

Medical Knowledge-Based System for Diagnosis from Symptoms and Signs

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ABSTRACT

This research proposes design and development of a medical knowledge-based system (MKBS) for diagnosis from symptoms and signs. This system was developed to support a knowledge construction and an inference engine. The knowledge construction was based on a concept of production rules, which was performed in tree structure. The inference engine used interactive forward chaining technique to infer a diagnostic result. The proposed system was designed to interact with user by using question forms of symptoms, and it was able to support text and picture information. The architecture of this system consisted of inference engine, knowledge base, user interface unit, knowledge acquisition unit, explanation module and blackboard. This medical knowledge-based system was developed by Borland *c++* language on Windows XP system. Finally this system was applied to check accuracy by comparing with general physician's diagnoses. The experimental result showed the diagnosis of the system more than 97% accurately at the 0.01 level of significance, when it is compared with diagnosis of a physician.

1. INTRODUCTION

The medical information technology for emulation of human reasoning process and human expert problem solving is knowledge-based system. In literature survey, MYCIN [1] is an expert system for diagnose or remedy bacterial infections, PUFF [2] is developed to diagnose lung disease, ANGY helps physicians to diagnose the narrowing of coronary vessels by identifying and isolating coronary vessels in angiograms, BABY aids clinicians by monitoring patients in a newborn intensive care unit (NICU), MECS-AI helps physicians to make diagnoses and to suggest treatments for cardiovascular and thyroid diseases, PIP assists physicians by taking the history of the present illness of a patient with edema, WHEEZE diagnoses

the presence and severity of lung disease by interpreting measurements of pulmonary function tests, NEOMYCIN helps physicians diagnose and treat patients with meningitis and similar diseases, MED1 helps physicians diagnose diseases associated with chest pain. GUIDON for instruct in bacterial infections, and HEME helps physicians diagnose hematologic diseases.

From these researches, we found that they benefit to public health. However the medical and public health in Thailand is based on the assumption that fundamental of public health is the heart of public health development. The important goal is population which can take care themselves, and they can learn and understand self-care, disease protection, and healing. However, there are not enough staffs of health for giving advice to population so this is an important problem for country development. From study we found almost diagnosis that is performed in history taking to chief complaint and symptoms. So this research presents design and development of the medical knowledge-based system. It is an alternative way to support public health of country, and this system help to create the medical knowledge-based system

2. DESIGN OF THE KNOWLEDGE-BASED SYSTEM

A process which is applied to design and develop a knowledge-based system in this research is called knowledge engineering as shown in figure 1. Knowledge engineer is a person who searches knowledge source, designs and selects development tools, develops, tests and adjusts the system before using in practical. The process of design system can describe in following:-

2.1 Knowledge Acquisition

Knowledge acquisition is a process of acquiring, organizing and studying knowledge. In this research, the knowledge is acquired from a physician and medical books for testing system. This knowledge can be divided by important fact into 20 facts, which are shown on table 1.

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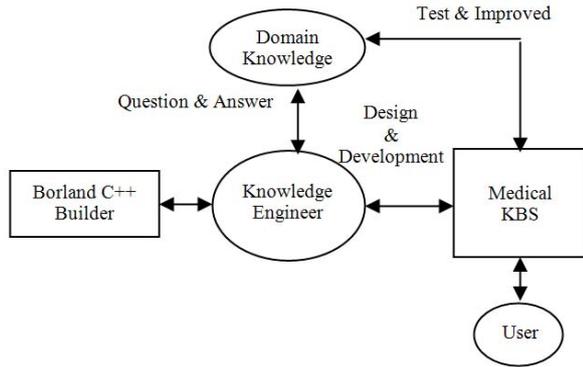


