Knowledge based Diagnosis of Abdomen Pain using Fuzzy Prolog Rules

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ABSTRACT

Decision support through Information Technology is an integral part of our lives. It is being increasingly used for decision-making in the medical science also. This article introduces the information explosion in medical field elaborating the need of a knowledge-oriented decision support system for diagnosis of abdomen pain. Main objective of the system is to assist doctors, assistants and social workers in their decision making process and create awareness in the area especially where trained manpower is in scarce. To impart the fuzziness of the domain, modified Prolog rule format is used, which is illustrated in a case of appendicitis. This article presents general framework of system, sample rules, resulting charts and sample screens of the prototype implementation.

Keywords: *Knowledge Based Diagnosis, Advisory System, Fuzzy Prolog, and Decision Tree.*

1. INTRODUCTION

There is an increasing appreciation of the role that computers and informatics are playing to improve the overall health delivery systems. Diagnosis requires far more critical decision-making on a wide range of options. It also requires a large amount of humanism [1]. Medical informatics has high visibility through applications in areas such as diagnostic techniques in ultrasonography, x-ray, computerized tomography scanning, nuclear magnetic resonance imaging etc. The other areas can be clinical laboratories, pathological investigations and computer-assisted decision-making. In medical practice, data acquisition as well as subsequent storage, retrieval and manipulation of the data are enhanced by efficient computerization through database in static fashion. Such decision-making through computers is cost effective and improves accuracy [2]. However, the decision support should be knowledge-oriented to improve effectiveness of the decisions made. Knowledge-oriented decision-making by its nature helps in identifying most plausible diagnosis and provides ease of choosing an appropriate treatment. Large amount of existing medical knowledge and rapid growth of the knowledge have resulted in a situation where even specialists find it increasingly difficult to assimilate and use the information that would be useful in making effective decisions. This leads the decision making a tedious and time-consuming process.

Most of the Indian population lives in rural areas where doctors and specialists are in scare. Due to scarcity of experts and information explosion in the field of medicine, there is a need of knowledge-oriented decision-making systems. The main objective of the system is to assist doctors, assistants and social workers in decision-making process for various kinds of the abdomen diseases. Information on the cause, diagnosis, symptoms, complications, prevention and treatment needs to be identified, documented and inferred by the system for benefits of the rural locality; especially where expertise is not available on demand. This type of system will be an efficient means to store and to pass experts knowledge in documental form for long time and it can provide primary advice to the health workers and patients in initial stage. Hence, an advisory system that applies the knowledge in diagnosis and determines patient's condition is the prime necessity in the medical field. This article proposes a general framework of knowledge-oriented decision support system for advisory, diagnosis and awareness for the field. As an illustration, a few sample fuzzy rules are formed with the help of domain experts for appendicitis case.

2. KNOWLEDGE-ORIENTED APPROACH

A Knowledge-Based System (KBS) has interdisciplinary approach of various disciplines like computer science, cognitive science, hardware field etc. The society and industry are becoming knowledge-oriented and rely on different experts' decision-making abilities depending on the information available. When expertise is unavailable, a KBS can act as an expert on demand to save time.

KBS can save money by leveraging expert, allowing users to function at higher level and promoting consistency [3]. One may consider the KBS as a productive tool, having knowledge of more than one expert for long period of time. Large percentage of the population in India lives in rural and remote areas, where medical facilities are unavailable. Hence, there is a need of a system that supports decisions and increases awareness in the area. Such system can potentially alleviate the immense diagnostic workload of rural health workers and medical practitioners. Also, it can assist in prevention of various diseases. In addition, by using such systems, user will get the advantage of the knowledge of more than one specialist. Such KBS uses Artificial Intelligence techniques for efficient and effective decision making in unstructured domain and apply reasoning and explanation facility for the domain problem to achieve high level of performance.

