Fuzzy-Based Approach to Predict Accident Risk on Road Network

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Abstract- Road Accidents are currently ranked as the eighth largest cause of death in the world. This research aims to evaluate the accident risk on the road. This research is working hard to raise awareness of the dangers to drivers, pedestrians, and to provide leadership, expertise about the road. The development of the risk rating system, which ranked risk of the road, according to their road condition, driver-based risk, and pedestrian crossing the road. This process initially focused on the National Highway Authority of India (NHAI). This system aims to know about accident zone of the given network.

Keywords- accident risk, fuzzy logic, risk factor classification,

Unfortunately road maintenance, driver’s education, vehicle upkeep and traffic regulations have not grown accordingly. A high accident level increases the dependency burden of the country. Working parents are killed or injured in traffic accidents leaving children who relied solely on these deceased persons for sustenance. Causalities from traffic accidents impose a heavy burden on the specialized health care facilities. In addition, the cost of repair and replacement of damaged vehicles demand resources that otherwise could be devoted to other high priority human development sectors such as education, food production and health. Thus, many countries pay dearly for the cost of the modernized transport system Šimurina, M. & Krstić B., (2003) and increased mobility in the absence of compensatory mechanisms for ensuring safety. The total cost of road accidents have been estimated to be more than one percent of GNP in developing countries (Down 1997).

This research aim:

• To monitor the accident on the road based on the risk
• To know about the accident zone
• Choose the low risk of the road
• Based on the risk to modify the road layout, to locate the accidental board, and speed break
• To find the overall risk of the zone

II. FUZZY LOGIC

Fuzzy logic is a mathematical logic that attempts to solve problems by assigning values to an imprecise spectrum of data in order to arrive at the most accurate conclusion possible. Fuzzy logic is designed to solve problems in the same way that humans do: by considering all available information and making the best possible decision from the given input. Fuzzy knowledge is often applied by advanced trading models or systems that are designed to react to changing markets. The goal of this type of system is to analyze the risk of the road in real time and to present the trader with the best available opportunity.
Thus Fuzzy Logic is a many to valued logic: it deals with reasoning that is approximate rather than fixed and exact.

Compared to traditional binary sets, where variables may take on true or false values, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false Novak et al (1999), Anderson (1993). Furthermore, when linguistic variables are used, these degrees may be managed by specific functions. Irrationality can be described in terms of what is known as fuzzective. In 1973, Professor Zadeh (1965) proposed the concept of linguistic or “fuzzy” variables. The variables can be linguistic objects or words rather than numbers. The sensor input can be a noun e.g. ‘temperature,’ ‘displacement,’ ‘velocity,’ ‘flow,’ or ‘pressure.’

![Fig 2 Fuzzy Logic Temperatures](image)

In the “Fig 2.1 the meanings of expressions cold, warm and hot are represented by functions mapping a temperature scale. A point on that scale has three truth ‘values’ – one for each of the three functions. The vertical line in the figure represents a particular temperature that the three arrows (truth values) gauge. Since the red arrow points to zero, this temperature may be interpreted as ‘not hot.’ The orange arrow (pointing at 0.2) may describe it as ‘slightly warm’ and the blue arrow (pointing at 0.8) ‘fairly cold.’

III. RISK FACTOR CLASSIFICATION

Quantification of risk factor of road accidents gathered through knowledge acquisition processes becomes inevitable because only then the fuzzy knowledge base could be constructed. The quantification of risk factors involves a combination of factors relating to various components of the road network. The risk factors (Adams 1995) do vary for each type of road. In order to arrive at the risk factor weights, knowledge acquisition process is to be undertaken. The principal knowledge acquisition processes for this endeavour are the following.

- Literature knowledge
- Domain expert knowledge engineering analysis

Knowledge acquisition is developed as a tool in establishing comparative evaluation of significance and it assesses priority weights for different accident risk categories of road network.


The consolidated risk factors obtained through knowledge acquisition processes of literature survey and domain experts’ knowledge engineering process are utilized in the subsequent procedure.

The risk factors are
- Road factor (B1)
- Driver-based factor (B2)
- Pedestrian crossing (B3)

Algorithm

**Input:** Graph G with road risk factors

**Output:** Accident risk value of the road

1. Get the collection of Triangular Fuzzy Number(TFN) risk factor
2. Call triplet(l,m,u) membership function
   
   \[
   U(x) = \begin{cases} 
   \frac{(x - l)}{(m - l)} & l \leq x \leq m \\
   \frac{(u - x)}{(u - m)} & m \leq x \leq u \\
   0 & \text{otherwise} \end{cases}
   \]
3. Calculate the TFN fuzzy number using Fuzzy Arithmetical operations
4. Use defuzzification Graded mean integration method
   
   \[
   p(A) = \frac{1}{6}(a1 + 4a2 + a3)
   \]
5. Accident risk value of the road

**Step 1:** Table 1 represents these risk values. The literature analysis and domain expert and knowledge engineering analysis used to classify the risk factors.
Step 2: The triplet \((l, m, u)\) membership function calls the linguistic variables LR, MR, AR, SR, VR. The orbit of the linguistic variable input and output shown in “Fig 3” and “Fig 4”.

