Provide a Medical Expert System Based On Simulated Annealing Algorithm

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Abstract

The core of expert systems is a useful and reliable knowledge of the specific application. In fact, this knowledge can be considered as a rule base which in the past was achieved manually by using the classical methods of analysis, but the knowledge gained from these manual methods are not reliable. Today there is a general and popular branch of computer science called data mining which is used in various areas such as expert systems. In fact, knowledge is considered an expert system can be achieved through data mining techniques instead of manual analysis. So that this knowledge can be improved during the data mining process using an optimization algorithm, such as the SA algorithm according to criteria such as accuracy and the ability to interpret. So we can gather the experience and knowledge of expert doctors in a data set then extract useful knowledge from these datasets using SA algorithm and use it to diagnose separately for each area.

Keywords: Expert system, Simulated Annealing, Medical, Knowledge Base

I. Introduction

With the development of information technology, decision systems, and computer-based decision-making in general have been very important. In this context expert systems have an important role as a part of the Artificial Intelligence. In expert systems, types of decisions are made using a computer. Expert systems, systems that are based on knowledge and knowledge is the most important part of their. The knowledge of experts in each of these systems can be transferred to computer. Expert systems have been widely used in the world of science including industrial control, aerospace, financial decision making, etc.

The purpose of expert systems is the availability of qualified personnel skills for non-specialists. This program simulates the model thinking man's performance and causing system performance close to the performance of a human expert or expert. So far, various expert systems have been introduced in the field of medical sciences and in this respect is one of the leading science. In diagnosis and treatment of specific diseases, early and immediate detection of patients is very effective, but sometimes there is no access to specialists for patients and so the system design
specialist knowledge to provide appropriate diagnosis and treatment can provide patients with timely treatment of patients.

One of the most commonly used in expert systems is diagnosis in medicine which in recent years many studies have been done about it. One of the major problems in medical science is diagnose diseases which usually based on various tests performed on the patient. As the number of these tests is high, diagnosis may be difficult even for a specialist's and in some cases, the detection process is very long and this problem can affect the disease process improvement. For this reason, in recent years, automatic detection of computer systems have been developed to help doctors. For example, one of the most important areas of automatic detection of diseases related to cancer diagnosis that often the diagnosis is benign or malignant state in a short time is difficult. Especially in some cases, such as blood cancer early detection of the disease is the most important factor in surviving a cancer patient. For this reason, the design of an expert system, especially in cancer medicine specialist can help the physician to show that under what circumstances the patient is showing signs of a benign or malignant.

Expert Systems as one of the main branches are related to artificial intelligence which has frequently been used in various medical fields. With the increasing demand for medical services, artificial intelligence in medicine in 1970 created a breakthrough in medical science which leading to proposals for computer programs to assist physicians and other health care providers in the diagnosis and treatment.

Related work: So far, various computer algorithms and techniques have been developed to detect diseases Which indicates the importance of data mining and artificial intelligence techniques in medical science. Such as the use of artificial neural networks, decision trees and support vector machine and k-neighbors closer, etc (Abbas, 2002) (Chou et al, 2004) (Ohmann et al, 1996) (Pendharkar et al, 1999) (Bellazy et al, 1998) (Fogel et al, 1998) (Carol et al, 1999) (Subhash et al, 2003) (Ta-Cheng et al, 2005). In all these methods the desired output is a binary output which show only a simple answer, for example, if the disease is cancer, these systems only show the benign or malignant in output. In addition, the accuracy and the ability to interpret the methods offered is too low that even physician will not be able to interpret them. For this reason, several methods have been developed which are used expert systems based on fuzzy knowledge-based and heuristics algorithms for diagnosis. These systems has good accuracy and the ability to interpret but mainly used on certain data sets and specific disease (Amin, 2011) (Jalil et al, 2012) (Angella et al 2006). The proposed method presented in this paper can enhance accuracy and interpretation of than other methods. In addition, the proposed method can also be used on a variety of data sets.

This paper is organized as follows: The second section describes the SA Algorithm. Section three describes proposed expert system. In Section four we describe UCI data set. The fifth section reports on computational results evaluating the performance of the proposed system and concludes the paper.

