CHAPTER 4

RISK FACTOR CLASSIFICATION

4.1 INTRODUCTION

In the previous chapter, an essential and fundamental treatment of fuzzy logic algorithm is attempted since it is the pedestal on which the entire investigation of the road traffic decision support system is embarked upon in the thesis. The simplification of the routing management system involves the incorporation, scrutiny, breakdown of details and categorization to evolve a reliable and consistent system. Fuzzy logic is the technique that facilitates the measurement of imprecise and dynamic factors for arriving at a reasonable judgment. Before the attempt is made to apply the fuzzy logic in determining a realistic and viable route in traffic, it is crucial to list the real-time factors involved. This chapter aims at the identification and classification of risk factors in road traffic analysis.

4.2 DEFINITION OF RISK

The Merriam-Webster dictionary (1994) defines ‘risk’ as the ‘possibility of loss or injury’ or ‘someone or something that creates or suggests a hazard.’ Road routing management predicament has been there since several centuries. The second half or to be precise, the last quarter of the twentieth century, witnessed a sea change in the unparalleled development in automotive technology, road construction, traffic management and road safety. For instance, the growing numbers of vehicles, ignorance of safety
norms and reckless driving have been part of the causes for the enormous number of accidents on roads. The World Health Organization described traffic accidents as the “epidemic of civilized societies”(‘Security’ 2006). Only recently computer based algorithms are investigated to support the road traffic management. The decisions in relation to traffic management in identifying the shortest path are based on human experience and judgment. Although statistics with reference to traffic accidents, driving violations and traffic volume, laws and policies could be collected relatively efficiently, resolutions have to be arrived at by the human beings alone based on the gathered information. The information, in most cases, may exist in an ambiguous, hazy and nebulous manner. Thus, it is essential to note that the factors involved in formulating traffic routing policies or decisions are copious.

An important aspect of real time path planning problems is the dynamic nature of the environment, in which the risk values associated with different locations change with time. For instance, personnel traversing a path might foresee a segment of the path becoming more risky due to the occurrence of a new event, for instance, an explosion which increases the risk values associated with some intermediate nodes of the path obtained after path traversal has been initiated from the source.

The relatively inconsistent and incompatible set of information gathered may pose annoyance and confusion to the analysts as the process involves the analysis and absorption of a substantial measure of assorted information. It should be remembered that human brain is capable of evaluating only a very tiny array of information described by Keshavet al(2005).
4.3 QUANTIFICATION OF RISK

Quantification of risk factor of road network 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 routing patterns. The risk factors do vary for each type of route. In order to arrive at the risk factor weights, knowledge acquisition process is to be undertaken. The principal knowledge acquirement 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 risk categories of road network.

The literature analysis is embarked upon to identify the risk factors associated with road pavement. The literature survey pertains to road environmental infrastructure and also human factors (Pedan 2004). The categorization of these factors is done by segregating the frequent factors from non-frequent factors. The domain expert knowledge engineering analysis is taken up to identify the risk factor of road environment condition. Here again, the search of details from each expert is concerned with risk factors relevant to either of the two sectors – frequent and non frequent factors. In addition to this, each expert is implored to make a comparative outlook of the present conditions drawing knowledge from their experience and expertise. Thus compilation of most of the associated risk factors of the road network is the mainstay of the significance of knowledge acquisition process exercise.
4.4 MAJOR MODULES OF RISK FACTORS

Sourced on the literature survey and the domain experts’ knowledge, the procedure for finding the road risk factors and their classification into two distinct and key divisions is adopted to simplify the routine of collection of information and organizing the domain model in an enhanced manner. Each major domain has a group of concepts and these concepts are related to one another by sharing the same semantic context. All the chief modules of risk factors are also related to one another in the composition of the entire domain i.e. identification of the risk factors in the road network. The dominant modules of risk factors identified are the following.

