CHAPTER 8

CONCLUSION

Road traffic management and identification of safe and convenient routing have ever been confronting the human population all along. These aspects become all the more crucial and critical in developing countries since transportation contributes in a great magnitude to the evolution at the national, regional, economic, industrial, social and cultural echelons. The heavy population in a country like India does not easily yield itself to viable solutions. The dismal state of road conditions and traffic bottlenecks coupled with obstacles on road add to the woes of road users. All these aspects and many other similar obstacles and hazards motivate and stimulate scientists and engineers to develop and implement pragmatic techniques in accomplishing best routes in road networks.

Chapter one of the thesis is an analysis of the various elements that necessitate the present study. The transportation problems that trouble Indian subcontinent are presented. While public transport remains the principal means of transport, traffic in Indian cities is commonly and blandly dead slow with traffic snarls, traffic jams and accidents that are regular as well as frequent. The network of roads in a country resembles the arterial network in a human body and in fact, roads in India account for 90 percent of passenger traffic and 65 percent of freight traffic. Even though several initiatives have come up to improve road development, the challenges still persist – weather-worn roads, accidents, congestion and poor maintenance. The Indian Road
Congress has envisaged plans to improve the situation by adopting a multi-modal transport concept.

All these conditions necessitate one need-finding a user based optimal route. Several algorithms have already come into operation to overcome the optimal route crises. No single existing routing application could satisfy all transportation problems. Hence a pragmatic approach is schemed in the present study taking into consideration the unpredictable risk factors on the Boulevard network. The optimal routing system detailed in the study envisages a model in advancing a fuzzy optimal route system applying hierarchical community mining - fuzzy ant dynamic routing on large road networks, Dijkstra’s fuzzy algorithm in route selection and code based community network. The historical perspective, the rationale, methodology and outline of the thesis with a note on scope for future study form the rest of the chapter.

Chapter two is devoted to community structure and community detection algorithms. Identification and analysis of communities yield knowledge on the complex systems and their functions. The basic concepts of a community are lucidly outlined. Then the various algorithms that relate to the detection of communities are listed. These include algorithms which have widespread applications in networking such as the algorithm of Girwan and Newman, exhaustive modularity optimization via simulative annealing, Cfinder, dynamic algorithm by Rosvall and Bergstrom and Potts model approach by Ronhovde and Nussinov. There is also mention of overlapping community detection algorithms like clique percolation, line graph and link partitioning and fuzzy detection.

Since the present study is related to the application of fuzzy logic algorithm in identifying the optimal path in large road networks, only fuzzy algorithm is taken up for description. Fuzzy community detection algorithms
quantify the strength of association between all pairs of nodes and communities. Nepusz’s solution to nonlinear constrained optimization problem through simulated annealing methods is for overlapping communities, Stochastic Block Model is a generative model for groups in a network. Nonnegative Matrix Factorization is a feature extraction and dimensionally reduction technique in machine learning that has been adapted to community detection. Psorakis has proposed a hybrid algorithm, Bayesian NMF. Wang combines disjoint detection methods with local optimization algorithms. Thus the community structure is an important property of complex networks that aids in deciding the optimal route in road network.

Chapter three is an exclusive enlightenment on fuzzy logic – a basic inquest. Zedah proposes fuzzy logic as a way of processing data by allowing partial set membership rather than crisp set membership or non membership. Fuzzy logic is a many-valued logic that deals with reasoning that is approximate rather than fixed or exact. Fuzzy logic is ideal for many control system applications since it mimics human control logic. The advantages of this algorithm include inherent robustness, convenience of modifications and tweakings, cost efficiency and low complexity and control of non linear systems otherwise impossible in mathematical modeling.

Fuzzy logic has a systematic and synergic series of actions beginning with defining the control objectives and criteria and culminating in testing the system, evaluating the results, tuning the rules and membership functions and retesting until satisfactory results are achieved. Another salient feature of the fuzzy logic applications is the use of non numeric linguistic variables to ease the expression of rules and facts.

There is the application of truth values in fuzzy logic process. Fuzzy set theory defines fuzzy operators on fuzzy sets. More than a few formal fuzzy systems of logic exist in mathematical logic as propositional
fuzzy logics. Fuzzy logic functions and fuzzy databases could be synthesized and there is a possibility of developing fuzzy relational database by defining fuzzy relations. As regards the expression of uncertainty, the common goal of fuzzy logic and probability, fuzzy set theory uses the concept of fuzzy set membership (i.e. how much a variable is in a set) whereas probability theory uses the concept of subjective probability (i.e. how probable does one think that a variable is in a set). In comparison, fuzzy logic and algorithms have one factor in common – dealing with possibilities more than probabilities. Fuzzy logic, thus, provides a completely different and unorthodox technique to approach a control problem.

Chapter four recounts the process of data collection and classification of risk factors with respect to risk factors on roads. Risk is defined as ‘the possibility of loss or injury’ or ‘someone or something that suggests a hazard.’ The risk factors of road network acquired through knowledge acquisition process need to be quantified as only then the fuzzy knowledge base could be constructed.

