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An Expert System of Determining Diabetes Treatment Based on Cloud Computing Platforms

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***Abstract*-- It is well known that the incidence of diabetes in *Saudi Arabia* is increasing. The statistics show that 17% of the citizens are diabetics and 28% of them are vulnerable to be diabetics. Also *Saudi Arabia* is the *third* country around the world in which is where diabetes is most prevalent among the adult population worldwide.**

In this paper, the authors survey some of the state of the art of researches on expert systems for the purpose of determining the treatment of the diabetes. Then by exploiting the cloud computing technology, the authors introduce a design and an implementation of a novel expert system for diabetes treatment which depends on cloud computing platform, *"Google App Engine"*.

Keywords – Diabetes Expert System, Cloud computing, Google App Engine.

I. INTRODUCTION

Expert Systems are computer programs that perform in an expert manner in a domain for which no human expert exists. One of the area in which we can take the advantage of expert system is determining the treatment of diabetes.

Diabetes is a disease in which levels of Blood Glucose, (blood sugar), are above normal. People with diabetes have problems converting food to energy because the pancreas does not make enough insulin or because the cells in the muscles, liver, and fat do not use insulin properly, or both. Some families have a history with diabetes, once one of the parents is diabetic, and then some of sons as well as the grandchildren are diabetic. Diabetes does not distinguish between adult and young. It is one of the major chronic illnesses prevailing today. This disease has many complications. It causes severe damage for the body organs. These serious degenerative complications are such as retinopathy, neuropathy and nephropathy. Furthermore, diabetes affects an estimated 2-4% of the world's population.

Sometimes diabetics underestimate the diabetes which needs daily dealing with it. Thanks to the development of technology, diabetics can test the Blood Glucose anywhere in their houses, their offices etc. They can use small measurement tools which are designed for that. But they do not have an expert to advice them in which is the best way to manage diabetes.

All of the above explains the importance of designing and implementing expert systems for diabetes. In this paper, the authors survey some of the state of the art of researches on expert systems for the purpose of determining the treatment for the diabetes. Then by exploiting the cloud computing technology, the authors introduce a design and an implementation of their novel expert system for diabetes treatment which depends on cloud computing platform, *"Google App Engine"*[15].

The rest of this paper is organized as follows: Section II gives a background. Section III introduces the literature review while Section IV introduces the author's solution for the diabetes expert system. Section V demonstrates the design and the implementation of the authors system and Section VI explains the future work. Section VII concludes the paper.

II. BACKGROUND

a) Diabetes

Diabetes is a disease in which levels of blood glucose, also called blood sugar, are above normal. People with diabetes have problems converting food to energy. Normally, after a meal, the body breaks food down into glucose, which the blood carries to cells throughout the body. Cells use insulin, a hormone made in the pancreas, to help them convert blood glucose into energy [22, 27].

The main Types of diabetes are Type1, Type2 and Gestational [23, 26]. Type 1 is developed because the body fails to produce insulin. Treatment requires the person to inject insulin, calculated diet, planned physical activity, and home blood glucose testing a number of times per day. Type2 results from insulin resistance where the cells fail to use insulin properly. Treatment includes diet control, exercise, home blood glucose testing, and in some cases, oral medication and/or insulin [24]. Gestational diabetes is developed when a pregnant woman, who have never had diabetes before, have a high blood glucose level during pregnancy. Treatment requires diet plan that provides the growing baby with sufficient calories and nutrients also reasonable exercise. Some may have to take insulin injections [25].

Fasting plasma glucose (FPG) test and Oral glucose tolerance test (OGTT) are used for diagnosing diabetes. They measure blood glucose after a person fasts at least eight hours. In OGTT the person must drink a glucose containing beverage two hours before the test. FPG and OGTT detect diabetes and pre-diabetes. OGTT can be used to detect Gestational diabetes where the glucose levels are measured four times during the test [21].

Table (1) presents FPG, Table (2) presents OGTT and Table (3) presents OGTT with Gestational.

