A Neural Expert System Based Dental Trauma Diagnosis Application

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Abstract—Dental traumas are frequently observed challenging medical situations that the dentists need to handle. This requires a quickly made correct diagnosis and treatment to prevent further complications. Follow up procedures also need to be properly planned for the treatment to be completed successfully. The main goal of this study is to develop a system that facilitates the diagnosis and treatment process for the general dentists and dental students by providing an easy method of accessing a standard guideline in dental traumatology. This system has a big advantage from another expert systems. By using neural network this system can create its own rule with examining previous diagnoses. Thus, the system can find new correlations never known before between symptoms. New correlations may provide faster and easier diagnosis. In this study, it was aimed to find new correlations by using multilayer perceptron algorithm in Weka framework. Although lack of scientific data, the system has showed us the capability of learning.

Keywords-neural expert system; knowledge based artificial neural network; dental trauma diagnosis

I. INTRODUCTION

Trauma in the mouth area is common and involves 5% of all injuries [1]. In pre-school children, face injuries that do not involve the head and mouth area constitute up to 40% of all body injuries [2]. Dental trauma is most common in younger people, accounting for 18% of injuries to the body [1, 2]. Child health is especially affected by such traumas since these traumas may have physical, esthetical and psychologic consequences [3]. There are many studies around the world showed that dentists' knowledge was insufficient and could not effectively manage such cases. Some of the results revealed that there was an unequal distribution of information among doctors regarding emergency management of dental trauma [4-11]. Dental traumas generally have specific symptoms to themselves. Better analyze of these symptoms, enables more reliable diagnose and faster treatment can occur. The system which inferences the symptoms in respect to rules inside the knowledge base is called a rule-based system. Although rule-based systems are proficient to diagnose, they are not able to learn. Furthermore, creating new rules requires lots of experience and to be an expert. The knowledge base of the expert system may not be updated if necessary due to a lack of expert persona. However, this deficiency of expert systems can be solved by adding artificial neural network (ANN). That ANN which is called as knowledge based artificial neural network (KBANN), is used as knowledge base of the expert system. That ANN is If ANN is trained well, it can specify which symptoms and patterns show what illness. Rule-based system which rules are extracted by ANN is called neural expert system. An application using neural expert system can provide quicker and more reliable diagnosis. International Dental Traumatology Association (IADT) has prepared detailed guidelines for making quick and accurate diagnosis [12]. These guidelines are in form of a decision tree which the dentists can follow to reach a specific type of trauma. Once the diagnosis is made, the treatment plan can also be created according the guidelines. Following the treatment, the guidelines also offer follow-up procedures and methods for handling the complications that may occur. The use of such a detailed guideline is important to perform standardization in the diagnosis and treatment procedures. The main objective of this paper is to present an expert system based dental trauma diagnosis system developed using the IADT guideline. The developed system can be used on both mobile and wearable devices such as smart glasses so that they can be used seamlessly at the time of diagnosis without affecting the normal interaction of the dentist with the patient. The system uses forward-chaining to reach a conclusion based on the findings by automatically inferring outcomes based on the IADT guideline tree. The complete guidelines were included in the system where a dentist can select the clinical and radiologic findings from the menus available.

II. LITERATURE REVIEW

A. Dental Trauma

"Dental" means related with mouth, teeth, dentistry or dentist. "Trauma" means physical injury and injury can define as the physical damage that results when a human body is suddenly subjected to energy such as mechanical, thermal or chemical in amounts that exceed the threshold of physiological tolerance [13]. Dental trauma is injury to the mouth, including teeth, gums, tongue etc. Due to the frequency, emergencies are a challenge for clinicians all over the world [3]. Also, dental injuries represent serious problems affecting children physically, aesthetically, psychologically

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and traumatic injuries to the primary teeth can affect the development and eruption of the permanent teeth [3].

B. Rule-Based Expert System

In general, an expert is who can do what others cannot do. If a system/machine/computer can do what an expert does, this system is called expert system. An expert system attempts to mimic human expertise [15]. Expert system decides according to rules in its knowledge base. These rules can be defined as an IF-THEN structure/ statements. In this structure the fact part is in the IF part and action part is in the THEN part, like antecedent and consequent [14]. A rule provides some descriptions of how to solve a problem using this structure and it is not too hard to create a rule or understand a rule. In other words, the rule-based expert systems provide an answer to a problem in place of an expert (human).

