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Fuzzy Expert System for Medical Diagnosis

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Abstract- Fuzzy systems are extensively used in both applied and experimental medicine and are one of the most prevalent subjects of today's Medical Informatics. Despite some limitations of their use due to information, economical, educational and other reasons these systems are widely acknowledged in medical institutions operating in all levels of healthcare. The accuracy of some up-to-date fuzzy systems today matches the diagnostic abilities of physicians that are why it holds an important role in risk-assessment and diagnostics in pharmocology. In this paper, I have done work on the fever symptoms that help in the diagnosis of dengue fever symptoms with the help of some doctors on the basis of fuzzy rule system I tried to give a better identification of dengue fever on the sample based, on the lab features and clinical symptoms.

Index Terms- Introduction, Signs and Symptoms, Cause, Mechanism, Diagnosis, Prevention and Control ,Implementation, Result Analysis, Conclusion, Future Scope, References .

I. INTRODUCTION

The dengue fever is known as break bone fever is an infectious tropical disease caused by the dengue virus. The fever, headache, muscle, joint pains and a characteristic skin rash that is similar to measles symptom. In a small proportion of cases, the disease are used to develop the life-threatening dengue hemorrhagic fever resulting in low level of blood platelets and blood plasma leakage or into dengue shock syndrome where dangerously low blood pressure occurs. The dengue was transmitted by several species of mosquito within the genus Aedes principally "A. aegypti" the virus has four different types: - Infection with one type usually gives lifelong immunity to that type but only short-term immunity to the others. The different type of infection increases the risk of several complication. There is no commercially availability of vaccine prevention which is used to reduce the habitat and the number of mosquitoes and limiting exposure to bites. The treatment of acute dengue is supportive using either oral or intravenous rehydration for mild or moderate disease and intravenous fluids and blood transfusion for more severe cases. The dengue fever has become increased dramatically since the 1960s with around fifty to hundred million people infected yearly. The descriptions of the condition date from 1779 and its viral cause and the transmission were elucidated in the early 20th century.The dengue has become a global problem since the Second World War and is endemic in more than 110 countries. The Apart from this eliminating the mosquitoes, work is ongoing on a vaccination as well as medication targeted directly at the virus.

II. SIGNS AND SYMPTOMS

People infected with dengue virus are approximately (80%) or only have mild symptoms such as an uncomplicated fever. Others have more severe illness (5%) and in a small proportion it is life threatening. The incubation period (time between exposure and onset of symptoms) ranges from 3 to 14 days but most often it is 4 to 7 days. Therefore travelers returning from endemic areas are unlikely to have dengue if fever or other symptoms start more than fourteen days after arriving at home. The children often experience with these symptoms which issimilar to those of the common cold and gastroenteritis (vomiting and diarrhea)and have a greater risk of severe complications though initial symptoms are generally mild but include high fever. The characteristic symptoms of dengue are sudden onset fever, headache (typically located behind the eyes), muscle, joint pains, and rash. The anothername of dengue is "break bone fever" which is comes from the associated muscle and joint pains. The infection is divided into three phases such as febrile, critical and recovery. The febrile phase involves the high fever which is often over 40°C (104 °F) and it is associated with generalized pain and a headache.This is usually occurringat last two to seven days. The vomiting may also occur. A rash occuring in 50 to 80% of those with symptoms in the first or second day of symptoms as flushed skin or later in the course of illness (days 4 to 7) as a measles-like rash. Some petechial (small red spotsthat do not disappear when the skin is pressed which are caused by broken capillaries) can appear at this point as may some mild bleeding from the mucous membranes of the mouth and nose. The fever is biphasic in natureand then returning for one or two days although there is wide variation in how often this pattern actually happens. In some people the disease proceeds to a critical phase around the time fever resolves and typically lasts one to two days. They may be significant fluid accumulation in the chest and abdominal cavity due to increased capillary permeability and leakage during this phase. This leads to depletion of fluid from the circulation and decreased blood supply to vital organs. During this phase, The organ become dysfunction and severe bleeding typically from the gastrointestinal tract may occur. Shock (dengue shock syndrome) and hemorrhage (dengue hemorrhagic fever) occur in less than 5% of all cases of dengue however those who have previously been infected with other serotypes of dengue virus ("secondary infection") are at an increased risk. The recovery phase occurs next with restoration of the leaked fluid into the bloodstream. This is usually occurring lasts two to three days. The improvement is used to often striking but they may be severe itching and a slow heart rate. Another rash may occur with either a macula popular or a vasculitic appearance which is followed by peeling of the skin. The fluid may occur at overload state if it

affects the brainaccording to this stage.It may cause a reduced level of consciousness or seizures. A feeling of fatigue may be occur at last for weeks in adults age.

