Detection of Anemia using Fuzzy Logic

Sonu Malu  
Mewar University  
Chittorgarh, Rajasthan  
India

B. L. Pal  
Mewar University  
Chittorgarh, Rajasthan  
India

Shiv Kumar  
Mewar University  
Chittorgarh, Rajasthan  
India

Abstract: Medical Science is considered as a field of uncertainty, vagueness and complexity. Fuzzy logic plays an important role to deal with these uncertainty, vagueness and complexity. Detection of diseases in medical is a very difficult task. To improve accuracy rate engineers helping in detection of the diseases by developing the Expert System using Fuzzy Logic. Fuzzy logic consists of many valued logic. It has varying values in the range of 0 and 1 instead of fix values. In this study, we developed a Fuzzy Expert system to detect Anemia on the basis of Symptoms as well as clinical test.

Keywords: Anemia, Fuzzy Logic, Fuzzy Expert System, CBC Test

1. INTRODUCTION
The blood that circulates throughout the body performs a number of critical functions. It delivers oxygen, removes carbon dioxide CO$_2$, and carries life sustaining nutrition’s. By acting as the vehicle for long-distance messengers such as hormones, blood helps the various parts of the body communicate with each other. This is carried out by blood cells through working in partnership with the liquid part of the blood (plasma). Anemia is a condition where number of healthy RBC in the blood is lower than normal. It is due to low RBC’s, destruction of RBC’s or loses of too many RBC’s. If your blood does not have enough RBC’s, your body doesn’t get enough oxygen it needs. As a result you may feel tired and other symptoms. But sometimes it is very difficult to detect anemia on the basis of symptoms only. In the domain of Anemia there is no such boundary between what is healthy and what is diseased. Having so many factors to detect anemia makes doctor’s work difficult. So, Experts require an accurate tool that considering these risk factors and give some certain result for uncertain terms.

2. LITERATURE REVIEW
When the studies in the literature related with this classification application are examined, it can be seen that a great variety of methods were used. Among these, [5] Fuzzy System have been used to diagnose the different types of anemia on the basis of symptoms such as Irritability, tachycardia, Memory weakness, Bleeding and Chronic fatigue. Another, [6] diagnose Liver disease using fuzzy logic on the basis of CBC Test which uses 4 parameters such as WBC, HGB, HCT and PLT. [7] Ali.Adeli, Mehdi. Neshat proposed a system to diagnose the heart disease using fuzzy logic. [8] Nidhi Mishra and Dr. P Jha also develop a fuzzy expert system to diagnose the Sickle Cell Anemia.

3. OBJECTIVES
The Objectives are:
1. Detect Anemia using Fuzzy Logic.
2. Classify Anemia on the basis of Accuracy.

4. DESIGN MODEL
4.1 Introduction
Three steps are used to monitor general health and Anemia. But we are focusing only on the Tests and Procedures. Three steps are as follows:
1. Medical and Family Histories
2. Physical Exam
3. Tests and Procedures.

4.2 Design of Fuzzy Logic System
Design model divided into five steps:
1. Problem Specification & define linguistic variables.
2. Define Fuzzy sets.
3. Define Fuzzy Rule.

5. METHOD
we describe the designing of the fuzzy expert system.

5.1 Design a Fuzzy Logic System
5.1.1 Problem Specification & Define linguistic variables: There are 3 input variables and 1 output variables.

Linguistic Variables:
• For Input Variables
Table 1 Linguistic Variables for Input Variables

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Input Variables</th>
<th>Linguistic Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hemoglobin</td>
<td>HGB</td>
</tr>
<tr>
<td>2</td>
<td>Mean Corpuscular Volume</td>
<td>MCV</td>
</tr>
<tr>
<td>3</td>
<td>Mean Corpuscular Hemoglobin</td>
<td>MCHC</td>
</tr>
</tbody>
</table>

• For Output Variables

Table 2 Linguistic Variables for Output Variables

<table>
<thead>
<tr>
<th>S.No</th>
<th>Output Variables</th>
<th>Linguistic Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anemia</td>
<td>Types of Anemia</td>
</tr>
</tbody>
</table>

5.1.2 Define Fuzzy Sets:

• Input Variables & Value Ranges:

Table 3 Values for all Input Linguistic Variables[6]

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Linguistic Variable</th>
<th>Ranges</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HGB</td>
<td>5 - 13.8 grams/deciliter</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.9 to 16.3 grams/deciliter</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.4 – 18 grams/deciliter</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>MCV</td>
<td>60 – 79.9 fl</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>79.9 to 100 fl</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100.1 - 120 fl</td>
<td>High</td>
</tr>
</tbody>
</table>

• Output Variables & Value Ranges:

Table 4 Values for all Output Linguistic Variables[6].

