DESIGN OF EXPERT SYSTEM FOR MEDICAL DIAGNOSIS USING FUZZY LOGIC

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ABSTRACT

This paper work proposes a model for the diagnosis of Hemorrage, brain tumor in human brain, cardiac disease in heart and thyroid disease in case of thyroid. System uses Fuzzy logic design: Fuzzifier, inference engine, rule base and defuzzification for the following model. The model take five input: protein, red blood cells, lymphocytes, neutrophils, eosinophils and give three output: normal, hemorrhage, brain tumor for Brain disease. While in Heart disease only one input is taken: C.P.K.M.B value giving output cardiac disease or not. Similarly for thyroid disease the three input are take: T-3 value, T-4 count, Ultrasenitive Hormone (T.S.H) giving output thyroid disease or not.The medical diagnosis for the model, fuzzy rules are formulated and applied using MATLAB simulation.The simulation result are calculated on the bases of design model.The work carried in the paper proposes to develop a control system to enhance the efficicency to diagnose a disease related to human disease.
Keywords : Fuzzifier, Inference Engine, Rule Base, Defuzzification, Simulation Result, Fuzzy Control System etc

1 INTRODUCTION

THIS project work proposed a diagnosis of the haemorrhage, brain tumour, heart disease and thyroid disease to show the probability of the disease. The simulation of fuzzy logic results shows the probability of the disease to occur and normal result probability. Hemorrhage and tumor occur by the abnormal increase or decrease of blood cells in the cerebrospinal fluid. The data range of the blood cells includes red blood cells, lymphocytes, protein, neutrophils, and eosinophils. These cells are used as input parameters for the fuzzy logic system. Cells make inputs which are to be fuzzified. On the basis of fuzzy rules fuzzified outputs are collected. The output describes which disease is probable and the chances of the normality by the change in the input parameters that are blood cells. The fuzzy surfaces are obtained and graphical relationship between the input parameters and output are shown. Heart disease the **CPK-MB test** is a cardiac marker used to assist diagnoses of an acute myocardial infarction. It measures the blood levels of two variants (isoenzymes CKM and CKB) of the enzyme phosphocreatine kinase. Thyroid-releasing hormone (TRH) is injected into the body through a vein. This hormone is naturally secreted by the hypothalamus and stimulates the pituitary gland. The pituitary responds by releasing thyroid -stimulating hormone (TSH). Large amounts of externally administered TRH can suppress the subsequent release of TSH. This amount of release-suppression is exaggerated in primary hypothyroidism, major depression, cocaine dependence, amphetamine dependence and chronic phencyclidine abuse.

1.1 Motivation

In the domain of medical diagnosis, there are numerous variables that affect the decision process thereby causing the differences in the opinions of the practitioners. There are many uncertain risk factors, so sometimes disease diagnosis is hard for experts. Having so many factors to analyze to diagnose the disease of a patient makes the physician's job difficult. So an accurate tool will be of a great help for an expert to consider all these risk factors and show certain results in uncertain terms. Motivated by the need of such an important tool, the professional form of artificial intelligence that is based on fuzzy logic for the diagnosis of the diseases pertaining to liver as well as other organs have been developed.

1.2 Contribution

The major contribution in this project is to develop a simulated

model. A disease is usually characterized by directly observable symptoms that prompt the patient to visit a physician. A series of clinical observations are undertaken to detect the presence of a disease. In this project "Design of Expert System for Medical Diagnosis Using Fuzzy Logic", the first step is determination of input and output variables. There are Five input variables and Three output variable for Brain Disease, one input and two output for Heart disease and three input and 2 output for Thyroid disease. The symptoms of the disease are expressed by the deviation of the observations from their normal values. All input variables their description value, associated fuzzy sets and their membership function ranges are presented.

