FUZZY RELATIONAL EQUATION IN PREVENTING DIABETIC HEART ATTACK

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Abstract

Data Mining aims at discovering knowledge out of data and presenting it in a form that is easily compressible to humans. Data Mining represents a process developed to examine large amounts of data routinely collected. The term also refers to a collection of tools used to perform the process. One of the useful applications in the field of medicine is the incurable chronic disease diabetes. Data mining algorithm is used for testing the accuracy in predicting diabetic status. *Fuzzy Systems* are been used for solving a wide range of problems in different application domain *Genetic Algorithm* for designing. Fuzzy systems allows in introducing the learning and adaptation capabilities. *Neural Networks* are efficiently used for learning membership functions. This disease is one of the most common metabolic disorders which affects the eyes, kidneys, blood vessels and nerves. Analysis of heart rate variability has been shown useful to detect diabetic autonomic neuropathy and is capable of defecting abnormalities before patients develop symptoms. This is clinically important as the presence of diabetic autonomic neuropathy is a good predictor of increased mortality. The availability of this diagnostic method has proved useful for assessing patients at increased risk from diabetes, making efforts to optimize their management and thereby improving their long term outcome. The greater increase in prevalence is however expected in Asia and Africa where most patients will likely be found by 2030.

Keywords : *Data Mining, Fuzzy systems, Genetic Algorithm, Neural networks, Diabetes.*

Fuzzy Relation Equations

Fuzzy relation equation is associated with the concept of composition of binary relations. Consider three fuzzy binary relations P(X,Y), Q(Y,Z) and R(X,Z), which are defined on the sets. $X=\{x_i / i\in I\}$, $Y=\{y_j / j\in J\}$, $Z=\{z_k / k\in K\}$, where we assume that I = N_n, J = N_m, and K = N_s. Let the membership matrices of P,Q and R be denoted by $P=[p_{ij}]$, $Q=[q_{jk}]$, $R=[r_{ik}]$, respectively, where $p_{ij}=P(x_i,y_j), q_{jk}=Q(y_j,z_k), r_{ik}=R(x_i,z_k)$ for all $i\in I(=N_n)$, $j\in J(=N_m)$ and $k\in K(=N_s)$. This means that all entries in the matrices P, Q and R are real numbers in the unit interval [0,1]. Assume that the three relations constrain each other in such a way that $P\circ Q = R$ … (1) where $\circ$ denotes the max – min composition. This means that max min $(p_{ij}, q_{jk}) = r_{ik}$ $\forall$ i $\in$ I and k $\in$ K, where $\vee$ and $\wedge$ represents min and max respectively. When P and Q are expressed as relation matrices the calculation $P\circ Q$ is almost the same as matrix multiplication, except that $\times$ and + are replaced by $\vee$ and $\wedge$, respectively. For this reason, the max - min composition is also called the max-min product. Matrix equation $(P\circ Q)=R$ encompasses $n\times s$ simultaneous equation (1.2). When two of the components in each of the equations are given and one is unknown, these equations are called as fuzzy relation equations. When matrices P and Q are given and matrix R is to be determined from (1.1) the problem becomes trivial. it can be solved by performing max-min multiplication like operation on P and Q as defined.

Disease and Immunology

Human body has many systems. All the systems perform their own common functions. When all the systems perform their functions in a coordinated manner, then the body is said to be in good condition. Keeping the body in good condition is called *Homoeostasis*. This also indicates that the person is healthy in physical, mental and social dimensions.

The word "disease" means "without ease" (uneasiness). Disease is the condition in the body in which the function of a system or an organ is distributed or abnormal. Diseases are caused due to various factors such as environmental factors, nutritional factors, genetic factors, metabolic factors etc. Based on these factors, the diseases are classified into three types. They are *communicable diseases*, *hereditary diseases* and *non communicable diseases*. Communicable diseases are caused by the *pathogens* which can spread from one person to another either directly or through some agents. Hereditary or genetic diseases are caused due to some genetic defects and can be inherited by subsequent generations. The non communicable diseases are caused due to metabolic disorders, nutritional deficiencies, hormonal and

enzymatic abnormalities etc. These diseases do not spread to others.

Non Communicable Diseases – Diabetes Mellitus

The normal glucose level in human blood is ranging between 80mg and 120mg/100ml. This level is perfectly maintained by a hormone called *insulin* secreted by *beta cells of Islets of Langerhans* in pancreas. Whenever the glucose level in the blood is increased, sufficient amount of insulin is secreted by bet cells. This insulin is responsible for removing the excess of glucose from the blood and storing it in the liver in the form of glycogen. It helps to maintain the glucose level in the blood.

Diabetes mellitus is caused due to the deficiency of insulin. Insufficient quantity of insulin can take only a part of excess of glucose to the liver for storage and the rest of excess of glucose level in the blood is always high. This condition is called *hyperglycemia*. When the blood with excess of glucose enters into the kidneys, the excess of glucose is excreted along with urine. This elimination of excess of glucose along with urine is called diabetes mellitus. When the kidneys receive the blood with lot of glucose, the tissues in the kidneys are destroyed which leads to renal failure. Ultimately this leads to the death of the individual.

