Prognostic Diagnosis of Gestational Diabetes Utilizing Fuzzy Classifier

Okpor M. D.
Department of Computer Science, Delta State, Polytechnic, Ozoro

Abstract
Gestational Diabetes occurs during gestation period or pregnancy. Gestational diabetes might be the result of the normal hormonal changes a pregnant woman's body experiences. During pregnancy, the placenta produces hormones that interfere with the actions of the hormone insulin. In a normal pregnancy, the woman's pancreas, the gland that produces insulin, can compensate for this by making additional insulin during pregnancy. However, if the pancreas cannot keep up with the body's demand for more insulin, gestational diabetes may develop. It is also a high-risk factor for the development of type II diabetes if not manage promptly. The symptoms of gestational diabetes includes; weight gain, excessive thirst, increased urination, vaginal infections,blurred vision,high blood pressure,weight Loss,fatigue,nausea,vomiting, general body weakness, vaginal discharge, loss of appetite, increased appetite, visual disturbance, visual impairment and skin redness. In this paper, the traditional procedure of the medical diagnosis of gestational diabetes employed by physicians is expressed using Fuzzy classifier. The proposed expert system eliminates uncertainty and imprecision associated with the diagnosis of gestational diabetes.

Keywords:
Diagnosis, fuzzy classifier, fuzzy logic, fuzzy set, Gestational diabetes

1. Introduction

Gestational diabetes is a specific form of diabetes that develops during gestation or pregnancy(BestMedicine, 2011; MedicineNet, 2011; Healthline, 2011 and WrongDiagnosis, 2011). Gestational diabetes is marked by high blood sugar levels and is a risk factor for the development of type II diabetes later in life (WrongDiagnosis, 2011). Complications of untreated gestational diabetes can be serious and include the development of preeclampsia in the mother and developmental problems, respiratory distress syndrome and excessive growth of the baby.

Gestational diabetes can occur as a result of the normal hormonal changes a pregnant woman's body experiences. During pregnancy, the placenta produces hormones that interfere with the actions of the hormone insulin. In a normal pregnancy, the woman's pancreas, the gland that produces insulin, can compensate for this by making additional insulin during pregnancy. However, if the pancreas cannot keep up with the body's demand for more insulin, gestational diabetes may develop. The role of insulin is to facilitate movement of sugar (glucose) from the bloodstream into the body's cells, where it is used for energy. Insulin also helps the liver to store excess glucose. When the body cannot process and use glucose properly, the body's cells do not get the energy they need. Medically, this is known as an inability to metabolize glucose, which results in high levels of sugar, or glucose, in the blood. This is called hyperglycemia (MedicineNet, 2011 and Righthealth, 2011).

Women at risk for gestational diabetes include women who have pre-diabetes or have a family history of diabetes or type II diabetes. Other risk factors include being older than 25 years when pregnant, obesity, and a history of gestational diabetes in a previous pregnancy, miscarriage and stillbirth in previous pregnancy (MedicineNet, 2011 and WrongDiagnosis, 2011) Gestational diabetes is common amongst African-American, Native American, Hispanic, or Asian ancestry. Gestational diabetes generally occurs between the 20th and 24th weeks of pregnancy (BestMedicine, 2011). It usually ends with the end of the pregnancy; the delivery of the baby and the hormone-producing placenta. However, prompt diagnosis and treatment of gestational diabetes during pregnancy is vital to preventing complications for the mother and the baby.

Pregnant women who develop gestational diabetes often do not experience symptoms initially. When they do occur, symptoms may include excessive thirst and excessive urination. It is recommended that all pregnant women begin receiving regular medical care as soon as possible in their pregnancies in order to most effectively be screened for the risk for gestational diabetes and other possible complications of pregnancy. Ideally, this medical care should begin before a pregnancy when a woman is contemplating having a baby.

Symptoms of gestational diabetes includes weight gain,excessive thirst,increased urination,vaginal Infections,blurred vision,high blood pressure,weight loss, fatigue,nausea, vomiting, general body weakness, vaginal discharge, loss of appetite, increased appetite, visual disturbance, visual impairment and skin redness (Healthline, 2011).