- \(LR = (0, 0.075, 0.15)\)
- \(R = (.10, 0.275, 0.45)\)
- \(AR = (.40, 0.55, 0.70)\)
- \(SR = (.65, .75, .85)\)
- \(VR = (.80, .90, 1)\)

Table 1

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Details</th>
<th>Linguistic variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>Road factor ((B_1))</td>
<td>{LR, MR, AR, SR, VR}</td>
</tr>
<tr>
<td></td>
<td>Driver-based Factor ((B_2))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pedestrian Crossing ((B_3))</td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>Accident risk value</td>
<td>{MIRO, ARO, HRO}</td>
</tr>
</tbody>
</table>

Fig. 3 Range of input linguistic variable

Fig. 4 Range of output linguistic variable

Step 3: The Fuzzy arithmetic operations used to combine the all risk factors of the road. The canonical Chou, C., (2003). The TFN fuzzy arithmetic formula shown in the Table 3.2

Table 2

<table>
<thead>
<tr>
<th>Fuzzy Arithmetic Operation</th>
<th>Operators</th>
<th>Formula</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summation</td>
<td>A+B</td>
<td>((l_1+l_2, m_1+m_2, u_1+u_2))</td>
<td></td>
</tr>
<tr>
<td>Subtraction</td>
<td>A(\backslash)B</td>
<td>((l_1\backslash l_2, m_1\backslash m_2, u_1\backslash u_2))</td>
<td></td>
</tr>
<tr>
<td>Multiplication</td>
<td>A(\times)B</td>
<td>((l_1\backslash l_2, m_1\times m_2, u_1\times u_2))</td>
<td></td>
</tr>
<tr>
<td>Division</td>
<td>A(\div)B</td>
<td>((l_1\div l_2, m_1\div m_2, u_1\div u_2))</td>
<td></td>
</tr>
</tbody>
</table>

Step 4: Defuzzify the results using graded mean integration method.

\[ p(A) = \frac{1}{6}(a1 + 4a2 + a3) \]

IV. EXPERIMENTAL EVALUATION

This research considers the road network 11 cities with 17 edges shown in “Fig. 5”. This algorithm developed in C#.net framework and conducted on Intel (R) Core (TM) i3to220 CPU @ 3.30 GHz. The system ran Microsoft windows.
In road network the edge between two cities have the risk factor of Road factor, Driver-based factor, and Pedestrian factor. By considering the computing complexities, only the five inputs are Low risk, Medium risk, Average risk, Strong Risk, Very strong risk defined for each input. The output risk factor of Medium risk output, average risk output, High risk output it shows the result in the Table 3.

Table 3

<table>
<thead>
<tr>
<th>Edge</th>
<th>$B_1$</th>
<th>$B_2$</th>
<th>$B_3$</th>
<th>Accident Risk Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0to1</td>
<td>LR</td>
<td>MR</td>
<td>SR</td>
<td>1.1</td>
</tr>
<tr>
<td>0to2</td>
<td>VR</td>
<td>SR</td>
<td>VR</td>
<td>2.55</td>
</tr>
<tr>
<td>0to3</td>
<td>LR</td>
<td>LR</td>
<td>LR</td>
<td>0.225</td>
</tr>
<tr>
<td>1to4</td>
<td>VR</td>
<td>VR</td>
<td>SR</td>
<td>2.55</td>
</tr>
<tr>
<td>2to4</td>
<td>AR</td>
<td>AR</td>
<td>MR</td>
<td>1.375</td>
</tr>
<tr>
<td>2to5</td>
<td>VR</td>
<td>SR</td>
<td>LR</td>
<td>1.725</td>
</tr>
<tr>
<td>3to5</td>
<td>AR</td>
<td>MR</td>
<td>MR</td>
<td>1.1</td>
</tr>
<tr>
<td>3to9</td>
<td>LR</td>
<td>LR</td>
<td>LR</td>
<td>0.225</td>
</tr>
<tr>
<td>4to7</td>
<td>AR</td>
<td>AR</td>
<td>MR</td>
<td>1.375</td>
</tr>
<tr>
<td>4to6</td>
<td>SR</td>
<td>SR</td>
<td>LR</td>
<td>1.575</td>
</tr>
<tr>
<td>5to6</td>
<td>VR</td>
<td>VRE</td>
<td>LR</td>
<td>0.975</td>
</tr>
<tr>
<td>5to9</td>
<td>MR</td>
<td>MR</td>
<td>AR</td>
<td>1.1</td>
</tr>
<tr>
<td>6to8</td>
<td>LR</td>
<td>LR</td>
<td>VR</td>
<td>1.05</td>
</tr>
<tr>
<td>7to10</td>
<td>AR</td>
<td>AR</td>
<td>LR</td>
<td>0.7</td>
</tr>
<tr>
<td>8to10</td>
<td>MR</td>
<td>MR</td>
<td>AR</td>
<td>0.9</td>
</tr>
<tr>
<td>8to11</td>
<td>VR</td>
<td>VR</td>
<td>SR</td>
<td>1.725</td>
</tr>
<tr>
<td>9to11</td>
<td>LR</td>
<td>LR</td>
<td>AR</td>
<td>0.7</td>
</tr>
</tbody>
</table>

It represents these risk values. The exercise is carried out in Matlab version 7.1. The various risk factors between two edges are tabulated and the risk weight between two edges is obtained.

Fig. 6 Accident risk value

“Fig.6” represents the graphical representation of Accident risk value between the cities. In 0to3, 3to9 road have the Medium risk output. 0to2, 1to4 road have the High risk output. Other road risk has the Medium risk output.

V. CONCLUSION

This research method is suitable for the investigation of road accident causation. This risk analysis proves to be a powerful tool for to know about the risk of the road. As a prerequisite for applying well established epidemiological methods for risk factor assessment based on road-based, driver-based and pedestrian-based factor, a new conceptual framework for accident involvement risk studies has been developed in this report. This research analyses are relevant in order for improvements in road condition, locate the accidental intimation board and speed break. A research analyses can tell us what to do to reduce the chance of being injured or even killed in an accident.

REFERENCES