Heart Disease and Stroke

Heart disease and stroke are much more likely to occur in people with diabetes than in other people. Most of these heart and blood vessel problems are due to a blockage or slowing down of blood flow in the body. Chest pain, shortness of breath or swollen ankles may be a sign of cardiovascular disease. Vascular inflammation leads to narrowing of the arteries and reduces blood flow leading to heart attack. Heart attack is the commonest cause of death for people with diabetes. Blocking or slowing of blood flow to the brain can cause of stroke. The risk of a stroke is 2 to 4 times higher in people with diabetes.

- Protect your heart and blood vessels

You may be able to reduce your risk of heart or blood vessel disease if you :

- Keep your blood glucose levels as close to normal as possible.
- Limit your intake of foods high in saturated fat, trans fat and cholesterol
- Limit your use of salt and foods high in salt
- Control your blood pressure and lipid levels
- Stop smoking
- Exercise regularly (always check with your doctor before starting a new exercise)

Diabetes and Heart Disease

Diabetic individuals are more prone to develop heart disease as compared to non-diabetic individuals. The danger signals of heart disease in diabetic are easy fatigability (person gets tired easily,) increased breathlessness on minimal exertion or even rest., chest pain in the centre or towards left side of chest, sudden uncontrolled blood sugar, and increase in the blood pressure.

Treatment of heart disease is always done at hospital with regular monitoring of various body and laboratory parameters.

Symptoms

The diabetic patients show the following symptoms:

a. Polyurea : It is the frequent excretion of excessive quantity of urine.
b. Polydipsia: It is the development of excessive thirst and increased consumption of water.
c. Polyphagia: It is the excessive appetite and the consumption of excessive food.

Loss of body weight, weakness, body ache, skin boils, loss of skin texture, cracked lips etc., are other symptoms.

Diabetes Insipidus

It is an uncommon disease in man, characterised by the persistent excretion of excessive quantity of dilute urine. It results in frequent thirst. It is caused due to the deficiency of a hormone called *Anti diluretic hormone* (ADH) secreted by the neurohypophysis of pituitary gland. Deficiency of ADH makes the wall of the renal tubule reabsorbs very less amount of water. The remaining water is excreted by the kidneys along with urine. This elimination of excess of water along with urine is called *diuresis* which is also termed as *diabetes insipidus*.

Symptoms

1. Frequent and excessive excretion of dilute urine.
2. Excessive thirst.
3. Loss of body weight.
4. Retarded growth in young individuals.

Coronary Heart Disease

Coronary heart disease is defined as an impaired of heart functions due to inadequate blood supply to the heart. The wall of the heart gets blood supply from the aorta through a pair of small coronary arteries. Due to some risk factors there may be blockage or narrowing of the coronary arteries which results in inadequate blood supply to the heart muscles. It is one of the biggest health problems in the world.

Risk factors

The risk factors causing coronary heart disease are classified into non-modifiable and modifiable risk factors. The non-modifiable risk factors are the age, male sex and family history.

The modifiable risk factors are smoking, hypertension, cholesterol, diabetes mellitus, sedentary life style (physical inactivity), obesity, deficiency of vitamins, alcoholism, mental stress etc.

The major risk factors taken as the attributes in the study.

H_1: High blood pressure
H_2: Smoking / Other Tobacco use
H_3: Overweight and obesity people
H_4: Abnormal blood fats
H_5: Inactive life style
H_6: Old Age

Five symptoms heads are used here to related to the risk factors H_1, H_2,….. H_6 related to diabetes as the row of fuzzy relational matrix.

The main attributes / heads S_1, S_2,….. S_5 related to the symptoms of diabetes are:

S_1 : Swelling of legs and ankles
S_2: Chest pain
S_3: Dyspnoea (shortness of breath)
S_4: Dizziness
S_5: Less blood flow

Using these related symptoms to diabetes along columns the fuzzy relational equations are formed using experts options.

Certain limits are set using the experts opinion.

$H_1 \geq 0.5$ High blood pressure
$H_2 \geq 0.5$ Smoking / Other Tobacco use
$H_3 \geq 0.5$ Overweight and obesity people
$H_4 \geq 0.5$ Abnormal blood fats
$H_5 \geq 0.4$ Inactive life style
$H_6 \geq 0.4$ Old Age

Result and Discussion

First Experts Opinion

The first expert opinions are general physician and diabetic doctors with minimum of 25 years experience and visiting maximum patients with complicated cases in their day to day life. Treating the patients regularly and bringing them to lead a normal life. These opinions are transformed into the fuzzy relation equation P given by

$$P = \begin{array}{c} \\ H_1 \\ H_2 \\ H_3 \\ H_4 \\ H_5 \\ H_6 \end{array} \begin{array}{c} \begin{array}{ccccc} S_1 & S_2 & S_3 & S_4 & S_5 \end{array} \\ \begin{pmatrix} 0.7 & 0.6 & 0.4 & 0.4 & 0.5 \\ 0.4 & 0.5 & 0.7 & 0.4 & 0.4 \\ 0.5 & 0.7 & 0.6 & 0.5 & 0.4 \\ 0.4 & 0.9 & 0.6 & 0.3 & 0.3 \\ 0.5 & 0.4 & 0.6 & 0.3 & 0.3 \\ 0.5 & 0.5 & 0.5 & 0.4 & 0.4 \end{pmatrix} \end{array}$$

Q^T = [.6 .8 .7 .4 .3]

R^T = [.48 .49 .56 .72 .42 .40].