III. Cause

A. Virology

Dengue fever virus (DENV) is an RNA virus of the family Flaviviridae genus Flavivirus. The other member of the same genus which include different type of virus. They may betransmitted by arthropods (mosquitoes or ticks) and are also referred as arboviruses (arthropod-borne viruses). The dengue virus genome (genetic material) contains about eleven thousand nucleotide bases which code for the three different types of protein molecules (C, prM and E) that form the virus particle and seven other types of protein molecules (NS1, NS2a, NS2b, NS3, NS4a, NS4b, NS5) that are only found in infected host cells and are required for replication of the virus. There are four type of strains of the virus which are called as serotypes and these are referred to as DENV-1, DENV-2, DENV-3 and DENV-

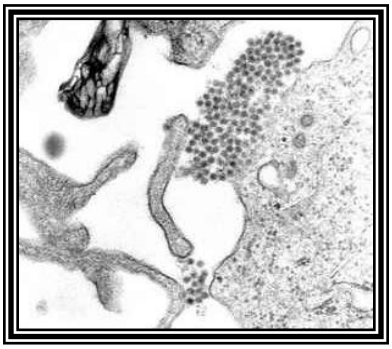


Figure 1.1 A TEM micrograph showing dengue virus virions

B. Transmission

The dengue virus was primarily transmitted by Aedes mosquitoes, particularly "A. aegypti". These mosquito are usually live in between the latitudes of 35° North and 35° South below an elevation of 1,000 metres (3,300 ft). They typically bite during the day particularly in the early morning and in the evening. Other Aedes species that transfer the disease such asA. albopictus,A. polynesiensis and A. scutellaris.The humans are the primary host of the virus but it is also circulates in nonhuman primates. An infection can be attainvia a single bite. A female mosquito takes a blood as a meal from a person which is infected with dengue fever the virus in the cells lining its gut. About 8 to 10 days later the virus spreads to other tissues including the mosquito's salivary glands and is subsequently released into its saliva. The virus seems to behaving no detrimental effect on the mosquito which was remains infected for life. The Aedesaegypti prefers to lay its eggs in artificial water containers to live in close proximity to humans and to feed off people rather than other vertebrates. The dengue can also be transmitted via infected blood products and through organ donation. In Singapore, dengue is endemic the risk is estimated to be between 1.6 and 6 per 10,000 transfusions. The vertical transmission (from mother to child) during pregnancy or at birth has been reported. The person-to-person mode of transmission have been reported but in unusual case. The genetic variation indengue viruse is region specific suggestive that establishment into new territories is relatively infrequent despite dengue emerging in new regions in recent decades.

Figure 1.2 the mosquito Aedes aegypti feeding on a human host

IV. Mechanism

When a mosquito carrying dengue virus bites a person the virus enters the skin together with the mosquito's saliva. It binds to and enter into the white blood cells and reproduces inside the cells while they move throughout the body. The white blood cells are used to produce a number of signaling proteins in which they are responsible for many of the symptoms such as the fever the flu-like symptoms and the severe pains. In severe infection, the virus increased inside the body frequently and many more human organs (such as the liver and the bone marrow) can be affected and fluid from the bloodstream leaks through the wall of small blood vessels into body cavities. The less blood circulates in the blood vessels and the blood pressure becomes so low that it cannot supply sufficient blood to vital organs. The dysfunction of the bone marrow leads to reduce the number of platelets in which they are necessary for effective blood clotting. This is used to increase the risk of bleeding the other major complication of dengue fever.