An expert system offers several advantages over human experts e.g. consistency, memory, objectivity so forth. The literature reveals several successful studies using expert systems in both medical diagnosis and other decision support systems. In 1967, DENDRAL [16] was developed by to use spectrographic data in order to identify chemical structure of substances [16-28]. MYCIN was the one of the oldest expert systems. It uses rule-based approach. It competed against human specialists and showed that it was a worthy opponent [19]. Because of success of MYCIN, new expert systems are developed. This research is good example to show the power of the rule-based systems.

C. ANN

This is a mathematical model which is inspired by human brain. What makes this model famous is that its capacity of learning and generalization. Like in other areas, ANN is very popular in medicine too. Medical Diagnosis using ANN is currently a very active research area in medicine. Artificial neural network consists of layer. Layers are constructed of nodes. Nodes are process units just like neurons in the human brain. Neurons in the neighbor layers can be bonded each other but neurons in the same layer cannot [20]. Readjusting of these weights provide learning process. ANN can be used for prediction or classification. This model works as "black box". This means the model can complete its duty correct but there is no representation of the knowledge.

D. Neural Expert System

This is a hybrid system which aims to merge ANN and rule-based expert system. ANN system can learn but it is not applicable to representation. On the other hand, rule-based system is perfect to show the knowledge to user. However, it cannot learn. These two systems share a common purpose. This purpose is predicting and classifying facts correctly. We can use this purpose a system's advantages to cover up to other one's disadvantages. By using ANN inside of the knowledge base of the expert system, expert system which have ability of learning can be created. ANN's input layer neurons are inputs (IF part) of rule-based system. The output layer neurons are consequence (THEN part) of rules in the rule-based system If there is enough prior knowledge about problem domain, initial structure of ANN can be decided as multilayer. Also using multilayer structure provides to deal with nonlinear problems. KBANN is used in many areas. Although it is widely used in health and biology fields such as in molecular biology analysis and classification of DNA sequences [21], characterizing medical problems, diagnoses many critical diseases.

III. System Architecture

A. Guidelines

The main goal of this application is helping dentists to diagnose. Thus, it causes improving patient's treatment standards implicitly. This application supports only Android operating system for now. It supports down to API level 15 to include capable of work with EPSON Moverio BT200. In this application, user(dentist) can create an account on the device. In this account user can add, delete or alter patients. In addition to this, user can add, delete or alter patient reports for every patient. Reports can be converted to PDF. Furthermore, user can send the symptoms to inference server to predict the disease. Using stored report entries, the system can make inference new rules. Then, these rules can be used to diagnose. Simplified system architecture can be seen on Figure 1.

B. Data Storage

All the dentist's data and his or her patients' data are stored on the user's device by using SQLite. These data are preserved locally. There are number of reasons. One of the most important one is privacy. Another reason is difficulty of meeting on a rendezvous point. To keep all data together, everyone needs to upload his or her data to somewhere. It requires time and internet connection. Even if that happens, if there are some patients with the same name and surname, data can be complete mess. The dentist's email address and user-generated rules are also stored in the device too.

Default rules and information data about illnesses (treatment, follow-up procedures, outcome) are kept on the server's database by using MySQL. Expert system may require a large amount of memory for both the storage of the rule-based system, the inference mechanism and information of the diagnosed illness.

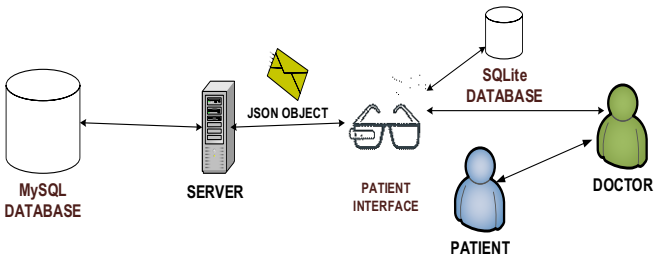

Figure 1.System Architecture

C. KBANN

Test instance is sent to the server. Using all rules which are known at the beginning, fully connected ANN is trained. All nodes in input layer demonstrates situation of symptoms. All symptoms can be in three position. If the symptom exists, it is expressed as 1. If it does not exist, it is expressed as -1. If the presence or absence is not known precisely, it is expressed as 0 (unknown situation). In input layer, all symptom has three nodes for these three positions. Output layer nodes represent diseases. Network makes classification to the test instance after training. If the network classifies correctly, it sorts all input layer nodes starting with the most important. That importance is determined by the absolute value of weight of the node. The most important symptom is written to the rule. The weights of the symptoms written the rule is summed if that node does not symbolize unknown situation. We can call that sum as KNOWN. This process is repeated until the sum of the weights of the symptoms written in the rule is greater than the sum of the absolute values of weights of the remaining symptoms (KNOWN > UNKNOWN). Mathematical expression shown in (1). The goal is to create the rule using the least number of symptoms.

$$\sum_{i=1}^{n} x_i w_j > \sum_{j=1}^{n} |w_j| \quad (1)$$

Where i ∈ KNOWN, j ∉ KNOWN and n is the number of neuron inputs in (1).