- Non frequently changeable
- Frequently changeable

The substance of the non frequently changeable factors remains invariable i.e. static for the entire duration of the optimal route selection. The matter of the frequently changeable factors remains vibrant i.e. dynamic all through the process of optimal route selection. The identified risk factors that fall under each module are mapped with the domain knowledge. These factors combine to represent road related environment, pavement, maintenance of road and traffic. The mapping of risk factors and their significance is done to have an improved comprehension of the concepts more closely related to each risk factor.

4.5 RISK FACTOR OF ROAD NETWORK AS A VARIABLE

A risk factor of road network remains a variable mostly associated with an increase in risk. On the odd occasion, the determinant is also used, being a variable associated with either increased or decreased risk. It
expresses an aspect of the road condition or a behavior that is associated with the progress or evolution of optimal route. Quite a lot of factors may have an effect on the risk of selecting an optimal route. In a different perspective, it be said that the preference of a safe route depends upon the permutation and combination of various factors in the system which include the roads inclusive of its condition and maintenance, environment and weather. The additional factors that may contribute directly may be traffic and hazards of different kinds. Several other issues may not, superficially, appear to influence route selection but they do play a role in route selection.

### 4.6 ROAD RAGE

The cause that necessitates route selection is safety through reduction of risks associated with road factors. The New South Wales Official Government Website details the health of young people with reference to road safety. The crucial implication derived from the statistics is the occurrence of the highest rate of causality in two age groups – 15-19 and 20-24. The causality figure is on the higher side for males than for females among all age groups. More than half of the accident victims or causalities are drivers and about one third of the victims are passengers. There are several factors associated with their risks – environmental (weather or road conditions), biological (fatigue) and social factors (peer pressure). Risks are also related to individual attitudes and behaviors. These individual factors are dependent upon the road users.

- Pedestrians
- Drivers
- Passengers
- Two wheeler riders
- Stray cattle
The risk multiplies several folds with driving at night and during weekends. Even here, the youth are more prone to accidents – victims or cause factors by Shope & Bingham (2008). The following statistics, of the year 2009, is illustrative of a higher percentage of risk relating to youth. The percentage of occurrence of crashes during different time intervals and specific days are indicated (Insurance Institute for Highway Safety, IIHS 2009).

- Between 6 p.m. and 9 p.m. – 18 percent
- Between 9 p.m. and Midnight – 17 percent
- Between Midnight and 3 a.m. – 16 percent
- Weekends – 55 percent
- Fridays – 16 percent
- Saturday – 21 percent
- Sunday – 18 percent

Some of reasons attributed to the mishaps are:

- Poor visibility
- Fatigue
- Poor road conditions
- Inebriated condition of drivers
- Rashness
- Dangerous curves
- Carefree driving by youth
4.7 LITERATURE ANALYSIS

Literature analysis may be explicated as the search for information on a topic in all related and relevant written works which may critically offer knowledge in three possible manners

- Theoretical assumptions
- Methodological contributions
- Substantive findings

These literary accounts come under the category of secondary sources as they provide us the information through others. They are in contrast with the primary sources which are direct. Therefore, the nature of the information obtained may have one of the following features influenced directly or indirectly by the presenter.

- Generalization
- Analysis
- Synthesis
- Interpretation
- Evaluation

As such, these documents do not portray the original but become a review or abstracted version. Nevertheless, these invaluable records present us the background study from a historical perspective, bridging the present and the past through comparison and contrast.
Thus the objectives of literature analysis could be summarized asunder.