Fig.1: Knowledge Engineering in this Research

Table 1: Fact List of CHIEF COMPLAINT

No.	Chief Complaint	No.	Chief Complaint
1.	Fever	11.	Cough
2.	Fever & Nasal discharge/Cough	12.	Apthous ulcer
3.	Fever & Bradypnea/ Chest pain	13.	Abdominal pain & Fever
4.	Fever & Rash/ Itching	14.	Weight loss
5.	Headache	15.	Vomitting
6.	Dizziness	16.	Epistaxis
7.	Nasal discharge	17.	Pykncardia
8.	Sore throat	18.	Bradypnea
9.	Chest pain	19.	Abdominal pain
10.	Diarrhea	20.	Fatigue

2.2 Architecture of A Medical Knowledge-based System

The system contains 6 components which are knowledge base, inference engine, user interface unit, explanation module, knowledge acquisition unit, and blackboard. It is shown in figure 2. This system is defined to support to manage the knowledge, such as creating and editing facts of users and physicians. Furthermore, it can add picture and explanation of facts, and a main window is shown in figure 3. Figure 4 shows a rules-editing window, and a fact-creating window is illustrated as figure 5. Lastly, fact list editing can be managed by a window in figure 6. So this system can help users or physicians for creating, updating and editing the knowledge every times. Because the system has accuracy and automatic engine for inference, so the efficiency of system is depended on knowledge of medical expert human. This knowledge is imported to the system, and the accuracy of system is depended on its.

2.3 Knowledge Base Design

In this research uses the production rule-based knowledge representation and it consists of list of rule (shown on table 2). The rule can be defined as IF p_i THEN c_i , and we define p_i as premise and c_i as conclusion of rule. For the relationship between each rule can be displayed in rule-tree structure. This structure consists of root node for starting rule, intermediate

node for intermediate rule, terminal node for conclusion rule, and link for relation description. The algorithm for transforming rule base to rule-tree structure can be done by scanning all rules in knowledge base for finding the linkage of rule relations, which is shown in figure 8.

2.4 Inference Engine and User Interface Design

Generally, physician will question the patient about chief complaint and other symptoms. He will diagnose body of patient, and he will send the patient to laboratory for careful diagnosis. However this research dose not considers the result from laboratory. So when we consider the process for diagnosis of physician, we will find 3 important components [3]. These components are problems of patient, data, and diagnosis. The diagnosis is an important condition for indicating accuracy. So design of inference engine of knowledge-based system must consider the process for diagnosis of physician, it is shown in figure 9. The inference engine of this knowledge-based system is interactive forward chaining (show in figure 10). It uses facts of symptom and indication of disease for definition direction of inference.

The process of interactive forward chaining inference in the medical knowledge-based system as figure 9. The system first obtains chief complaint from the patient and places it in the blackboard. The inference engine then scans the rules in some predefined sequence looking for one whose premises match the contents in the blackboard or query the patient. If it finds a rule, it adds the rule's conclusion to the blackboard, firing the rule, then cycles and checks the rules again looking for new matches. On new cycle, rule that previously fired are ignored. This process continues until no matches are found. At this point the blackboard contains facts supplied by the patient and inferred by the system.

To illustrate this process of interactive forward chaining consider the following medical rulebase :

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RULE 1
IF The patient has sore throat
  AND The patient has suppurative inflammation of tonsil
  gland
THEN The patient is tonsillitis disease

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RULE 2
IF The patient's temperature is > 37 °C
THEN The patient has a fever

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RULE 3
IF The patient has edema and pain at lymph node under
  Chin
  AND The patient has a fever
THEN The patient may be lymphadenitis disease

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illustrates the interactive forward chaining pro-

cessing of the patient's symptom and sign:: sore throat, temperature = $38^{\circ}C$, edema and pain at lymph node under chin.