Knowledge acquisition is developed as a tool in establishing the comparative evaluation of significance and assigning priority weights for different risk categories of road network. The principal knowledge acquisition modes adopted are literature survey and domain expert knowledge engineering analysis. The dominant modules of risk factors made out are non-frequently changeable and frequently changeable. While the non-frequently changeable factors remain static for the entire duration of the optimal route selection, the frequently changeable factors remain vibrant throughout the process of selection. A risk factor of road network remains a variable mostly leading to an increase in risk. Therefore the cause that necessitates route selection is safety through the reduction of risks associated with road factors. Literature survey of risk factors is based on three attributes
– theoretical assumptions, methodological contributions and substantive findings. The National Motor Vehicle Causation Survey (NMVCCS) is taken as the base for findings. Road access control, road pavement and environmental factors and human factors have also been gathered. All the data are tabulated.

Domain experts’ knowledge acquisition process is done carefully since the expert should be 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. The categorization of domain expertise relating to road network problems is done on the following lines – weather information experts, traffic information experts, highway patrol experts and NHAI-toll road operators. The mode of collection of data is the personal interview technique and standardized questions are posed to relevant domain experts. The answers provided by them are consolidated and recorded in concept mapping format. Concept mapping is an exceptional tool in such cases since it is capable of representing 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. Finally, risk factors collected through both channels are synthesized and tabulated. This forms the base for further processing.

Chapter five is on hierarchical community mining – fuzzy ant dynamic routing on large road networks. Hierarchical approach enables avoiding precomputing and storing of a large amount of data. The technique adopted is a combination of fuzzy logic and ant colony system. The hierarchical community algorithm has two phases – distance based community phase and high level community phase. The former is chosen for
the current study. The community detection phase, structural closeness measure and neighborhood random walk distance are some elements of hierarchical model. In the treatment of fuzzy ant based algorithm, ant routing and fuzzy logic for ant based algorithm are aspects of dynamic ant routing process.

All the membership functions for the fuzzy sets of inputs are chosen to be trapezoidal in shape since such a shape with its fine features easily yields to uncomplicated computation. The experimental evaluations involve preprocessing, dynamic shortest path selection, intra community result and inter community path result. Thus the hierarchical community mining algorithm could compute optimal dynamic routes for same community nodes pair and different community nodes pair on large road networks based on user parameters.

Chapter six is an endeavor in the formulation of a user based decision support system in route selection, the shortest path from origin to destination. Out of the several standard shortest path algorithms, Dijkstra’s algorithm, the most classical shortest path algorithm, is adopted for the study with a few adaptations. Fuzzy numbers and fuzzy arithmetic operations such as triangular fuzzy number, trapezoidal fuzzy number and defuzzification of graded mean integration method are explained. Then Dijkstra’s algorithm is scrutinized. Assessment criteria, phases in fuzzy Dijkstra’s algorithm and graphical manifestation of fuzzy Dijkstra’s algorithm are aspects of examination. Then fuzzy Dijkstra’s algorithm is applied to single source shortest paths and the efficiency is also illustrated. This is followed by the numerical model of fuzzy shortest path algorithm. This chapter has, thus, proved to a large extent, that Dijkstra’s algorithm could greatly aid in locating the shortest route, using fuzzy parameters, efficiently and effectively.
Chapter seven is a delineation of the integration of knowledge based technique and algorithmic method through code based community integrated approach which substantially reduces the computation time and space in route finding. Transportation network, naturally occurring as well as synthetically generated, could be represented graphically. Community is represented graphically through vertices as city points and edges as routes between cities. A few ideas on community, community detection and community insights are recollected at this juncture. The code base is applied to each community network with postal index number as the code for each city. The design of hierarchical network in community is done next. The consolidated risk factors are subjected to fuzzy inference process in several steps.

Then comes the stage in which vague description in natural language is adapted to a precise mathematical term and is the special feature of fuzzy logic. In the fuzzification process, each linguistic variable is assigned triangular based membership function. In the defuzzification stage, the fuzzy number is converted into a crisp value; the fuzzy results are transformed into crisp outputs. This approach is not only pragmatic but also effective in finding the optimal route in road networks.

Thus, the optimal routing has become the uppermost concern of all the road users of the large road networks and the researchers, in turn, move heaven and earth to get a breakthrough in the invention of an algorithm that best suits the road user in saving him time, cost and distance by making an allowance for the road risk factors related to road pavement, environment and human factors.

The quest for innovation in research is endless. As such, the scope of this research does not end with this study. As amplification and strengthening of this research, the risk factors associated with the vehicular
movement could also be brought into the ambit of analysis. For instance, the selection of a ‘good route’, which is safer and more secure, could be done. This becomes all the more pertinent with the constant and heavy traffic in routes involving vehicles transporting hazardous materials such as petroleum products, acids and gases. The caution, precaution and the follow up safe evacuation measures in case of emergencies, which are incorporated in the route and which would bolster the confidence and choice of the road users could also be integrated into the study.

To conclude, the present study, endeavoring to discover an optimal user friendly route in large road networks using fuzzy logic algorithm, has proven that a user decision support system in the selection of the optimal path in terms of efficiency based on roads risk factors is professional and in real time operational mode.

This blueprint is highly economical that facilitates appreciable reduction in fuel consumption, significant rise in vehicle life span through the least wear and tear as well as the least maintenance cost. In addition, the fatigue, weariness and exhaustion of the drivers as well as the passengers are eliminated or shrunk to the bare minimum.