1.3 Related Survey

The studies reported on fuzzy expert systems in medical diagnosis covers wide spectrum including the need, importance, potential and approaches for designing of the expert systems for medical diagnosis applications [3], [4], [10], [13]. Computer assisted applications for patient's diagnosis and treatment seems to be the more recent area of interest [2], [5], [18]. The Fuzzy Expert System has proved its usefulness significantly in the medical diagnosis for the quantitative analysis and qualitative evaluation of medical data, consequently achieving the correctness of results. The literature survey reveals that, the commercially available expert system shells are rigorously used to write the application specific rule-bases. It has been found that the frameworks are developed for generation of fuzzy expert systems with respect to specific diseases, general purpose diagnostic systems as well as for counseling of personal health [7], [16], [17]. Design of expert system frameworks for medical treatment and prevention of high risks related with the human health widened the scope for implementation of fuzzy Concept in medical field [11]. Suitability of computer systems using fuzzy methods and computerized monitoring and medical decision making systems have been reported [6], [8], [9], [15]. The object oriented frameworks to construct FES are proposed [12], [14]. It has been notified that, 21% reported research is devoted towards the development of methodologies and models. The share of studies conducted at architectural development level International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11 (2012) © Research India Publications; http://www.ripublication.com/ijaer.htm of fuzzy expert system shells and frameworks have been also found to be significant, i.e. 14%. The neuro-fuzzy approach has been used by many researchers and developed many fuzzy expert systems incorporating artificial intelligence to it. The investigation reveals that, 13% studies are contributed to the development of neuro-fuzzy based expert systems.

Figure 1 shows the percentage distribution of studies reported based on classification of articles in last two & half decades. The graph shows an exponential growth in the interests of various researchers for the development of fuzzy applications in the medical field. The penetration of fuzzy concept in medical field seems to be at par up to the year 2000. The recent span shows the exponential growth and more attention of researchers toward the development of fuzzy based expert systems specific to medical diagnosis. This accelerated trend intensifies the demand for focus on the development of more intelligent medical fuzzy expert systems. Figure 1. Percentage distribution of studies reported based on classification of articles.

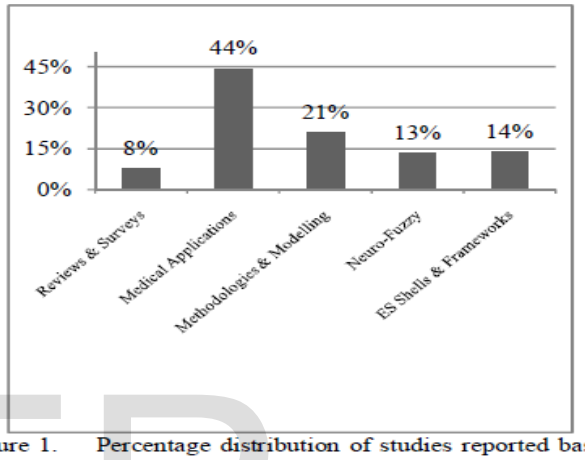

Figure 1. Percentage distribution of studies reported based on classification of articles

1.4 Over view of fuzzy logic medical diagnosis control system

This work proposes diagnostic system using fuzzy logic control system and its design and simulation. Predefined patterns and the behaviour of a process are mostly controlled by diagnostic systems. The problems controlled by such systems involve suggestions for a certain treatment after identification. Diagnostic systems are in the form of an expert system based on rules. Sure patterns are explained by set of rules which is called as rule based expert system. Evaluation of rules is done after the collection of observed data. Identification of pattern and suggestion of problem linked with that pattern is given when the rules are logically satisfied.

These are the type of white blood cells used in the defensive and immune system of the body. Lymphocytes are in the bone marrow. These are also white blood cells. Eosinophils are the type of white blood cells and use in the immune system of the body. These are present in blood, bone marrow and in tissues. Protein enters the CSF through blood also protein transfer from brain to CSF.

A. Heart disease the **CPK-MB test** is a cardiac marker used to assist diagnoses of an acute myocardial infarction. It measures the blood levels of two variants (isoenzymes CKM and CKB) of the enzyme phosphocreatine kinase.