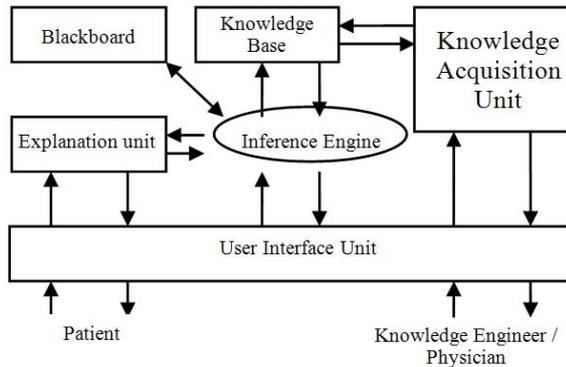


Fig.2: Architecture of the Medical Knowledge-Based System

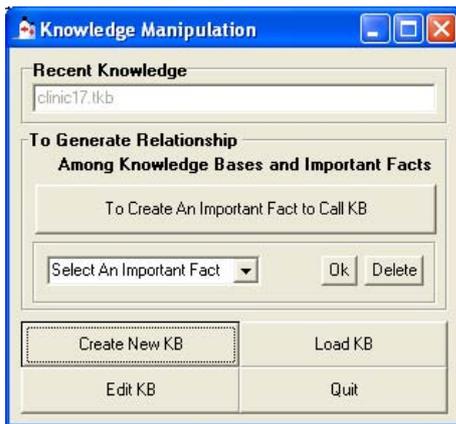


Fig.3: Knowledge Manipulation Window

3. EXPERIMENT AND RESULT

After the system is developed, it must require for testing the accuracy. So this research defines the method to check by comparing between system and physician diagnosis. For this testing, general disease (followed on table 1) is considered, and we divide the process for testing into 2 sections. They are alpha test ($\alpha - Test$) and beta test ($\beta - Test$). We use alpha test for testing and improving, and we use beta test for evaluating.

3.1 Alpha Testing

This section the system is tested by a physician and knowledge engineers. The objective of this testing is system improvement before using in practical.

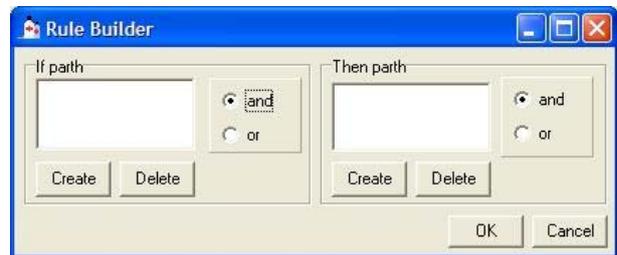
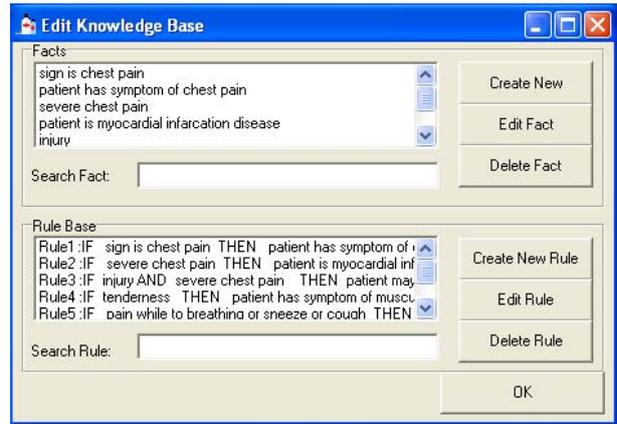