V. Diagnosis

The diagnosis of dengue is typically made clinically on the basis of reported symptoms and physical examination this applies especially in endemic areas. The disease can be difficult to differentiate from other viral infections. The probable diagnosis are based on the fever and two other of the following infection which is as follow:- Nausea and vomiting, rash, pain, low white blood cell, positive tourniquet test or any warning sign in someone who lives in an endemic area. The warning signs typically occur before the onset of severe dengue. The tourniquet test is particularly useful in settings where no laboratory investigations are readily available involves the application of a blood pressure cuff at between the diastolic and systolic pressure for five minutes followed by the counting of any petechial hemorrhages a higher number makes a diagnosis of dengue more likely. The diagnosis should be considered in anyone who develops a fever within two weeks of being in the tropics or

subtropics. It is difficult to distinguish dengue fever and chikungunya is a similar viral infection that shares many symptoms and occurs in similar parts of the world to dengue. The investigations are used to perform to exclude other conditions that cause similar symptoms such as malaria, viral, fever, typhoid, disease, measles and influenza. The earliest change detectable on laboratory investigations is a low white blood cell count which may then be followed by low platelets and metabolic acidosis. A moderately elevated level of amino transferees from the liver is commonly associated with low platelets and white blood cells. In severe disease, the plasma leakage results in the hem concentration (as indicated by a rising hematocrit) and hypoid buminemia. Pleural effusions or ascites can be detecte by physical examination when large but the demonstration of fluid on ultrasound may assist in the early identification of dengue collison syndrome. The use of ultrasound is limited by lack of availability in many settings. Dengue shock syndrome occurs if pulse pressure drops to less than or equal to 20 mm Hg while peripheral vascular collapse is evidenced. Dengue fever may be diagnosed by microbiological laboratory testing. This is done by virus isolation in cell cultures nucleic acid detection by PCR viral antigen detection or specific antibodies (serology). Virus isolation and nucleic acid detection are more accurate than antigen detection but these tests are not widely available due to their greater cost. All tests can be negative in the early stages of the disease. The PCR and viral antigen detection are more accurate in the first seven days. In 2012, The PCR test was introduced that can run on equipment used to diagnoseinfluenza this is likely to improve access to PCR-based diagnosis. These laboratory tests are only of diagnostic value during the acute phase of the illness with the exception of serology. The test for dengue virus-specific antibodies types IgG and IgM can be useful in confirming a diagnosis in the later stages of the infection. The IgG and IgM are produced after 5 to 7 days. The highest levels (titres) of IgM are detected following a primary infection but IgM is used to produce in secondary and tertiary infections. The IgM becomes undetectable 30 to 90 days after a primary infection but earlier following re-infections. The IgG remain detectable for over 60 years and in the absence of symptoms is a useful indicator of pastinfection. After a primary infection the IgG reaches peak levels in the blood after 14 to 21 days. In subsequent re-infections levels peak earlier and the titres are usually higher. The IgG and IgM are used to provide protective immunity to the infecting serotype of the virus. In the laboratory test, the IgG and IgM antibodies can cross-react with other flaviviruses such as yellow fever virus which can make the interpretation of the serology difficult. The detection of IgG alone is not considered diagnostic unless blood samples are collected fourteen days apart and a greater than fourfold increase in levels of specific IgG is detected. The detection of IgM was consider a diagnostic with symptoms in a person. The dengue is caused by flavivirus transmitted by bite of aedes mosquito. These are four sero types of virus. Dengue is of three types:-

- Dengue fever
- Dengue Hemorrhagic Fever
- Dengue Shock Syndrome

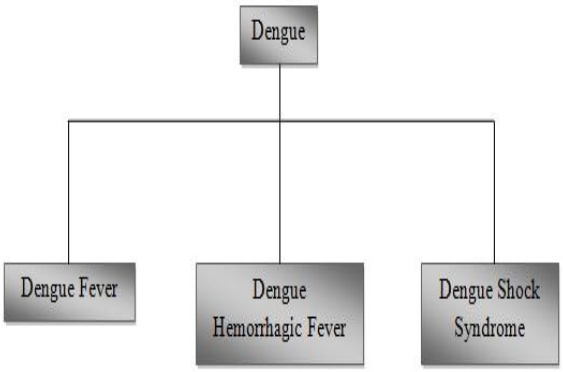


Figure 1.3Types of Dengue Fever

A. Dengue Fever

After incubation period of 4-5 days there is

- High fever , chills
- Break bone aching headache
- Sore Throat
- Prostration
- Malaise

Initially the skin appears flushed or blotched but 3 to 4 days after the onset of fever a maculopopolar rash which spares palms and soles appears in 50% of cases. As rash fades localized clusters of petechiae on extensor surface of limbs became apparent.