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2. Literature Review

Diagnostic evaluation of gestational diabetes /testing for gestational diabetes includes a glucose challenge test. In this test, a pregnant woman drinks a sugary solution. One hour later a simple blood glucose test is performed. If the glucose level is higher than normal, the woman will need a series of similar tests to confirm a diagnosis of gestational diabetes. If a woman is found to have gestational diabetes, other tests will be performed to assess the health of the baby and the mother.The list of diagnostic tests mentioned in various sources as used in the diagnosis of Gestational diabetes includes (WebMD, 2009 and BMJ, 1998):

2.1 Physical Examination

a. Test for the mother
b. Oral glucose tolerance test
c. Tests for the baby/Physical exam
d. Ultrasound
e. Fetal movement records
f. Fetal monitoring
g. Non-stress test
h. Stress test (oxytocin challenge test)
i. Amniocentesis - can detect if baby's lungs are mature; more common for maternal type diabetes than GDM (Gestational diabetes mellitus)

Gestational diabetes is treatable, especially if detected early in pregnancy. Treatment greatly lowers the baby's chances of having problems. With treatment, most women with gestational diabetes have healthy pregnancies and healthy babies. Without treatment, mothers with gestational diabetes tend to have very large babies and a harder time with labor and delivery (MedicineNet, 2011 and Righthealth, 2011) Treatment of gestational diabetes includes regular monitoring of blood sugar levels and eating a carefully controlled diet prescribed by a health care professional. If also includes regular exercise appropriate to pregnancy as prescribed. It these measures do not adequately control glucose levels, than some women may need insulin injections until after pregnancy and delivery when blood glucose levels generally return to normal.

Expert systems are knowledge-based systems that contain expert knowledge. An expert system is a program that can provide expertise for solving problems in a defined application area in the way the experts do. They use human knowledge to solve problems that normally would require human intelligence. These expert systems represent the expertise knowledge as data or rules within the computer. These rules and data can be called upon when needed to solve problems (PCAI, 2002; NIJ 2011 and Steffen 2011).

Fuzzy systems are rule-based expert systems based on fuzzy rules and fuzzy inference.

Fuzzy sets were introduced by Zadeh (1965) to represent/manipulate data and information possessing non statistical uncertainties. Fuzzy sets provide a means of representing and manipulating data that are not precise, but rather fuzzy. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth - truth values between "completely true" and "completely false", (Christos and Dimitros, 2008; Kasabov, 1998 and Robert 2000). The theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. A fuzzy set is called triangular fuzzy number (Figure 1) with peak (center) a, left width $\alpha>0$ and right width $\beta>0$ if its membership function has the form:

Fuzzy systems often learn their rules from experts. When no expert gives the rules, adaptive fuzzy systems learns by observing how people regulate real systems (Leondes, 2010). The difference between classical and fuzzy logic is something called “the law of excluded middle” (Bart and Satoru, 1993 and Ahmad, 2011). In standard set theory, an object does or does not belong to a set. There is no middle ground. In such bivalent systems, an object cannot belong to both its set and its compliment set or to neither of them. This principle preserves the structure of the logic and avoids the contradiction of object that both is and is not a thing at the same time (Zadeh, 1965). However, fuzzy logic is highly abstract and employs heuristic (experiment) requiring human experts to discover rules about data relationship (Angel and Rocio, 2011).

Fuzzy classification assumes the boundary between two neighboring classes as a continuous, overlapping area within which an object has partial membership in each class (Kuang; Ting-Hua and Ting-Cheng, 2011). It not only reflects the reality of many applications in which categories have fuzzy boundaries, but also provides a simple representation of the potentially complex partition of the feature space. In (Sun and Jang1993), propose an adaptive-network-based fuzzy classifier to solve fuzzy classification problems. Conventional approaches of pattern classification involve clustering training samples and associating clusters to given categories. The complexity and limitations of previous mechanisms are largely due to the lacking of an effective way of defining the boundaries among clusters. This problem becomes more intractable when the number of features used for classification increases, (Christos and Dimitros, 2008; Kasabov, 1998; Robert 2000 and Rudolf, 2008).

