Analyzing Chest Pain Cases Using Forward Chaining System

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Abstract

A large number of expert systems require the use of forward chaining or data driven inference. Rule-based systems are really only feasible for problems for which any and all knowledge in the problem area can be written in the form of IF-THEN rules. In this paper, Forward Chaining Reasoning Method is used to diagnose chest pain cases that can be caused by whether heart, lungs or gastrointestinal diseases. In our system, chest pain symptoms, signs and laboratory investigations are given as inputs, and it will run as data-driven process and find the goal by depth first search and make decision among nine diseases. Firstly, the causes of diseases (heart, lungs or gastro intestine) are analyzed by applying Forward Chaining Method to discriminate the underlying causes of chest pain. At last, the severity (stage) of diseases can be defined by using Rule-Based System.

Keywords: Artificial Intelligence (AI), Rule-based system, Forward chaining method, Chest pain cases.

1. Introduction

Expert systems (ES) are computerized advisory programs that attempt to imitate the reasoning processes and knowledge of experts in solving specific types of problems. They are used more than any other applied AI technology. Expert systems are of great interest to organizations because of their potential to enhance productivity and to augment work forces in many specialty areas where human experts are becoming increasingly difficult to find and retain [2].

Expert systems of today support many problem solving activities such as decision making, knowledge fusing, designing and planning, forecasting, regulating, controlling, monitoring, identifying, diagnosing, prescribing, interpreting, explaining, training etc. by using different techniques and it is expected that future expert systems will support even more activities [6].

There are two approaches for controlling inference in rule-based ES: forward chaining and backward chaining (each of which has several variations). Backward chaining is a goal-driven approach in which you start from an expectation. Often this entails formulating and testing intermediate hypotheses (or sub hypotheses). Forward chaining is a data-driven approach. In this approach, we start from available information as it comes in, or from a basic idea, and then try to draw conclusions [2].

Chest pain is a common symptom that is caused by many different conditions. Some causes require prompt medical attention, such as angina, heart-attack or tearing of the aorta. Other causes of chest pain that may not require immediate medical intervention include spasm of the esophagus, gallbladder attack, or inflammation of the chest wall. An accurate diagnosis is important in providing proper treatment to patients with chest pain.

In this paper, we propose forward chaining method by looking for the facts that match the IF portion of its IF-THEN rules. As each rule is tested, the program works its way toward a conclusion.

2. Related Works

Fatimah Ibrahim employs expert system rules to detect different eye diseases. Expert rules were developed based on the symptom of each type of eye diseases, and they were presented using a tree graph using forward chaining [3].

Chien-Chih Wang, Ming Nan Chien, and Chua-Huang Huang express temporal relationships among diseases that may have mutual affect potentially. First, the temporal relationship between diseases of each patient is searched, and then, the temporal relationships of all patients are analyzed to determine the correlation of these diseases. The time stamped diagnostic data are built as facts and the physician specified rules of diseases are built as inference rules of the inference engine [1].

Nu Aye Aye Khin, University of Computer Studies, Yangon, intended to develop and implement a diagnosis expert system for the CHD (Coronary Heart Disease). This system focused on the rule-based expert system by applying the combination of forward and backward chaining; mixed chaining approach for inference engine [4].

Shantakumar B.Patil and Y.S.Kumaraswamy have employed the Multi-layer Perceptron Neural Network with Back-propagation as the training algorithm. The results thus obtained have illustrated that the designed prediction system is capable of predicting the heart attack effectively [7].

3. Background Theory

In this section, we introduce the background theories used to implement forward chaining method in rule-based system.

3.1. Architecture of Rule-based Expert Systems

The main elements of a rule-based system are facts, rules, and the engine that acts on them. The core of the architecture consists of the working memory (fact base), the rule base (knowledge base) and the inference engine (rule engine).

- Knowledge base contains the domain specific problem-solving knowledge.
- Facts represent what we know at any time about the problem we are working at.
- Rules represent relationships between the facts
- Inference engine is a general program that activates the knowledge in the knowledge base.

