The composite rule of Zade's derivation is formulated as follows: if the fuzzy relationship between the input (x) and output (y) variables is known, then with the fuzzy value of the input variable $x = \tilde{A}$, the value of the output variable is determined as follows: $y = \tilde{A} \circ R$, where $\circ$ – sign of maximin composition.

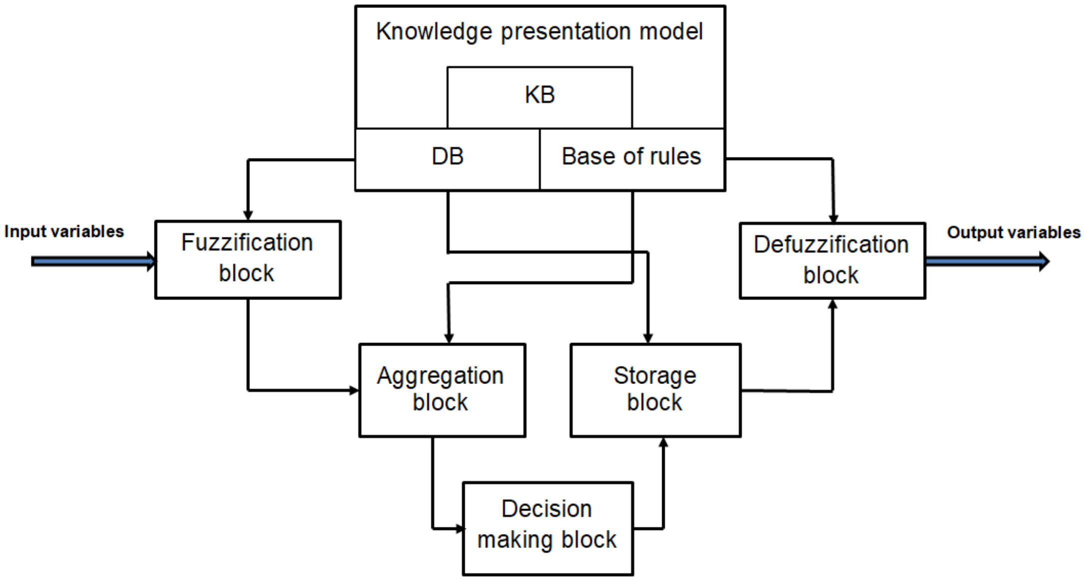

Figure 2. Scheme of the fuzzy logic inference mechanism

The scheme includes the following operations:

– formation of the basis of the rules of the system of fuzzy logical derivation;

– comparison of the values of membership functions of different input variables to obtain the weights of each rule (*aggregation*);

– determination of initial fuzzy values from each rule (accumulation);

– transformation of the values of the membership functions of the output variables into the output value (*defuzzification*).

In order to implement the scheme of the mechanism of fuzzy logic output, calculation functions are specified in ISPPR, which allow to calculate:

– the degree of uncertainty of the antecedent to the extent of the uncertainty of its components;

– the degree of uncertainty of the consequent by measures of the uncertainty of the rule and the prerequisites of the rule;

– the aggregate degree of uncertainty of the statement regarding measures derived from the rules.

The introduction of the degree of uncertainty will enable the combination of degrees of reliability C_n^k factors of importance of knowledge Ini and several pieces of evidence confirming or refuting the same hypothesis. It should be noted that the implementation of the mechanism of logical inference in knowledge bases affects the general strategy of inference: on the one hand, it is necessary to achieve the use of all relevant factors and rules, on the other hand, to achieve their uniform and one-time impact on the decision-making process. Situational uncertainty in the subject area, as a multiple factor in making a decision

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regarding the possibility of formalization, must be transferred to the plane of mathematical calculations, which can be done in the form of applying the basic principles of using mechanisms of logical derivation.

It is known that the main elements of a frame *KRM* are:

1. The generalized linguistic variable of the frame *KRM* has the following form:

$$\omega = (n, T(n), U, G, M), \quad (1),$$

where ω is a linguistic variable; $T(n)$ is the term-set of its values, which are names of vague variables; U – domain of definition of each fuzzy variable; G – some syntactic procedure that serves to expand the set $T(n)$ generation of new elements; M is a special semantic procedure that interprets the values of the linguistic variable, which are formed as a result of the execution of the G procedure, into a fuzzy variable, i.e forms a corresponding fuzzy set.

