Fuzzy Logic Based Thyroid Diagnosis system

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ABSTRACT

This study aims at designing and implementing thyroid disease diagnosis system. Thyroid is one of the most important glands in our body which maintains metabolism. Nowadays most of the people suffer from thyroid related problems. This study uses T3, T4 and Thyroid Stimulating Hormone as inputs to the fuzzy expert system. Fuzzy expert systems performs better than the traditional methods of thyroid diagnosis.

Keywords: Thyroid, hyperthyroidism, hypothyroidism, Thyroid Stimulating Hormone.

1. INTRODUCTION

Thyroid is a small butrefly shaped gland found in front of neck wrapped aroung the windpipe. Thyroid gland is one of the most important glands in our body because it controls our body metabolism. The two hormones produced by thyroid gland are namely Thyroxine (T4) and Triiodothyronine (T3). These two hormones together is known as thyroid hormone. When the level of thyroid hormone is small pituitary gland produces a hormone called Thyroid Stimulating Hormone (TSH) which then stimulates thyroid gland to produce more hormones. When the level of thyroid hormone is high pituitary gland produces less TSH which in turn releases less thyroid hormone. Thyroid gland and pituitary gland work together to main the metabolism of our body. When the levels of thyroid stimulating hormone is not balanced properly by the thyroid gland, two types of thyroid related disease occur: Hyperthyroidism and hypothyroidism. Hyperthyroidism also known as overactive thyroid occurs when thyroid gland produces excess amount of thyroid hormones and hypothyroidism also known as underactive thyroid occurs when thyroid gland produces a lesser amount of thyroid hormones.

Symptoms of hyperthyroidism vary from hypothyroidism. Symptoms of hypothyroidism are feeling cold when other people do not, Constipation, Muscle weakness, Weight gain, even though you are not eating more food, joint or muscle pain, feeling very tired, pale, dry skin, dry, thinning hair, slow heart rate, less sweating than usual, a puffy face and more than usual menstrual bleeding. Symptoms of hyperthyroidism are weight loss, eating
more than usual, rapid heartbeat, feeling nervous, irritable, hot, muscle weakness, trembling in your hands and fingers, increased sweating, lighter menstrual periods than normal.

Women are more likely to suffer from thyroid related problems than men. The main issues faced by women due to thyroid are menstrual problems, problems to get pregnant and problems during pregnancy. Usually thyroid disease is diagnosed by performing blood test for TSH, T3, T4, TSH receptor antibody (TSI) and Antithyroid antibody. In this paper T3, T4 and TSH are given as input to the fuzzy expert system for the diagnosis of thyroid disease.

2. RELATED WORK


3. PROPOSED SYSTEM

The proposed system uses mamdani fuzzy inference system for the diagnosis of thyroid disease. The mamdani fuzzy inference system uses input variables and output variables for generating rules. Fuzzification and defuzzification are done to convert the real crisp values into fuzzy values and vice versa. The proposed thyroid diagnosis system takes three inputs namely T3, T4 and Thyroid stimulating hormone (TSH) and one output as in fig1. This output variable contains three values not probable, uncertain and probable. Membership functions for the input variables are given in table1.

![Fig1. Inputs and output of mamdani inference engine](image-url)
Table 1. Membership Functions of Input variables: T-3,T-4 & TSH.

<table>
<thead>
<tr>
<th>Membership function</th>
<th>T-3 Range</th>
<th>T-4 Range</th>
<th>TSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0-1</td>
<td>60-65</td>
<td>0.25-0.9</td>
</tr>
<tr>
<td>Medium</td>
<td>1-1.7</td>
<td>63-80</td>
<td>0.8-3</td>
</tr>
<tr>
<td>High</td>
<td>1.6-2.5</td>
<td>78-120</td>
<td>2.8-5</td>
</tr>
</tbody>
</table>

3.1 Input Variables

3.1.1 Triiodothyronine (T3)

Triiodothyronine (T3) is a hormone produced by thyroid gland. Increased or decreased level of this hormone causes thyroid disease. T3 input variable has three fuzzy sets namely low, medium and high. Membership function of these fuzzy sets is triangular. Membership functions for the fuzzy sets are given in fig 2 and fuzzification of T3 is done by the below function.

\[
\begin{align*}
\mu_{low} &= \begin{cases} 
   x - 0.5, & 0 \leq x \leq 0.5 \\
   0.5 & x = 0.5 \\
   1 - x, & 0.5 \leq x \leq 1 \\
   1 - 0.5, & 1 \leq x \leq 2 \end{cases} \\
\mu_{medium} &= \begin{cases} 
   x - 1, & 1 \leq x \leq 1.5 \\
   1 - 1.5 & x = 1.5 \\
   1.7 - x, & 1.5 \leq x \leq 1.7 \end{cases} \\
\mu_{high} &= \begin{cases} 
   x - 1.6, & 1.6 < x \leq 2 \\
   2 - 1.6, & x = 2 \\
   2.5 - x, & 2 \leq x \leq 2.5 \\
   2.5 - 2 & 2.5 \leq x \leq 2.5 \end{cases}
\end{align*}
\]