3.2. Inferencing with Rules

Inferencing with rules involves implementation of the modus ponens and other inferencing approaches. The inference mechanism in most commercial expert systems uses the modus ponens approach, which is reflected in the search mechanism with the rule interpreter [2].

Rule-based systems are adaptable to a variety of problems. In some problems, information is supplied with the rules and the AI tracks them to see where they direct. An example of this is a medical diagnosis in which the problem is to diagnose the underlying disease based on a set of symptoms.

A problem of this nature is solved using a forward chaining that compares data in the working memory against the conditions (IF parts) of the rules and determines which rules to fire.

3.3. Forward Chaining Method

The forward chaining method emulates human deductive reasoning. It is a data-driven process that starts when certain information is provided by the user. Clues are collected as we move toward a conclusion [2].

Figure 1. shows the forward chaining procedure.

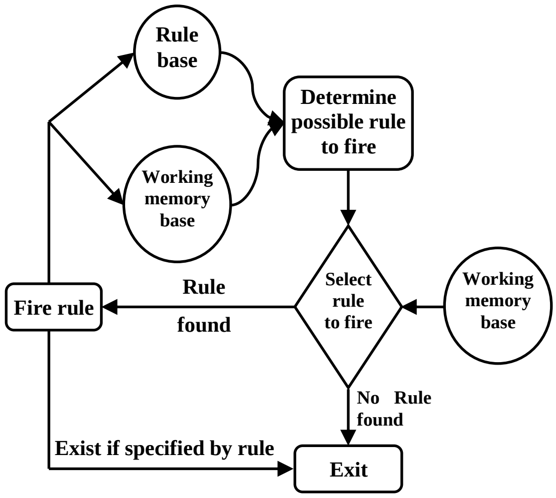
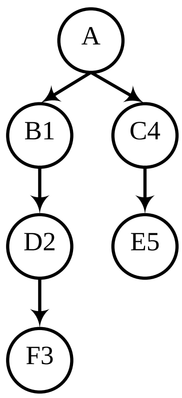


Figure 1. Forward chaining procedure

Every rule in the rule base can be checked to see if its premise or conclusion can be satisfied by previously made assertions. This process may be done on one of two directions, forward or backward, and it will continue until no more rules can fire, or until a goal is achieved [2].

The example of depth-first-search forward chaining procedure is as shown in figure 2.



IF A THEN B AND C
IF B THEN D
IF C THEN E
IF D THEN F

Figure 2. Depth-first-search forward chaining procedure

4. The Proposed System

The system development tasks for chest pain diagnosing are as follows:

(a) Considering objectives and scope
(b) Knowledge acquisition (collecting data, reading papers and reports, discussions with domain experts, case studies, etc.)
(c) Early planning and selection of system
(d) System design and development
(e) Testing and validation
(f) Reviews and modifications
(g) Implementation

In this paper, we introduced chest pain diagnosing expert system, based on forward chaining rule-based approach. The overview of the system is shown in figure 3.

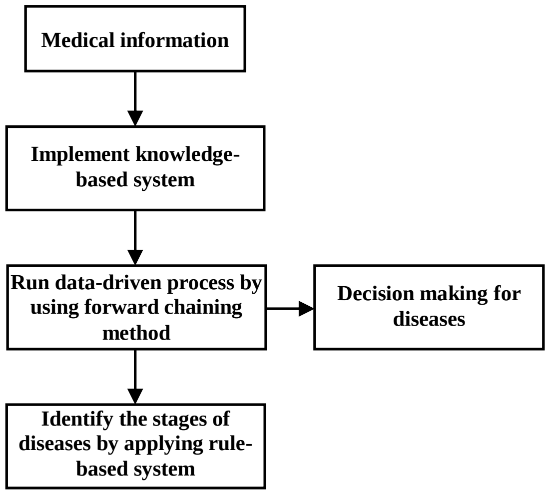


Figure 3. System overview

According to the depth-first-search forward chaining procedure as in figure 2, we implement our system for analyzing chest pain diseases.