The large amount of existing medical knowledge and the rapid growth of that knowledge during the last quarter of the 20th century resulted in a situation where most clinicians find it increasingly difficult to assimilate the field information, which could be useful in making optimal clinical judgment. The system can provide a solution to much of the problems created by such information explosion. Decision making by the clinician in the management of patient's data is a highly intellectual activity, which involves: (i) skill in gathering and evaluating the information about the patient; and (ii) ability to effectively utilize the large body of medical knowledge. The system can facilitate to improve the clinician's performance of each of this task.

3. STRUCTURE OF THE SYSTEM

The model of the discussed system is given in Figure 1 representing the overall process structure of KBS for medical diagnosis. The basic components of the system are the knowledge base, inference engine, and a workspace. The knowledge base of the system plays a key role in the procedure of decision-making [4] by efficiently storing the domain knowledge and patients history. Temporary results can be stored in workspace. The inference engine is a program, which infers the knowledge available in the knowledge base [5].

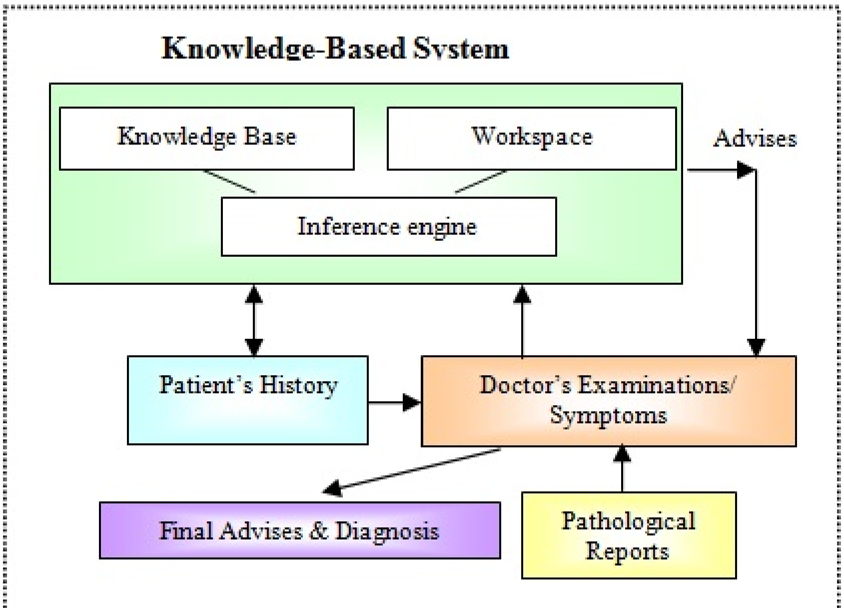


Figure 1. Structure of the system

The knowledge base of the proposed system first receives the preliminary information from the patient through self-administrated questionnaires and retrieves the patient's history, if any, stored in the knowledge base. After evaluating the inputs, the program presents a new questionnaire to the patient. Using the information, the system suggests action/advisory for further tests and/or conclusion about the patient's disease. An expert may have a manual control/justification of the given suggestions and alternatives depending on degree of uncertainty associated with the patient's response and overall decision-making process.

The knowledge of the expert in the decision-making can be represented in various forms. The knowledge of expert can be easily represented into rule-based format as a set of conditional rules [6]. Rules may be chained according to the knowledge it represents. Considering the uncertainty of the diagnosing process, the fuzzy rules are used here. To accommodate such fuzziness, typical Prolog rule format is modified. Each rule has a basic form -

IF antecedents THEN consequent

If certain antecedents are evaluated as True, then it logically follows the consequent. As denoted above, the modified Prolog rule format is

Hypothesis (Name, Disease, Probability);
Symptom (Name, Indication, Probability);
Symptom (Name, Indication, Probability);
…
Symptom (Name, Indication, Probability).
.... Eq. (1)

Here Hypothesis and Symptoms are user defined predicates in Prolog [7]. These predicates use symbols (variables) like Name (user name), Disease (disease name) and Probability (chances in percentage). Probability factors given along with the rules for the concerned advises are considered as the degrees of uncertainty related with the decision taken [8]. These values are determined by taking samples from experts. The hypothesis proved true if patient's data has all the indications given in symptom lists. Systems knowledge base consists of such multiple fuzzy rules representing the domain knowledge in the form of Prolog code.