- To see what has and has not been investigated.
- To develop general explanations for observed variations in a behavior or phenomenon
- To identify potential relationships between concepts and also formulate researchable hypotheses
- To learn how others have defined and measured key concepts
- To identify the data sources used by others
- To develop alternative research projects
- To discover how a research project is related to the work of others

4.7.1 National Motor Vehicle Causation Survey

The National Motor Vehicle Causation Survey (NMVCCS) conducted by National Centre for Statistics and Analysis (NHTSA) between 2005 and 2007 is taken up for consideration in order to get details of risk factors associated with road network. The information collected is related to the factors associated with driver, vehicle, environment and roadway soon after the occurrence of a crash. The sources of the information range from the driver’s accounts, statements obtained from eye witnesses through interviews to the assessment made by NMVCCS research personnel. The study focuses on the associated factors recorded as ‘non-driving activities,’ such as ‘conversation’ and ‘inattention’ in the NMVCCS data. The basic tenet made is that these factors exist during the pre-crash period also. But no conclusion
is drawn on whether this factor is also a cause or not for the crash. The inattention on the part of the driver was categorized into two kinds of distractions.

- External
- Internal

External factors that might have affected the concentration are the following:

- Talking over mobile phone
- Conversing with passengers
- Listening to music
- Meddling with audio / video systems

Internal factors, cognitive ones, might include overconfidence, extreme feeling of sadness or happiness, sudden bouts of pain and worries relating to family, personal health or illness and money.

The entire analysis of the NMVCCS weighted data is done with focus on distractions in driving and the influence of the following associative factors on it.

- Age and gender of the driver
- The flow of traffic on the specific route
- Speed restrictions
- Environment
The highest percentage of drivers who are influenced by the external factors is 27.5 and these drivers have also to grapple with problems like ‘disabled’ vehicles precariously parked on roadsides and sudden appearance of obstacles en route. Three other external factors, ‘accident prone zone,’ ‘traffic bottlenecks or congestions’ and ‘unchecked free flow of traffic without speed limits,’ account for close to 17 percent of crashes. The ‘construction zone’ factor represents the lowest incidence of crashes with 12.4 percent.

The grounds for the high incidence of accidents or mishaps are listed by Singh et al (2013).

- Inadequate road infrastructure
- Lack of suitable road safety policies and norms
- Lack of road signs
- Mixed pattern of road traffic
- Non compliance of safety rules
- Inexperienced drivers
- Disregard for the safety of the pedestrians

These and other aspect of findings compiled by Singh et al is cataloged in Table 4.1.
Table 4.1 Risk factors identified by Singh et al

<table>
<thead>
<tr>
<th>Driving activities</th>
<th>Non-driving activities</th>
<th>Environmental factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looking at movement/actions of other occupants</td>
<td>Inattentive, thought focus unknown</td>
<td>Clear weather</td>
</tr>
<tr>
<td>Dialing/hanging up phone</td>
<td>Future event (vacation, wedding, etc.)</td>
<td>Cloudy</td>
</tr>
<tr>
<td>Adjusting radio/CD player</td>
<td>Preceding argument</td>
<td>Rainy</td>
</tr>
<tr>
<td>Adjusting vehicle controls</td>
<td>Financial problems</td>
<td>Snow/Sleet/Blowing snow</td>
</tr>
<tr>
<td>Retrieving object from floor and/or seat</td>
<td>Family problems</td>
<td>Other weather conditions</td>
</tr>
<tr>
<td>Retrieving object from other location</td>
<td>Personal problems</td>
<td></td>
</tr>
<tr>
<td>Eating or drinking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading map/directions/newspaper, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focused on other objects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversing with passenger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Talking on phone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text messaging</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.7.2 Factors as Regards Optimal Route/Safe Route

The features of a road also play a significant role in the selection of an optimal route for a safe and comfortable journey. A road is not just a stretch of concrete or bitumen or mud layer. It comprises of several elements or sections which need some elucidation.
• Drains: This section includes ditches, culverts, drifts, causeways. All these structures relate to water. The continuous flow of drain water or the choked drains cause erosion of pavements and weaken the roads. Their overflow during the monsoon seasons could also damage roads and create potholes which could not be noticed from a distance.

• Guard rails or road dividers prevent crash or collision of vehicles and also fall from flyovers. These guard rails or barriers are designed suitably to minimize the damage to vehicles or occupants even if there is an accident.