2. The knowledge A_k of the frame *MPZ* is determined as follows (example):

$$A_k = IF(\omega_1\mu_1(u)U_1AND \dots AND\omega_i\mu_i(u)U_i\omega_i\mu_i(u)U_i)THEN\omega_k\mu_k(u)U_k), \quad (2)$$

where $\mu(u)$ – membership function; U is the domain of $\mu(u)$.

3. Decisions

$$R = \{A_1, A_2, \dots, A_k\} \text{ (as a set of known } A_k). \quad (3)$$

For each generalized linguistic variable determined by the set of values of the input parameters, we will uniquely match the elements of the set of reliability factors C_n^k and the elements of the set of knowledge importance factors I_n^l. The value of A_k is determined by an expert and formalized by an engineer based on knowledge (*k* and *l* are, respectively, subsets within the set of factors *n*), and:

$$C_n^k, I_n^l = (0,].. \quad (4)$$

Since in many subject areas of medicine, in particular diagnostics, there are clearly unclear cause-and-effect relationships, a simpler and more effective option for building an *KRM* is a combined approach based on the frame structure of the knowledge model with the use of production rules, which provides for this way of organizing the computational process, with to which the program of transformation of the information structure of the *KRM* is given in the form of a system of production rules of the form: «Antecedent → Consequent»[11]. Production rules facilitate the formation of explanations, results of conclusions and calculations. They can process unplanned but useful interactions. In other words, they can use a portion of knowledge when needed.

From here, we will present expert knowledge about the choice of a solution in the form of a set of vague linguistic statements, equal to:

$$A = (IF(\alpha_1 THEN\beta_1 AND \dots AND(\alpha_i THEN\ \beta_j, \quad (5)$$

where α_i – a generalized linguistic variable defined on a set of input parameter values; β_j – a generalized linguistic variable defined on a set of initial parameter values.

The essence of the mechanism of logical derivation in this case is to determine the dependence of the variable β on the corresponding value α, taking into account the reliability factor C_n^k and the knowledge importance factor I_n^l.

Thus, in order to use the mechanism of the procedure of fuzzy logical conclusion, the following two problems must be solved:

1. It is necessary to construct some mapping by means of which the value β of the declared fuzzy variable α is put into a mutually unambiguous correspondence of the membership function. This task is solved by repeating the membership function of the closest base value of the linguistic variable α.

2. It is necessary to determine the degree of truth β in relation to the linguistic statement α. This value of the de α gree of truth is expertly determined by a fuzzy set on the interval (0,1).

Since taking into account factors with an insufficient degree of reliability can lead to the generation of a low-quality solution, factors with a C_n^k value greater than 0.8 are usually considered.

It should also be noted that since in this *KRM* each reason corresponds to an explanation, in which as a consequence a ready-made mechanism for the implementation of this reason is laid, the procedure of general fuzzy logical derivation is significantly simplified.

For example, to determine possible diseases of patients according to one of the indicators of a general blood test, the production rules in a knowledge representation model can be written in the following form [13]:

– *IF* «*hemoglobin is above normal*» *THEN* «*this is a sign of blood coagulation when the body is dehydrated, which can lead to an increase in blood pressure, an increase in the risk of thrombosis, myocardial infarction, stroke*»;

– *IF «hemoglobin is below normal» THEN «this is a sign of one of the types of anemia, the cause of which can be a deficiency of iron, vitamin B12, hyperhydration (excess water in the body)»;*

– *etc.*

At the same time, it should be borne in mind that hemoglobin norms, like other signs, depend on the gender, age and condition of the patient's body. The normal concentration of hemoglobin in the blood in adults is: in men – *135-160 g/l*, in women – *120-140 g/l*. For pregnant women, the indicator is slightly lower – from *110 g/l*.

It should also be noted that the deviation from the norm of only one indicator can indicate different diseases, therefore it is important to determine the degree of truth β in relation to the linguistic expression α for each indicator when fixing identical signs of the disease.

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Conclusion

The development of IDSS medical decisions provides an opportunity not only for advisory assistance at various stages of the treatment and diagnostic process (diagnosis, prognosis, treatment selection), but also the opportunity to improve the qualifications of doctors during the use of IDSS.

Systems based on artificial intelligence methods provide the doctor in the process of dialogue, obtaining answers to questions about the decision-making process and explaining the proposed hypothesis. At the same time, the doctor can find out the signs necessary to clarify the proposed hypothesis, as well as additional diagnostic studies in case of complications. These are the features of the intelligent SPPR, which are called the "transparency" of the system, which contribute to the acquisition of additional knowledge by the doctor in case of incomplete manifestation in complex cases, in particular, in rare diseases.

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