There are two sites for chest pains in diagnosing of 9 diseases in this system: central and peripheral. We start first investigation by asking which site the chest pain suffered. And then, we ask basic signs that the patient suffered and make choice which disease may be happened by utilizing the forward chaining method like a depth first search approach as shown in figure 4(a). and (b).

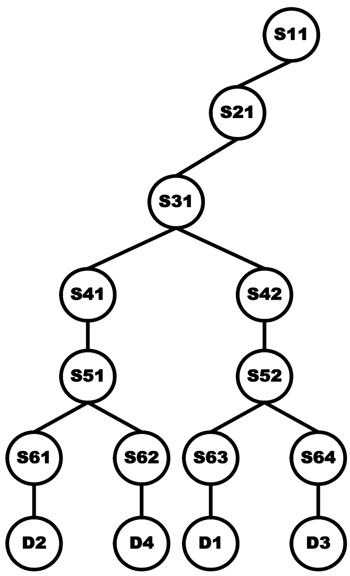


Figure 4(a). First Investigation of Central Chest Pain by Forward Chaining Method

For figure 4(a). and figure 4(b)., the symptoms are as follow;

S11 = chest pain central
S21 = palpitation; S22 = no palpitation
S31, S33 = dyspnoea
S32, S34 = no dysnoea
S41 = cough; S42 = no cough
S51, S52 = fever; S53 = no fever
S61, S63 = no cyanosis
S62, S64 = cyanosis
S71 = sputum
S81 = hemoptysis
S91 = syncope; S92 = no syncope

The disease's names are

D1: Ischaemic Heart Disease
D2: Pericarditis Disease
D3: Aortic Dissection Disease
D4: Pulmonary Embolism Disease
D5: Pneumonia Disease
D6: Bronchogenic Carcinoma Disease (Cancer)
D7: Tuberculosis Disease (TB)
D8: Reflux Oesophagitis Disease
D9: Oesophageal Spasm Disease

After that, we make second examination with other risk factors for the disease. Finally, we confirm with main symptoms to ensure the disease suffered by applying forward chaining approach as in the first investigation.

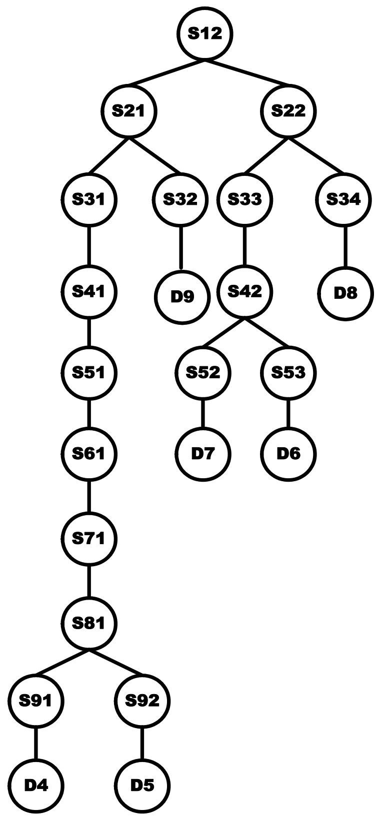


Figure 4(b). First investigation of Peripheral Chest Pain by Forward Chaining Method

Furthermore, we identify the stage for three diseases such as Ischaemic Heart Disease, Pneumonia Disease and Reflux Oesophagitis Disease. We use the following facts and build rules in the rule-base.

Ischaemic Heart Disease

- Age >= 65
- Cholesterol >= 5.5
- Coronary angiography stenosis > 50%
- Aspirin used in last 7 days
- More than 2 episodes of rest pain in 24 hours
- ST deviation on ECG > 1mm

This disease has 3 stages.

Pneumonia Disease

- Confusion <= 8
- Urea > 7
- Respiratory Rate >= 30/minute
- Blood Pressure < 90 systolic
- Age >= 65

This disease has 3 stages.

Reflux Oesophagitis Disease

- Mucosal breaks (Extend) < 5mm
- Mucosal breaks (Extend) >= 5mm
- Oesophageal Circumference < 75%
- Oesophageal Circumference >= 75%

This disease has 4 stages.