Table (1) FPG

Plasma Glucose Result (mg/dL)	Diagnosis
99 or below	Normal
100 to 125	Pre-diabetes (impaired fasting glucose)
126 or above	Diabetes

Table (2) OGTT

2-hour Plasma Glucose Result (mg/dL)	Diagnosis
139 or below	Normal
140 to 199	Pre-diabetes (impaired glucose tolerance)
200 or above	Diabetes

Table (3) OGTT with Gestational

When	Plasma Glucose Result (mg/dL)
Fasting	95 or higher
At 1 hour	180 or higher
At 2 hours	155 or higher
At 3 hours	140 or higher

b) Cloud Computing Platforms

Cloud computing represents the new revolution in IT world. This area and its related technology are worthy to be used in IT solutions. One of these technologies is the cloud computing platforms, in which the users can access the services through web browsers [16]. Cloud computing offers three kinds of services [17], Infrastructure-as-a-Service (IaaS), in which providers like, Amazon [18], provide machine instances to developers. Platform-as-a-Service (PaaS), in which providers like, Google App Engine [19], provides a programming environment that abstracts machine instances and other technical details from developers. Software-as-a-Service (SaaS) like, Microsoft's (Windows Live) Hotmail [20], dose not interfaces with user information (e.g. documents).

In this paper the authors choose using cloud computing platform "Google App Engine".

c) Google App Engine

Google App Engine is "a system that exposes various pieces of Google's scalable infrastructure so that you can write server-side applications on top of them" [28]. Also we can define Google app engine as a platform which allows host web applications on Google's infrastructure and run it. Google App Engine offers scalable and deployment environments whenever traffic and data storage needed. Developers can access Google's BigTable database, storage, and the same technologies for access control, security, and Web-services integration. Google app engine supports Python scripting language and Java [29]. In addition, it includes an authentication system to validate the identity of programmers participating in the development process. By using Google App Engine, there are no servers to maintain and no administrators needed. The idea is that the user just uploads his application and it is ready to serve its own customers [28].

Google app engine is applying a dynamic web serving, with full support for common web technologies such as HTML, XML and CSS. Google can storage data with queries, sorting and transactions by using MSQL query. And as mentioned before all applications can automatic scaling and load balancing. APIs for authenticating users and sending email using Google Accounts these services guarantee a high level of security [28, 30].

III. LITERATURE Review

Expert Systems are computer programs that perform in an expert manner in a domain for which no human expert exists. Expert systems for diabetes use many technologies, neural network, fuzzy logic, and web applications.

The concept of **neural networks** has its own background in the biological nervous system. It is a very complicated structure consisting of neurons (nerve cells) and connections between them. Artificial neural networks, as it is easily predicted, consist of artificial neurons. From a technical point of view, is the element of which the features match the chosen features of the biological neuron? The artificial neuron is not a faithful copy of the biological neuron, but the element that should fulfill particular functions in the artificial neural network. Such an artificial neuron is in a sense a transducer with the signal at the entrance, and it is then multiplied by the particular for each transducer, weighting kit and summed up. We receive the new signal at the way out, which defines the neuron activity. The most important feature of the neural networks is their ability to learn to adjust the weighting factors. Learning is done in particular cycles, so each task to solve for the neural networks is at the same time a new stimulus, causing the increase of knowledge of a particular network. The neural networks represent the sphere of the artificial intelligence [6].

Artificial neural networks **(ANNs)** have been used very successfully over the past seven years for a variety of pattern recognition and expert system applications. They require to be trained on sets of patterns which display typical features of the system and, once trained, can then be generalized using a variety of other data. The knowledge acquired through training is embedded in the weight matrices of the ANN. Further, through a dynamic learning process, they can assimilate information on a continuous basis [1].

In [1], the longer-term aim of this study is to investigate the feasibility of using an artificial neural network (ANN), in conjunction with a neuro-fuzzy expert system, for educating and advising Type 1 diabetic patients regarding their optimum short-term therapy. In this paper the authors described the use of an artificial neural network (ANN) which is able to predict blood glucose levels BGL for a specific patient. This predicted BGL may then be used in a neuro-fuzzy expert system to offer short-term therapeutic advice regarding the patients' diet, exercise and insulin regime (for insulin-dependent or Type 1 diabetics). They discussed the ANN training requirements and they compared BGL predictions for two Type 1 diabetic patients with actual BGL measurements which they found that Most of the ANN predictions are very close to the measured values provided by the patient's BGL meters (difference of 1.5mmoYl or less).

In [2], this paper designed and developed a hybrid Decision Support System (DSS) which consists of a Feed-forward Neural Network (FNN), a Classification and Regression Tree (CART) and an improved Hybrid Wavelet Neural Network (iHWNN) in order to predict the risk of a T1DM patient to develop diabetic retinopathy. The proposed system is able to store a wealth of information regarding the clinical state of the T1DM patient and continuously provide health experts with predictions regarding the possible future complications that they may present. The system has been evaluated and tested using data from the medical records of 55 T1DM patients. The DSS showed an excellent performance resulting in an accuracy of 98%. The results indicate that the proposed DSS can provide a valuable tool for the physicians towards the classification of a T1DM patient as a high risk case to develop diabetic retinopathy.