Fuzzy classifier is a subset of fuzzy system since there fully application is only utilized using fuzzy system. While the fuzzy system on one hand operate an object into class (enabling them to work together), fuzzy classifier provide the fuzzy self learning rule (conditional statement)

which enable the system to be fully optimal. Fuzzy systems are fundamental methodologies to represent and process linguistic information, with mechanisms to deal with uncertainty and imprecision (Reza and Ali, 2011).

3. Methodology

Fuzzy classifier is applied to the diagnosis of Gestational diabetes using the model prescribed in Figure 2. The system is developed in an environment characterized by Microsoft Windows XP Professional Operating System, Microsoft Access Database Management system, Visual Basic Application Language and Microsoft Excel.

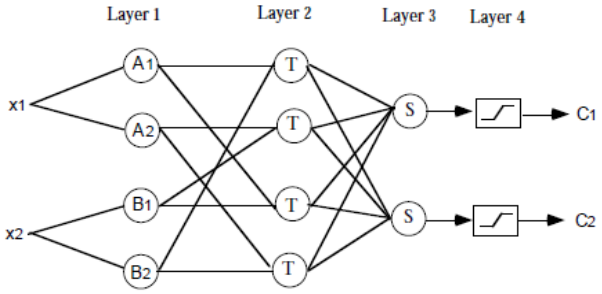

Figure 2:Fuzzy Classifier System for the Diagnosis of Gestational Diabetes

The system parades two input variables X1 and X2 which are symptoms of gestational diabetes. The training data are categorized by two classes C1and C2. Each input is represented by the two linguistic terms, thus we have four rules.

Layer 1: The output of the node is the degree to which the given input satisfies the linguistic label associated to this node. This is governed by the bell-shaped membership functions

Ai (u) = exp [-1/2 (u-ai1/bi1)2],

Bi (v) = exp [-1/2 (v-ai2/bi2)2],

which represent the linguistic terms, where {ai1, ai2, bi1, bi2} is the parameter set. As the values of these parameters change, the bell-shaped functions vary accordingly, thus exhibiting various forms of membership functions on linguistic labels Aiand Bi. In fact, any continuum, such as trapezoidal and triangular-shaped membership functions are also quantified candidates for node functions in this layer. The initial values of the parameters are set in such a way that the membership functions along each axis satisfy:-completeness, normality and convexity. The parameters are then tuned with a descent-type method.

Layer 2: Each node generates the signal corresponding to the conjunctive combination of individual degrees of match of gestational diabetes symptoms. The output signal is the firing strength of the fuzzy rule with respect to gestational diabetes.

We take the linear combination of the firing strengths of the rules at Layer 3 and apply sigmoidal function at Layer 4 to calculate the degree of belonging to a certain class. Given training set {(xk, yk), k = 1, . . . , K} where xkrefers to the kth input pattern then

(1, 0)T If XK belongs to Class 1

YK =

(0, 1)T If XK belongs to Class 2

The error function for pattern k can be defined by

EK = 1/2 [(01K -Y1K)2 + (02K - Y2K)2]

whereykis the desired output and okis the computed output.

Using fuzzy IF-THEN rules to describe a classifier, assume that K patterns xp= (xp1, xpn), p = 1, . . . , K are givenfrom two classes, where xpis an n-dimensional crisp vector. Typical fuzzy classification rules for n = 2 are like

IF xp1is small and xp2is very large THEN xp= (xp1, xp2) belongs to Class C1

IF xp1is large and xp2is very small THEN xp= (xp1, xp2) belongs to Class C2

wherexp1and xp2are the features of pattern (or object) p, small and very large are linguistic terms characterized by appropriate membership functions.

