AN EFFECTIVE CHIKUNGUNIYA VIRUS DIAGNOSIS METHOD USING FUZZY SOFT EXPERT SYSTEM

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Abstract— The adept technique is mostly utilized in artificial intelligence in medical (AIM). They contain clinical data about a committed assignment and inclined to reason information with from contextual investigations to create clear outcomes. Chikungunya is an infection that brought about by an infection that spreads through mosquito chomps. The most common manifestations of chikungunya are fever and joint ache. In the proposed expert diagnose system using the fuzzy rule set for Chikungunya. The Expert System has six input variables. The input variables are PT-PCR, Serological test, joint pain, Headache, Muscle Pain and Body Temperature that detects output situation of a Chikungunya to be No, borderline, severe or deep-rooted. In order to validate the proposed algorithm MATLAB simulation is followed and outcomes achieved that express simultaneousness to the output values according to the Mamdani Model of the Fuzzy control System. The general precision of the Proposed Expert System is 94%.

Index Terms— Chikungunya virus, Fuzzy expert system, Fuzzy inference system, Fuzzy soft expert system, Chikungunya virus infection, DC-MFES, MFES

1 Introduction

Chikungunya is a disease that caused by a virus that spreads through mosquito bites. The most common symptoms of chikungunya are fever and joint ache. Computer-aided testing has a main part to identify infections or disease in medicinal. Decision taking system are using frequently in medicinal as a result of their precision and efficiency. Medical skilled are at ease to use in that kind of decision expert system.

Chikungunya is a contamination caused by a virus that spreads through mosquito bites. The most common symptoms of chikungunya are fever and joint ache. Other signs and symptoms may encompass headache, muscle pain, joint swelling, or rash. It cannot be handed from individual to man or woman. It has been visible in as many as sixty countries in Asia, Europe, Africa, and the Americas. There is no vaccine or medication to prevent Chikungunya. [1]

Chikungunya fever may also bring about a continual segment as well as the section of acute infection. Within the extreme phase, tiers have been identified. A viral level in the course of the primary five to seven days, in the course of which viremia happens, observed by using a convalescent level lasting about ten days, at some stage in which signs and symptoms improve and the virus cannot be detected within the blood. Typically, the ailment starts with a sudden high fever that lasts from a few days to per week, and sometimes up to ten days. The fever is commonly above thirty-nine degree and on occasion achieving forty degree and may be biphasic lasting numerous days, breaking, after which returning.

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Fuzzy logic is worthy for nonlinear and complex mathematical models. Fuzzy logic plays an important role in counter productivity of handling huge clinical data processing in a way to present it in an understandable way. The other important function of fuzzy logic is to convert the human language rules into mathematical values.

2 Literature review

Chikungunya is a disease that effect in humans characterized through fever, rash, and pain in muscle mass and joints. Chikungunya is a disease resulting from the arbovirus that stocks the identical vector with dengue virus. One specific problem in identifying Chikungunya contamination is its overlapping distribution with dengue viruses. The use of gadget gaining knowledge of techniques has taken an awesome role within the diagnosis of this disorder. Our focus is to take a look at clinical and bodily prognosis of chikungunya viral fever patients. Our mission objectives to integrate special sources of information and to discover patterns of analysis, for predicting the viral inflamed sufferers and their consequences related to Chikungunya virus.[3][4]

Chikungunya Virus disease is the main cause of mortality in the world including Egypt. The early detection of disease is a very important element for fitness of lives. Even enough work is required for early detection of diseases and still looking

challengeable. Reseatcher proposed a fuzzy soft expert system for the prediction of Chikungunya Virus disease based on fuzzy soft set theory but with low accuracy. [5]

Fuzzy logic help the system designer and as well as the computer machine. The ultimate results obtained from the fuzzy logic are much precise and authentic and represents such a system that works in the real world., Fuzzy logic controllers are integrally reliable because of its ability to capture heuristic expertly. Fuzzy logic controllers perform well in a controlled situation. [6]

3 Proposed Fuzzy Based Work

Our proposed Diagnosis of Chikungunya Virus Using Fuzzy Soft Expert System (DC - MFSES) is described in this area. At the first stage, we determined the factors which can impact upon diagnosis of Chikungunya Virus disease. If these factors were not relevant then we discarded. Other relevant factors were selected for the next step. These selected relevant factors were now converted into their fuzzy crisp values. These fuzzy crisp values were converted into fuzzy input sets by using fuzzification. After fuzzification, fuzzy rules were determined with the help of the medical experts then fuzzy rules were applied on fuzzy input sets in inference. Fuzzy output sets were generated as output by inference. Fuzzy output sets converted into the crisp output and obtained diagnosis of Chikungunya Virus disease using crisp values.