Investigation:-

- Leucopenia/TLC decrease
- SGOT/SGPT increases
- Platelets may or may not be decreased

B. Dengue Hemorrhagic Fever

Occurs more commonly in children in endemic area and is most likely to occur in secondary infections and in infections with serotype Z

- Fever
- Signs of hemorrhage such as ecchymosed, GIT bleed, epistaxis
- Restlessness, Epistaxis and abdominal pain

Investigation:-

- TLC decreased
- SGOT/SGPT increased
- Platelets decreased
- BT/CT abnormal
- X-Ray shows infiltrate effusion

C. Dengue Shock Syndrome

- Acute fever
- Hemorrhagic manifestation
- Severe abdominal pain
- Bleeding
- Consciousness level decreased
- Hypothermia

Investigation:-

- TLC decreased
- SGOT/SGPT increased

- Platelet Decreased
- Blood pressure falls
- Electrolyte imbalance

Diagnosis:-

- IgM and IgG ELISA after febrile phase.
- Virus may be detected during acute phase PCR or detection of specific viral protein NS1 by ELISA helpful during first few days of infection.

VI. Characteristics

Dengue fever is a severe, flu-like illness that affects infants, young children and adults but seldom causes death. The Dengue should be suspected when a high fever (40°C/ 104°F) is accompanied by two of the following symptoms: severe headache, pain behind the eyes, muscle and joint pains, nausea, vomiting, swollen glands or rash. The symptoms are usually occur last for 2–7 days, after an incubation period of 4–10 days after the bite from an infected mosquito. The severe dengue is a potentially deadly complication due to plasma leaking, fluid accumulation, respiratory distress, severe bleeding or organ impairment. The warning signs occur in between 3–7 days after the firstsymptoms in conjunction with a decrease in temperature (below 38°C/ 100°F) and include: severe abdominal pain, persistent vomiting, rapid breathing, bleeding gums, fatigue, restlessness, blood in vomit. The next 24–48 hours of the critical stage can be lethal; proper medical care is needed to avoid complications and risk of death.

VII. Prevention and Control

At present, the only method to control or prevent the transmission of dengue virus is to combat vector mosquitoes through:

- preventing mosquitoes from accessing egg-laying habitats by environmental management and modification;
- disposing of solid waste properly and removing artificial man-made habitats;
- covering, emptying and cleaning of domestic water storage containers on a weekly basis;
- applying appropriate insecticides to water storage outdoor containers;
- using of personal household protection such as window screens, long-sleeved clothes, insecticide treated materials, coils and vaporizers;
- improving community participation and mobilsation for sustained vector control;
- applying insecticides such as space spraying during outbreaks as one of the emergency vector control measures;
- Active monitoring and surveillance of a vector should be carried out to determine effectiveness of control interventions.

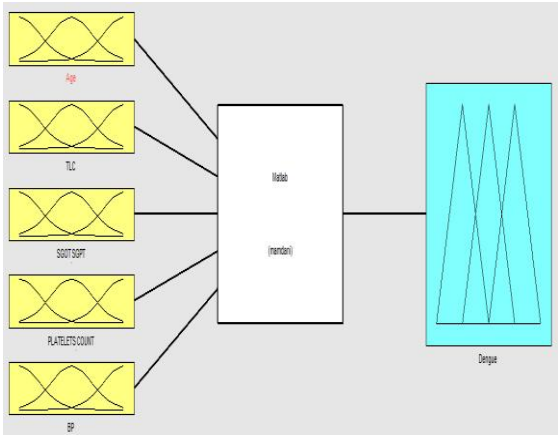
VIII. Implementation

The proposed Fuzzy based methodology is implemented in MATLAB 7.10. MATLAB (Matrix Laboratory) environment is one such facility which lends a high performance language for technical computing. Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping is used to provide a basis from which decisions can be made. Following figure gives the snap shot of MATLAB window while using FIS editor for 5 inputs and 1 output.

