

**Fuzzy Relational Equation In Preventing Neuropathy Diabetic**

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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. It is a process that is developed to examine large amounts of data routinely collected. *Fuzzy Systems* are been used for solving a wide range of problems in different application domain *Genetic Algorithm* for designing. Fuzzy Systems allows us to introduce the learning and adaptation capabilities. The fuzzy set framework has been used in several different process of diagnosis of disease. Fuzzy logic is a computational paradigm that provides a mathematical tool for dealing with the uncertainty and the imprecision typical of human reasoning. Fuzzy relational between symptoms and risks factors for *Diabetic* based on the expert's medical knowledge is taken and also related complications or due to some common metabolic disorder it may lead to vision loss, heart failure, stroke, foot ulcer, nerves. In this paper the fuzzy set A is taken as symptoms observed in the patient and fuzzy relation R representing the medical knowledge that relates the symptoms in set S to the diseases in set D, then the fuzzy set B of the possible diseases of the patients can be inferred by means of the compositional rule of inference. *Neural Networks* are efficiently used for learning membership functions, fuzzy inference rules and other context dependent patterns; fuzzification of neural networks extends their capabilities in applicability. First experts detection is only based on patients articulate that is compared by medical knowledge, that may lead to various modifications and due to patients rejections of certain symptoms may be inappropriate. The proposed detection system uses one committee of *Multilayer Perceptron Neural Networks (MLP)* for each one of the entity. Using back propagation algorithm the multilayer perceptron works again and again to remove errors in the network.

**Keywords - Data Mining, Diabetic, Fuzzy systems, Genetic Algorithm, Multilayer Perceptron (MLP), Neural networks.**

**I. INTRODUCTION**

Health and Commonwealth Government have identified diabetes to be a significant and growing global public health problem with the expected incidence in Australia to increase from 4% to 10% by 2010<sup>1</sup>. An estimated 40 million Indians suffer from diabetes, and the problem seems to be growing at an alarming rate. By 2020, the number is expected to double and reach epidemic proportions, even as half the numbers of diabetics in India remain *undiagnosed*. Diabetes has debilitating consequences on many of the body's vital organs if remained unchecked and controlled, the biggest problem being that of eyesight<sup>2</sup>.

India has the dubious distinction of being the diabetic capital of the world. Home to around 33 million people with diabetes, 19% of the world's diabetic population is from India. Nearly 12.5% of Indian's urban populations have diabetes. The number is expected to escalate to an alarming 80 million by the year 2030. Amongst the chronic diabetic complications, diabetic foot is the most devastating result. Over 50,000 leg amputations take place every year due to diabetes in India<sup>3</sup>.

Diabetes patients can often experience *loss of sensation* in their *feet*. Diabetes slowly steals the persons *vision*. It is the cause for *common blindness and cataracts*<sup>4</sup>. Cardiovascular diseases are rising. Nearly 3.8 crore cases were detected in 2005 and experts believe the number will go upto 6.4 crore by 2015.

**II. LITERATURE REVIEW**

The risk of developing Type 1 diabetes depends on the action of a number of genes in combination with environmental factors. The pathogenic process is unknown, but at the time of diagnosis the autoimmune destruction of the insulin producing beta cells of pancreas has proceeded to a level where an individual is unable to survive without insulin replacement therapy. Type 1 diabetes is the second most common chronic disease of children in Finland, with approximately 0.4% of total population being affected. Type 1 diabetes is the HLA (Human Leukocyte Antigen); locus on chromosome 6p21.3 (*IDDM1*). Recent genome scans have identified non-HLA loci linked to Type 1 diabetes, with much weaker effects than *IDDM* (Insulin-Dependent Diabetes

Mellitus). The presented studies demonstrate the advantages of utilizing the data mining approach in complex trait mapping<sup>5</sup>.

Fuzzy Systems is used for solving a wide range of problems in different application domains. The topic has attracted considerable attention in the Computation Intelligence community. The paper briefly reviews the classical models and the most recent trends for Genetic Fuzzy Systems<sup>6</sup>.