5. Implementation of Overall system flow

The flow of the system is, first, we get the patient's chest pain site (i.e. whether central or peripheral).

Secondly, we inquire basic signs that the patient suffered. In this step, we apply forward chaining method to search among 9 diseases. If the signs are matched with one of 9 diseases, we display possible disease name. If not, display "Disease cannot be identified" message.

Then, we inquire general risk factors that the patient suffered. In this step, we only utilize rule-based system to find out the name of suffered disease.

Finally, we confirm main symptoms that the patient suffered and make final decision using forward chaining method again.

After making final decision for disease, we consider if there will be needed to identify the stage of the suffered disease. If the disease is needed to identify the stage, we will need to check the stage using rule-based system. After that, we display the disease's name and its stage.

Some diseases cannot get enough data to identify the stage and also in medical field, they are rare to suffer with stages (e.g Pericarditis, Aortic Dissection, Pulmonary Embolism, Oesophageal Spasm).

But Tuberculosis (TB) and Bronchogenic Carcinoma (Cancer) diseases can get information but because of the limitation of time, it is left as further extension of this system. So such diseases will not involve identifying stages.

The overall system flow is as shown in figure 5.

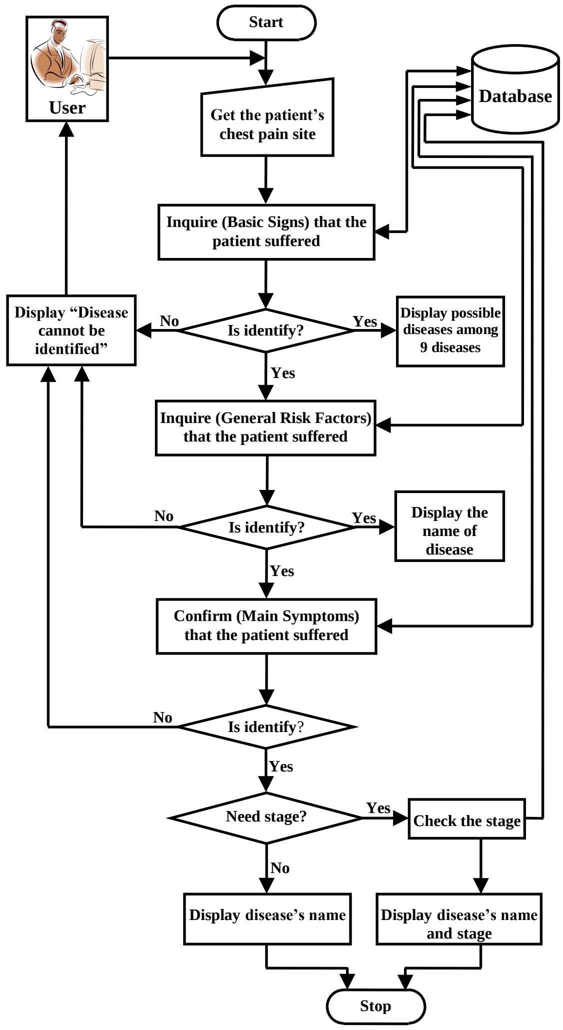


Figure 5. System flow diagram

6. Clinical features

There are nine diseases to distinguish in our system. They are Ischaemic Heart Disease, Pericarditis Disease, Aortic Dissection Disease, Pulmonary Embolism Disease, Pneumonia Disease, Bronchogenic Carcinoma Disease (Cancer), Tuberculosis Disease (TB), Reflux Oesophagitis Disease, and Oesophageal Spasm Disease.

In the first investigation, the signs that we should ask the patient are chest pain site, palpitation, dyspnoea, cough, fever, cyanosis, sputum, hemoptysis and syncope.

In the second investigation, the risk factors may be family, smoking, alcohol, hypertension, diabetes, hyperlipidemia, obesity, and sedentary.

The final confirmation asks the main symptoms such as characters, radiation, aggrevating and relieving factors.