In some locations, the test has been superseded by the troponin test. However, recently, there have been improvements to the test that involve measuring the ratio of the CK-MB1 and CK-MB2 isoforms.

The newer test detects different isoforms of the B subunit specific to the myocardium whereas the older test detected the presence of cardiac-related isoenzyme dimers.

1.4.1 Blood tests for thyroid

1. The measurement of thyroid-stimulating hormone (TSH) levels is often used by doctors as a screening test. Elevated TSH levels can signify an inadequate thyroid hormone production, while suppressed levels can point at excessive unregulated production of hormone.
2. If TSH is abnormal, decreased levels of thyroid hormones T4 and T3 may be present; T4 and T3 levels may be determined with blood tests to confirm that their levels are decreased.
3. Auto antibodies may be detected in various disease states (anti-TG, anti-TPO, TSH receptor stimulating antibodies).
4. There are two cancer markers for thyroid derived cancers. Thyroglobulin (TG) for well differentiated papillary or follicular adenocarcinoma, and the rare medullary thyroid cancer has calcitonin as the marker.
5. Very infrequently, TBG and transthyretin levels may be abnormal; these are not routinely tested.

To differentiate between different types of hypothyroidism, a specific test may be used. Thyroid-releasing hormone (TRH) is injected into the body through a vein. This hormone is naturally secreted by the hypothalamus and stimulates the pituitary gland. The pituitary responds by releasing thyroid - stimulating hormone (TSH). Large amounts of externally administered TRH can suppress the subsequent release of TSH. This amount of release-suppression is exaggerated in primary hypothyroidism, major depression, cocaine dependence, amphetamine dependence and chronic phencyclidine abuse. There is a failure to suppress in the manic phase of bipolar disorder.

2.0 Design algorithm of fuzzy logic medical diagnosis control system

The work related to the proposed design model of fuzzy logic medical diagnosis control system for the diagnosis of human disease like for hemorrhage and brain tumor for Brain disease ,Thyroid disease & Heart disease is discussed. It also gives the probability of normality of human.

2.1 Design Algorithm for Brain disease

This algorithm is designed for the five fuzzy input variables. Table 1 shows the membership functions of the five variables: proteins, red blood cells, lymphocytes, neutrophils and eosinophils. The ranges of inputs variables are given in the table.

Membership function-MF	Protein Range	Red Blood Cell Range	Lymphocytes Range	Neutrophils Range	Eosinophils Range
Low	200-500	0-5	50-75	0-3	0-10
High	400-1150	3-50	60-97	3-60	0-18
Very High	700->1200	24- >50	80- >100	38- >72	13-25

Table:1.1 Membership Functions of Input variables: Protein, RBC, Lymphocytes, Neutrophils and Eosinophils

Fig 1, Fig 2, Fig 3, Fig 4 and Fig 5 show the membership function plots for each fuzzy input. The three membership functions, f1 [1], f1 [2] and f1 [3] are used to show the various ranges of input fuzzy variable "Protein" in a plot consisting of two regions as shown in Fig. 1.

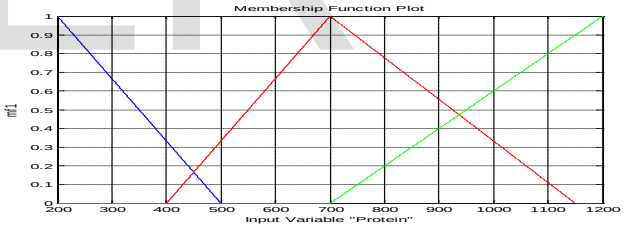

Figure 2 Plot of membership functions for input fuzzy variable protein for fuzzy logic medical diagnosis control system

The three membership functions, f2 [1], f2 [2] and f2 [3] are used to show the various ranges of input fuzzy variable "Red blood cell" in a plot consisting of two regions as shown in Fig. 2