Figure 1.4 Fuzzy Inference System with 5 input&1 output.

Inputs are Age, TLC, SGOT/SGPT, PLATELETS COUNT and BP. The output is Dengue.

A) Membership Function Editor for AGE



Age:-

a) 0 – 16 Child
b) 15-45 Young
c) 44-90 Old

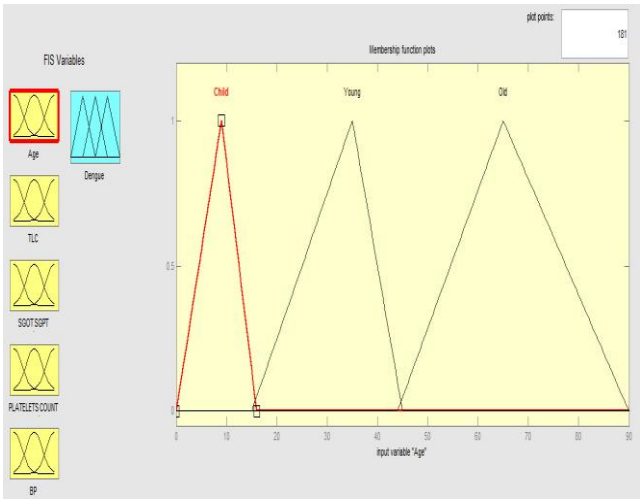


Figure1.5 Membership Function Editor for Age

Here Age is the 1st input membership function which is further divided in to three parts i.e. child, young and old. Child

age is range from 0-16. Young age is range from 15-45. Old age is range from 44-90.

B) Membership Function Editor for TLC

TLC:-a) 3500 - 4000 Low
b) 3900 – 11000 Medium
c) 10000 – 15000 High

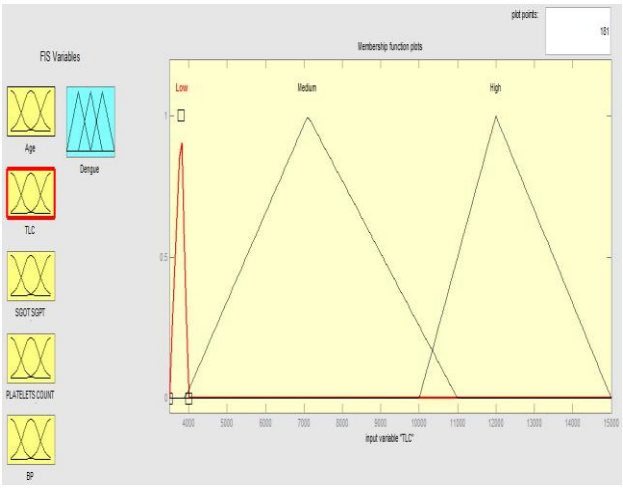


Figure 1.6 Membership Function Editors for TLC

Here TLC is the 2nd input membership function which is further divided in to three parts i.e. Low, Medium and High. Low ranges from 3500 - 4000. Medium ranges from 3900 - 1100. High ranges from 10000 - 15000.

