Using a Hybrid Artificial Intelligence for decision making in medicine

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Abstract

A medical consultation is a process, which utilizes clinician's intelligence and expertise. There are intelligent systems, which provide assistance to the clinician. But, most of these systems have been developed using individual Artificial Intelligence (AI) techniques, which address only few tasks of this entire process. This paper describes how a hybrid system can provide a better solution, by combining different AI techniques. The hybrid AI system includes a patient record system, which is used to maintain patient information, integrated with the following modules. Expert system module is used to make diagnoses, genetic algorithm module is used to optimize the process of selecting drug treatment, and artificial neural network module is used to predict the response to the prescribed drug treatments. We have implemented this system, and have already demonstrated the usefulness of some of these modules.

Key words: Hybrid Artificial Intelligence Systems, Medical Decision Support, Expert Systems, Genetic Algorithms, Artificial Neural Networks.

1. Introduction

In medical practice, the key tasks are gathering and recording patient's information, arriving at a diagnosis, treating the illness and predicting the response to drug treatment and outcome of the illness. Doctors need to make important decisions, when performing these tasks, with regard to the diagnosis, investigations to be done, optimum treatment and long-term care according to the outcome of the illness. Although modern Information Technology provides some solutions as separate systems for some of the above medical aspects, they are not integrated to form a reasonably complete medical system. Since the medical decisions are made concerning all the relevant aspects, it would be very productive to have such systems. This paper presents how several techniques in artificial intelligence can be integrated to form better system for clinical practice in medicine. In our research work, we have selected the field of psychiatry to demonstrate the applicability of those techniques.

2. Solutions with AI techniques

The field of artificial intelligence has evolved with a set of techniques that can be applied to simulate human intelligence and expertise. AI techniques implement computer programs of natural intelligence [1]. For example, experts systems emulates experts' problem solving behavior [2]. These techniques have successfully implemented human intelligence features such as handling incomplete information, provision of explanation for answers, use of heuristics for problem solving and uncertainty handling in answers. It has been shown that these techniques can be applied in bio-medical domains [3]. Even as far as thirty years back, in mid nineteen seventies, people have developed expert systems such as MYCIN for making diagnosis [4]. Artificial Neural Networks is a model of human brain, which emulates problem solving especially in non-algorithmic situations[5]. Tasks of optimization have been successfully handled with Genetic Algorithms in different problem domains [6]. Genetic algorithms provide a computer model implementing human

intelligence of ability to provide optimal and evolutionary solutions.
It is evident that each AI technique is capable of implementing only some intelligent features. None of AI technique can implement all the intelligent features of humans. Therefore, hybrid AI systems would be the solution for handling most of the real world situation. In particular, medical domains need emulation of human experts problem solving, arriving at optimal solutions and even processing on non-algorithmic data.

Hence we have used hybrid AI systems for medical domain. We argue that a reasonable complete medical system needs to be an AI hybrid system comprising at least Artificial Neural Networks, Genetic Algorithms and Expert Systems.

3. Hybrid System for Medicine

We have developed an AI hybrid system using above-mentioned AI techniques, which has a general patient record system that is integrated with an expert system for making diagnoses, a genetic algorithm module, which optimizes drug treatment, and an artificial neural network module, which is used to predict the responses to the treatment. Figure 1 shows the components of this model.

