ISSN 2348-1196 (print)
International Journal of Computer Science and Information Technology Research ISSN 2348-120X (online)
Vol. 3, Issue 2, pp: (1046-1051), Month: April - June 2015, Available at: www.researchpublish.com

A Fuzzy Reasoning Based Approach for Determining Suitable Paths in Spatio-Temporal Application

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Abstract: **In current era of technology, geospatial applications play a significant role in finding route information between source and destination. Various works has been carried out to find optimal path, between two geographic locations. Other than finding shortest path, several applications have contributed effort on finding optimal path by considering temporal factor such as traffic condition. The traffic of a route depends on certain time slot, events occurring in the city and one important factor is weather condition. However, in existing researches not much effort has been given on determining optimal path based on weather condition. This paper provides an approach to determine optimal path between two locations that considers the current weather condition. One of the important factors is water clogging on the roads due to rainfall, and flood. A fuzzy logic based approach has been used to find out severity of the water clogging over the roads. In the proposed approach, a set of paths between two locations is determined using spatial topological reasoning. The optimal path from the available set is determined based on shortest distance and severity of water clogging. A case study focused on Mumbai city, India has been presented to show the efficacy of the proposed approach.**

Keywords: **Fuzzy Logic, Route Finding, Geospatial, Spatio-temporal.**

I. INTRODUCTION

The demand for geospatial information for various development and business activities has increased to great extend in recent time. Nowadays, the population is increasing like bubble in cities. With increasing rate of population the transport modes are also getting increased, it in tern results growing traffic. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow. Most of the applications that provide route information between two locations are attempting to consider these facts. Wiener et al. in 2008 presented study of path planning under spatial uncertainties [5]. In a hierarchical planning scheme was used to navigate the shortest possible path to find an object hidden in one of four places and to bring it to the final destination [5]. Mao et al in 2008 designed and compared different path finding algorithms for a graph whose edge weights mutate randomly to a significant extent [3]. Although the route navigators provide a general idea about what constitutes optimal route but it is difficult to express in search interfaces [7]. The traffic in a path varies with respect to time and the algorithm calculates shortest path in a dynamic fashion. Google Map have implemented in providing route information considering the traffic. The traffic of a route is triggered by several factors like, festival, rally, peak hours etc. One of the important feature is weather condition, a slow moving traffic is caused due to fog. One of the key factor form traffic can be water clogging on the routes due to heavy rainfall and flood. The water clogging over the routes may result on increased traffic jam. In this work, a framework has been proposed that finds route between two geographic locations considering traffic occurred due to water clogging on the roads. The water clogging is a key factor which is followed by heavy rainfall and flood. The traffic condition of the route changes with respect to severity of the water clogging. The severity of water clogging is determined based on fuzzy logic based approach. Based on the severity of water logging the feasibility of route between source and destination has been decided. The rest of the paper is organized as, section II, discuss about related works.[6] In section III the overall architecture of the framework has been discussed, section IV presents a case study. Section V concludes the paper.

II. RELATED WORKS

All prior studies on path finding and path planning behavior assumed that all required spatial information was available but in real life navigators deal with incomplete or imprecise spatial knowledge resulting in spatial uncertainties [5]. Wiener et al. in 2008 presented experiments studying path planning under spatial uncertainties. In those researches a hierarchical planning scheme was used to navigate the shortest possible path to find an object hidden in one of four places and to bring it to the final destination [8]. Mao et al in 2008 designed and compared different path finding algorithms for a graph whose edge weights mutate randomly to a significant extent [3]. Nikolova et al. in 2006 presented new complexity results and efficient algorithms for optimal route planning in the presence of uncertainty. They employed a decision theoretic framework for defining the optimal route and identified a family of appropriate cost models and travel time distributions that were closed under convolution and physically valid [4]. Cornelis et al. in 2004 showed which criteria must be met for path finding algorithm correctness and explained an efficient method, based on defuzzification of fuzzy weights, for finding optimal paths [2].In a given transport network, several paths may connect two geographical locations. Google Earth can determine the shortest path between two geographical locations. However, for traveling from one location to another, shortest path may not be the only criteria. Some other properties have to be taken into consideration, viz. traffic condition of the path, quality of the path. Many research has been done regarding these topics even now a days Google earth is also providing the traffic condition of the road in three manner heavy, medium and minimal but the climatic condition is not taken as one of the factor for finding optimal route(s)/path(s) between source and destination.[9] So here we are trying to consider these factors in our research. For example,[1] a given route is suitable, if length of the route is short and quality of the path is good. Again the quality of a path is good if the route is wide and texture of the route is smooth. And after all these condition there is another important factor that we have taken in consideration i.e. climatic condition means after finding the optimal path(s) ,the climatic condition will be checked and according to that we will decide whether it is the optimal path or we have to go for another. Therefore, it can be shown as follows [6].