In [3], they presented an expert system using back-propagation to support the diagnosis of citizens in U-Health system. This system consists of a network system to collect data and a sensor module which measures pulse, blood

pressure, diabetes, blood sugar, body fat diet with management and measurement of stress etc, by both wired and wireless and further portable mobile connections. They implemented user interface module of U-Health System for Biometric Data sensing & Expert System for automatic Diagnosis and comprehensive diagnosis system in association with hospital DBs. Only four results out of a 100 total evaluation data differ from Doctor's diagnosed results, resulting in about 96% accuracy. It is found that the proposed algorithm predicts the diagnosis strength that outperforms the efficiency of expert system with the knowledge base.

In [4], a neural network based predictive control structure is proposed and applied to treat the problem of diabetes management. The control approach is to predict future plant behavior; hence it specifies accurate control actions necessary to stabilize slow process systems such as physiological systems. The controller adapts to a specific plant and to any changes in its behavior during the control process. When the system was trained using experimental data its overall performance improved continuously during its work. The system proved to be applicable to this particular problem, managing efficiently all selected test cases. It was noticed during the controller test that the diabetic patient is affected by a far history of his blood glucose concentration and insulin treatment profiles, and the controller was able to deal successfully with this phenomena in the control process.

In [5], this paper describes the design of a novel fuzzy neural network estimator algorithm (FNNE) for predicting the glycaemia profile and onset of hypoglycemia in insulin-induced subjects, by modeling the changes in heart rate and skin impedance parameters. Hypoglycemia was induced briefly in 12 volunteers (group A: **6** non-diabetic subjects and group B: **6** Type 1 IDDM patients) using insulin infusion. Their skin impedances, heart rates and actual blood glucose levels (BGL) were monitored at regular intervals. The FNNE algorithm was trained using all subjects from group A and validated tested on the remaining subjects from group **B.** The mean error of estimation of BGL profile for the training data set (group A) was 0.107 **($p < 0.05$)** and for the validated/tested data set (group B) was **0.139** ($p < 0.05$). Furthermore, the FNNE algorithm was able to predict the onset of hypoglycemia episodes in group A and group B with a mean error of 0.071 (p 0.03) and **0.176** ($p < 0.05$) respectively.

In [7], the authors present the Intelligent Diabetes Assistant (IDA) to help diabetics and care providers manage diabetes. They use the machine learning approach with telemedicine. In IDA they monitor the behavior and health of the diabetics frequently and instantaneously through mobile phone and with an armband that measures exercise. They found out that using IDA makes data collection from patients easier and faster. The system makes the data analysis more efficient for the physician and improves the therapy advice.

In [8], the authors discuss the AIDA diabetes simulator which simulates glucose-insulin interaction using a compartmental model, and recommends further appropriate simulations via a rule-based inference engine. They consider using artificial neural network to present a blood glucose level simulation system.

In [9], the authors present a system for real time monitoring and management of diabetes. They use GPRS, HTTP, IP-based networks to provide continuous monitoring of the patients. The authors implement an appropriate storage using remote database, warehouse and WEB server. The system provides a novel medical record management of diabetes using smart data acquisition and visualization technologies to automate decision support system and facilitate treatment design.

In [10], the authors present an expert-telemedicine system. In this system the diabetes patient can store blood glucose measurements, insulin injection doses, hypoglycemic events, dietary intakes and exercise activities through his laptop by using internet connection. The system depends on a rule-base system to give the patient a recommendation of insulin dosage.

"A **fuzzy expert system** is an expert system, which consists of fuzzification, inference, knowledge base, and defuzzification subsystems, and uses fuzzy logic instead of the Boolean logic to reason about data in the inference mechanism"[11]. In other words, a fuzzy expert system is an expert system that uses fuzzy logic instead of Boolean logic. A fuzzy expert system is a collection of membership functions and rules that are used to reason about data. Unlike conventional expert systems, which are mainly symbolic reasoning engines, fuzzy expert systems are oriented toward numerical processing. This perfect way to solve decision making problems, which has no exact algorithms, but instead the problems solution can be satisfactorily approximated heuristically relying on human expertise in form of If-Then rules.

