Using Intelligent systems in Pharmacy

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Abstract—**This paper is devoted to the issues of the constructing the expert systems in the area of pharmacy. The use of expert systems in pharmacy allows reach a new level in the process of intelligent search the appropriate pharmacy products for the clients and pharmacists.**

Index Terms—**Expert system, pharmacy market, intelligent search.**

I. INTRODUCTION

Nowadays, science and technology are developing with a high speed. As an example we can take an artificial intelligence, task is the understanding of human intelligence. In other words, artificial intelligence is a scientific field, which develops methods, that allows electronic computers to solve intellectual problems, if they are solved by man. Furthermore, artificial intelligence as a scientific discipline consists of several major trends. It should be noted, that nowadays as a progressive direction of artificial intelligence have become expert systems. Purpose of expert system is forming and outputting the recommendations depending on the current situation, which describes a collection of data and also user input data interactively. Moreover, recommendations issued by the computer must conform to the recommendations of highly qualified specialist.

Today on the pharmaceutical market we can observe a lot of different systems that work with storing and extracting the data. For example, in Kazakhstan there are some web-oriented systems like vidal.kz, i-teka.kz and eurapharma.kz, which allow searching drugs, sorting the search results by price and give some special information about this drug. These types of systems use only data management and processing. But in the most cases the pharmacists and clients need more intelligent results and recommendations about the proposed drugs. For instance, the relevance certain type of drugs for people with some contraindications by health. Also as everyone knows, that pharmacist's life like feeling tired or lacking of information that may lead to make an error in drug selecting or dispending. That is why the creation of expert systems in Kazakhstan's pharmacy market will be useful for pharmacists, minimizing their efforts and time. In other words, system will greatly facilitate the decision making process of the pharmacists, especially in unusual situations when the selection needs to be more accurate and complete.

II. EXPERT SYSTEM STRUCTURE

To develop such type of expert system we have considered the following components like user interface, inference engine and knowledge base.
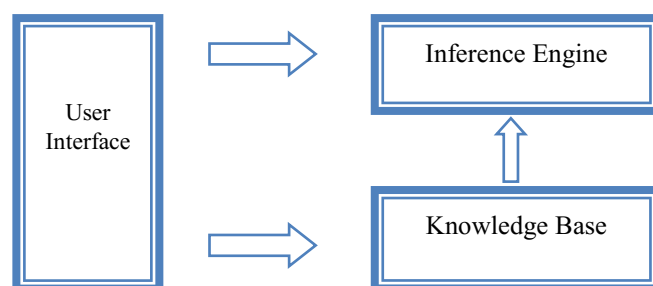

Figure 1. Major parts of an expert system

User Interface is a tool, which shows relationship between the user and system. In other words, user interface enables users to interact with our system. Interface of this system simple and easy to use.
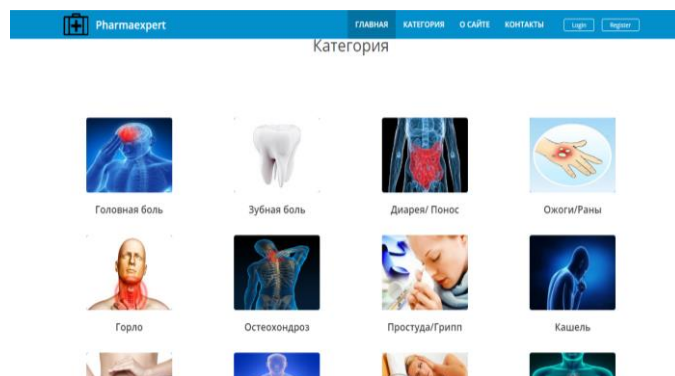

Figure 2. Category of diseases

In the main page of this system shows the list of all disease's categories (Figure 2). After selecting one disease, appears another page which shows a list of contraindications only selected category drugs (Figure 3). In this web-page a pharmacist can choose one or more contraindications, also at the client's discretion, he can choose other options, such as a form of release and price of drugs.