In proposed system six input variables were used to diagnosis Chikungunya Virus disease using fuzzy logic mathematically can be written as

$\mu_{PT\text{-}PCR \cap Serological \cap JP \cap Headache \cap MP \cap BT}$ (pt,sr, jp,h,mp,bt)

$=\min [\mu_{PT\text{-}PCR}(pt), \mu_{Serological}(sr), \mu_{JP}(jp), \mu_{Headache}(h), \mu_{MP}(mp), \mu_{BT}(bt)]$

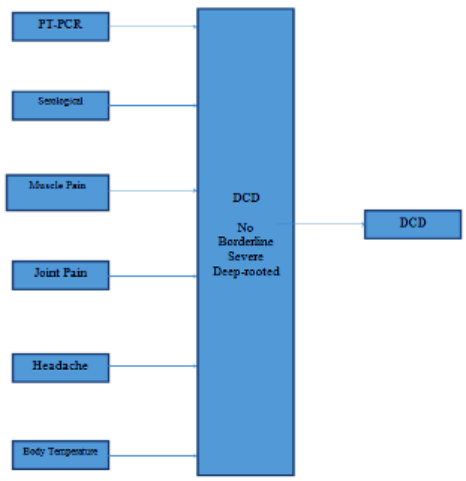

Fig. 1 Proposed Implementation Clinical Decision Support System in the Diagnosis Chikungunya Virus Disease Using Fuzzy Logic System Model

3.1 Input Variables

To diagnosis Chikungunya Virus disease, the statistical values of fuzzy input variables are used. Fuzzy Input Variables are statistical values used to diagnosis the chikungunya disease. Six input variables are used in the proposed study. Six input variables are used in the proposed study. The description of all input variables with their numerical values is shown in below table

3.2 Output Variables

TABLE 1
INPUT VARIABLE WITH RANGES

The above shown variables are used in fuzzy as input

Sr. No.	Input Variables	Range	Description
1	PT-PCR (IU/L)	0 – 53 45 – 60 >55	Normal Borderline Positive
2	Serological Test (g/dL)	< 5.0 4.5 – 6.5 >6.0	Normal Bacterial Virus
3	Joint Pain	0 – 7 4 – 45 >42	No Minimum Maximum
4	Headache	0 – 13 8 – 45 >40	No Minimum Maximum
5	Muscle Pain	0 – 0.2 0.1 – 3.5 >3.4	No Pain Minimum Maximum
6	Body Temprature (°C)	<35 30 – 45 40 – 55 >50	Hypothermia Normal Fever Hyperpyrexia

Diagnosis of Chikungunya Virus Disease using fuzzy logic has only one variable as output. It is listed below

3.2 Membership Functions

TABLE 2
OUTPUT VARIABLE

Sr. No.	Output Variables	Range	Description
1	Diagnosis Chikungunya Virus Disease **(DCD)**	0 – 0.3 0.25 – 0.55 0.50 – 0.85 0.75 – 1.0	No Border Line Severe Deep-rooted

The membership function of this system gives curve values between 0 and 1. The membership function provides a mathematical function that offers statistical values of input and outputvariables.