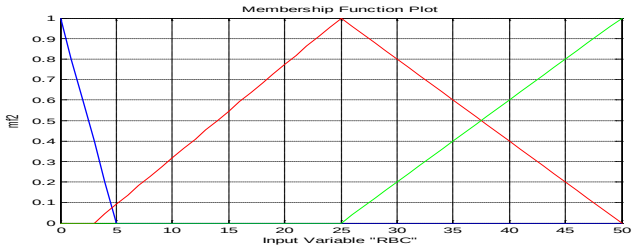

Figure 3 Plot of membership functions for input fuzzy variable-red blood cell for fuzzy logic medical diagnosis control system

The three membership functions, f3 [1], f3 [2] and f3 [3] are used to show the various ranges of input fuzzy variable "Lymphocytes" in a plot consisting of two regions as shown in Fig. 3.

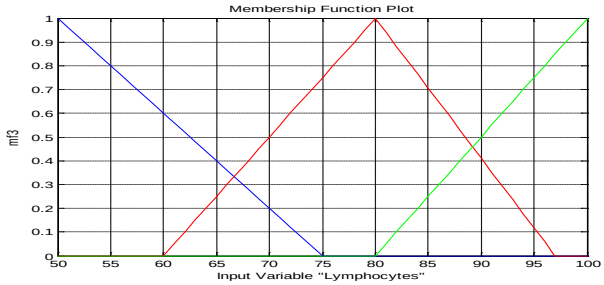

Figure 4 Plot of membership functions for input fuzzy variable- lymphocytes for fuzzy logic medical diagnosis control system

The three membership functions, f4 [1], f4 [2] and f4 [3] are used to show the various ranges of input fuzzy
variable "Neutrophils" in a plot consisting of two regions as shown in Fig. 4.

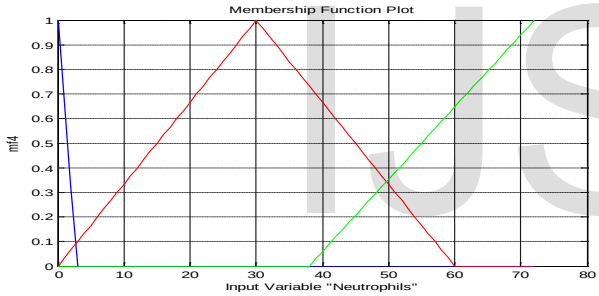

Figure 5 Plot of membership functions for input fuzzy variable-neutrophils for fuzzy logic medical diagnosis control system

The three membership functions, f5 [1], f5 [2] and f5 [3] are used to show the various ranges of input fuzzy
variable "Eosinophils" in a plot consisting of two regions as shown in Fig. 5.

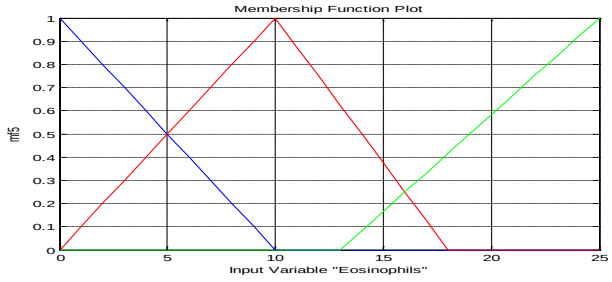

Figure 6 Plot of membership functions for input fuzzy variable-eoinophils for fuzzy logic medical diagnosis control system

There are three output variables. The plot of membership function for each variable consists of three functions.

Membership Function	**Range**	**Normal**	**Hemorrhage**	**Brain Tumor**	**Singleton**
MF1	0-0.4	Normal	Not Probable	Not Probable	S1=0
MF2	0.1-0.9	Not Normal	Uncertain	Uncertain	S2=0.005
MF3	0.6-1	Uncertain	Probable	Probable	S3=0.01

Each membership function's detail is shown in Table 2.