Path risk ←− ((path length (P*L*), *path quality* (PQ)) *path quality* ←− (path width (P*L*), average roughness (R*a*)) climatic condition)

III. OVERALL ARCHITECHTURE

When we choose optimal path we are considering the following conditions, we have done all the research on the city Mumbai, India, by studying various articles [11] and history [12] of the city reference with the climatic condition.

A. Nearest Water Body:

After finding the optimal path we need to take in consideration these climatic factors, if the route is nearer to any water body then the risk is high and it goes far from the water body the percentage of risk is decreased. The risk of a route with respect to Distance of Water Body and path quality is deter- mined by membership value. The fuzzy membership functions for path risk [μR (DWB)] with respect to the Distance of Water Body (DWB) from the path can be described as: Universe of dis- course of distance of water body in μR (DWB) is 0-30 in kilometres. Therefore, the risk membership value (μR) falls with decrease in distance from water body. The path risk membership function [μR (DWB)] w.r.t distance of water body in (DWB) is given in equation 1.

$$\mu R(DWB) = \begin{cases} (DWB/\alpha) & \text{if } 0 \le DWB \le \alpha \\ 1 & if\ DWB \ge \alpha \end{cases} \quad (1)$$

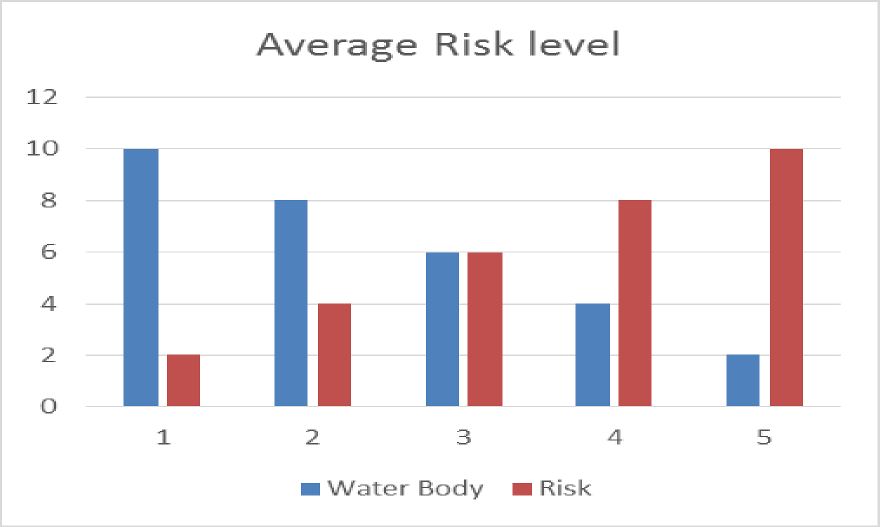

Fig.1 Average Risk Level

B. Rainfall Level:

The below graph shows the percentage of risk according to the rainfall in the city, as the rainfall increases the level of 4500mm in a 24 hr., the risk of water logging increases. For the testing purpose we have took 7km as discrete distance of road from water body, the complete concept is shown in the following fig (2):