TABLE 3
MEMBERSHIP FUNCTIONS

Sr. No	Input Variables	Mathematical Representation of Membership Function (MF)
1	PT-PCR (IU/L) $\mu_{PT}(pt)$	$\mu_{PT,\ Normal}(pt) = \begin{cases} 1 & if\ pt \le 45 \\ \frac{53-pt}{5} & if\ 48 \le pt \le 53 \\ 0 & otherwise \end{cases}$ $\mu_{PT,\ borderline}(pt) = \begin{cases} \frac{pt-53}{5} & if\ 48 \le pt \le 53 \\ 1 & if\ 53 \le pt \le 55 \\ \frac{55-pt}{5} & if\ 55 \le pt \le 60 \\ 0 & otherwise \end{cases}$ $\mu_{PT,\ Positive}(pt) = \begin{cases} \frac{pt-55}{5} & if\ 55 \le pt \le 60 \\ 1 & if\ pt \ge 60 \\ 0 & otherwise \end{cases}$
		$\mu_{SR,\ normal}(sr) = \begin{cases} 1 & if\ sr \le 4.5 \\ \frac{4.5-sr}{0.5} & if\ 4.5 \le sr \le 5 \end{cases}$
3	Joint Pain $\mu_{JP}(jp)$	$\mu_{JP,\ NO}(jp) = \begin{cases} 1 & if\ jp \le 4 \\ \frac{7-jp}{3} & if\ 4 \le jp \le 7 \\ 0 & otherwise \end{cases}$ $\mu_{JP,\ MIN}(jp) = \begin{cases} \frac{jp-4}{3} & if\ 4 \le jp \le 7 \\ 1 & if\ 7 \le jp \le 42 \\ \frac{45-jp}{3} & if\ 42 \le jp \le 45 \\ 0 & otherwise \end{cases}$ $\mu_{JP,\ MAX}(jp) = \begin{cases} \frac{jp-42}{3} & if\ 42 < jp < 45 \\ 1 & if\ jp \ge 45 \\ 0 & otherwise \end{cases}$
4	Headache $\mu_{Headache}(h)$	$\mu_{Headache,\ No}(h) = \begin{cases} 1 & if\ h \le 13 \\ \frac{13-h}{5} & if\ 8 \le h \le 13 \\ 0 & otherwise \end{cases}$ $\mu_{Headache,\ MIN}(h) = \begin{cases} \frac{h-8}{5} & if\ 8 \le h \le 13 \\ 1 & if\ 13 \le h \le 40 \\ \frac{45-h}{5} & if\ 40 \le h \le 45 \\ 0 & otherwise \end{cases}$ $\mu_{Headache,\ MAX}(h) = \begin{cases} \frac{h-40}{5} & if\ 40 \le h \le 45 \\ 1 & if\ h \ge 45 \\ 0 & otherwise \end{cases}$

Sr. No	Input Variables	Mathematical Representation of Membership Function (MF)
5	Muscle Pain $\mu_{MP}(mp)$	$\mu_{MP,\ No\ Pain}(mp) = \begin{cases} 1 & if\ mp \le 1 \\ \frac{0.2-mp}{0.1} & if\ 0.1 \le mp \le 3.5 \\ 0 & otherwise \end{cases}$ $\mu_{MP,MIN}(mp) = \begin{cases} \frac{mp-0.1}{0.1} & if\ 0.1 \le mp \le 0.2 \\ 1 & if\ 0.2 \le mp \le 3.4 \\ \frac{3.5-mp}{0.1} & if\ 3.4 \le mp \le 3.5 \\ 0 & otherwise \end{cases}$ $\mu_{MP,\ MAX}(mp) = \begin{cases} \frac{mp-3.4}{0.1} & if\ 3.4 \le mp \le 3.5 \\ 1 & if\ mp \ge 3.5 \\ 0 & otherwise \end{cases}$
6	Body Temperature $\mu_{BT}(bt)$	$\mu_{BT,\ hypothermia}(bt) = \begin{cases} 1 & if\ bt \le 30 \\ \frac{30-bt}{5} & if\ 30 \le bt \le 35 \\ 0 & otherwise \end{cases}$ $\mu_{BT,\ Normal}(bt) = \begin{cases} \frac{bt-30}{5} & if\ 30 < bt < 35 \\ 1 & if\ 35 \le bt \le 40 \\ \frac{40-bt}{5} & if\ 40 \le bt \le 45 \\ 0 & otherwise \end{cases}$ $\mu_{BT,\ Fever}(bt) = \begin{cases} \frac{bt-40}{5} & if\ 40 \le bt \le 45 \\ 1 & if\ 45 \le bt \le 50 \\ \frac{50-bt}{5} & if\ 50 \le bt \le 55 \\ 0 & otherwise \end{cases}$ $\mu_{BT,\ Hyperpyrexia}(bt) = \begin{cases} \frac{bt-50}{5} & if\ 50 \le bt \le 55 \\ 1 & if\ bt > 55 \end{cases}$