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Linguistic Variable</th>
<th>Ranges</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HypoChromic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCV is 60 – 79.9 fl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NormoChrormic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCHC is 28 – 31.9 g/dl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HypoChromic</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NormoChrormic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCV is 60 – 79.9 fl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NormoChrormic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCHC is 32 - 36g/dl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HypoChromic</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HyperChromic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCV is 60 – 79.9 fl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HyperChromic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCHC is 36.1 - 40 g/dl</td>
<td>MicroCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HyperChromic</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>NormoCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HypoChromic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCV is 80 - 100 fl</td>
<td>NormoCytic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HypoChromic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCHC is</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.1.3 Define Fuzzy Rules:
As we have total 3 input variables so total number of possible non conflicting fuzzy inference rules are $3^2 = 9$ rules.

First 3 rules are for Symptoms based testing:
1. If (irritation is Effective) && (Heart_Rate is High) && (Disorder is cancer) then HGB is low.
2. If (irritation is Effective) && (Heart_Rate is High) && (Blood_Loss is Stomach / intestine bleeding) then HGB is low.
3. If (irritation is Effective) && (Heart_Rate is High) && (Disorder is cancer) && (Blood_Loss is Stomach / intestine bleeding) && (Weak_Memory is Effective) then HGB is low[5].

Further, 3 rules are for the classification of anemia on the basis of MCV only:
4. If (HGB is Low) && (MCV is Low) then MicroCytic is High.
5. If (HGB is Low) && (MCV is Medium) then NormoCytic is high.
6. If (HGB is Low) && (MCV is High) then MacroCytic is high.

At last 9 rules are for the further classification of anemia on the basis of all three parameters such as HGB, MCV, & MCHC.
7. If (HGB is Low) && (MCV is Low) && (MCHC is Low) then MicroCytic is HypoChromic.
8. If (HGB is Low) && (MCV is Low) && (MCHC is Medium) then NormoCytic is HypoChromic.
9. If (HGB is Low) && (MCV is Low) && (MCHC is High) then MacroCytic is HypoChromic.
10. If (HGB is Low) && (MCV is Medium) && (MCHC is Low) then NormoCytic is HypoChromic.
11. If (HGB is Low) && (MCV is Medium) && (MCHC is Medium) then NormoCytic is NormoChromic.
12. If (HGB is Low) && (MCV is Medium) && (MCHC is High) then MacroCytic is HypoChromic.
13. If (HGB is Low) && (MCV is High) && (MCHC is Low) then MacroCytic is HyperChromic.
14. If (HGB is Low) && (MCV is High) && (MCHC is Medium) then MacroCytic is NormoChromic.
15. If (HGB is Low) && (MCV is High) && (MCHC is High) then MacroCytic is HyperChromic[6].

Table 5 Illustration of applied rules with Respect to MF[6]

<table>
<thead>
<tr>
<th>Rule No.</th>
<th>Linguistic Variable 1</th>
<th>Linguistic Variable 2</th>
<th>Linguistic Variable 3</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>MCV is 80 - 100 fl</td>
<td>MCHC is 32 - 36 g/dl</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>MCV is 80 - 100 fl</td>
<td>MCHC is 36.1 – 40 g/dl</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>MCV is 100.1 – 120 fl</td>
<td>MCHC is 28 – 31.9 g/dl</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>MCV is 100.1 – 120 fl</td>
<td>MCHC is 32 - 36 g/dl</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>HGB is 5 – 13.8 g/dl</td>
<td>MCV is 100.1 – 120 fl</td>
<td>MCHC is 36.1 – 40 g/dl</td>
<td></td>
</tr>
</tbody>
</table>
5.1.4 Build Fuzzy Expert System:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Input Variable</th>
<th>Values</th>
<th>Ranges Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HGB</td>
<td>10.9 g/dl</td>
<td>5 &lt; 10.9 &lt; 18 g/dl</td>
</tr>
<tr>
<td>2</td>
<td>MCV</td>
<td>31.00 fl</td>
<td>60 &lt; 31.00 &lt; 79.9 fl</td>
</tr>
<tr>
<td>3</td>
<td>MCHC</td>
<td>30 g/dl</td>
<td>28 &lt; 30 &lt; 31.9 g/dl</td>
</tr>
</tbody>
</table>

6. RESULTS AND DISCUSSION

7. CONCLUSION

In this paper, fuzzy logic is applied to classify and detect Anemia on the basis of CBC Test. The success of fuzzy detection in its application to a real clinical case shows that fuzzy detection is an improvement of probabilistic logic. Results have been shown from this fuzzy expert system with
past time expert system are more efficient and less expensive. It
detect anemia on the basis of both Symptoms and CBC Test.
From the viewpoint of an end-user, the results of this work can
facilitate laboratory work by reducing the time and cost.

8. FUTURE WORK
The future work will focus on developing a machine learning
approach to classify different types of anemic RBCs in
microscopic images. The method described in this dissertation
can be extends in future very efficiently. We can classify
anemia on the basis of RBC structure using digital image
processing. We can also provide some CBC reports and load
that report as it is in our system and detect anemia in future. We
can also detect anemia and classify it only on the the basis of
CBC Test without using symptoms test.

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