The aim of the paper is to investigate the fuzzy-nearest neighbor (FK-NN) classifier as a fuzzy logic method that provides a certainty degree for prognostic decision and assessment of the markers, and to compare it with: 1) logistic regression as a statistical method and 2) multilayer feedforward backpropagation neural networks an artificial neural-network tool, the latter two techniques having been widely used for oncological prognosis. The overall results obtained indicate that the FK-NN-based method yields the highest reductive accuracy, and that it has produced a more reliable prognostic marker model than the statistical and artificial neural-network-based methods<sup>7</sup>.

Genetic Algorithms (GAs) are considered as a global search approach for optimization problems. Through the proper evaluation strategy, the best "chromosome" can be found from the numerous genetic combinations. In this paper, a data mining-based GA is presented to efficiently improve the *Traditional GA* (TGA). Experimental results in the area of digital watermarking show that our data mining based GA successfully reduces the number of evolutionary iterations needed to find a solution<sup>8</sup>.

The effectiveness of designing and applying hybrid intelligent methodologies to various medical domains of application.. The main reason for this success seems to be the synergy derived by the computational intelligent components, such as machine learning, fuzzy logic, neural networks, genetic algorithms, or other intelligent heuristics. The paper concludes with some thoughts and remarks, regarding the use of hybrid intelligent systems in medicine and biomedicine<sup>9</sup>.

The publicly available Pima Indian diabetic database (PIDD) at the UC Irvine Machine Learning Lab has become a standard for testing data mining algorithms to see their accuracy in predicting diabetic status from the 8 variables given. Looking at the 392 complete cases, guessing all are non-diabetic gives an accuracy of 65.1%. Apply rough sets to PIDD using ROSETTA software, there are many different options within the software to choose from. Rough sets are a useful addition to the analysis of diabetic databases<sup>10</sup>.

The aim is to investigate the characteristics of medical images. The computation time increases as the image size grows. Furthermore, an automatic diagnosis system or a chaos forecast model could be developed using quantitative indexes, such as the fractal dimension and lacunarity, introduced in this paper<sup>11</sup>.

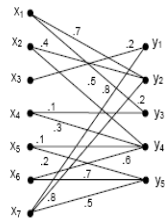
Neural networks multi criteria approach that explored in this article is wrapper based and uses a genetic algorithm in conjunction with a relatively fast, inter pattern distance-based, neural-network learning algorithm. However, this general approach works with any inductive learning algorithm<sup>12</sup>. Real-life data mining applications are interesting because they often present a different set of problems for data miners. In this paper, knowledge discovery on this diabetic patient database is discussed. A user-oriented approach that provides step-by-step exploration of the data in order to better understand the discovered patterns<sup>13</sup>.

**III. 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  $P \circ Q = R \dots (1)$  where  $\circ$  denotes the max-min composition. This means that  $\max_{j \in J} \min_{i \in I} (p_{ij}, q_{jk}) = r_{ik} \forall i \in I$  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. Illustrate the sagittal diagram of a binary fuzzy relation R(X,Y) together with the corresponding membership matrix in Figure 1.1.



The inverse of a fuzzy relation R(X,Y) denoted by  $R^{-1}(Y,X)$  is a relation on  $Y \times X$  defined by  $R^{-1}(y,x) = R(x,y)$  for all  $x \in X$  and for all  $y \in Y$ . A membership matrix  $R^{-1} = [r^{-1}yx]$  representing  $R^{-1}(Y,X)$  is the transpose of the matrix R for R(X,Y) which means that the rows of  $R^{-1}$  equal the columns of R and the columns of  $R^{-1}$  equal the rows of R. Clearly  $(R^{-1})^{-1} = R$  for any binary fuzzy relation. Thus a fuzzy binary relation can be represented by the sagittal diagram. The corresponding membership matrix as

	$y_1$	$y_2$	$y_3$	$y_4$	$y_5$
$x_1$	0	7	5	0	0
$x_2$	0	4	0	1	0
$x_3$	2	0	0	0	0
$x_4$	0	0	1	1	0
$x_5$	0	0	0	3	7
$x_6$	0	0	0	6	7
$x_7$	2	0	8	0	5

R is the membership matrix.

IV. DISEASE AND IMMUNOLOGY

Diabetic Neuropathy

Diabetic neuropathy is the collective name for damages to nerves from diabetes. Diabetic neuropathy occurs in approximately 50% of individuals with long-standing diabetes.