• Street markings: Markings are painted lines or other symbols drawn on the road to serve a message i.e. speed breakers, pedestrian crossings and lane indicators. They need constant remarking at regular intervals of time since the flow of traffic and rain and shine would erase them in a short course of time.

• Traffic lights: An important facet in road traffic management and a device that effectively prevents hazards on roads, this device fails to serve its purpose in times of acute need for reasons everyone is familiar with – inadequate maintenance, improper control, absence of a constant power source and disrespectful disobedience.

• Streetlights: Streetlights do provide a clear view to the vehicle users in the congested street environment in cities and towns during night.

• Paving of roads: The roads are commonly paved with concrete and bitumen. The normal life of a concrete topped road is between 10 and 12 years whereas the bitumen topped road has a life between 6 and 8 years. About the other kinds, the less
said the better. Rain and shine wear them out quickly and it becomes a nightmare and in fact, an impossibility, to traverse in these roads during monsoon seasons.

4.7.3 Access Control of Roads

The design of roads is centered on their service levels. The service levels have some determining factors.

- Reliability of access
- Comfort and speed
- Road safety
- Road operating costs
- Environmental costs

From the perspective of these service levels, Lebo & Dieter Schelling (2001) have identified four levels of access in the design and service of roads.

- No motorized access
- Partial motorized access with interruptions during substantial periods of the year i.e. rainy season
- Basic reliable all season access for the prevailing means of transport with limited periods of inaccessibility
- Full high quality uninterrupted all year access
4.7.4 Summation of Risk Factors through Literature Survey

After an evaluation of various factors associated with road network and road safety through literature survey, the risk factors are summarized in two ways. In one classification, the risk factors are segregated into two types – road and environmental factors and human factors. These are then subdivided into frequently changeable factors and non-frequently changeable factors. The details are listed in Table 4.2.

Table 4.2 Road risk factors – road and human factors

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Frequent changeable factor</th>
<th>Non-frequent changeable factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road and Environmental factor</strong></td>
<td>Increasing/decreasing Pedestrian way and turn of road, accident zone report</td>
<td>Strike/festival on road</td>
</tr>
<tr>
<td><strong>Human factor</strong></td>
<td>Road design and road layout, speed limits Pedestrians way facilities</td>
<td>School, College, Shopping rush on road</td>
</tr>
</tbody>
</table>

In Table 4.3, risk factors are classified into frequent and non-frequent factors.

Table 4.3 Road risk factors – Frequent and Non-frequent

<table>
<thead>
<tr>
<th>Frequent factors</th>
<th>Non-frequent factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Pavement</td>
<td>Traffic condition</td>
</tr>
<tr>
<td>Number of tollgates</td>
<td>One way or two way of road</td>
</tr>
<tr>
<td>Number of bridges</td>
<td>Width of the road</td>
</tr>
<tr>
<td>Number of junctions</td>
<td>Number of pedestrian crossings</td>
</tr>
<tr>
<td>Number of traffic signals</td>
<td>Number of U turns</td>
</tr>
<tr>
<td>Number of curves</td>
<td>Strike/Festival on road</td>
</tr>
<tr>
<td>Traffic creating obstacles</td>
<td></td>
</tr>
</tbody>
</table>
4.8 DOMAIN EXPERTS KNOWLEDGE ENGINEERING ANALYSIS

Expertise is defined as the set of capabilities that underlines the performance of human experts, including extensive domain knowledge, heuristics rules, that simplify and improve approaches to problem solving, meta-knowledge and meta-cognition and compiled forms of behavior that afford great economy in skilled performance. Expertise can be expressed in text books, case studies and documentation but typically is possessed by ‘domain experts’ Nasuti (2000).

Knowledge acquisition is defined as the process of extracting, structuring and organizing knowledge from several sources, usually human domain experts for use in a program. Knowledge acquisition is considered by many to be the most difficult and precarious stage in the knowledge engineering process.