II. Simulated Annealing(SA) Algorithm

The purpose of this paper is to create an expert system for medical applications. The most important part of an expert system is a knowledge of domain. Various algorithms can be used to obtain such knowledge which most of these algorithms to extract knowledge from the massive
amounts of data available. So these algorithms should be able to search in a large data space, but this search must also be associated with a certain intelligence. Important class of problems can be formulated as a search real minimum function of many variables. These problems include programs in various fields such as physics, chemistry, biology, economics, computer graphics, image processing, medical, etc. Although sometimes we know, there are issues such as problems of NP-Complete which no algorithm cannot find a real minimum in a polynomial time, but for this purpose successfully developed heuristic algorithms. Among these algorithms Simulated Annealing technique or simply SA in extensive grounds have been shown to be very successful.

Simulated Annealing is a method of heuristics which used for the purpose of simulation heating physical objects. The initial idea of this method was introduced by Metropolis (metropolis et al, 1953). Simulated Annealing optimization search continues as an idea to escape from local optimal solutions and the convergence to the global optimum solution proposed (Kirkpatrick et al, 1983). From then on Simulated Annealing is used in a wide range of optimization problems in classification and clustering, and achieved good results (Eaun, 2006) (Hamid et al, 2008) (Yudong et al, 2012).

This process is as follows: First, the object is heated to a high temperature, then cools slowly as to be almost in equilibrium thermodynamic system at any time. In equilibrium, the object has many configurations, which corresponds to a certain energy level. The current configuration next configuration is a random perturbation is applied to obtain the energy levels corresponding to the current energy. Suppose that show $E_c$ current energy levels and $E_n$ a new energy level. If $E_c > E_n$ then new energy level is acceptable, Otherwise, the new energy will be accepted with a probability which $T$ is the temperature of the balance. Therefore admission to a worse energy level in the high temperature is high. With a gradual decrease in temperature, and repeat the simulation Metropolis is not possible to further improve when the new energy levels can be taken.

III. The proposed expert system

An expert system generally consists of six sections which are shown in Figure 1.

![Figure 1. Components of an expert system](image-url)
Among the components of the expert system, the knowledge base has the most important role in the success of an expert system and as the core and runs at the center of an expert system. So the most important step to build an expert system is how to create a knowledge base. Knowledge Base is a set of rules and data related to the area of interest which these rules are used to classify the data in the dataset. In the past, the knowledge base created by using manual methods and through interviews with experts in the field which does not seem particularly useful method. In recent years, innovative and evolutionary optimization algorithms have been used to build the knowledge base and the desired results are achieved.

Following the method proposed for the system to create a strong knowledge base provides as follows:

**Step 1:** Create a set of basic rules in the field in question at random.

**Step 2:** Use of existing rule set and apply on the collection of existing data for classification, measurement accuracy desired.

**Step 3:** Change existing rule set by the SA algorithm in order to optimize and increase the accuracy of classification.

**Step 4:** Repeat steps 2 and 3 to reach acceptable precision, or to stop after a certain repetition.

In fact, by applying the above steps, a set of exact rules will be achieved which they can be used to classify new samples. Furthermore, given the importance of step 3, this step is described in more detail.

**Mapping SA process to create optimization rule set**

SA is an iterative search method is that the temperature of the physical metals. This method starts with an initial solution and the confusion and proper evaluation functions and is trying to address the problem of random search in state space. Inappropriate solutions are accepted by probability is determined by temperature \((T)\). The possibility of inappropriate acceptance solutions at high temperatures is higher and the likelihood decreased with decreasing temperature. In fact, the adoption of solutions is inappropriate in order to escape from local optimal solutions. At high temperatures, almost random search, while at low temperatures Search is almost greedy. At zero, the search is very greedy and just good solutions are accepted.

As mentioned, knowledge Base is the core of an expert system which is a set of rules and data. Set rules in the knowledge base plays an important role in the success of an expert system so a good set of rules can provide an appropriate knowledge base during the process of inference which effective support for expert system. SA algorithm in data mining has been used for various issues and corresponding process and rules for classification and clustering is presented.

SA process that is used to classify the rules can be considered as follows(Hamid et al, 2008):

- object is heated: If-then rules of the classifier.
- Current configuration: Set the current rules.
- disrupt the current configuration: changes in the current set of rules.
- calculate the energy of the new configuration: calculate the evaluation function to set new rules.
- Accept the new configuration provided that its energy is less than the current energy: Adoption of new rules provided that the evaluation function is less than the value of the evaluation of the current rules.
- adoption of a series based on the following configuration possibilities: acceptance of new rules with regard to the amount of the costs to be met if the probability of adoption.
In the process, the cost function is equivalent to the cost of configuration. That is the function used an evaluation function to classification of the data set.