Nerves Affected with Diabetic Neuropathy

Somatic nerves (nerves to our body wall, and limbs) as well as Autonomic nerves (nerves to internal organs like heart and stomach) are affected with diabetic neuropathy. But the most common entity is distal symmetric polyneuropathy. A decrease in sensations from the legs is the commonest and earliest symptom of this; but later on hands are also involved with this symptom. Patients with trust symptom used to feel as if they have worn anaesthetic socks and gloves. Hyperesthesia,(increased sensation), parathesia (a sensation of numbness, tingling, sharpness, or burning) and pain also occur later on. Loss of sensation in the foot acts as a tricky risk factor for provoking ulceration and its complications, very often.

Treatment Options for Diabetic Neuropathy

Better blood sugar control with avoidance of alcohol, supplementation of vitamins like B12' B6' folate and symptomatic treatment are the mainstays of management. On disappearance of the pain of acute diabetic neuropathy over the first year, analgesics may be discontinued. Chronic, painful diabetic neuropathy is difficult to treat but may respond to 'tricyclic antidepressants' should be avoided in persons with kidney damage.

Preventive Measures of Diabetic Neuropathy

Maintenance of better blood sugar control, regular exercises, diet rich in minerals and vitamins(especially those with enough B12' B6' folate) and abstinence from alcohol and tobacco form the mainstays of neuropathy prevention in diabetes mellitus.

Precautions to be taken by Diabetic Patients with Neurologic Complications, while going for Exercises

It will be better to abstain for persons with neurologic complications of diabetes-especially if having peripheral neuropathy, from traumatic and weight-bearing exercises such as running, since such activities may easily lead to foot ulcers and stress fractures.

Complications of the Nerves in Diabetes

Majority of patients with diabetes develop complications of the nerves. About 60% patients with about 25 years duration of diabetes are found to develop these complications though the number may increase upto 90% in many cases. These complications are detected in both Type 1 and Type 2 Diabetes and mainly in middle-aged are elderly individuals. Invariably they are seen in uncontrolled mild diabetes of long duration. The nerves involved may be nerves of the hands and feet are these of the brain and spinal cord.

V. RISK FACTORS - NERVE DAMAGE

- H<sub>1</sub>: Direct damage due to lack of carbohydrate metabolism.
- H<sub>2</sub>: Due to reduced blood supply to the nerves.
- H<sub>3</sub>: Due to deposition of fat in large and small arteries supplying the nerves of hands and feet or brain.

Symptoms of Nerve Damage in Diabetics

The spectrum of symptoms reported by patients with nerves complication are given below :

- S<sub>1</sub>: Burning, cramp-like, piercing are dull aching pain in the feet and legs rarely in hand especially at night.
- S<sub>2</sub>: Tingling, numbness are coolness in feet and legs followed by pain in muscles and insensitivity to hot, cold and pain sensations.
- S<sub>3</sub>: Inability to maintain balance of body and strength and direction of movements of hands and feet.
- S<sub>4</sub>: Deformities of toes and nails, thickened skin and ulcers an sale (due to. insensitivity of feet to. repeated injuries).
- S<sub>5</sub>:Pain, weakness and thinning of muscles of thigh.
- S<sub>6</sub>: Inability to control passing of urine.
- S<sub>7</sub>: Repeated diarrheas are constipation.
- S<sub>8</sub>: Abdominal cramps.
- S<sub>9</sub>: Inability to sweat.
- S<sub>10</sub>: Intolerance to extreme temperatures.
- S<sub>11</sub>: Impotence.
- S<sub>12</sub>: Fall in blood pressure on suddenly standing up from lying dawn position.
- S<sub>13</sub>: Sudden attacks of weakness or paralysis usually on one side of body (Stroke).
- S<sub>14</sub>: Infections of the brain.

Diagnosis is made by nerves conduction studies (velocities) of affected nerves and Electromyography. Treatment varies according to the presenting feature. Vitamins have no role in treatment. It is universally known that diabetes are very prone to develop infections of different types. About 8.5% of diabetic patients are known to die due to infections inspite of availability of various antibiotics. The major causes of infections are Poor control of diabetes, Reduced immunity or resistance to fight diseases, Defects in the blood vessels and nerves.