Figure 3. Page of contraindications

After clicking one or more type of contraindications, appears recommendation page (Figure 4), which shows one suitable drug with full instruction including type of drug, price, indications, dosage, adverse effects and contraindications.

Figure 4. Recommendation page

Also, as shown in table (Figure 5) pharmacist can recommend other drugs if client not satisfied with prices or other instructions of drug. It means system shows other drugs as sub-drugs which have same number of symptoms, contraindications with essential. Furthermore, it should be noted, that in table presents only drugs from chosen category.

Figure 5. Table of sub-drugs

Furthermore, in our system we considered:

- ✓ only frequent diseases, in which people don't need the doctor's prescription;

- ✓ only such drugs which are available without doctor's prescription.

Likewise, how this user interface works and how they will interact with each other depends on inference engine. Because inference engine is a main brain of our system, also it plays main role to get all appropriate information from database.

III. INFERENCE ENGINE

Inference Engine is a mechanism that's manages the expert systems and decide if the problem has reached an acceptable solution or not [3]. In our case we use the classification by categorizing all the drugs. Also, in order to give recommendation system will use if-then rule by counting the numbers of contraindications and fuzzy logic rule. For instance, if the number of contraindications in one drug more than others in selected category, then system will remove this type of drugs and recommends only one suitable drug with minimum number of contraindications by using classification. Furthermore, we considered the Dempster-Shafer's theory of believe and decided to improve this system by using this theory.

IV. KNOWLEDGE BASE FORMING

The core of the proposed expert system is Database. It is very important to know how data are stored in database and by which logic or rules they interact with the interface. If inference engine is a universal thinking machine, then knowledge base is the over what this machine will think [2].
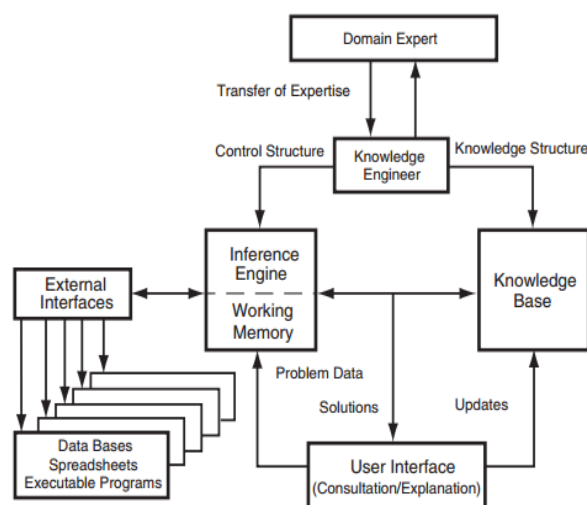

Figure 6. Integration of ES components

That is why the success and effectiveness of our expert system mostly depends on the completeness and the quality of the information stored in the system's knowledge base. In our knowledge base part, we have a table with column names like:

- name of drugs;
- type of drugs;
- price;
- pharmacological properties;
- indications;

- adverse effects;
- dosage;
- contraindications.

V. STEPS IN THE SYSTEM DEVELOPMENT PROCESS

All tasks implemented step by step in terms of time.

1) Problem selection:

At this stage:
- the problem area is defined;
- specialists - experts are selected;
- the group of developers are selected;
- the detailed plan of development prepares.

As we noted above, in some cases pharmacists can make an error in drug selecting or dispending. Also when we come to the pharmacy and ask them an instruction of one drug, in most cases pharmacists become to search this drug and start reading instruction of drug. It takes more time, especially when we are in hurry. In our point of view, it is one of the problems on pharmaceutical market in our country.

2) Development of ES prototype (Prototyping):

The prototype system is a reduced version of ES and correctness representation of facts, designed for check, communications and strategy of experts [1]. Development of ES prototype is divided into six stages:

- identification of a problem;
- extraction of knowledge;
- conceptualization (structuring) of knowledge;
- formalization;
- realization of a prototype;
- testing.

a) Identification of a problem – acquaintance and training the group members of a developers, and also creation of informal formulations of a problem. At this stage our tasks are specified and planned the course of development ES prototype. Moreover, in this stage are defined:

- resources (time, people, etc.);
- sources of knowledge (book, additional experts);
- the available similar ES;
- classes of solvable tasks, etc.