Sr. No	Output Variables	Mathematical Representation of Membership Function (MF)
1	Diagnosis Chikungunya Virus Disease $\mu_{DCD}(dcd)$	$\mu_{DCD,\ No}(dcd) = \begin{cases} 1 & if\ dcd \le 0.20 \\ \frac{0.25-dcd}{0.05} & if\ 0.20 \le dcd \le 0.25 \\ 0 & otherwise \end{cases}$ $\mu_{DCD,\ Borderline}(dcd) = \begin{cases} \frac{dcd-0.20}{0.05} & if\ 0.20 < dcd < 0.25 \\ 1 & if\ 0.25 \le dcd \le 0.40 \\ \frac{0.50-dcd}{0.10} & if\ 0.40 < dcd < 0.50 \\ 0 & otherwise \end{cases}$ $\mu_{DCD,\ Severe}(dcd) = \begin{cases} \frac{dcd-0.40}{0.10} & if\ 0.40 < dcd < 0.50 \\ 1 & if\ 0.50 \le dcd \le 0.60 \\ \frac{0.75-dcd}{0.15} & if\ 0.60 < dcd < 0.75 \\ 0 & otherwise \end{cases}$ $\mu_{DCD,\ Deep\text{-}rooted}(dcd) = \begin{cases} \frac{dcd-0.60}{0.15} & if\ 0.60 < dcd < 0.75 \\ 1 & if\ dcd \ge 0.75 \\ 0 & otherwise \end{cases}$

Following are the membership functions of output variable to diagnose chikungunya virus infection

3.3 Rule Based Lookup Table

The lookup table for proposed Implementation Clinical Support System in the Chikungunya Virus Disease using Fuzzy Logic contains 6 inputs and 1 output which makes 972 all possible rules. This lookup table is developed with the help of medical and lab experts.

TABLE 4
LOOKUP TABLE

Rules	PT-PCR	Serological	Joint Pain	Headache	Muscle Pain	Body Temperature	Results
1	Normal	Normal	No	No	No	Normal	No
2	Normal	Normal	Min	No	No	Normal	No
3	Normal	Normal	No	Min	No	Normal	No
4	Normal	Normal	No	No	Min	Normal	No
5	Normal	Normal	No	Max	No	Normal	No
6	Normal	Normal	Maximum	Minimum	No	Hypothermia	Borderline
7	Normal	Normal	Maximum	Minimum	No	Normal	Borderline
8	Normal	Normal	Maximum	Minimum	No	Fever	Borderline
9	Normal	Normal	Maximum	Minimum	Minimum	Hypothermia	Severe
10	Normal	Normal	Maximum	Minimum	Minimum	Normal	Severe
11	Normal	Normal	Maximum	Minimum	Minimum	Fever	Severe
12	Normal	Normal	Maximum	Minimum	Minimum	Hyperpyrexia	Severe
13	Border	Normal	No	No	No	Hypothermia	Borderline
14	Border	Normal	No	No	No	Normal	Borderline
15	Positive	Virus	Maximum	Minimum	Maximum	Hypothermia	Deep-rooted
16	Positive	Virus	Maximum	Minimum	Maximum	Normal	Deep-rooted
17	Positive	Virus	Maximum	Minimum	Maximum	Fever	Deep-rooted
18	Positive	Virus	Maximum	Minimum	Maximum	Hyperpyrexia	Deep-rooted
19	Positive	Virus	Maximum	Maximum	No	Hypothermia	Deep-rooted
20	Positive	Virus	Maximum	Maximum	No	Normal	Deep-rooted

Fuzzy IF-THEN rules are the conditional statements which are applied on the membership functions. These IF-THEN rules are part of the fuzzy rule base. Rules surface, rules viewer etc. are depending upon fuzzy rule base. Fuzzy rule base of our expert system has 972 rules. Rules are denoted by

Rw^n, where $1 \leq n \leq 972$

Rw^1= IF PT-PCR is Normal AND Serological is Normal AND Joint Pain is No AND Headache is No AND Muscle Pain is No AND Body Temperature is Normal THEN Diagnosis Chikungunya Virus Disease is No.