IV. The introduction of medical data set

To evaluate the proposed approach, We have used the data sets related to the medical field in the repository UCI which are used as a reference in machine learning problems (https://www.ics.uci.edu/~mlearn/databases/).

The evaluation used three data sets Parkinson, Dermatology and SPECT Heart.

Parkinson Data Set
Oxford Parkinson's Disease Detection Dataset contains 197 instances. The dataset was created by Max Little of the University of Oxford, in collaboration with the National Centre for Voice and Speech, Denver, Colorado, who recorded the speech signals. The original study published the feature extraction methods for general voice disorders. This dataset is composed of a range of biomedical voice measurements from 31 people, 23 with Parkinson's disease (PD). Each column in the table is a particular voice measure, and each row corresponds one of 195 voice recording from these individuals ("name" column). The main aim of the data is to discriminate healthy people from those with PD, according to "status" column which is set to 0 for healthy and 1 for PD.

Attribute Information:
Matrix column entries (attributes):
name - ASCII subject name and recording number
MDVP:Fo(Hz) - Average vocal fundamental frequency
MDVP:Fhi(Hz) - Maximum vocal fundamental frequency
MDVP:Flo(Hz) - Minimum vocal fundamental frequency
MDVP:Jitter(%),MDVP:Jitter(Abs),MDVP:RAP,MDVP:PPQ,Jitter:DDP - Several measures of variation in fundamental frequency
MDVP:Shimmer,MDVP:Shimmer(dB),Shimmer:APQ3,Shimmer:APQ5,MDVP:APQ,Shimmer:DDA - Several measures of variation in amplitude
NHR,HNR - Two measures of ratio of noise to tonal components in the voice
status - Health status of the subject (one) - Parkinson's, (zero) - healthy
RPDE,D2 - Two nonlinear dynamical complexity measures
DFA - Signal fractal scaling exponent
spread1,spread2,PPE - Three nonlinear measures of fundamental frequency variation

Dermatology Data Set
Aim for this dataset is to determine the type of Eryhemato-Squamous Disease. this data set contains 366 instances. This database contains 34 attributes, 33 of which are linear valued and one of them is nominal. The differential diagnosis of erythemato-squamous diseases is a real problem in dermatology. They all share the clinical features of erythema and scaling, with very little differences. The diseases in this group are psoriasis, seboreic dermatitis, lichen planus, pityriasis rosea, cronic dermatitis, and pityriasis rubra pilaris. Usually a biopsy is necessary for the diagnosis but unfortunately these diseases share many histopathological features as well. Another difficulty for the differential diagnosis is that a disease may show the features of another
disease at the beginning stage and may have the characteristic features at the following stages. Patients were first evaluated clinically with 12 features. Afterwards, skin samples were taken for the evaluation of 22 histopathological features. The values of the histopathological features are determined by an analysis of the samples under a microscope. In the dataset constructed for this domain, the family history feature has the value 1 if any of these diseases has been observed in the family, and 0 otherwise. The age feature simply represents the age of the patient. Every other feature (clinical and histopathological) was given a degree in the range of 0 to 3. Here, 0 indicates that the feature was not present, 3 indicates the largest amount possible, and 1, 2 indicate the relative intermediate values.

**Attribute Information:**
Clinical Attributes: (take values 0, 1, 2, 3, unless otherwise indicated)
1: erythema
2: scaling
3: definite borders
4: itching
5: koebner phenomenon
6: polygonal papules
7: follicular papules
8: oral mucosal involvement
9: knee and elbow involvement
10: scalp involvement
11: family history, (0 or 1)
34: Age (linear)

Histopathological Attributes: (take values 0, 1, 2, 3)
12: melanin incontinence
13: eosinophils in the infiltrate
14: PNL infiltrate
15: fibrosis of the papillary dermis
16: exocytosis
17: acanthosis
18: hyperkeratosis
19: parakeratosis
20: clubbing of the rete ridges
21: elongation of the rete ridges
22: thinning of the suprapapillary epidermis
23: spongiform pustule
24: munro microabcess
25: focal hypergranulosis
26: disappearance of the granular layer
27: vacuolisation and damage of basal layer
28: spongiosis
29: saw-tooth appearance of retes
30: follicular horn plug
31: perifollicular parakeratosis
32: inflammatory monoluclear infiltrate
33: band-like infiltrate
SPECT Heart Data Set