These symptoms are given based on the adult diabetic and given values for Q.

Where Q^T = [.6 .8 .7 .4 .3].

Hence P and Q are in the fuzzy relation equation $P \circ Q = R$. Using the max-min principle in the equation $P \circ Q = R$.

R^T = [.48 .49 .56 .72 .42 .40] is obtained.

In the fuzzy relation P is considered as weightages of the experts, Q is the symptoms of diabetic patients and R is the computed resultant for risk factors. It is also assumed that the diabetic condition of patient is badly affected by risk factors when the adult age crosses.

According to the experts opinion the heart attack risk in diabetic patient is more when fat content is more in blood. Overweight and obesity is in the second risk, followed by smoking, due to increase in blood pressure.

Clinical Research Opinion

The experiment is carried over the diabetic patients at Erode, Erode District, Tamilnadu, SouthIndia, India. Various diabetic care centers are taken for survey. But for the research experimental purpose SRC Diabetes Care Center, Erode is chosen. As the center is situated in the heart of the city which has all the facilities, various specialist visit their hospital, various complicated cases have recovered to nominal condition by suggesting regular checkups. It has been proved to be a successful care centre based on patient's statement. Patients are very satisfied by the treatment by the experts. So for the research purpose training set data's are collected from the diabetes care centre for the experimental purpose. It is the only teaching centre approved by state IMA covering areas from Salem to Coimbatore, about 100 doctors of various specialists are given training in diabetes.

Clinical opinion is taken from diabetes care centre situated at Erode, a town of Tamilnadu, India. Clinical Research opinion is considered the second expert opinion. The diabetic care centre has patients from various districts of Tamilnadu. The data's are collected from the patients directly for the research purpose through Questionnaire method. Questionnaire is prepared by various diabetic experts' general opinion with the symptoms they expect from the patient. Minimum 500 patients visit diabetic care centre per week. Various specialists visit the hospital based on their schedule, to check patients with other complications. Based on the questionnaire the matrix is obtained taking risk factors along with symptoms and it is transformed into the fuzzy relation equation P given by

$$P = \begin{array}{c} \\ H_1 \\ H_2 \\ H_3 \\ H_4 \\ H_5 \\ H_6 \end{array} \begin{array}{c} \begin{array}{ccccc} S_1 & S_2 & S_3 & S_4 & S_5 \end{array} \\ \begin{pmatrix} 0.7 & 0.6 & 0.4 & 0.4 & 0.5 \\ 0.4 & 0.5 & 0.7 & 0.4 & 0.4 \\ 0.5 & 0.7 & 0.6 & 0.5 & 0.4 \\ 0.4 & 0.9 & 0.6 & 0.3 & 0.3 \\ 0.5 & 0.4 & 0.6 & 0.3 & 0.3 \\ 0.5 & 0.5 & 0.5 & 0.4 & 0.4 \end{pmatrix} \end{array}$$

$Q^T = [.6 \quad .9 \quad .8 \quad .4 \quad .5 \quad .4]$

$R^T = [.54 \quad .56 \quad .63 \quad .81 \quad .48 \quad .45]$

These symptoms are given based on the risk factors for diabetic patients. Where $Q^T = [.6 \quad .8 \quad .7 \quad .4 \quad .3]$. Hence P and Q are in the fuzzy relation equation, then R is calculated as $P \circ Q^T = R$. Using the max-min principle in the equation $P \circ Q^T = R$. i.e., $R = [.48 \quad .49 \quad .56 \quad .72 \quad .42 \quad .40]^T$ is obtained.

It states that a diabetic patient is badly affected by the symptoms of fat in blood and overweight and obesity is in the second risk, followed by smoking, due to increase in blood pressure. The result obtained by experimental survey and experts opinion the result obtained are similar which satisfies fuzzy relations.

Conclusion

Diabetic heart attack can be controlled by regular check-up of blood sugar and proper control with medicine, by monitoring regular blood pressure. Regular Tests of heart function. Prevention on weight gain by promoting salt restricted fat-free diet and regular exercise. A special test of fat content "Lipid Profile" if available may be done. It indicates the magnitude developing heart disease. Controlling smoking and drinking of alcohol. Health is wealth if health is lost everything is lost. Hence bearing this in mind let's join hands to lead a diabetic free life.

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