Rw^2= **IF** PT-PCR is Normal AND Serological is Normal AND Joint Pain is Min AND Headache is No AND Muscle Pain is No AND Body Temperature is Normal **THEN** Diagnosis Chikungunya Virus Disease is No.

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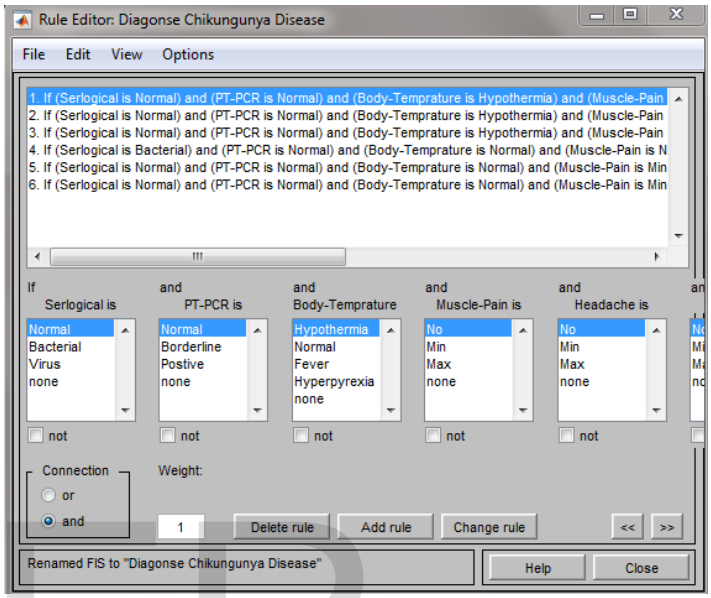
Rw^{972}= **IF** PT-PCR is Positive AND Serological is Virus AND Joint Pain is Max AND Headache is Max AND Muscle Pain is Max AND Body Temperature is Hyperpyrexia **THEN** Diagnosis Chikungunya Virus Disease is Deep-rooted.

3.4 Rule Based Inference Engine

Fuzzy inference is the way towards mapping from an offered contribution to a yield utilizing fuzzy logic. Its main component of fuzzy inference is membership functions, fuzzy logic operators and if-then rules. A single fuzzy relation is created by all rules in the fuzzy rule base. It lies under the inner product on the input which can be seen as an only fuzzy IF-THEN rule.



All rules in the fuzzy rule base are collective into a single fuzzy relation that lies under inner product on the input universe of discourse, which is then viewed as an only fuzzy IF-THEN rule. A suitable operator for combining the rules is union.

Let R_{DCD}^n be a fuzzy relation that represents fuzzy IF-THEN rule of the proposed expert system which is,

R_{DCD}^n= $PT\text{-}PCR^n$ x $Serological^n$ x $Headache^n$ x MP^n x Joint $Pain^n$ x BT^n---------→DCD^n

3.5 De-fuzzification of processed Data

Defuzzifier is one of the most essential components of an expert system. It is the process of mapping the fuzzy sent to the crisp output. Centre of gravity defuzzifier, the center of average defuzzifier and maximum defuzzifier are three types of defuzzifier. The best defuzzifier amongst them is the centre of gravity defuzzifier. In our proposed clinical support system in the diagnosis of Chikungunya Virus disease, the center of gravity defuzzifier is used.