Symptoms which are summed (KNOWN) composes IF PART of the new rule. Value of class attribute which is disease's name also, is going to be ELSE PART of the new rule.

ANN is created by using Multilayer Perceptron algorithm inside Weka framework of Java. Table 1 gives a comparison of the performance of some classification algorithms within the Weka framework. Created ANN is exported as executable jar file. That file runs on the server. Training data and test data are in arff format.

D. Rule-Based Expert System

The server was created by using Node JS. In this server, there are data about illnesses and rules to inference. Sent from user device symptoms come to the server to be inferenced. At the end of inferencing by using node-rules module, illness is specified. Information about the illness are fetched from server's database and they are sent to user. Data communication is available between the server and user device by sending and receiving JSON objects and by post method. The server uses forward chaining method.

If the user wants to use his or her own created rules, rules are sent with symptoms to the server. The server inferences the illness by using rules come from the user by using KBANN as explained previous section.

E. COMMUNICATION

Data and rule sending processes between client and server occurs via JSON objects. If the client sends private information like some patient's personal information, that JSON object is sent and received the result through POST method. Otherwise, GET method used.

Medical report can be sent to email address as PDF file. This file consists of three parts. Patient's personal information, illness information and illness path. CT Images are added into PDF report if any.

IV. RESULTS

Due to the unavailability of a public dataset, we curated our own dataset according to the rules given in IADT guidelines. Data was generated according to all combinations of IADT rules. Table 1 shows the performance comparison of the different algorithms for using classification of instances created according to the IADT guidelines. In such kind of these classification problems, generally decision trees are used. Initial experiment started with decision tree, but later other well-known algorithms are started to use due to insufficient accuracy of decision tree algorithm.

The well-known algorithms shown in Table 1 were selected due to accuracy percentages. Other algorithms can be used too. Multilayer Perceptron algorithm, which is used as seen, has made correct classification in %78.125 ratio in cross-validation 10 folds test as seen in Table 1 and Figure 2. Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), accuracy and kappa are considered metrics. They are basic parameters for a classification evaluation, this is the main reason why they are selected for performance comparison. This rate of accuracy is sufficient for such a considering complexity of data set used in experiment. It proves that expert system which uses that algorithm in its knowledge base can learn.

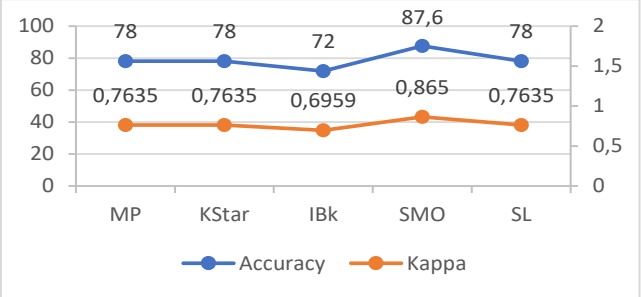

Figure 2. Accuracy & Kappa statistics

Figure 3 shows the simple interface of the application developed for this study. The interface allows symptom input by the dentist.

Table 1. Performance comparison for various algorithms

Features	**Algorithms**				
	Multilayer Perceptron (MP)	KStar	IBk	SMO	Simple Logistic (SL)
Total Number of Instances	32	32	32	32	32
Correctly Classified Instances	25	25	23	28	25
RMSE (Root Mean Squared Error)	0.1384	0.1603	0.1733	0.1114	0.2454
MAE (Mean Absolute Error)	0.0416	0.0402	0.0691	0.031	0.1247

Figure 3. A view from the application

V. CONCLUSION

This is the first wearable diagnosis system in dentistry for diagnosis of dental traumatic injuries along with multiple other features. Tools like diagnosis glasses may help the students/clinician to diagnose and treat traumatic dental injuries especially during the early stages of their work life and during emergencies in places where there is a lack of specialists to give convenient diagnosis and manage dental injuries.

Future research is planned to test the diagnostic capabilities of dentists, private practitioners, and undergraduate students in order to check whether the application helps these health care providers to minimize errors in the diagnosis of traumatic tooth injuries.

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