A Framework for Medical Diagnosis using Hybrid Reasoning

Deepti Anne John, Rose Rani John

***Abstract*—The traditional method of reasoning was rule-based reasoning (RBR). It does not use past experiences to reason. Case-based reasoning (CBR), on the other hand uses past experiences to derive results for new cases. Both rule-based reasoning and case-based reasoning have their own pros and cons. The shortcomings of one are overcome by the merits of the other. In this paper the phases of RBR and CBR have been briefly explained. A framework has been proposed for the implementation of a hybrid system which uses both RBR and CBR for medical diagnosis.**

***Index Terms*—Diagnosis, Rule-based reasoning, Case-based reasoning, Hybrid reasoning.**

I. Introduction

The framework for medical diagnosis intends to create a medical expert system which can be used from the patients' side to diagnose the disease he is suffering from. An individual can continuously monitor his health status from this system which can help in early and easy diagnosis of diseases. The medical diagnosis expert system can get the symptoms and the laboratory results from user and can suggest an appropriate curing method after the diagnosis has been made. Thus an initial diagnosis can be made at home. Diagnosis and treatment of diseases will be home-based rather than hospital-based.

Especially in medicine, the knowledge of experts does not only consist of rules, but of a mixture of textbook knowledge and experience. The latter consists of cases, typical and exceptional ones, and the reasoning of physicians takes them into account. Medical knowledge based systems therefore contain two knowledge types: objective knowledge, which can be found in textbooks, and subjective knowledge, which is limited in space and time and changes frequently[12]. Objective knowledge can be handled by rule-based reasoning (RBR) and subjective knowledge can be handled by case-based reasoning (CBR).

In the framework that has been proposed, primary diagnosis is done based on the RBR which is followed by CBR to make results more accurate.

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Deepti Anne John is a second year M-Tech degree student at the Karunya university. She is with the Computer Science department(e-mail: deeptiannejohn@rediffmail.com)

Rose Rani John is a lecturer at the Karunya University. She is now with the department of Computer Science(e-mail:roseranijohn@karunya.edu)

II. Rule-Based system

A. Anatomy of rule-based system

A set of rules exist that operate over a collection of facts stored in a working memory. Logic is provided to identify which rule to fire (based on the antecedents) and then modify working memory (based on the consequents).

- *Working memory*

The working memory is the structure where the currently known facts are stored. It can be altered only through the consequent of a rule.

- *Rules memory*

The rules memory contains a set of rules that operate over the working memory. Rules are constructed in two parts and include an "antecedent" and a "consequent". The antecedent defines those actions that must be true for the rule to be triggered. The consequent is the set of actions taken after the rule has been fired.

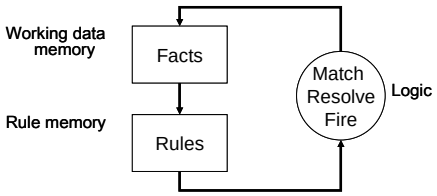

Fig.1 Anatomy of rule-based system

B. Phases of a rule-based system

- *Match phase*

Each of the rules is checked to see if the set of antecedents for the rule can be matched with facts in the working memory. If so then the rule is added to the conflict set.

- *Conflict Resolution phase*

The purpose of the conflict resolution phase is to pick a rule to fire, out of the conflict set. Given more than one rule in the set, some criteria must be defined to determine which rule to fire.

- *Action phase*

Action phase performs the set of consequents for the particular rule to be fired. These actions could be adding facts to the working memory, removing facts from working memory or some other action [8].

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III. CASE-BASED REASONING

A. Stages of case-based reasoning

• *Retrieve*
Given a target problem retrieve cases from memory which are relevant to solving it.

• *Reuse*
Map the solution from the previous case to the target problem. This requires adapting solution to fit to the new situation.

• *Revise*
Having mapped the previous solution to the target situation, test the new solution in the real world

• *Retain*
Retain the new solution once it has been confirmed or validated [9].