C) Membership Function Editor for SGOT/SGPT

SGOT/SGPT: -
a) 0 - 40 Low
b) 35-50 Medium
c) 45-55 High

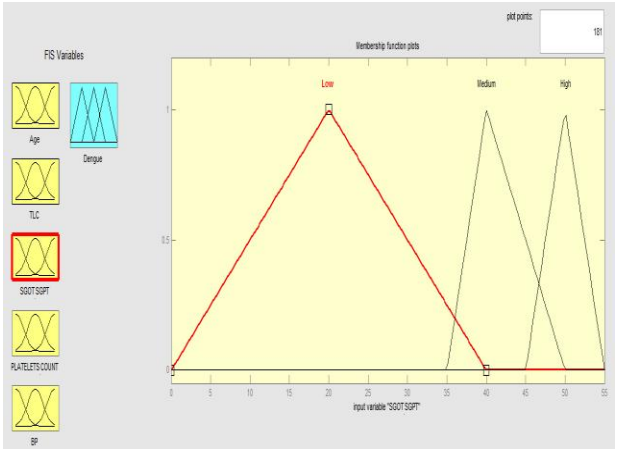


Figure 1.7 Membership function editor for SGOT/SGPT

Here SGOT/SGPT is the 3rd input membership function which is further divided in to three parts i.e. Low, Medium and High. Low ranges from 0 - 40. Medium ranges from 35 - 50. High ranges from 45 - 55.

D) Membership Function Editor For PLATELETS COUNT

Platelets Count :-a) 35000 – 150000 Low
b) 140000 – 450000 Medium
c) 440000 – 470000 High

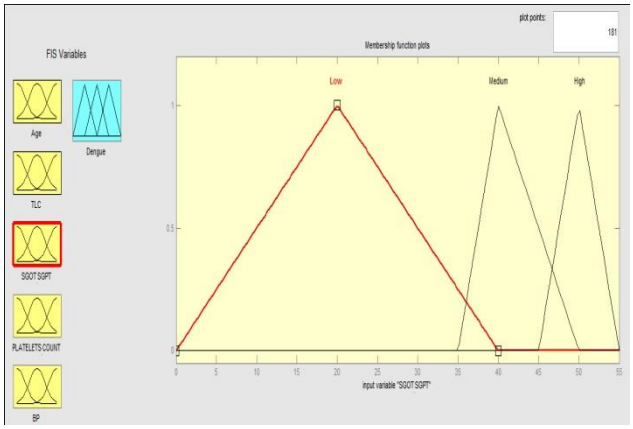


Figure 1.8 Membership Function Editors for PLATELETS COUNT

Here PLATELETS COUNT is the 4th input membership function which is further divided in to three parts i.e. Low, Medium and High. Low ranges from 35000 - 150000. Medium ranges from 140000 - 450000. High ranges from 440000 - 470000.

E) Membership Function Editor For BP

BP :- a) 100 / 60 90 - 110 Low
b) 120 / 80 100 – 120 Medium
c) 140 / 90 115 – 150 High

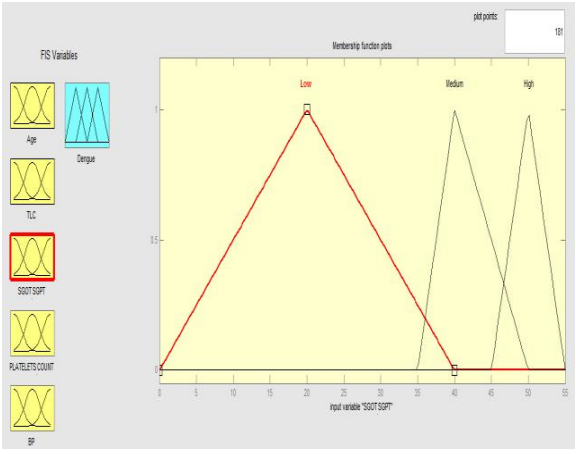


Figure 1.9 Membership Function Editors for BP

Here BP IS THE 5TH input membership function which is further divided into three parts i.e. Low, Medium and High. Low ranges from 90-110. Medium ranges from 100-120. High ranges from 115-150