Types of Infections: Urinary infections are commonest and increase during pregnancy. Chest infections like tuberculosis and pneumonia, Skin infection-Boils, carbuncles, fungal infections especially in the genital area in females, Rarely infections of bones

and gall bladder.

Treatment involves control of blood sugar levels and proper antibiotics:

$H_1 \geq 0.5$  Direct damage due to lack of carbohydrate metabolism.

$H_2 \geq 0.5$  Due to reduced blood supply to the nerves.

$H_3 \geq 0.5$  Due to deposition of fat in large and small arteries supplying the nerves of hands and feet or brain.

**VI. RESULT AND DISCUSSION**

**1. First Experts Opinion**

The first expert opinions are general physician and diabetic doctor's 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

$$P = \begin{pmatrix} S1 & S2 & S3 & S4 & S5 & S6 & S7 & S8 & S9 & S10 & S11 & S12 & S13 & S14 \\ H1 & 0.5 & 0.4 & 0.6 & 0.3 & 0.2 & 0.3 & 0.5 & 0.1 & 0.2 & 0.1 & 0.3 & 0.4 & 0.4 & 0.3 \\ H2 & 0.5 & 0.3 & 0.2 & 0.1 & 0.3 & 0.4 & 0.5 & 0.2 & 0.1 & 0.3 & 0.4 & 0.6 & 0.7 & 0.2 \\ H3 & 0.2 & 0.3 & 0.1 & 0.4 & 0.5 & 0.6 & 0.4 & 0.5 & 0.3 & 0.5 & 0.4 & 0.5 & 0.6 & 0.6 \end{pmatrix}$$

$$Q^T = [.5, 4 .6 .4 .5 .6 .5 .5 .3 .5 .4 .6 .7 .7]$$

$R^T = [.40 .50 .40]$ . These symptoms are given based on the adult diabetic and given values for Q. Where  $Q^T = [.5 .4 .6 .4 .5 .6 .5 .5 .3 .5 .4 .6 .7 .7]$ . Hence P and Q are in the fuzzy relation equation  $P \circ Q = R$ . Using the *max-min* principle in the equation  $P \circ Q = R$ .

$$R^T = R^T = [.40 .50 .40] \text{ is obtained.}$$

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.

**2. 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. 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. 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 expects from the patient. Minimum 500 patients visit SRC 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

$$P = \begin{pmatrix} S1 & S2 & S3 & S4 & S5 & S6 & S7 & S8 & S9 & S10 & S11 & S12 & S13 & S14 \\ H1 & 0.5 & 0.4 & 0.6 & 0.3 & 0.2 & 0.3 & 0.5 & 0.1 & 0.2 & 0.1 & 0.3 & 0.4 & 0.4 & 0.3 \\ H2 & 0.5 & 0.3 & 0.2 & 0.1 & 0.3 & 0.4 & 0.5 & 0.2 & 0.1 & 0.3 & 0.4 & 0.6 & 0.7 & 0.2 \\ H3 & 0.2 & 0.3 & 0.1 & 0.4 & 0.5 & 0.6 & 0.4 & 0.5 & 0.3 & 0.5 & 0.4 & 0.5 & 0.6 & 0.6 \end{pmatrix}$$

$$Q^T = [.4 .5 .6 .3 .4 .5 .5 .6 .4 .4 .3 .5 .6 .6]$$

$R^T = [.36 .42 .36]$ . These symptoms are given based on the risk factors for diabetic patients. Where  $Q^T = [.4 .5 .6 .3 .4 .5 .5 .6 .4 .4 .3 .5 .6 .6]$ . 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.,  $R = [.36 .42 .36]^T$  is obtained.

It states that a diabetic neuropathy patient is badly affected by the risk factor of reduced blood supply to the nerves the second risk, followed due to the lack of carbohydrate metabolism and finally Due to deposition of fat in large and small arteries supplying the nerves of hands and feet or brain. The result obtained by experimental survey and experts opinion the result obtained are similar which satisfies fuzzy relations.

**VII. CONCLUSION**

Diabetic neuropathy can be controlled by regular check-up of blood sugar and proper usage of antibiotic by physician advice

controlling various skin, chest, urinary infections. If the diabetes is controlled properly in a diabetic patient automatically immunity or resistance to fight disease increases. Monitoring regular nerve function can be checked by Electromyography.

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