The rules in a fuzzy expert system are usually of a form similar to the following:

If x is low and y is high then z = medium

where x and y are input variables (names to know data values), z is an output variable (a name for a data value to be computed), low is a membership function (fuzzy subset) defined on x, high is a membership function defined on y, and medium is a membership function defined on z. The part of the rule between the "if" and "then" is the rule's _premise_ or _antecedent_. This is a fuzzy logic expression that describes to what degree the rule is applicable. The part of the rule following the "then" is the rule's _conclusion_ or _consequent_. This part of the rule assigns a membership function to each of one or more output variables. Most tools for working with fuzzy expert systems allow more than one conclusion per rule. A typical fuzzy expert system has more than one rule. The entire group of rules is collectively known as a rule base or knowledge base.

In [12], the main purpose of Diabetes Care Decision Support System is to use artificial intelligence techniques to generate personalized diabetes care plan. To build a personalized care plan, this paper combined case-based reasoning and ontology technology from artificial intelligence to solve this problem. The Knowledge that's been collected in this paper such as health information, pharmaceutical care, diet care, sports care and other knowledge, help to build diabetes care ontology directly and structurally.

The result of the paper is to show that this system can provide personalized diabetes care plan efficiently.

In [13], This paper is to utilize ACO to extract a set of rules for diagnosis of diabetes disease and using a Fuzzy Logic for mining among Pima Indian diabetes data set. Ant colony optimization (ACO) has been used successfully in data mining field to extract rule based classification systems.

In [14], this paper introduced how to find the diabetes diagnose expert system (DDES) by means of information technology and integrated rule reasoning implementation working with forward/backward reasoning and accurate/inaccurate reasoning. The system mainly composed by the human-machine interface, knowledge base, database, interpreter, reasoning machine. A developed practical expert system can reduce the misdiagnosis rate of diabetes diagnosis, and help promote the prevention and treatment of diabetes.

IV. Problem Solution

After we surveyed the literature, we found a lot of researches have been conducted in the area of diagnoses and determining the treatment of diabetes. These researches use several techniques to produce efficient expert systems for the purpose of diagnosis and determining diabetes treatment. These technologies vary from web-based applications to neural network and fuzzy logic.

As we mentioned above, diabetes is one of the major chronic illnesses prevailing today which have serious degenerative complications. This explains the importance of designing and implementing a diabetes expert system.

The authors recommend using more new evolving technologies in designing expert systems for diabetes. One of the most important technologies is cloud computing. To the best of our knowledge, no diabetes expert system has been designed or implemented using web technology with cloud computing.

Cloud computing is an emerging technology. It is the fastest growing area in information technology which aroused the concern of the whole world. Using cloud computing platforms will decrease the cost for care providers and guarantee the availability of the patient information. Furthermore, it facilitates the access to the system through mobile phones, smart phones and Ipads. Therefore, the diabetics can take the advantages of these technologies to send information about their daily diabetes state to their care providers.

V. System

We designed and implemented a cloud computing expert system for the purpose of helping the diabetics to manage the diabetes and give them advises about what they should do. Also care providers as well as physicians can get the benefit of this system in helping them to speed up the process of making the decisions for which is the suitable therapy for the diabetes.

The inputs to the system are personal information about the patient like his age, gender, weight etc. and diabetes types which are Type 1, Type 2 and Gestational. Also the system takes as an input three blood sugar tests breakfast, lunch and dinner. There is another input which is HBA1C (A1C) test. A1C is measured for people with diabetes to provide an index of average blood glucose for the previous three to four months. It tells what percentage of the hemoglobin has glucose sticking to it. The less glucose that remains in the bloodstream the better diabetic's health will continue to be. The normal level of A1C in people without diabetes is approximately 4% to 6%. Figure (1) shows the interface of the system.

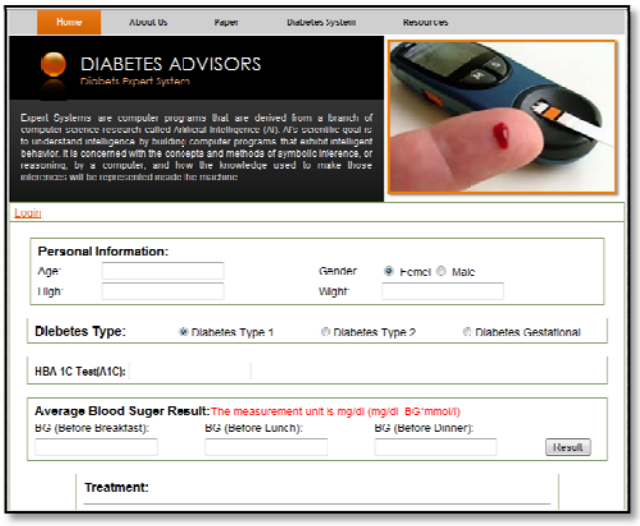

Figure 1. System Interface

After the patient enters all the information needed, the system calculates the average of the three tests and compares the result with the normal blood sugar which ranges from 80 to 140, if it is above 140 then it is high and if it is below 80 then it is low.