Table:1.2 output membership Functions fuzzy Logic Medical Diagnosis Control System

2.2 Design Algorithm for Thyroid Disease

This algorithm is designed for the three fuzzy input variables. Table 2.1 shows the membership functions of the three variables: T-3, T-4 & TSH. The ranges of inputs variables are given in the table.

Membership function-MF	**T-3 Range**	**T-4 Range**	**TSH Range**
Low	0-1	60-65	0.25-0.9
High	1-1.7	63-80	0.8-3
Very High	1.6-2.5	78-120	2.8-5

Table:2.1 Membership Functions of Input variables: T-3,T-4 & TSH.

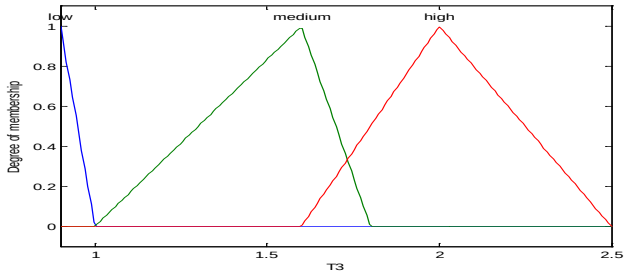

Figure 6 Plot membership functions for input fuzzy variable T-3 for fuzzy logic medical diagnosis control system

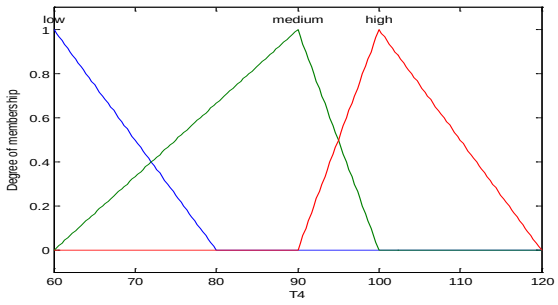

Figure 7 Plot membership functions for input fuzzy variable T-4 for fuzzy logic medical diagnosis control system

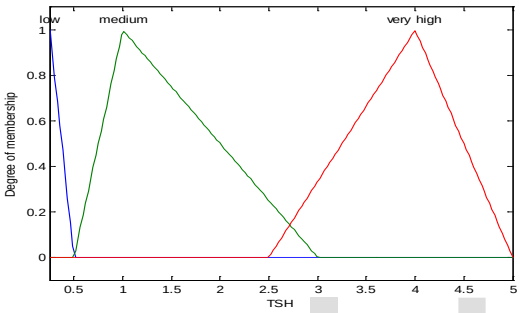

Figure 8 Plot membership functions for input fuzzy variable TSH for fuzzy logic medical diagnosis control system

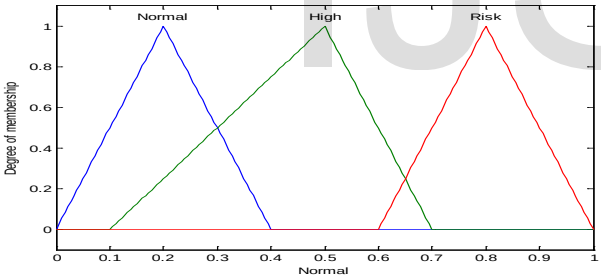

Figure 9 Plot membership functions for Output fuzzy variable Normal for fuzzy logic medical diagnosis control system

Membership Function	Range	Normal	Thyroid
MF1	0-0.4	Normal	Not Probable
MF2	0.1-0.7	Not Normal	Uncertain
MF3	0.6-1	Uncertain	Probable

Table:2.2 output membership Functions fuzzy Logic Medical Diagnosis Control System for Thyroid

2.3 Design Algorithm for Heart Disease

This algorithm is designed for the three fuzzy input variables. Table 2.3 shows the membership functions of the three variables: CPKMB, RR & HR. The ranges of inputs variables are given in the table

Membership function-MF	CPKMB Range	RR Range	HR Range
Low	0-2	30-48	0-0.6
High	1-8	60-100	0.6-1.2
Very High	6-10	100-200	1.2-2

Table: 2.3 Membership Functions of Input variables: CPKMB, RR & HR.