A domain expert is defined as an articulate, knowledgeable person with a reputation for producing good solutions to problems in a particular field. The key to the identification of an expert is whether the expert has really the knowledge needed and the criteria for selection depend on the expertise, experience and reputation of the individual.

4.8.1 Domain Experts for Road Networks

With regard to the selection of experts for routing in road network, the following domains alone have been taken up to facilitate uncomplicated collection, consolidation and computation of data.

- Highway department experts
- Traffic information experts
- Highway patrol experts
- NHAI-toll road operators
- Police record for an accidental details

The different risk factors that are associated with these experts are brought out in Table 4.4.

**Table 4.4 Risk factors and domain experts**

<table>
<thead>
<tr>
<th>Experts</th>
<th>Frequent changeable factor</th>
<th>Non-frequent changeable factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway department experts</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Traffic information experts</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Highway patrol experts</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>NHAI-toll road condition.</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Police record for an accidental details</td>
<td>-</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**4.8.2 Methodology for Knowledge Acquisition**

Of the several methodologies in the knowledge acquisition process, interview technique is adopted for eliciting the required information. The interview centered around a question and answer session focusing on road problem solving and observation analysis. The questions that are posed to different domain experts are listed below.

1. Could you tell us the exact complaints or suggestions often made by road users?

2. Is it profitable to take part in NHAI activities?
3. List the different categories of roads and their locations.

4. Can you tell us the criterion on which the toll is collected – condition of the road or optimal route or distance?

5. What are your views about the use of sidewalks by pedestrians?

6. List the various factors associated with road pavement.

7. Describe the condition of road pavement during different seasons – summer / winter / rainy?

8. What are the various reasons that prompt you to close the road or block the traffic temporarily?

9. When do you normally change the two-way traffic flow to one-way? What are the reasons for such changes?

10. Can you tell us the most frequently changeable road factors?

11. Do you think the strikes that paralyze road traffic are a frequent or non frequent changeable road factor?

12. Tell us some of the activities associated with driving or non-driving on roads?

13. Can you provide us the details regarding accidents in this stretch of the road?

14. What is your idea about the choice of the drivers regarding routes? Do they prefer NHAI routes or some other highways? If so, why do they do so?

4.8.3 Concept Mapping

Concept mapping is a generic term associated with the representation of ideas through pictures and maps including a description of the process. Concept mapping is an integrated process and its steps include
brainstorming, statement analysis and synthesis, unstructured sorting of statements, multidimensional scaling and cluster analysis and the generation of numerous interpretable maps and data displays.

A concept mapping is a structured methodology with a historical perspective of ‘knowledge as design’, as a natural human philosophy which naturally results in user centered design praxis. It is designed to capture and represent the relationship between concepts in the domain expert understanding of the problem space. It also allows multiple inputs and indexing of the knowledge base to readily access specific information. Figure 4.1 is a concept map that represents the non frequent aspects of road risk factors and Figure 4.2 represents frequent aspects.

Figure 4.1 Non-frequent changeable factors
CONCLUSION

The process of capturing knowledge is defined as the collection, organization, evaluation and incorporation of knowledge to achieve a target or solution. Knowledge acquisition is the most difficult and precarious stage in the knowledge engineering process. The sum up, the chapter begins with the definition of risk and details the procedures to be adopted to arrive at the various risk factors associated road network – literature survey and domain experts’ knowledge engineering analysis. After an elaborate detailing of each procedure, summation of risk factors on roads is done in two ways – tabular form for literature survey and concept mapping for domain experts’ knowledge. The risk factors identified through these procedures are synchronized and presented in Figure 4.3.
Figure 4.3 Consolidation of risk factors

With this foundation on the various risk factors associated with road network and routing, the following chapter details a facet of route selection – hierarchical community mining – fuzzy ant dynamic routing on large road networks.