After the disease is classified, we identify the stages such as stage 1, stage 2, etc… for the diseases

Ischaemic Heart Disease, Pneumonia Disease, and Reflux Oesophagitis Disease.

7. Experimental Results for our Proposed System

For the proposed system, data were firstly collected from physicians/doctors, patients, and then, to examine this system, we discussed with doctors and met with suffered 153 patients from Yangon General Hospital, Workers Hospital and North-Okkalapa General Hospital in 2010.

Table 1. illustrates the number of patients analysis and the number of patients those are matched with our system and also the respected accuracy percentage for each disease.

Table 1. Number of patients and matched patients with our system and accuracy percentage

Disease	Case Inquiry	Case correct	Accuracy percentage
1: Ischaemic Heart Disease	25	25	100%
2: Pericarditis	15	12	80%
3: Aortic Dissection	17	15	88.24%
4: Pulmonary Embolism	10	10	100%
5: Pneumonia	15	13	86.67%
6: Bronchogenic Carcinoma	16	15	93.75%
7: Tuberculosis	25	25	100%
8: Reflux Oesophagitis	15	14	93.33%
9: Oesophageal Spasm	15	15	100%

8. Limitations

The present model assumes that the symptoms for defined disease are fixed. In this system, the adaptation process is not involved like in Case-Based Reasoning (CBR). User can enter signs, risk factors and main symptoms and can recognize the decision of disease, but patient record is not kept in database of the system. This system mostly acceptable for patients, but to get more accurate decision, physician would consider other investigations such as laboratory investigation and ECG scanning charts.

9. Conclusion

This paper analyzes chest pain cases using Forward Chaining Method and Rule-Based System. The attempt tries to notify what disease may be suffered and which stage may be occurred in relating to chest pain cases.

The benefits of this approach are that the system can automatically investigate the symptoms and can make decision for the suffered disease without involving human physician. User can check the symptoms that he/she suffered and can define chest pain disease.

Moreover, for the physicians/ doctors, this system can help them when there is some symptoms they did not notice and it will support to get more specific solutions more easily and quickly.

Although only forward chaining method is used similar to earlier ones, it can decide for 9 diseases with many different symptoms for their stages. This system mostly acceptable for patients, but physicians would rely 70% on this system. Because these fixed facts are general symptoms only and for more accurate decision, physicians would consider other investigations such as laboratory tests and charts.

9. References

[1] Chien-Chih Wang, Ming Nan Chien, Chua-Huang Huang , "A rule-based disease diagonistic system using a temporal relationship model", Fuzzy Systems and Knowledge Discovery 2007. Fourth International Conference, Haikou, 24-27 August 2007.

[2] Efraim Turban, *Expert Systems and Applied Artificial Intelligence*, California State University at Long Beach.

[3] Fatimah Ibrahim, "Intelligent system for Diagnosing Eye Diseases", Project No. FJ 388/A, Prosiding Seminar Penyelidikan Jangka Pendek 2003, University of Malaya, 12 March 2003.

[4] Nu Aye Aye Khin, *Development of Coronary Heart Disease Diagnosis System by Using Mixed Chaining Approach*, University of Computer Studies, Yangon, May 2009.

[5] Peter, Pak Fong Chan, B.Sc. (ENG), M.I.C.E., M.H.K.I.E. *An Expert System for Diagnosis of Problems in Reinforced Concrete Structures*, Department of Computer Science, Royal Melbourne Institute of Technology, City Campus, Melbourne Vic 3001, Australia, December 1996.

[6] Rajkishore Prasad, Kumar Rajeev Ranjan, A.K Sinha, and M. M. Prasad, **"**Using ESTA to Develop Expert System For the Natural Resource Management**"**, Map India 2003, 6thAnnual International Conference and Exhibition, NewDelhi, India, 2003.

[7] Shantakumar B.Patil and Y.S.Kumaraswamy, "Intelligent and Effective Heart Attack Prediction System Using Data Mining and Artificial Neural Network", *European Journal of Scientific Research*, © EuroJournals Publishing, Inc. 2009, ISSN 1450-216X Vol.31 No.4 (2009), pp.642-656.