Data on cardiac Single Proton Emission Computed Tomography (SPECT) images. Each patient classified into two categories: normal and abnormal. The dataset describes diagnosing of cardiac Single Proton Emission Computed Tomography (SPECT) images. Each of the patients is classified into two categories: normal and abnormal. The database of 267 SPECT image sets (patients) was processed to extract features that summarize the original SPECT images. As a result, 44 continuous feature pattern was created for each patient. The pattern was further processed to obtain 22 binary feature patterns

Attribute Information:
1. OVERALL_DIAGNOSIS: 0,1 (class attribute, binary)
2. F1: 0,1 (the partial diagnosis 1, binary)
3. F2: 0,1 (the partial diagnosis 2, binary)
4. F3: 0,1 (the partial diagnosis 3, binary)
5. F4: 0,1 (the partial diagnosis 4, binary)
6. F5: 0,1 (the partial diagnosis 5, binary)
7. F6: 0,1 (the partial diagnosis 6, binary)
8. F7: 0,1 (the partial diagnosis 7, binary)
9. F8: 0,1 (the partial diagnosis 8, binary)
10. F9: 0,1 (the partial diagnosis 9, binary)
11. F10: 0,1 (the partial diagnosis 10, binary)
12. F11: 0,1 (the partial diagnosis 11, binary)
13. F12: 0,1 (the partial diagnosis 12, binary)
14. F13: 0,1 (the partial diagnosis 13, binary)
15. F14: 0,1 (the partial diagnosis 14, binary)
16. F15: 0,1 (the partial diagnosis 15, binary)
17. F16: 0,1 (the partial diagnosis 16, binary)
18. F17: 0,1 (the partial diagnosis 17, binary)
19. F18: 0,1 (the partial diagnosis 18, binary)
20. F19: 0,1 (the partial diagnosis 19, binary)
21. F20: 0,1 (the partial diagnosis 20, binary)
22. F21: 0,1 (the partial diagnosis 21, binary)
23. F22: 0,1 (the partial diagnosis 22, binary)

V. Evaluation Of The Proposed Method

This approach is implemented by using C# programming language. Since different results were obtained in each run, the program was run 5 times and in each run data set was divided into 10 parts almost equal which 9 parts were used as training set and one part was used as a test set. In addition, the knowledge base of the system uses the 20 rule to classify data. The results of the program on each of the three data sets shown in Tables 1 to 3.
### TABLE I
RESULT 1: PARKINSON DATA SET

<table>
<thead>
<tr>
<th>Iteration</th>
<th>Train accuracy(%)</th>
<th>Test accuracy(%)</th>
<th>Active Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>97.23</td>
<td>96.65</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>96.67</td>
<td>96.00</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>97.11</td>
<td>95.39</td>
<td>18</td>
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<tr>
<td>4</td>
<td>97.05</td>
<td>96.78</td>
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<tr>
<td>5</td>
<td>97.58</td>
<td>96.84</td>
<td>19</td>
</tr>
</tbody>
</table>

### TABLE II
RESULT 2: DERMATOLOGY DATA SET

<table>
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<th>Iteration</th>
<th>Train accuracy(%)</th>
<th>Test accuracy(%)</th>
<th>Active Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98.10</td>
<td>97.00</td>
<td>19</td>
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<tr>
<td>2</td>
<td>98.41</td>
<td>97.35</td>
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<tr>
<td>3</td>
<td>98.23</td>
<td>97.88</td>
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<td>4</td>
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<td>17</td>
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<tr>
<td>5</td>
<td>98.58</td>
<td>97.69</td>
<td>19</td>
</tr>
</tbody>
</table>

### TABLE III
RESULT 3: SPECT HEART DATA SET

<table>
<thead>
<tr>
<th>Iteration</th>
<th>Train accuracy(%)</th>
<th>Test accuracy(%)</th>
<th>Active Rules</th>
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<tbody>
<tr>
<td>1</td>
<td>97.57</td>
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<td>18</td>
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<tr>
<td>2</td>
<td>97.09</td>
<td>96.15</td>
<td>17</td>
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<tr>
<td>3</td>
<td>97.66</td>
<td>97.20</td>
<td>19</td>
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<tr>
<td>4</td>
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<td>17</td>
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<tr>
<td>5</td>
<td>97.74</td>
<td>97.25</td>
<td>19</td>
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</table>

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**References**


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