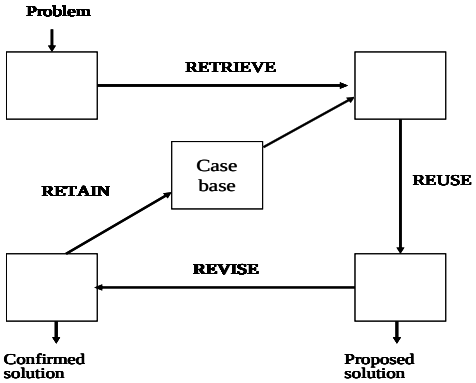

Fig.2 The stages of case-based reasoning

B. Measuring similarity in CBR

The similarity of the problem (target) case to a case in the case-library for each case attribute is determined. This measure may be multiplied by a weighting factor. Then the sum of the similarity of all attributes is calculated to provide a measure of the similarity of the case in the case-base to that of the target case[10].

$$Similarity(T,S) = \sum f(T_i S_i) \times w_i$$

T - Target case
S - Source case
i - An individual attribute from 1 to n
f - similarity function for attribute i
w - weight of attribute i
Similarity falls in the range zero to one

IV. ADVANTAGES AND DISADVANTAGES OF RBR AND CBR

The main advantages of RBR are:

- *Compact representation of general knowledge.*
Rules can easily represent general knowledge about a problem domain in autonomous, relatively small chunks.

- *Naturalness of representation.*
Rules are a very natural knowledge representation method, with a high level of comprehensibility, since they look like natural language expressions.

- *Modularity.*
Each rule is a discrete knowledge unit that can be inserted into or removed from the knowledge base, without taking care of any other technical detail.

- *Provision of explanations.*
There is ability to provide explanations for the derived conclusions in a straightforward manner.

The main disadvantages of RBR are:

- *Knowledge acquisition bottleneck.*
The standard way of acquiring rules through interviews with experts is cumbersome and time-consuming. The chief reasons are the inability of an expert to express his/her knowledge and/or the unavailability of experts.

- *Brittleness of rules.*
It is not possible to draw conclusions from rules when there are missing values in the input data.

- *Inference efficiency problems.*
In certain cases, the performance of the inference engine is not the desired one, especially in very large rule-bases.

- *Difficulty in maintenance of large rule-bases.*
The maintenance of rule-bases is getting a difficult process as the size of the rule-base increases.

- *Problem solving experience is not exploited.*
A rule-based system is not self updatable, in the sense that there is no inherent mechanism to incorporate experience acquired from dealing with past problems.

- *Interpretation problems.*
The general nature of rules may create problems in the interpretation of their scope during reasoning.

The main advantages of CBR are:

- *Ability to express specialized knowledge.*
This feature of cases among other advantages circumvents interpretation problems suffered by rules (due to their generality).

- *Naturalness of representation.*
Cases are a simple knowledge representation method and very comprehensible to the user.

- *Modularity.*
Each case is a discrete, independent knowledge unit that can be inserted into or removed from the case-base, without any problem.

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- *Easy knowledge acquisition.*

Knowledge acquisition in case-based representations is not usually a problem, due to the fact that in most application domains cases are available.

- *Self-updatability.*

Knowledge in the form of new cases faced during real-time operation can be incorporated into the case-base extending the effectiveness of the system. This self-updatability also facilitates the maintenance of the case-base.

- *Handling unexpected or missing inputs.*

A case-based system can handle unexpected cases not recorded in the system or missing input values by assessing their similarity to stored cases and reusing relevant cases.

- *Inference efficiency.*

Adapting preexisting cases to handle new problems is usually more efficient than having to solve a problem from scratch

Main disadvantages of CBR are

- *Inability to express general knowledge.*

Cases, by nature, express specialized knowledge. So, they cannot express general knowledge.

- *Knowledge acquisition problems.*

Although knowledge acquisition is not a problem when a sufficient number of cases are available in a domain, various knowledge acquisition problems may arise when dealing with domains, where cases are either unavailable or are available in a limited (insufficient) amount

- *Inference efficiency problems.*

The efficiency of the inference process in CBR is not always the desirable. Efficiency problems involve two main aspects: case retrieval and adaptation. Degradation of the time efficiency of case retrieval is associated with the utility problem, a problem occurring in learners when knowledge learned in an attempt to improve a system's performance degrades performance instead.