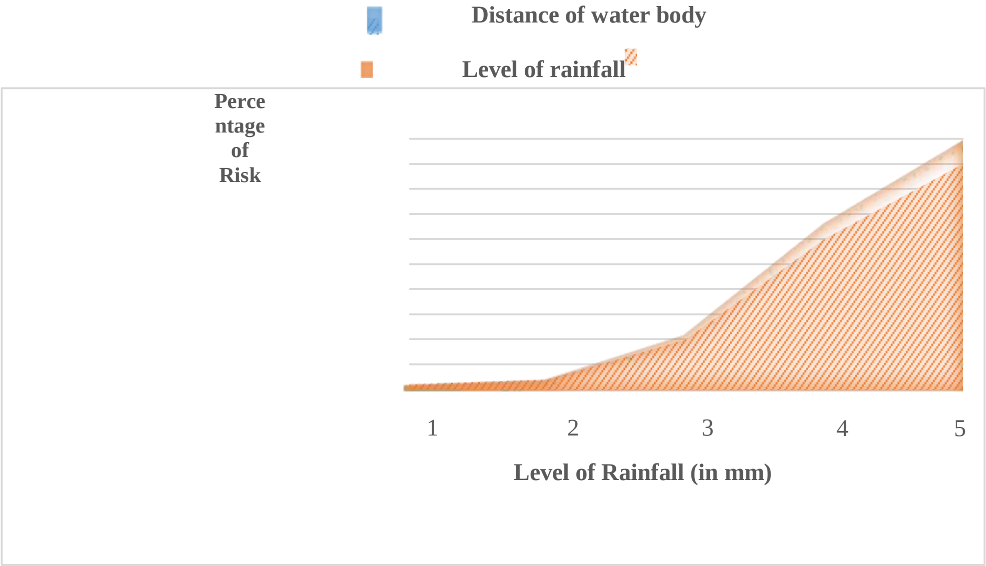

Fig.2 Level of rainfall

The fuzzy membership functions for path risk [μR (RL)] with respect to the Rainfall Level in the area of path can be described as: Universe of dis- course of Rainfall Level μR(RL) is 0-4500 in millimeters. Therefore, the risk membership value (μR) falls with increase in level of rainfall. The path risk membership function [μR (RL)] w.r.t Rainfall Level (RL) is given in equation 2.

$$\mu R(RL) = \begin{cases} 1 - (RL/\beta) \text{ if } 0 \leq RL \leq \beta \\ 0 \quad\quad if\ RL \geq \beta \end{cases} \quad (2)$$

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Path risk	α cut
Poor	$0 \le \min(\mu R(WBD), \mu R(RL)) < 0.4$
Medium	$0.4 \le \min(\mu R(WBD), \mu R(RL)) < 0.7$
Good	$0.7 \le \min(\mu R(WBD), \mu R(RL)) \le 1.0$

Where β=4500mm (rainfall level in millimeter). The fuzzy membership functions, given in equations 1 and 2, can be expressed through other commonly used membership functions (Gaussian MF, Bell MF) or mathematical expression depending on change of risk with respect to optimal path and climatic conditions.

The *α- cuts* offer a way to limit attention to a subset of a fuzzy set and also offer a complete characterization of a fuzzy set that can be easily compared to other fuzzy sets [10].

Nearest Water Body(Km)	Rainfall Level	Path Quality
7	1000	Medium
15	500	Good
25	4000	Poor
7	3000	Poor
15	3500	Medium
25	4500	Poor

C. Path Risk Determination:

In a given transport network, routes connecting two geographical locations are determined (refer Fig. 2). For example (refer Fig. 2), given two locations S and D, there are three paths, namely path a, path b, path c.

Path a: (a1, a2, a3, a4, a5)
Path b: (b1, b2, b3, b4)
Path c: (c1, c2, c3, c4)

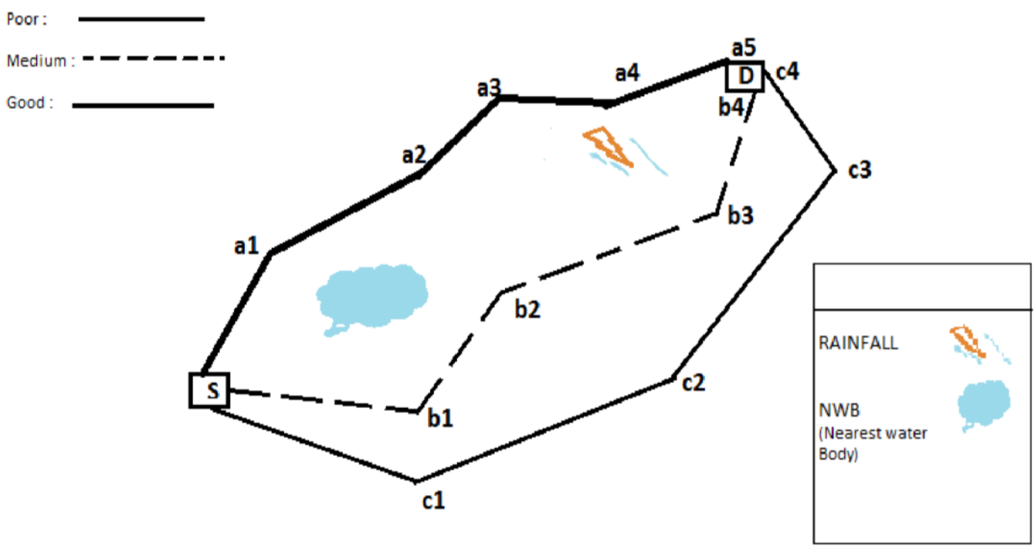

Fig.4 Transport Network

IV. CASE STUDY

The following case study was carried out in THANE area of MUMBAI city, calculated paths are according to our algorithms.