The task of fuzzy classification of Gestational diabetesis to generate an appropriate fuzzy partition of the feature space. In this context the word appropriate means that the number of misclassified patterns is very small or zero. Then the rule base should be optimized by deleting rules which are not used. The scheme is extensible to any number of input and classes.

4. Results and Discussion

The fuzzy partition for each input feature consists of gestational diabetes symptoms (weight gain, excessive thirst,increased urination, vaginal infection,blurred vision,high blood pressure,weight loss, fatigue, nausea,vomiting, general body weakness, vaginal discharge, loss of appetite, increased appetite, visual disturbance, visual Impairment andskin redness). However, it can occur that if the fuzzy partition of Gestational diabetes is not set up correctly, orif the number of linguistic terms for the input features is not large enough,then some patterns will be misclassified.The rules that can be generated from the initial fuzzy partitions of the classification of gestational diabetes is thus

a. Have Gestational diabetes (C1)

b. Might have Gestational diabetes (C2: Patient May or May not have the disease)

c. Not Gestational diabetes (C3)

If the patients have at least five or more symptoms (C1), having at least four symptoms (C2) and if the patients have less than four symptoms (C3).

The Fuzzy IF-THEN Rules (Ri) for gestational diabetes is

R1: IF the patient is experiencing weight gain THEN he/she has class C3.

R2: IF the patient is experiencing weight gain and excessive thirst THEN he/she has class C3.

R3: IF the patient is experiencing weight gain, excessive thirst and increased urination THEN he/she has class C3.

R4: IF the patient is experiencing weight gain, excessive thirst, increased urination and vaginal infection THEN he/she has class C2.

R5: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection and blurred vision THEN he/she has class C1.

R6: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision and high blood pressure THEN he/she has class C1.

R7: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure and weight loss THEN he/she has class C1.

R8: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss and fatigue THEN he/she has class C1.

R9: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss, fatigue and nausea THEN he/she has class C1.

R10: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss, fatigue, nausea and vomitingTHEN he/she has C1.

R11: IF the patient is experiencingweight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss, fatigue, nausea vomiting and general body weakness THEN he/she has C1.

R12: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss, fatigue, nausea vomiting, general body weakness and vaginal discharge THEN he/she has C1

R13: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss, fatigue, nausea vomiting, general body weakness, vaginal discharge and loss of appetite THEN he/she has C1

R14: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss, fatigue, nausea vomiting, general body weakness, vaginal discharge, loss of appetite and increased appetite THEN he/she has C1

R15: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss, fatigue, nausea vomiting, general body weakness, vaginal discharge, loss of appetite, increased appetite and visual disturbance THEN he/she has C1.

R16: IF the patient is experiencing weight gain, excessive thirst, increased urination, vaginal infection, blurred vision, high blood pressure, weight loss, fatigue, nausea vomiting, general body weakness, vaginal discharge, loss of appetite, increased appetite, visual disturbance and visual impairment THEN he/she has C1.

R17: IF the patient is experiencing weight gain, excessive thirst, increased urination,

vaginal infection, blurred vision, high blood pressure, weight loss, fatigue, nausea, vomiting, general body weakness, vaginal discharge, loss of appetite, increased appetite, visual disturbance, visual impairment and skin redness THEN he/she has C1

5. Conclusion

This work demonstrates the application of Information and Communication Technology (ICT) in the domain of differential diagnosis of gestational diabetes utilizing fuzzy classifier method when given a set of symptoms. Using fuzzy classifier methodology, differential diagnosis of gestational diabetes into three major classes “Having gestational diabetes, Might have Gestational diabetes and Not havingGestational diabetes” were presented. The system is designed to diagnose Gestational diabetes and not to prescribe drugs but can be expanded to do so after in future research. Soon there would be a fully computerized system to handle diagnosis of diseases in general. A system of this nature that has the ability to diagnose a person suffering from gestational diabetes should be introduced in the health sector to assist doctors in making diagnosis most especially in cases of severe illnesses.

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