Fig.4: Rule Builder Window

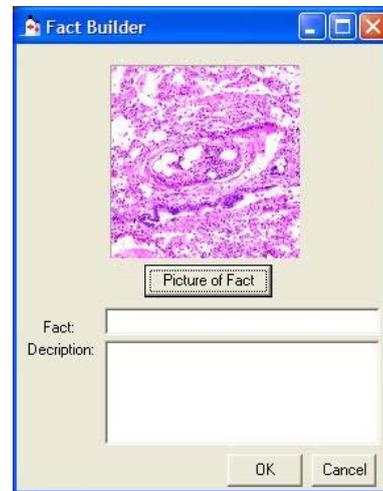


Fig.5: Fact Builder Window



Fig.6: Window of Chief Complaint for KB

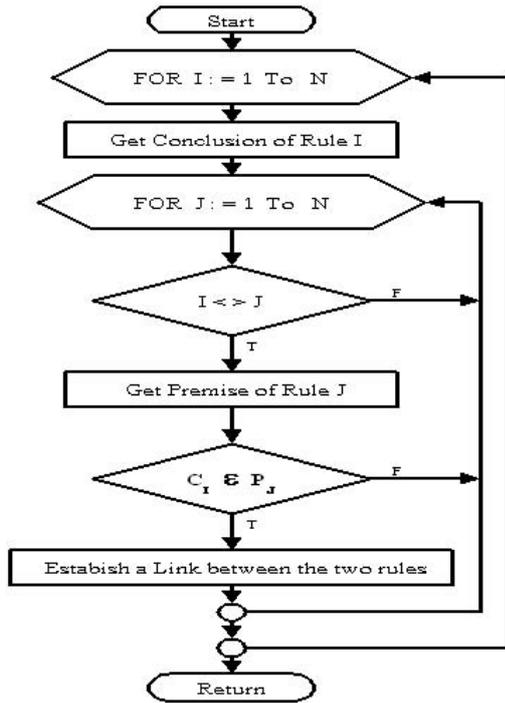


Fig.7: Tree Structure Representation Process

Table 2: Production RULE List

Rule No.	Production Rule
1.	IF p ₁₁ AND p ₁₂ AND THEN c ₁
2.	IF p ₂₁ AND p ₂₂ AND THEN c ₂
3.	IF p ₃₁ AND p ₃₂ AND THEN c ₃
⋮	⋮
n.	IF p _{n1} AND p _{n2} AND THEN c _n



