CHAPTER 4
PROPOSED FUZZY EXPERT SYSTEM FOR DIAGNOSIS OF DENGUE

The dengue fever, also known as life-threatening disease, is caused by dengue virus. It is also referred to break bone fever which is one amongst the major deadly diseases around the world transmitted by blood-feeding-mosquito i.e. Aedesaegypti. According to data provided by National Vector Born Disease Control Program, Delhi and Maharashtra have the highest mortality rate in India whereas as per WHO, 40% population of world is affected by this disease. A lot of viral infection exists in the world, but dengue fever virus infection causes more illness and death. It comes severe for the people who have weak immune system. An early diagnosis of this disease can help for quick recovery in patient. It can be broadly classified into three categories which are Dengue Fever (DF), Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS). In all the three types, DSS are the most dangerous type of dengue fever and the recovery is even more difficult as compare to DF & DHF.

The biggest problem with dengue fever is, it is identify only when patient is on very critically stage and unfortunately there is no special tool developed for identifying dengue within 1-2 days continues fever. There lots of type fever causes death but dengue fever has highest numbers of death.

The proposed system will solve the problem by selecting a subset of useful feature from a set of features. One of the main objectives of the present study is to develop a control system to enhance the efficiency to diagnose dengue disease related to human. The developed fuzzy expert system can explore crisp and linguistic data with loosely defined boundary conditions for decision-making. It is implemented in MATLAB for the mentioned contexts for the comparison and validation with the dataobtained from SAIMS Hospital, Indore. The proposed fuzzy controller makes the machine to take intelligent decisions as similar to that of humans.
4.1 Database used for Diagnosis of Dengue

In this study, different levels of dengue fever are categorized using fuzzy logic toolbox and by the help of hospital dataset. This proposed method used the database provided by SAIMS hospital, Indore. All the patient data belong to year 2017. In the proposed system, 6 input attributes are used which are Age, WBC Count, AST/ALT, Platelet Count, BP and Fever. The output field referred to diagnosis of dengue in the patient and the result shows that the patient has dengue or not. It consists of integer value from 0-3 (no dengue), 3-5 (DF), 5-8 (DHF) and 8-10 (DSS). Here, increasing value shows increasing dengue risk. The proposed Fuzzy Logic Controller is designed using MATLAB fuzzy logic tool for dengue diagnosis which consists of 6 Linguistic Inputs and produces 1 output.

4.2 Proposed Fuzzy Expert System for Dengue Diagnosis

4.2.1 Input and Output Parameters

Input Parameters

- A1: Age
- A2: WBC Count
- A3: AST/ALT
- A4: Platelet Count
- A5: BP
- A6: Fever

Output Parameters

- R: Result

4.2.2 Proposed Algorithm

Algorithm 1 Algorithm for Diagnosis of Dengue Disease

Require: Crisp Value for Input.

INPUT

Input the fuzzy set for Age, WBC Count, Platelet Count, AST/ALT, BP and Fever
**OUTPUT**

Output the fuzzy set for *Result*

**METHOD**

Begin

For each input do

**Step 1:** Input the crisp values for *Age, WBC Count, Platelet Count, AST/ALT, BP* and *Fever*

**Step 2:** Set the triangular membership function for the fuzzy number with equation.

\[ f(x; a, b, c) = \begin{cases} 
0, & x \leq a \\
\frac{x - a}{b - a}, & a \leq x \leq b \\
\frac{c - x}{c - b}, & b \leq x \leq c \\
0, & c \leq x 
\end{cases} \]

OR

\[ f(x; a, b, c) = \max \left( \min \left( \frac{x - a}{b - a}, \frac{c - x}{c - b} \right) \right) \]

**Step 3:** Built the fuzzy numbers for *Age, WBC Count, Platelet Count, AST/ALT, BP* and *Fever*

**Step 3.1:** Built the fuzzy number for *Result* for the output set.

**Step 4:** Fuzzy inference are executed by Mamdani’s method.

**Step 4.1:** Input the rule as \{Rule 1, 2…k\}

**Step 4.2:** Matching degree of rule with OR fuzzy disjunction are calculated for fuzzy input set \(A1_1, A1_2, A1_3, A2_1, A2_2, A2_3,A3_1, A3_2, A3_3, A4_1, A4_2, A4_3, A5_1, A5_2, A5_3, A6_1, A6_2, A6_3, R1, R2, R3, R4 \).

**Step 5:** Defuzzify into the crisp values by \(R=\)

\[ R \leftarrow \frac{\sum_{i=1}^{n} Z_i \cdot \mu(Z_i)}{\sum_{i=1}^{n} \mu(Z_i)} \]

Where \(Z_i\) means the weight for \(\mu(Z_i)\) and \(\mu(Z_i)\) means the number of fuzzy numbers of the output fuzzy variable DC.

**Step 6:** Present the knowledge in the form of human nature language.

End.