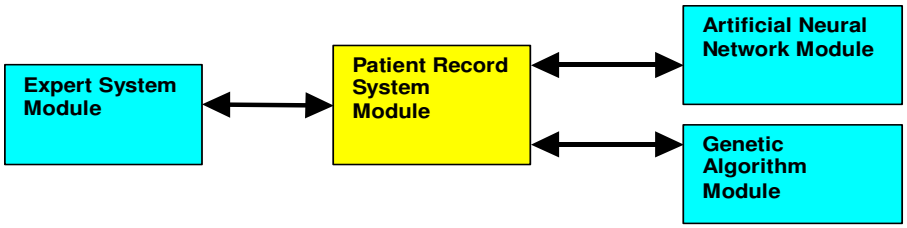

Figure 1. Components of the hybrid AI system

We developed this system particularly to be used in psychiatry practice. To explain how this system is used, we consider the process of recording patient information, arriving at a diagnosis, prescribing treatment and predicting the responses to the treatments prescribed by a psychiatrist. To start with it is needed to obtain general information from the patient such as demographic data, past medical conditions, social information and so on. This information needs to be documented. Then when the patient tells his or her psychiatric problems, psychiatrist thinks about some possible diagnoses. Then to confirm the possibility of patient having those illnesses, psychiatrist start asking specific questions to check whether certain features, which are specific to those diagnoses, are found in the patient. Some of these symptoms may be found in more than one illness, if such a symptom is found in the patient, it gives rise to the possibility of having some more diagnoses. This in turn leads the psychiatrist to ask new set of questions and the process continues until psychiatrist tests all the possible diagnoses [7]. Recently, we have demonstrated how successfully, an expert system handles this process[8]. Once a diagnosis is made, the psychiatrist needs to prescribe medication. Before prescribing a drug many factors have to be considered[9]. Some drugs may be too expensive for one patient while another patient is able to afford it. Better drugs are sometimes expensive. A patient who gets little sleep needs medication to increase the sleep while some patients who already show signs of drowsiness should not be given sedative drugs. Some drugs should not be given to a patient who has heart diseases. Ultimately the psychiatrist, needs to select the optimum drug for each individual patient taking in to consideration all those factors. We believe that a genetic algorithm can better handle this process. Once a drug is selected, its response may be highly variable in psychiatric patients, influenced by many factors,

such as the nature of the drug, its dose, duration of the illness, number of times the illness relapsed and so on [10]. Psychiatrist needs to guess the possible response level, to plan necessary alternative treatment modalities. We believe that an artificial neural network can better handle this task, using past data on drugs prescribed to patients and patient factors and how they responded to those drugs. We have shown that artificial neural networks can be used to make predictions with medical data[11]. Also some research work has shown that artificial neural networks perform better than statistical techniques such as multiple regressions when making predictions with existing data [12]. The patient record system is used to record and retrieve all information regarding the patient. We also have demonstrated usefulness of patient record systems earlier [13].

4. Design and Implementation

The development of modules of genetic algorithms, artificial neural networks, basic expert system and the integration of the system has been done using Visual Basic. MS-Access has been used as the database for the system. The choice of programming environment and tools improve the common use of the system.

4.1 Patient Record System

Patient record system has the following set of modules. *Medical Data Recorder Module* does recording and retrieving demographic data consultations, investigation findings. *Report Generator Module* does issuing diagnosis cards, medical certificates and prescriptions. *System Config Module* allows the user to configure system settings. Patient Record System uses Patient Database, which stores patient data. It consists of tables for storing demographic data, consultation findings, investigation findings, and drug information. Figure-2, shows the components of the patient record system. This database is interfaced with expert system module, genetic algorithm module and neural network module.

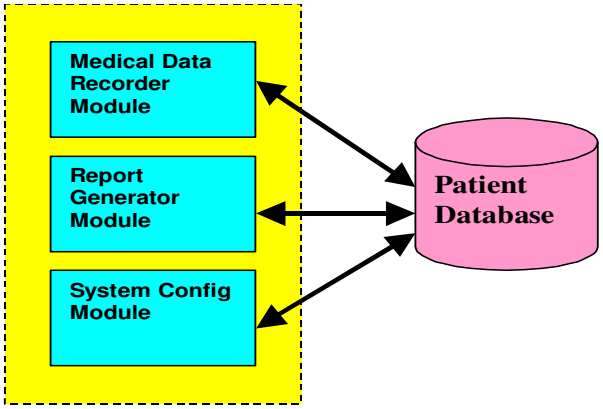

Figure 2. Components of the patient record system

4.2 Expert System Module

Expert system has three main components, namely User Interface module, Inference engine and Rule Base. Figure-3 shows these components. Descriptions of each of these components are given below.