4. AN ILLUSTRATIVE CASE OF AN APPENDICITIS PROBLEM

An intelligent advisory system for abdomen pain can also take care for the appendicitis problem including various other abdomen diseases. Interactive sample rules are proposed here, that can directly assist doctors or other health workers in finding the probability of having particular disease like appendicitis.

Appendicitis usually commences as in inflammation of the mucous membrane or lymph follicles, which may terminate in one of the following ways [9]:

- Resolution
- Ulceration
- Suppuration
- Gangrene
- Fibrosis

The system prepares the history of patient by asking several questions in the language understood by layman and predicts the probability of having a disease and presents advice for further treatment.

4.1 Sample Rules for the Above Case

Sample rules in modified prolog for the prototype implementation of the system are given as follows:

R1 Hypothesis(Patient, appendicitis, 0.1) :-
symptom(Patient,pain_ur, 0.4),
symptom(Patient, pain_shift_rif, 0.1),
symptom(Patient, o_test_result, 0.2).

R2 Hypothesis(Patient,rs_test, 1.0) :-
symptom(Patient,pain_rif, 1.0),
symptom(Patient, vomit, 0.8),
symptom(Patient, less_temp, 1.0),
symptom(Patient, tenderness_site, 0.8).

R3 Hypothesis(Patient, appendicitis, 0.6) :-
symptom(Patient,pain_ur, 0.7),
symptom(Patient, o_test_result, 1.0).

R4 Hypothesis(Patient,o_test, 1.0) :-
symptom(Patient,pain_rif, 1.0),
symptom(Patient, vomit, 0.8),
symptom(Patient, less_temp, 1.0),
symptom(Patient, tenderness_site, 0.8).

R5 Hypothesis(Patient, appendicitis, 0.4) :-
symptom(Patient,pain_ur, 0.7),
symptom(Patient, o_test_result, 0.3).

R6 Hypothesis(Patient,p_test, 0.8) :-
symptom(Patient,pain_ur, 0.7),
symptom(Patient, pain_shift_rif, 0.6),
symptom(Patient, vomit, 0.6),
symptom(Patient, less_temp, 0.8),
symptom(Patient, tenderness_site, 0.5).

R7 Hypothesis(Patient, appendicitis, 1.0) :-
symptom(Patient,pain_rif, 1.0),
symptom(Patient, o_test_result, 1.0).

R8 Hypothesis(Patient,p_test, 1.0) :-
symptom(Patient,pain_ur, 0.7),
symptom(Patient, pain_shift_rif, 0.6),
symptom(Patient, vomit, 0.8),
symptom(Patient, less_temp, 0.8),
symptom(Patient, tenderness_site, 0.6).

R9 Hypothesis(Patient, appendicitis, 1.0) :-
symptom(Patient,pain_rif, 1.0),
symptom(Patient, rs_test_result, 1.0).

R10 Hypothesis(Patient,p_test, 1.0) :-
symptom(Patient,pain_rif, 1.0),
symptom(Patient, vomit, 0.8),
symptom(Patient, less_temp, 1.0),
symptom(Patient, tenderness_site, 0.8).

R11 Hypothesis(Patient, appendicitis, 1.0) :-
symptom(Patient,pain_rif, 1.0),
symptom(Patient, p_test_result, 1.0).

R12 Hypothesis(Patient, appendicitis, 0.1) :-
symptom(Patient,pain_ur, 0.2),
symptom(Patient,pain_er, 0.2),
symptom(Patient, pain_rif, 0.1),
symptom(Patient, vomit, 0.8),
symptom(Patient, less_temp, 0.8),
symptom(Patient, o_test_result, 0.2).

As stated above, the knowledge collected from the field expert is codified in the Prolog language to form a rule base for the application. These rules are sequentially executed to come to a concluding/diagnosis. If the mentioned symptoms match, the hypothesis of having the appendicitis is true to some extent. For example, according to rule 6 (R6) 'If patient has pain in Umbilical Region and the pain shifts to Right Illias Fossa Region along with vomiting and tenderness symptoms at the site of appendicitis' (Region 4 in Figure 3), then Psoas Test is recommended with 80% probability. When rule 6 (R6) is true, the system will check all rules sequentially and fires rule 11 (R11) concerning the Psoas Test result in the symptom and conclude the probability of appendicitis.