F) Membership Function Editor For DENGUE

Dengue:-a) 0 - 3 No Dengue

b) 2.6 - 4 DF
c) 3.8 - 6 DHF
d) 5.8 - 10 DSS

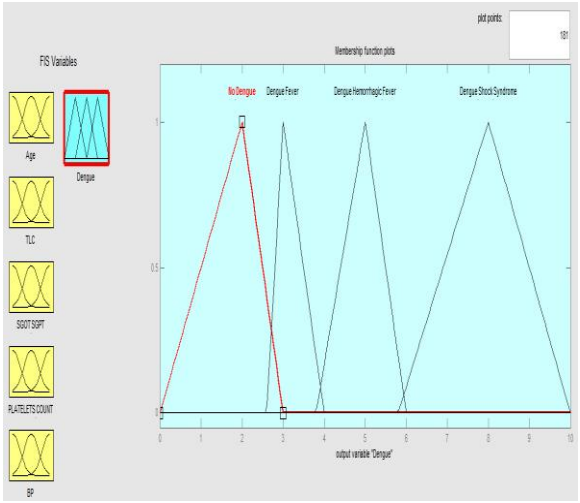


Figure 1.10 Membership Function Editors for DENGUE

Here Dengue is the output mebership function which is further divided into four parts i.e. No Dengue, DF, DHF and DSS. No Dengue ranges from 0-3. DF ranges from 2.6-4. DHF ranges from 3.8-6 and DSS ranges from 5.8 -10.

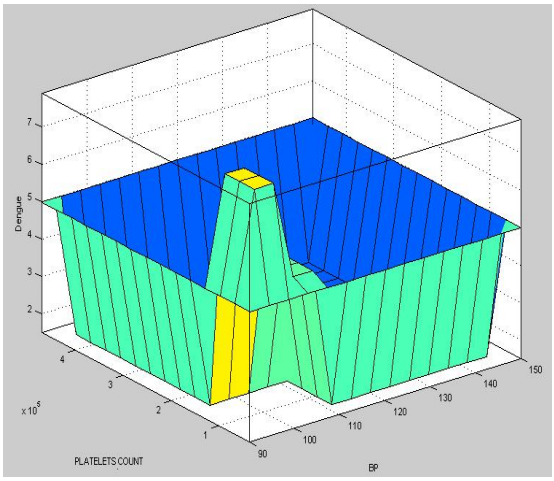
G) Rule Viewer

After selecting the membership functions, the rules are also generated using the Rule-Editor. Then the rules can be viewed using the Rule-Viewer. In Fuzzy Inference Systems, based on the knowledge provided by the Domain Experts (Doctors), decisions are made and outputs are generated. While collection of this type of knowledge generates a fuzzy knowledge base system, which is basically collection of some fuzzy IF-THEN rules. In this proposed system, 729 such type of fuzzy IF-THEN rules is generated by consulting various Domain Experts (Doctors).

Figure 1.11 Membership Function Editors for Rules viewer

H) Surface Viewer

There are total 729 rules that are generated using Fuzzy Inference System. After this, Surface-Viewer can be used. Using the Surface Viewer, a three-dimensional curve is seen that represents the mapping from two inputs and one output. If there are two inputs and one output, the entire mapping in one plot can be seen. When there is more than one input, there may be trouble in displaying the results. According to the Surface Viewer which is equipped with pop-up menus that provide a feature to select any two inputs and any one output for plotting. The Surface-Viewer is shown in Figure 1.12



Figuer 1.12 Membership Function Editor for Surface Viewer

In Surface-Viewer, TLC and Age are taken as input and the output is Dengue. In the similar way, a surface can be viewed for other pairs of the input. The other pairs of the inputs can be Age, TLC and SGOT/SGPT.

IX. Result Analysis

The output of my thesis is coming out to be more reliable and dependable as I have used the fuzzy approach to diagnose the dengue disease. Till date the best work done in this field was of "A New Intelligence-Based Approach for Computer-Aided Diagnosis of Dengue Fever" who had worked upon he probabilistic model to predict the occurrence or the non-occurrence of dengue for a patient based on the symptoms generated. Therefore my thesis implementation can be more useful and accurate as compared to the previous work.

X. Conclusion

The result of the implementation suggests that an almost 100% accurate in predicting the type of dengue fever. As per the actual data matched with the results generated by the training tool, it was found that 95+ % of the results generated by the tool were similar to the actual data of the patients. However it may not be the best result but it is sufficient to prove the working.

XI. Future Scope

The present can be extended for further diagnosis of disease other than dengueand the prediction would become almost correct for any types of fever.It can also be extended by using the

neural approach in it.A good level expert can be consulted for better improvement. The parameters undertaken can be strengthening if more detail about the disease may be found and embedded in the training module.

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