User Interface module provides a graphical user interface. During the consultation, it pops up questions to know whether patient is having features of possible illnesses. Responses to these questions have to be marked with a mouse click, if those features were found in the patient. It also outputs the diagnosis made, at the end of a

consultation process, in the form of a report, diagnoses which were made with reasons.

Rule base was developed using a relational database system, which stores a set of rules each of which consists of the diagnosis and a set of its features. There are two types of rules. First type is non-specific rules, which cluster features commonly found together but not specific to any diagnosis. Second type of rules include features, which are specific to a particular diagnosis.

Inference engine consists of three components, namely, *Dynamic Table of Features*(DTF), *Feature eliciting module*(FEM) and *Diagnosis Making Module*(DMM). At the beginning, DTF stores a set of general and non-specific set of features, which is seen with most of the illnesses. FEM, loads this symptoms in a form of questions to the human computer interface module. User has to indicate whether these features are found in a patient or not. Then FEM updates the DTF by marking that those features were found. Then FEM access the Rule base and locates the rules, which includes any of those features. Then it writes other features, which are associated with that particular diagnosis in this rule, to the DTF, if it does not contain them already. This creates a forward chaining process, which is repeated until all related rules are tested. Finally, the DTF includes the features of illnesses found in a particular patient, at the end of the consultation process. Now DMM, starts checking the diagnosis- specific rules against those symptoms. If any of those rules match, a diagnosis is made.

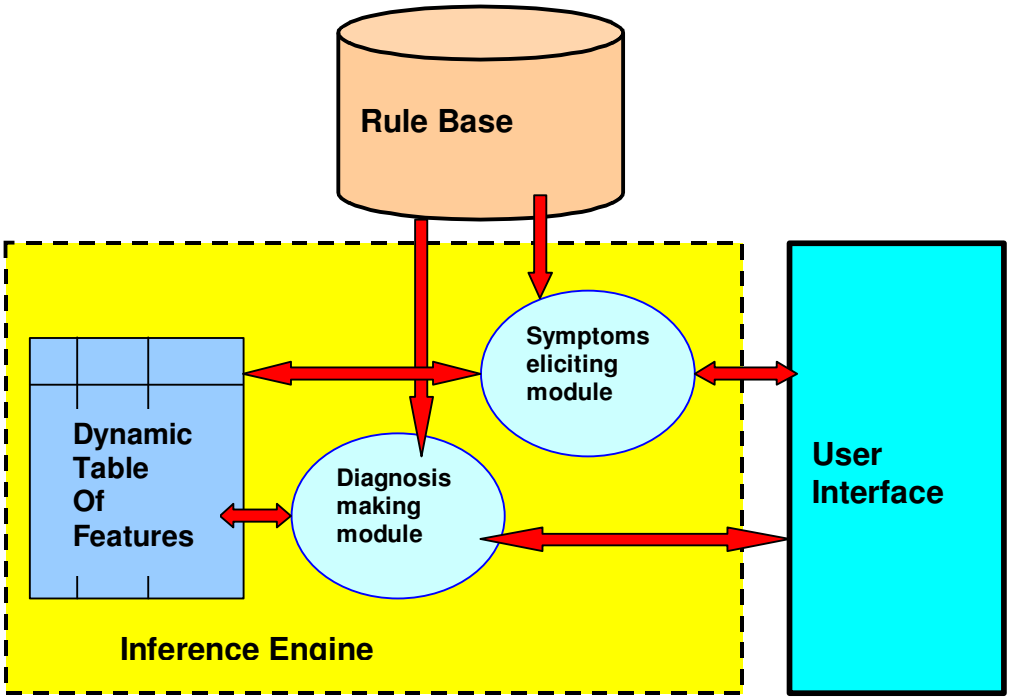

Figure 3. Components of the Expert System

4.3 Genetic Algorithm Module

We developed this module to prescribe an antipsychotic drug and an antidepressant drug. For all the drugs in each category, there is a table with includes a unique gene code in binary, and a profile which includes the cost, level of sedation caused, and other side effects. The gene code of two categories of drugs are crossed and mutated. Figure-4 explains this process. For the resultant new pair of gene codes, the corresponding drugs are searched from the database and their profiles are loaded. At the beginning, patient related parameters such as affordability, amount of sedation required, any medical problems affected by the side effects of those medications are