Fig 2. Membership functions of input variable –T-3 range

3.1.2 Thyroxine (T4)

Thyroxine (T4) is a hormone produced by thyroid gland. Increased or decreased level of this hormone causes thyroid disease. T4 input variable has three fuzzy sets namely low,
medium and high. Membership function of these fuzzy sets is triangular. Membership functions for the fuzzy sets are given in fig 3 and fuzzification of T4 is done by the below function.

\[
\mu_{\text{low}} = \begin{cases} 
\frac{x - 60}{63 - 60}, & 60 \leq x \leq 63 \\
1, & x = 63 \\
\frac{65 - x}{65 - 63}, & 63 \leq x \leq 65 
\end{cases} \quad \mu_{\text{medium}} = \begin{cases} 
\frac{x - 63}{70 - 63}, & 63 \leq x \leq 70 \\
1, & x = 70 \\
\frac{80 - x}{80 - 70}, & 70 \leq x \leq 80 
\end{cases}
\]

\[
\mu_{\text{high}} = \begin{cases} 
\frac{x - 78}{100 - 78}, & 78 \leq x \leq 100 \\
1, & x = 100 \\
\frac{120 - x}{120 - 100}, & 100 \leq x \leq 120 
\end{cases}
\]

3.1.3 Thyroid Stimulating Harmone (TSH)

Thyroid Stimulating Harmone (TSH) is a harmone produced by pituitary gland. When the level of thyroid harmone is small pituitary gland produces a harmone called Thyroid Stimulating Harmone (TSH) which then stimulates thyroid gland to produce more harmones. When the level of thyroid harmone is high pituitary gland produces less TSH which in turn releases less thyroid harmone. TSH input variable has three fuzzy sets namely low, medium and high. Membership function of these fuzzy sets is triangular. Membership functions for the fuzzy sets are given in fig 4.
3.2 Output Variable

3.2.1 Thyroid Occurrence

The output variable thyroid occurrence has three values namely not probable, uncertain and probable. Membership function of these fuzzy sets is triangular. Membership functions for the fuzzy sets are given in fig 5 and fuzzification of thyroid occurrence is done by the below function.

\[
\mu_{\text{low}} = \begin{cases} 
  0 & 0 \leq x \leq 0.2 \\
  \frac{x - 0}{0.2 - 0}, & 0.2 \leq x \leq 0.4 \\
  1, & x = 0.4 \\
  \frac{0.4 - x}{0.4 - 0.2}, & x > 0.4 
\end{cases}
\]

\[
\mu_{\text{medium}} = \begin{cases} 
  0 & 0.1 \leq x \leq 0.1 \\
  \frac{x - 0.1}{0.5 - 0.1}, & 0.1 \leq x \leq 0.5 \\
  1, & x = 0.5 \\
  \frac{0.7 - x}{0.7 - 0.5}, & 0.5 \leq x \leq 0.7 
\end{cases}
\]

\[
\mu_{\text{high}} = \begin{cases} 
  0 & 0.6 \leq x \leq 0.6 \\
  \frac{x - 0.6}{0.8 - 0.6}, & 0.6 \leq x \leq 0.8 \\
  1, & x = 0.8 \\
  \frac{1 - x}{1 - 0.8}, & 0.8 \leq x \leq 1 
\end{cases}
\]

4. RESULTS AND DISCUSSION

Rules are generated based in the three input variables T3, T4 and TSH and one output variable as
1. If (T-3-Range is low) and (T-4-Range is low) and (TSH is low) then (Thyroid_occurrence is Not_probable)
2. If (T-3-Range is low) and (T-4-Range is low) and (TSH is medium) then (Thyroid_occurrence is uncertain)
3. If (T-3-Range is low) and (T-4-Range is medium) and (TSH is medium) then (Thyroid_occurrence is uncertain)
4. If (T-3-Range is medium) and (T-4-Range is low) and (TSH is low) then (Thyroid_occurrence is Not_probable)
5. If (T-3-Range is medium) and (T-4-Range is medium) and (TSH is medium) then (Thyroid_occurrence is uncertain)

The rules are generated using rule editor as in fig 6 and fig 7 shows the rule viewer and surface viewer in fig 8. And operator is used here for generating rules.
5. CONCLUSION

Thyroid diagnosis system designed and implemented using fuzzy logic performs in an efficient manner for the diagnosis of disease given T3, T4 and TSH as inputs.

REFERENCES