Such multiple rules can be developed from a decision tree by maintaining the decision sequence. This is illustrated in Figure 2 in the form of decision tree that has critical information with proper directions for the discussed case. For structured decision-making, the whole abdomen region is divided into nine major parts as shown in Figure 3. For each of these 9 parts a separate tree can be prepared. Figure 4 shows results of the prototype implementation using the above discussed rules.

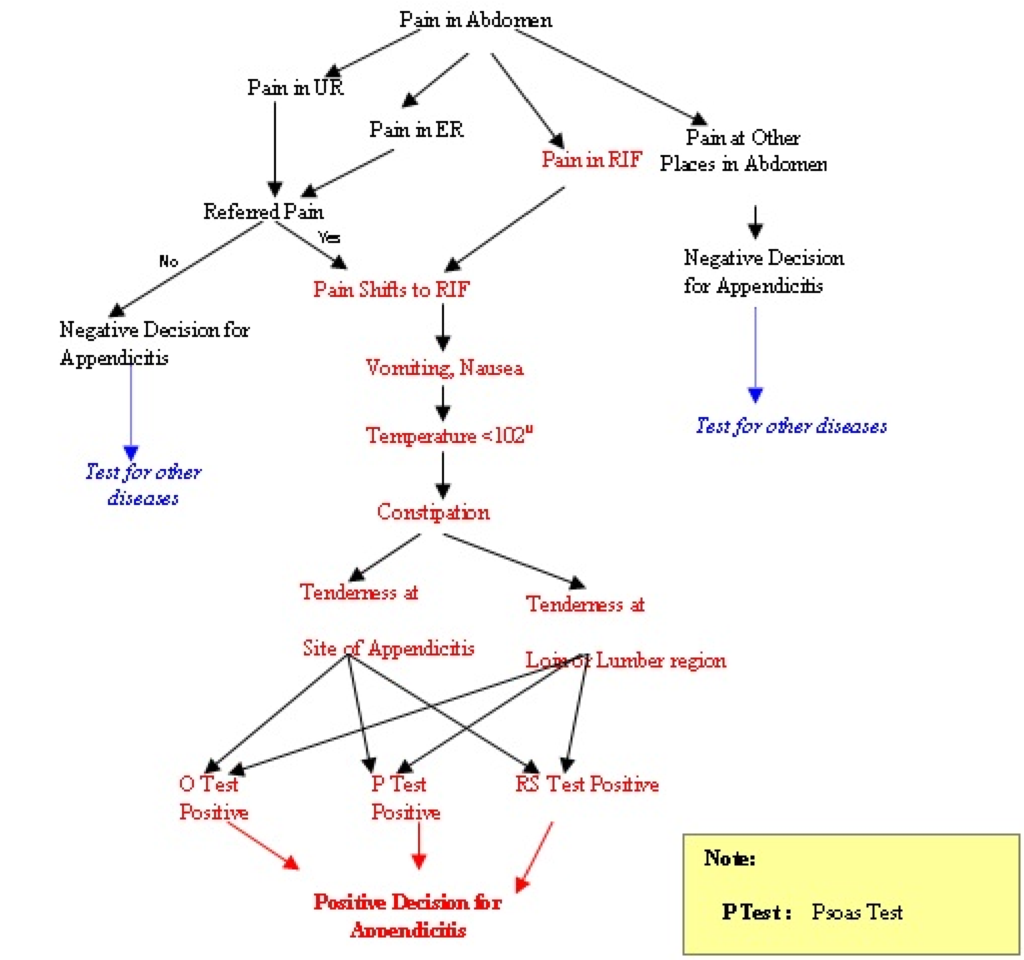
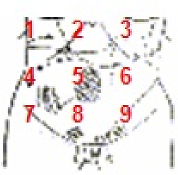