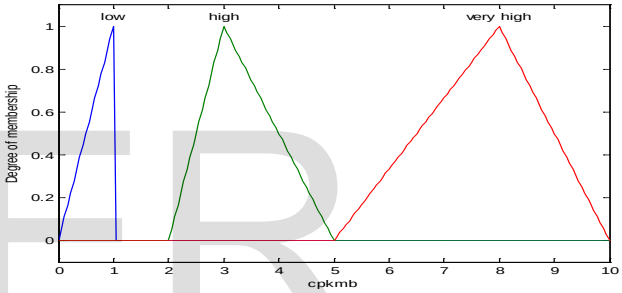

Figure 10 Plot membership functions for input fuzzy variable CPKMB for fuzzy medical diagnosis control system

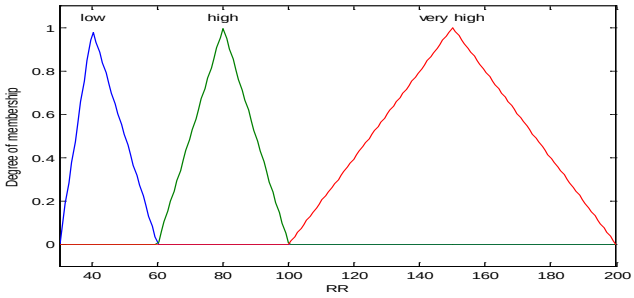

Figure 11 Plot membership functions for input fuzzy variable RR for fuzzy medical diagnosis control system

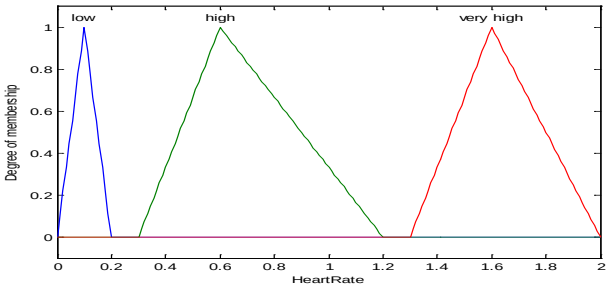

Figure 12 Plot membership functions for input fuzzy variable HR for fuzzy medical diagnosis control system

Membership Function	Range	Normal	Heart Disease
MF1	0-0.4	Normal	Not Probable
MF2	0.1-0.7	NotNormal	Uncertain
MF3	1.2-2	Uncertain	Probable

Table:2.4output membership Functions fuzzy Logic Medical Diagnosis Control System for Thyroid

3.0 Result and Discussion

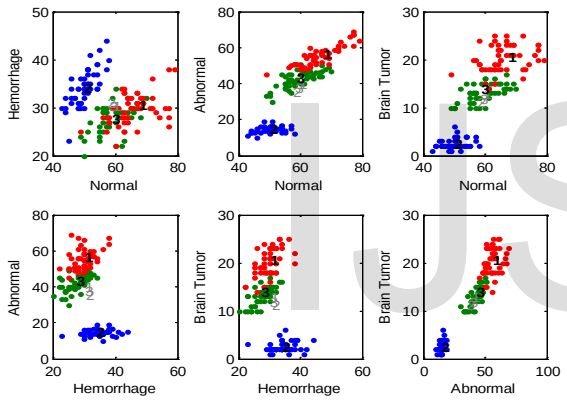

Figure 13 MATLAB Simulation Plot for Fuzzy Logic Medical Diagnosis control system

The medical diagnosis system is based on fuzzy logic model. It is designed for diagnosis of disease in human brain, Heart & thyroid. This system consists of five input variables: protein, red blood cells, lymphocytes, neutrophils and eosinophils is case of Brain disease. The rule base of this system is used to determine the three output parameter value in ase of brain : normal, haemorhage, brain tumor, according to the five input values.