During the implementation of our project we considered all available and similar ES in the sphere pharmacy as DoseChecker, PharmADE, Microbiology, etc. Also we have considered all sources and have consulted with opinions of experts who work in pharmacies and of course have consulted with programmers to know which programming languages or platforms are better to realize ES.

b) Extracting the knowledge - getting the all possible knowledge concepts from engineer about the certain type of subject area. To extract the knowledge engineer uses various methods: analysis of texts, conversations, lectures, discussions, interview, observation, and others.

c) Conceptualization (or structuring) knowledge - development of non-formal description of domain knowledge in the form of a graph, table, or chart, which reflects the basic concepts and the relationship between the concepts of the subject area. At this stage, are determined: the terminology, the list of basic concepts and their attributes, relationships between concepts, the structure of the input and output of information, decision-making strategy, etc.

Firstly, we collected all dates about the drugs and by means of an experts' knowledge have divided them into categories.

Figure 7. Category of drugs

Also, it should be noted that we have considered only frequent diseases and drugs which are available without doctor's prescription in our country. In figure 7 shown the table of categories of all drugs, which are used in database part.
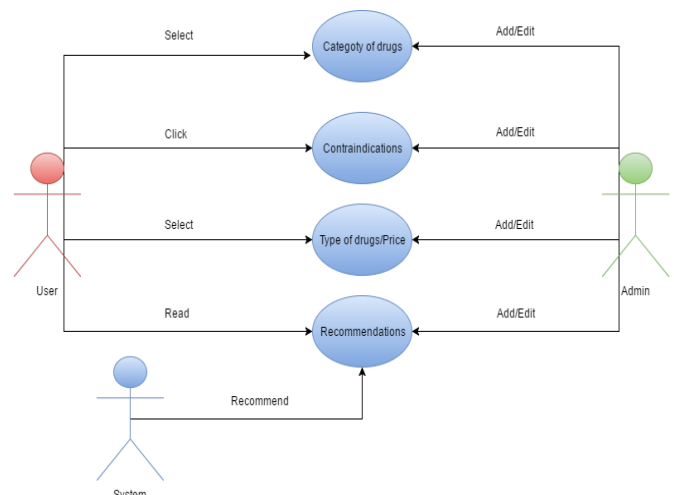

Figure 8. Class diagram of system

In figure 8 shown class diagram of project, where admin can add and edit all dates and user can see it. Also system can recommend only one suitable drug, using dates which are added by admin.

d) Formalization of knowledge is a development of knowledge base in language of knowledge representation. In this stage are used: logical methods, productional models, semantic models, frames, the object focused languages.

As a logical method we have decided to use if-then rule and fuzzy logic. Because for the beginning developers of expert systems, this logic rules are more suitable.

e) Realization of a prototype – development of complex program showing the viability of approach in general. At this stage ES prototype (including the knowledge base, other

program modules) is created with the help of: programming languages (traditional, specialized), tools of development of ES, "empty" covers of ES.

In order to store all dates in database and to create a website we stopped to use MySQL and PHP. Because, today an expert system developers have an opportunity to develop, realize their applications via the web also. Since all data are stored in database, this language is suitable to connect with database and to solve complex problems.

f) Testing – is a process of identification mistakes in approach and realization of a prototype. The prototype is checked on: convenience and adequacy of the interface of input-output, quality of test examples, completeness and consistency of rules in the knowledge base.

During the testing we have detected some mistakes. For example, our system not considered the type of drugs after clicking contraindication part. Also, in contraindications page (Figure 3) appeared all contraindication of all added drugs. It was some kind of mistake because one contraindication shouldn't have repeated twice in selected category. In this stage we have corrected all our mistakes which have appeared in a testing time.

3) Development of a prototype to industrial ES:

The main work at this stage consists in extension of the knowledge base. After establishment of the main structure of ES knowledge the knowledge engineer starts development and adaptation of interfaces by means of which system will communicate with the user and with the expert. The system should give to the user an opportunity to specify the unclear moments, to stop work and etc.