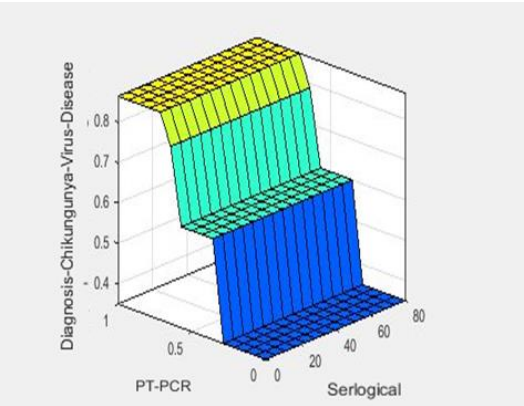


Fig. 3 Showing relationship between PT-PCR and Seriological medical test to diagnose chikungunya virus infection

This figure shows a defuzzification which depends on PT-PCR and Serological. It reflects the output value of Diagnosis of Chikungunya Virus Disease. This figure shows for all PT-PCR, Serological is Normal, then there is no change of virus disease

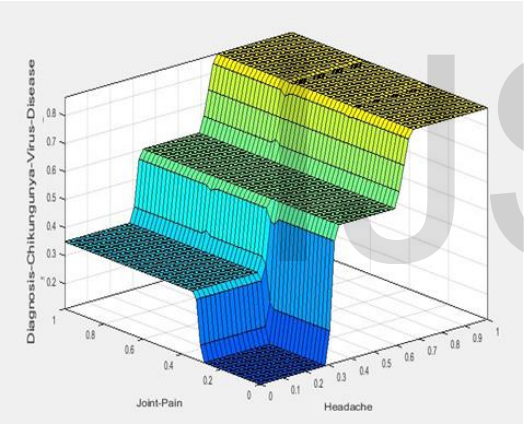


Fig. 4 Showing relationship between Joint Pain and Headache physical input variable to diagnose chikungunya virus infection

This graph shows the output of diagnosis of Chikungunya Virus disease on depends on Joint Pain and Headache. It shows that Joint Paint is No and Headache is No values 0 – 0.33, then no chance of diagnosis Chikungunya Virus disease.

4 SIMULATION AND CONCLUSION

For simulation results, MATLAB R2017a tool is used. MATLAB is an efficient and accurate tool for programming, data analysis, visualization, and computing. For simulation results, five inputs and one output variable are used. In this research, the proposed implementation clinical support system in the diagnosis of Chikungunya disease using fuzzy logic not only diagnosis Chikungunya disease, but it also shows the different levels of Chikungunya disease.

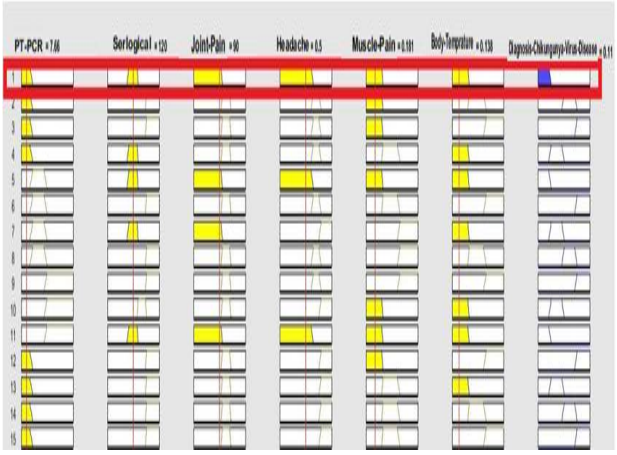


Fig.5 Lookup Diagram of PT-PCR Negative for Proposed Diagnosis Chikungunya Disease Expert System

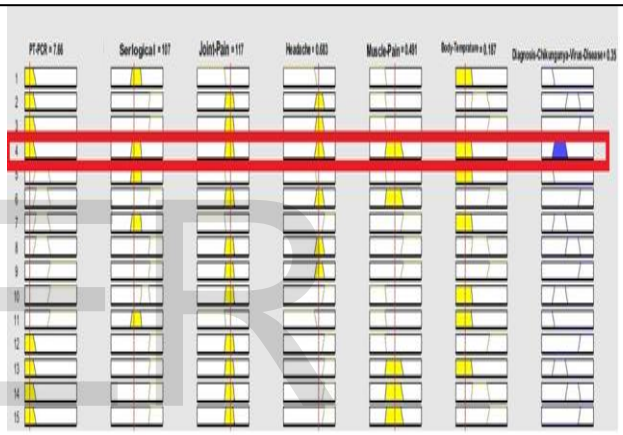


Fig. 6 Lookup Diagram of Chikungunya Borderline for Proposed Diagnosis Chikungunya Disease Expert System