Results	Normal	Haemorhage	Brain tumor
MATLAB Simulation	0.444	0.485	0.575
Calculated Values	0.432	0.464	0.6

Table: 3.1 Comparsion between Simulation & Calculated value

Calculation has been made for the input values, PROTEIN=450, RED BLOOD CELL=3.02,LYMPHOCYTES = 64.8, NEUTROPHILS=2.54and EOSINOPHILS = 4.87.

This thyroid algorithm consists of three input variables: T-3, T-4 & TSH . The rule base of this system is used to determine the two output parameter value in case of thyroid : normal, Thyriod according to the three input value.

Calculation has been made for the the input values for thyroid Disease

T-3=0. 9,T-4= 65 and TSH= 0.29 for Normal Patient.

T-3= 2.3, T-4 = 115 and TSH = 11 for Thyroid Patient

Result	Normal	Thyroid
Matlab Simulation	**0.913**	**0.632**
Calculated Value	**0.851**	**0.681**

Table: 3.2 Comparsion between Simulation & Calculated value

Heart algorithm consists of three input variables: CPKMB, RR & HR. The rule base of this system is used to determine the two output parameter value in case of Heart disease : normal, have Cardiac disease according to the three input value.

CPKMB=1,RR= 35 and HR = 0.2 for Normal Patient.

CPMKB= 9, RR= 180 and HR = 1.8 for Cardiac Patient.

Result	Normal	Cardiac
Matlab Simulation	**0.913**	**0.632**
Calculated Value	**0.851**	**0.681**

Table: 3.3 Comparsion between Simulation & Calculated value

Designing Process involve the designing phase of Front page consist of GUI, Patient Information , Brain Disease, Heart Disease, Thyroid button as input buttons. Next below button developed for Membership Function as input Protein, RBC, Lymphocytes, Neutrophils and Eosinophils. Each Membership function have three values MF1, MF2 & MF3. Training Fuzzy System button consist of training fuzzy system through Mamdani Model. Through Mamdani Model system is trained with 17rules. Fuzzy System button display the 17 rules graphics, and at last close button the close the graphics.

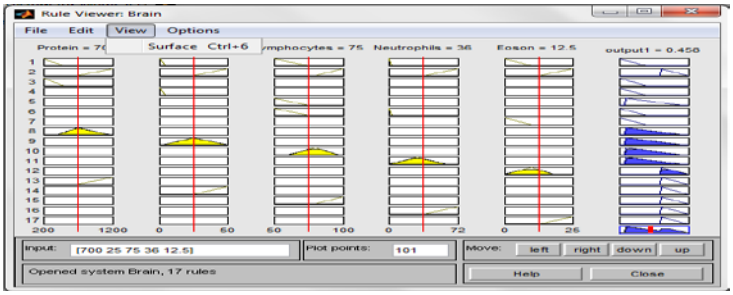

Figure: 14 Result Comparison shown in other Papers "Design Model of Fuzzy Logic Medical Diagnosis Control System"

4.0 Conclusion & Future Work

Both the design model and simulation result are same. The designed system can be extended for any number of inputs. Normal, hemorrhage and the brain tumor all depend on the inputs protein, red blood cell, lymphocytes, neutrophils and eosinophils. We can define this system for any number of inputs. As the inputs are the blood cells and the designed system use five blood cells as inputs, similarly we can define this system more than five inputs to get more efficient human diagnose results.

The design work is being carried out to design state of the art fuzzy logic medical diagnosis control system in future using FPGA.

5.0 Acknowledgement

This research work was carried out in the various laboratories of Electronics Department and the Department of Computer Science GC University. Paper propose the further improvement in finding the suitable out on the bases of calculation to define the human disease in Normal, Certain or Uncertain mode.

6.0 Reference

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