In this project as experts pharmacists will add categories, add new drugs to the existing castegories, also edit dates.

Users can choose one category from list of them, then click contraindications by chosen category and if they need, can choose type of drugs and price. After that system will recommend them most suitable drug by couting number of contraindications.

4) Stage joining of system:

The ES connection with other programs is carried out in the environment at which it will work. For confirmation of system usefulness, it is important to give to each of users an opportunity to give some real tasks to ES to check how it will carry out them. Joining includes ensuring communication of ES with the existing databases and other systems at the enterprise.

In this stage, we connected all works that we have done. For example, database part we connected with user interface part by using logical rules as if-then and fuzzy logic.

5) Support of system:

Complete systems in order to improve its performance and increase portability can transcode into another language (such as C), but this will reduce its flexibility. This can be done with the systems, which are designed for problem areas where knowledge is not changed. If the subject area for a system is changed, then it is necessary to maintain the tool in that environment in which it was created.

VI. USING SOFTWARE TOOLS AND SYSTEM EFFECTIVENESS

Today, expert systems developers have the opportunity to distribute their applications via Web. Since all data are stored in the database, we should choose and connect it with one web based programming language. The development of the most web based expert systems embodies a number of benefits. For instance, the use of an internet based database was effective in storing large amount of facts and data for web based expert systems, also using PHP or HTML makes it easier to enhance the expert system user interface [7]. After analyzing and testing various types of Web oriented programming languages, we stopped at the PHP, because this language is simple to use and allows complex conditions and complex conclusions. Additionally, to PHP we used programming languages like Laravel (framework of PHP), JavaScript, HTML, CSS, MySQL, bootstrap, OOP, MVC. By using this languages and production model of the expert system we can achieve approximately 70% of the efficiency of the proposed recommendations. In order to increase effectiveness of the system we plan to expand database in terms of diseases and recommendations for them.

VII. CONCLUSION

The development of such types of expert systems relates to the different issues of the data store structure, its relationships representations, and relevance of the appropriate rules models [5] that serve as a base for intelligent search and filtering. The main idea is to find the relevant links between the data stored, special conditions (rules) and proposed solutions (recommendations). Thus, further researches in this area may discover some new options for selection process and facilitate the process of choosing the essential drugs.

During the performance of this work all the tasks have been achieved set of objectives. As a result of this work created expert system as web application(pharmaexpert.kz) in the sphere pharmacy, which can greatly facilitate the decision making process.

It is supposed that this expert system will be actual for pharmacists, minimizing their efforts, time and likelihood of making errors during the selecting and dispending drugs to clients.

In the course of performance of this work have been studied the ES development environments, logical rules and their application, also general principles of creation knowledge base.

Furthermore, ES for pharmacy is developed with the purpose to facilitate and to automate activity of experts in order to avoid errors due to the human factors. Unlike the person, our system has a smaller probability of mistakes. Also, in the future we planned develop it as a mobile application and expand dates about diseases and symptoms.

EXPERT'S OPINION

Expert #1: Development such type of system in the field of pharmacy is very good. But as we all know medicine is not staying in one place, it means, every day have been created new drugs and are included to the pharmaceutical market. I would like to, that this system has become a self-learning and working as experts in the future. And of course, people should entrust their health to this system, how they are entrusted to the doctors during the inspection.

Expert #2: In my opinion, system should include not only such diseases in which people don't need a doctor's prescription, but also it should be able to connect with hospitals, in order to get doctor's diagnosis for other diseases.

Expert#3: You should to develop it with the help of experts in the field of medicine and pharmacy, because they know better than others. And of course in your system not enough drugs, symptoms and contraindications. I think if you develop this system with experts it will be great and people start to use and believe to your system.

Expert #4: I think that you should consider that one tablet has a similar instruction with other tablets. So you have to deal with such situations, for example in case when person by his health reasons cannot use some kind of drugs then he cannot use the tablets that have the same properties.

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