- *Provision of explanations.*

Some kind of explanations can be provided for the reached conclusions, but not in a straightforward manner as in rule-based systems. It is difficult to explain all reasoning steps[7].

V. The Hybrid System

There is a knowledge base which stores the set of rules. The symptoms acquired from the user go to the RBR module. The rules are in the form of "If-Then". If the RBR module is not able to make a diagnosis of the type of the disease, then the CBR module is sought after. A set of cases are stored in the case-base. If the similarity of the present case is above the threshold value with respect to the stored cases, then the case is retrieved. The case is reused and revised. The new case is retained in the case-base.

There are many strategies that can be used to combine RBR and CBR

A. In parallel

The RBR and CBR are both used to make the diagnosis at the same time in parallel.

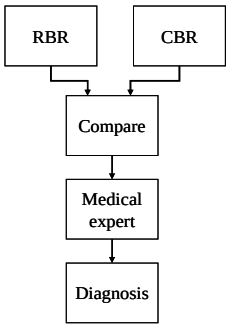

Fig.3 RBR and CBR in parallel

The results of the two are compared by the medical expert and results are checked and approved by the medical practitioner [2].

This strategy utilizes the merits of both RBR and CBR. The disadvantage of this is that there will be redundancy of information stored in the case-base and rule-base

B. RBR followed by CBR

In this the RBR module comes first followed by the CBR module. This strategy is appropriate when the rules are reasonably efficient and accurate to begin with[11].

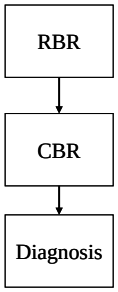

Fig. 4 RBR followed by CBR

C. CBR followed by RBR

Here the CBR module comes first followed by the RBR module. . If the rules are deficient in some way, the CBR-first strategy may make more sense[11].

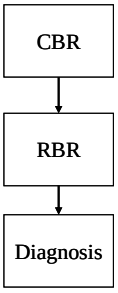

Fig. 5 CBR followed by RBR

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VI. THE PROPOSED FRAMEWORK

Following a detailed study, a frame work has been designed to implement the intelligent system for diagnosis of diseases. There have been many approaches in implementing an expert system for diagnosis of various diseases. The first and foremost one is using the rule-based reasoning technique. This is based on the rules and facts stored in the database. The problem with this approach was that the rate of diagnosis was quite low. The disease could be diagnosed only if the rules could be fired. Adaptation to the change in the course of diagnosis according to the cases already reported was not there. Then the case-based reasoning techniques were used for diagnosis of diseases like Diabetes [4]. Integrating the two reasoning systems, a reasoning method named the hybrid reasoning system was used in a number applications including medical diagnosis of various diseases [2], [3], [5], [6]. The hybrid system is designed by encompassing the Rule-based system and Case-based system. The hybrid reasoning system has been added to the framework to make the diagnosis much more accurate than when there is only one reasoning system. The rate of diagnosis increases as the CBR module takes care of cases which cannot be solved by the RBR module. There are different modules for arriving at a diagnosis and for suggesting an appropriate treatment for diseases

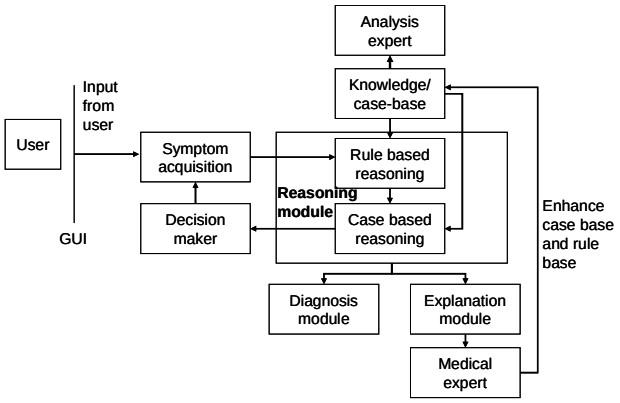

Fig.3 Proposed Framework for medical diagnosis

A. The Various Modules of the Proposed Framework

- *Input and Symptom Acquisition*

A Graphical User Interface (GUI) is used to get the input from the user. A new user can login. He/she requires giving information about his/her username, password, age and sex. The details about the symptoms are got from the user or patient. Various diseases will have symptoms which vary from each other. There will be a questionnaire to be answered by the user. The user will enter the symptoms suffered as well as laboratory results if available.