Fig.10: Main Window for The Medical KBS

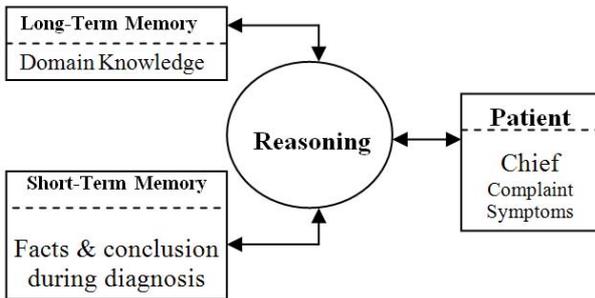


Fig.8: Process for diagnosis of Physician

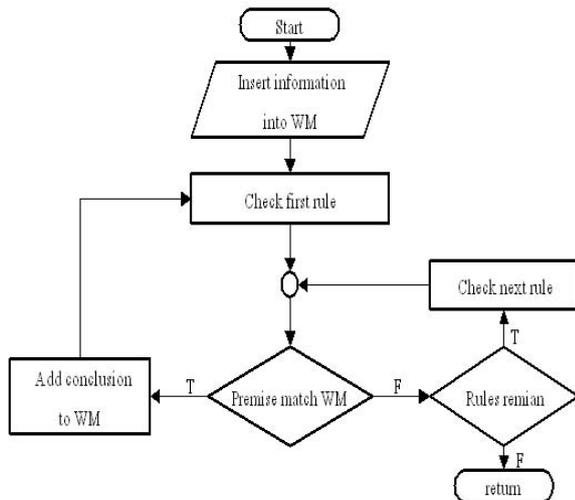


Fig.9: Interactive Forward Chaining Inference Process

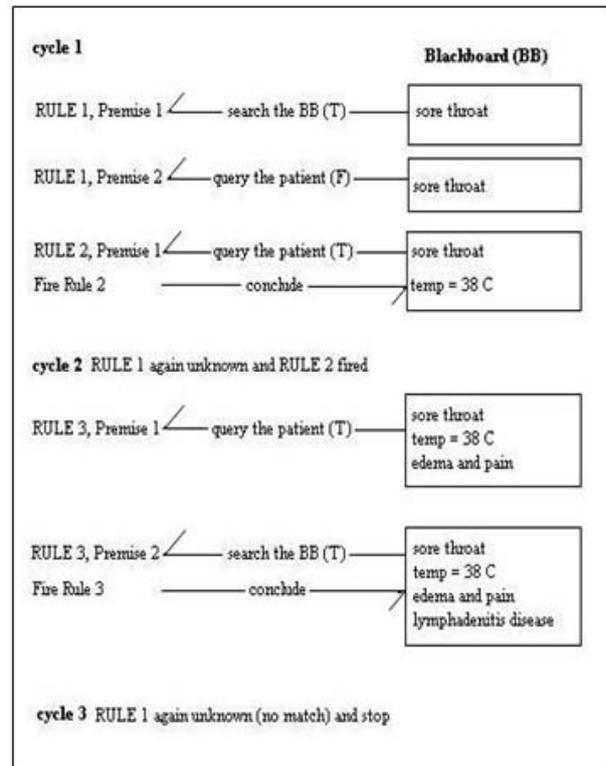


Fig.11: Example of Interactive Forward Chaining Processing



Fig.12: Window for Select Chief Complaint

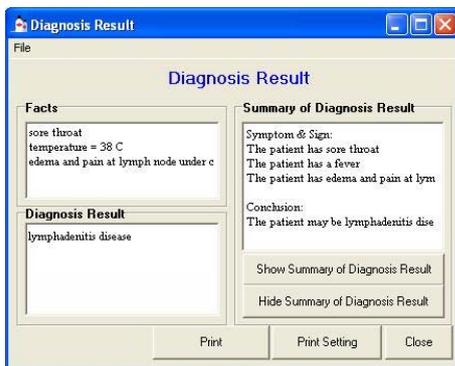


Fig.13: Diagnosis Results Window

This testing are unit test and system test which consists of 2 elements. They are a process for debugging the operation of system by knowledge engineer, and a process for checking the knowledge of diagnosis by a physician.

3.2 Beta Testing

The beta testing is an acceptable testing, which used to evaluate the performance of the medical knowledge-based system. The method of evaluation is comparison between diagnosis of system and a physician. We use simple random technique to select patients from clinic and hospital.

The result is shown on table 3. We will see the proposed system has an accurate diagnosis at 98.864% (435 persons from 440 persons) when we compare with a physician. However, we found missing diagnosis at 1.136% (5 persons from 440 persons).

4. CONCLUSION

The testing result of the medical knowledge-based system for diagnosis from symptoms and signs is found that the diagnosis of the system more than 97% accurately at the 0.01 level of significance, when it is compared with diagnosis of a physician. Although the accuracy of knowledge for diagnosis is an important variable to indicate the accuracy of system, but

Table 3: Results of Evaluation

Diagnosis Result	Patients	
	Number Of Patients (Frequencies)	Percentage
Satisfy	435	98.864
Dissatisfy	5	1.136
Total	440	100.0
99 percent confidence level of satisfactory diagnosis (P)	$0.9756 \leq P \leq 1.00$	

data is imported from patients that have some effects. These effects are occurred from the confusion and hesitation of patients. So the medical knowledge-based system requires a method for resolving the uncertain data such as Fuzzy inference or certainty factor. For the experimental results, we compare diagnostic results between system and a physician in each case. So if we use physicians, who are more than one person, for each case, and we use a group of medical expert humans to diagnose the patient then the medical knowledge-based system is completely. Additionally it should have diagnosis following, which help the system that is believable. However a physician may be missing diagnosis in sometimes because he is absolutely in body, emotion, times, or another factors. Finally we can say that the medical knowledge-based system for diagnosis from symptoms and signs is a tool for help to create medical knowledge-based system.

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