The system gives the appropriate treatment based on the diabetes type and the two tests (average blood sugar test, A1C test) that the patient entered. If it is Type1 the treatment will be calculated diet, planned physical activity, multiple daily insulin injections and home blood glucose testing a number of times per day. Based on average blood sugar test the insulin doses could be increased or decreased or could be the same. If it is Type 2 the treatment will include diet control, exercise, home blood glucose test and oral medicines. If the A1C test is over 10% or A1C is over 7.5 % plus average blood test glucose is over 324, then the patient must take insulin injections. If the type is gestational then treatment requires consulting a registered dietitian to help design a reasonable diet plan -- one that will address the gestational diabetes but still provides the growing baby with sufficient calories and nutrients. Also reasonable exercise four to five times a week helps the body use insulin more efficiently, which helps control blood sugar levels.

Figure 2.a Treatment for anonymous diabetic

There are two situations in the system, if the patient wants to store a record or not. If he wants a record he must log in, therefore, the system stores his information and he can retrieve it. If the patient does not want a record to be stored

he simply enters all the information and the system will give him the appropriate treatment. Figure (2.a) shows a treatment for an anonymous diabetic without a stored record, whereas; Figure (2.b) shows a treatment for a diabetic with a stored record.

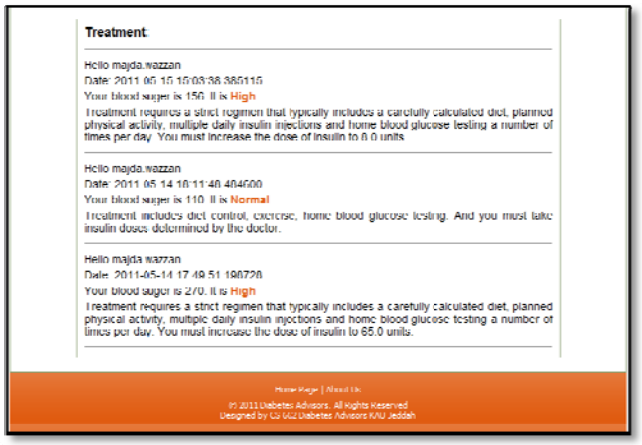

Figure 2.b Treatment for a diabetic with stored record

VI. Discussion and Future work

We introduced the initial stage of our system in this paper. Our system is uploaded over Google App Engine and is available online through http://cs662-diabetes.appspot.com/ and can be tested. It is an open source application and implemented using Python and HTML.

Our system has already been tested through entering blood glucose by 15 diabetics with different types of diabetes and by the help of two physicians. The system results show correct treatments for these diabetics.

The presented system guarantees the security of the diabetic's information by using the authentication log-in using diabetic e-mail, so no one other than the diabetic can view his information. At the same time, the system is flexible and any anonymous can take the benefit of the service without logging in and without a stored record. But the system is more useful when the diabetic logs in therefore he can retrieve his previous profile from his stored record. Also, our system is easy to use and doesn't need experience to use it more than familiarity with web-applications. The user can use the system through his browser and doesn't need to install any other software.

For future work, the authors will implement the diabetic electronic record in more sophisticated manner. Also, we plan to add some facilities to facilitate the communications between the diabetics and their care providers. Some of these facilities are exchanging SMS messages, E-mails, to enable the diabetic to send his blood sugar measurements and other information to the care provider or to the physician through the system to be stored in his electronic record. Furthermore, we will provide a version of our system for smart phones and I-pads.

VII. Conclusion

In this paper, the authors survey the state of the art of researches in expert systems for the purpose of diagnosis and determining the treatment of the diabetes. Then the authors introduce a new cloud computing based expert system for diabetes treatment using Google App Engine. This system is an open source so researchers and developers can add to it. It is web-based, flexible, easy to use, and guarantees the security. The authors will develop their system in sophisticated manner and will provide a version for smart phones and I-pads.

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