obtained. The values of these parameters are used by the fitness function to compare with the profiles of those drugs, to decide on their applicability. Thus after testing for many generations of drug pairs, the optimum pair of the drugs is decided using the fitness function.

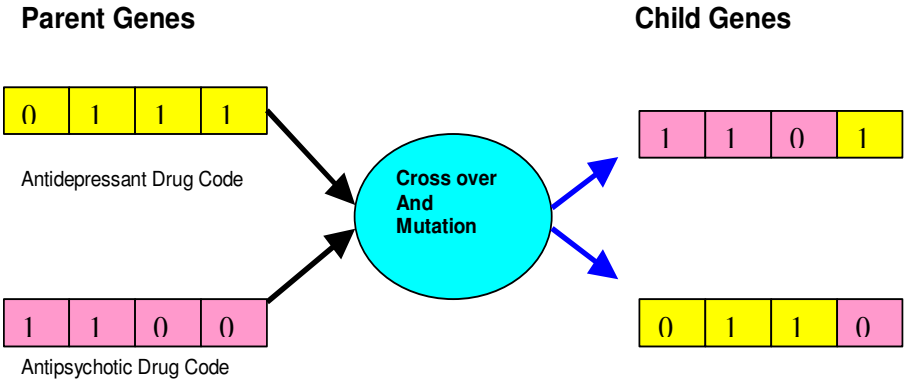

Figure 4. Genetic algorithm generating gene codes for drugs

4.4 Neural Network Module

We developed an artificial neural network with three layers with delta training algorithm, to predict the response to the treatment with a particular drug treatment using the patient related parameters. Input parameters, which are, the drug, its dose, duration of the illness, number of illness relapses and age of illness onset together with the level of response to this particular drug that exists in our patient record database. These data are used to train the artificial neural network. After prescribing a drug, how well it will respond to a particular illness can be predicted, by giving the values for those input parameters of a particular patient. This is explained in Figure–5.

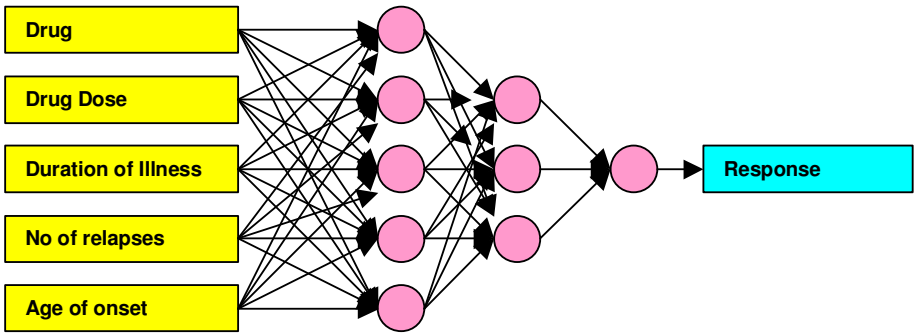

Figure 5. Topology of the neural network

5. Conclusion

We have shown how the hybrid AI system, which we developed, can be used to assist psychiatrists in their clinical practice. We have combined some AI techniques and other software modules, which we had used earlier, with good results [8],[11],[13]. The same hybrid system can be extended and customized for use in other medical sub specialties. In medical sub specialties, where the process of arriving at a diagnosis is dealt with uncertainty, expert system module can be further enhanced using a fuzzy logic inference engine or incorporating evidential reasoning [2].

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