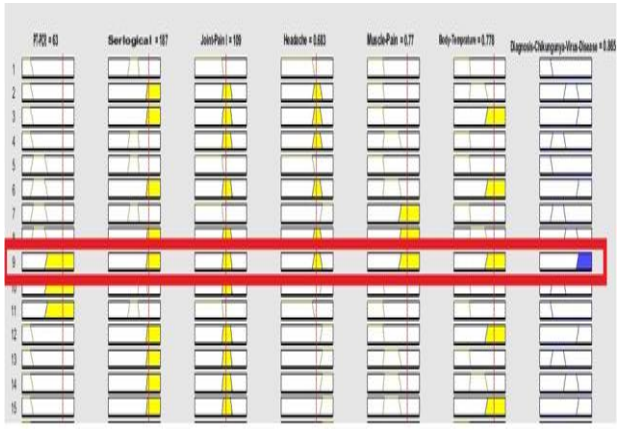


Fig. 7 Lookup Diagram of Acute Chikungunya for Proposed Diagnosis Chikungunya Disease Expert System

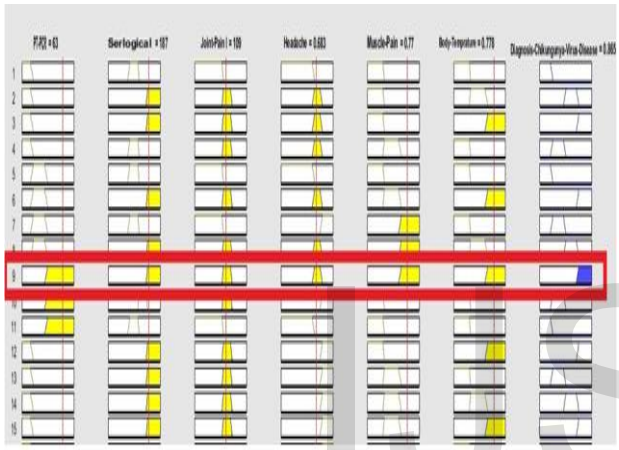


Fig.8 Lookup Diagram of Deep-rooted Virus for Proposed Diagnosis Chikungunya Disease Expert System

The above shown pictures are simulated results of chikungunya virus taken from different patient lab reports and processed by expert doctor's rule through mamdani fuzzy expert system

The overall precision of the proposed Implementation Clinical Support System in the Diagnosis Chikungunya Disease using Fuzzy Logic is 94% shown in Fig. 4.9. The results of the decision support system when shared with the specialist, they found them a very much supportive in taking a decision about the level/degree of the Chikungunya disease. They found it a well-established mechanism which has shown a variety of strength in processing and presenting a combination of different variables so comprehensively that the early decision regarding the Chikungunya ailments can be made without any doubt.

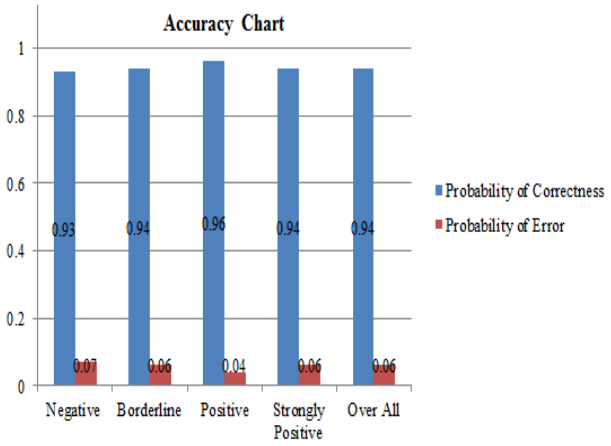


Fig. 9 Accuracy Chart of Diagnosis Chikungunya virus using fuzzy soft expert system

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