Figure 2. A decision tree for the appendicitis



Legends :

1. Right Hypochondrium
2. Epigastric Region (ER)
3. Left Hypochondrium
4. Right Lumber Region
5. Umbilical Region (UR)
6. Left Lumber Region
7. Right Illias Fossa Region (RIF)
8. Hypogastrium Region
9. Left Illias Fossa Region

Figure 3. Major parts of abdomen region

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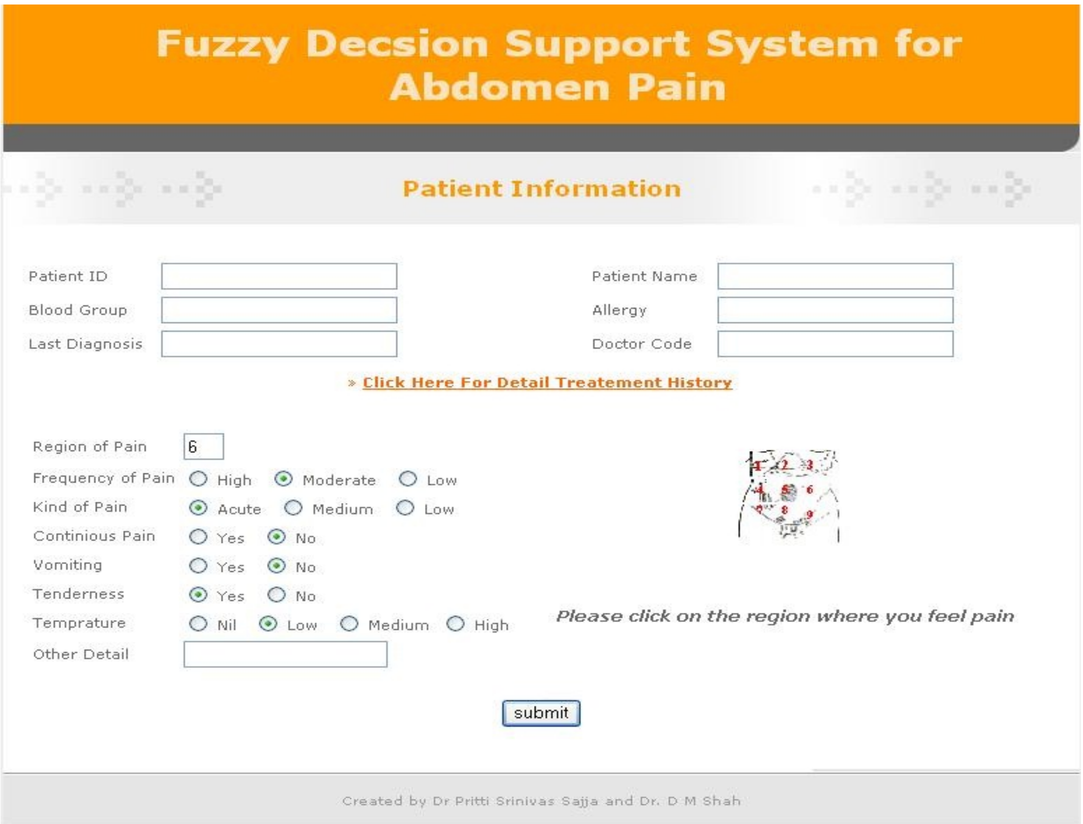

Figure 4. Resulting output of the experiment

5. CONCLUSION

The paper discusses architecture, and an experiment of abdomen pain using a model of a KBS for medical diagnosis. In similar manner, such system can be enhanced further for all possible cases in abdomen pain. Different types of customized heuristic can be incorporated with the fuzzy prolog rule structure used here.

This type of system can be proved an efficient means to store and pass experts knowledge in documental form for long time. Hence it can be used as a training and documentation tool also.

Using the proposed design one may go for the diagnosing and advisory systems in different domain. Development of an editor which enables knowledge engineer or expert to edit knowledge within the framework leads to a generic commercial product for KBS in diagnosing and advisory category.

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