End of the Algorithm
### 4.2.3 Parameters of Proposed Membership Functions

Following are the member functions with their ranges of variable.

#### A) Age

<table>
<thead>
<tr>
<th>Input Filed</th>
<th>Ranges</th>
<th>Fuzzy Variables</th>
<th>Fuzzy Set Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0 – 14</td>
<td>A11</td>
<td>Child</td>
</tr>
<tr>
<td></td>
<td>14 – 44</td>
<td>A12</td>
<td>Young</td>
</tr>
<tr>
<td></td>
<td>44 – 100</td>
<td>A13</td>
<td>Old</td>
</tr>
</tbody>
</table>

#### B) WBC Count

<table>
<thead>
<tr>
<th>Input Filed</th>
<th>Ranges</th>
<th>Fuzzy Variables</th>
<th>Fuzzy Set Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC_Count</td>
<td>3 - 4</td>
<td>A21</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>4 - 11</td>
<td>A22</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>11 - 16</td>
<td>A23</td>
<td>High</td>
</tr>
</tbody>
</table>

#### C) AST/ALT

<table>
<thead>
<tr>
<th>Input Filed</th>
<th>Ranges</th>
<th>Fuzzy Variables</th>
<th>Fuzzy Set Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST/ALT</td>
<td>1 - 7</td>
<td>A31</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>7 - 55</td>
<td>A32</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>55 - 65</td>
<td>A33</td>
<td>High</td>
</tr>
</tbody>
</table>

#### D) Platelet Counts

<table>
<thead>
<tr>
<th>Input Filed</th>
<th>Ranges</th>
<th>Fuzzy Variables</th>
<th>Fuzzy Set Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PlateletCount</td>
<td>5 - 15</td>
<td>A41</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>15 – 40</td>
<td>A42</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>40 - 50</td>
<td>A43</td>
<td>High</td>
</tr>
</tbody>
</table>

#### E) Blood Pressure

<table>
<thead>
<tr>
<th>Input Filed</th>
<th>Ranges</th>
<th>Fuzzy Variables</th>
<th>Fuzzy Set Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP</td>
<td>60 - 90</td>
<td>A51</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>90- 120</td>
<td>A52</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>120 - 180</td>
<td>A53</td>
<td>High</td>
</tr>
</tbody>
</table>

#### F) Fever
Input Filed | Ranges | Fuzzy Variables | Fuzzy Set Value
--- | --- | --- | ---
Fever | 94 - 99 | A61 | Normal
| 99- 102 | A62 | High
| 102 - 108 | A63 | Very High

G) Result: After creating membership function of all input variable, we need to use membership function for output which is called result. Following are the ranges of Result.

Output Filed | Ranges | Fuzzy Variables | Fuzzy Set Value
--- | --- | --- | ---
Result | 0 – 3 | R1 | No Dengue
| 3 - 5 | R2 | DF
| 5 – 8 | R3 | DHF
| 8 – 10 | R4 | DSS

Table 4.1: Parameters of Proposed Membership Functions

<table>
<thead>
<tr>
<th>Fuzzy Variables</th>
<th>Representation of Fuzzy Variables</th>
<th>Fuzzy Numbers</th>
<th>Representation of Fuzzy Numbers</th>
<th>Fuzzy Triangular Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age A1</td>
<td></td>
<td>Child A1</td>
<td>A11</td>
<td>[0 7 14]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Young A1</td>
<td>A12</td>
<td>[14 30 44]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Old A1</td>
<td>A13</td>
<td>[44 70 100 100]</td>
</tr>
<tr>
<td>WBC Count A2</td>
<td></td>
<td>Low A2</td>
<td>A21</td>
<td>[3 3.5 4]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal A2</td>
<td>A22</td>
<td>[4 7 11]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High A2</td>
<td>A23</td>
<td>[11 13 16]</td>
</tr>
<tr>
<td>AST / ALT A3</td>
<td></td>
<td>Low A3</td>
<td>A31</td>
<td>[1 3 7]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Normal A3</td>
<td>A32</td>
<td>[7 30 55]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High A3</td>
<td>A33</td>
<td>[55 60 65]</td>
</tr>
<tr>
<td>Platelet Count A4</td>
<td></td>
<td>Low A4</td>
<td>A41</td>
<td>[5 10 15]</td>
</tr>
</tbody>
</table>
4.3 Summary of this Chapter

This chapter reveals the proposed methodology for the diagnosis of dengue disease. In this study, different levels of dengue fever are categorized using fuzzy logic toolbox and by the help of hospital dataset. This proposed method used the database provided by SAIMS hospital, Indore. All the patient data belong to year 2017. In the proposed system, 6 input attributes are used which are Age, WBC Count, AST/ALT, Platelet Count, BP and Fever. The output field referred to diagnosis of dengue in the patient and the result shows that the patient has dengue or not. It consists of integer value from 0-3 (no dengue), 3-5 (DF), 5-8 (DHF) and 8-10 (DSS). Here, increasing value shows increasing dengue risk.