- *Knowledge-/Case-base*

The rules required by the rule-based reasoning are stored in this module. This module also stores the cases required by the case-based reasoning. The rules take the form of "If-Then". The rules are stored internally using facts and rules. The case-base stores a number of cases already recorded and the learned cases after a diagnosis has been made. An inference about the disease a patient has, is made using the rules in the knowledge-base and cases in the case-base

- *Reasoning Module*

This module consists of RBR and CBR. Rule-based and case-based reasoning can be combined in three main orders: RBR first, CBR first, or some interleaving of the two. The framework presented here adopts the RBR-first strategy, using CBR merely to patch errors left by RBR. This strategy is appropriate because the set of rules that can be provided is accurate and efficient.

The inputs received from the user as symptoms and signs of the disease are fed into the RBR portion of the reasoning module. The rules of the knowledge base are accessed to make a diagnosis. If one can be made, it is presented to the user. If a diagnosis cannot be made, the inputs are fed into the CBR module to make a diagnosis. Based on the cases recorded beforehand, a diagnosis is made and presented to the user. If a diagnosis cannot be made, the user is given the intimation that a diagnosis cannot be made.

- *Decision Maker*

At times there are situations when further questions have to be asked to the patient based on the histories of the cases recorded in the case-base. The decision maker module is connected to the CBR. It makes queries about the additional parameters required to arrive at a diagnosis. Based on the answers retrieved, further filtering of cases can be done. From this we can reduce the number of cases that have to be dealt with. We can retrieve cases specific to the given patient [3].

- *Analysis Expert*

The analysis expert can make on analysis of the data stored in the knowledge base. An example for this is like finding a trend in a particular age group or sex or region [3]. This module can be used for further research. Research can be conducted on why people of a particular group (like a particular age group) are more affected than people of other groups. This helps in taking preventive measures for the group of people.

- *Diagnosis Module*

Diagnosis or the inference engine makes the diagnosis of the disease based on the symptoms entered by the user [1]. Based on the results produced by the reasoning module, a conclusion is arrived at disease suffered by the patient. Based on conclusion, a diagnosis is made and the patient is given advice on the treatment that should be taken to cure him/her of his/her disease.

- *Explanation Module*

Explanation module gives the explanation or the path through which the diagnosis was reached. The diagnosis can be taken with the help of the RBR module or by consulting the CBR module too. There are three possibilities here. First a wrong diagnosis can be made by the intelligent system. Second a right diagnosis can be made through a wrong path. Third a right diagnosis can be made in the right path. This is looked into by the medical expert and if the route of diagnosis and the diagnosis is right, then the new case is entered into

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the case-base. Else necessary changes are made to the rules so that a right diagnosis is made [10].

VII. Success Criteria

The main criteria selected for the determination of the success of the system is accuracy of diagnosis and the rate of diagnosis. The number of diseases that can be diagnosed by the expert system should be high and should match the human medical expert. The accuracy of the system should also be high enough when the common symptoms for various diseases are input.

VIII. Conclusion

The advantages and disadvantages of RBR and CBR have been studied. The merits of one complement the demerits of the other. A framework has been proposed for the hybrid system that combines the RBR system with the CBR to get an appropriate diagnosis of diseases. This framework can be used in the diagnosis of specific diseases like diabetes, cardiac diseases, lung diseases, anemia etc. The case-base and the rule-base will be enriched according to the new cases that come. Work is being done on the implementation of the framework. Rate of diagnosis with RBR and CBR will be compared to the rate of diagnosis with the hybrid system.

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