Source: It's the starting point of a commuter.
Destination: It's the destination of a commuter.

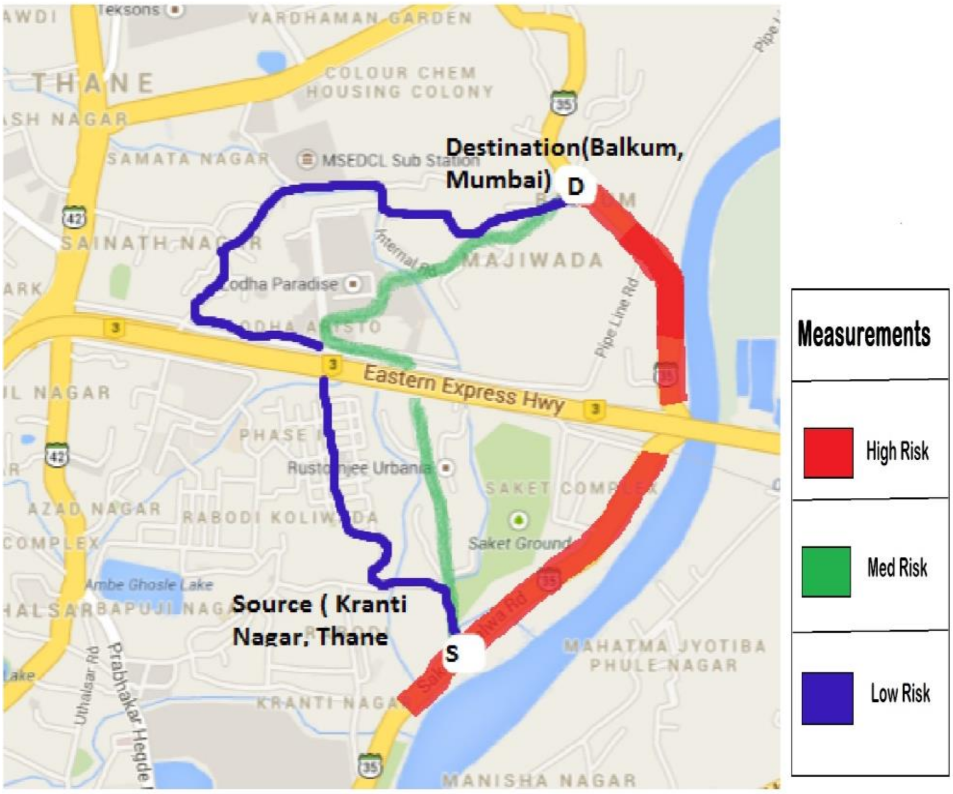

Fig 3: map shows feasible routes between source Kranti nagar Thane and destination Balkum Thane.

A random selection of source and destination was done to show feasible path within source and destination. According to normal algorithm maps shows multiple paths which are most short distance and easily reachable, but a commuter requires most feasible path to reach the destination. Therefore, according to fuzzy logic and climatic factors maps shows path which reach destination but with most feasibility Following map shows three routes within source (Krantinagar) and destination (Balkum). Where Red path is shortest but most worst path to travel as water body is very near and current rainfall has caused the place to overflow from danger level, Green path is medium but due to some local traffic problems that's road to is not feasible, but Violet colored road is long but at current time it's best way to travel, so it is suggested

V. CONCLUSION

In this paper, an approach for optimal path calculation between two locations has been discussed. The proposed method, considers the spatiotemporal factors that effect on the time required for traveling from a source to destination. The temporal effects can be traffic, rainfall, accident on or nearby road. The methodology, has considered the effect of climatic condition over the traffic on transport. The heavy rainfall leads to the problem of water logging, flood that affects the traffic adversely. These temporal factors are needed to be considered determining optimal path between two location. The given methodology considers the Nearer Water Body (NWB) from the route/path that is been selected as optimal path and the level of rainfall to calculate the possibility of water logging due to overflow of water form NWB . Given a source (Kranti Nagar, Thane) and destination (Balkum, Mumbai), all routes between those locations are calculated. The fuzzy reasoning has been used to determine the possibility and severity of water clogging over each road. The severity factor is used to determine the traffic condition of each road. The possible routes between source and destination are returned with fuzzy membership value, which intern determines the optimality of the route.

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