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A Geolocation Based Algorithm for Vehicular Congestion Avoidance Using Fuzzy Logic

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ABSTRACT

The main aim of this research paper is to design and implement an algorithm for vehicular congestion avoidance in Smart Cities using Fuzzy Logic. The main parameters considered in the algorithm are Received Signal Strength, Velocity of vehicle and inter-vehicular distance. The algorithm computes the ranking of the vehicles based on their velocity and proximity to the site of accident/breakdown, to decide on the candidate vehicles which can benefit from the information from the accident / breakdown and subsequent congestion avoidance.

Keywords: *Vehicular Traffic, Received Signal Strength (RSS), Fuzzy Inference System (FIS), Universe of Discourse, Vehicular Velocity, Vehicular Ad hoc Network (VANET)*

1. INTRODUCTION

Vehicular Ad Hoc Networks are one of the key components in the evolution of smart cities. VANETs can be used for traffic monitoring and management [1] [2]. They also play an important role in Intelligent Transportation Systems. VANETs can be termed as the type of Mobile Ad Hoc Network in which the Onboarding Units are fitted in the vehicles [3] [4]. The Onboarding Units (OBUs) are used for inter-vehicular communication. In case of an accident, emergency information can be circulated to the nearby vehicles so that necessary actions can be taken to avoid getting into a congested traffic zone. This can be possible by using VANETs [5] [6].

The paper has been organized as follows: Section 2 provides the theoretical background. Section 3 captures the design and implementation part. Section 4 gives the Simulation Results followed by Conclusion in Section 5.

2. RELATED WORK

A. Received Signal Strength (RSS), Distance & Velocity

Fig 1 shows a scenario for the vehicular traffic moving on the highway connecting smart cities. Fig 2 provides the Geometrical representation of vehicular collision and vehicular traffic. Point A, represent the point of collision and B, C represent the location of two nearby vehicles of interest. From GPS co-ordinates, their relative distance can be calculated. RSS is one of the important parameters in VANET. The OBUs of the vehicles are able to communicate with each other & RSUs (Road Side Units) and continuously measure the RSS value from nearby vehicles. High RSS value denotes the delivery of the emergency message at a faster pace. RSS value changes with vehicular velocity.

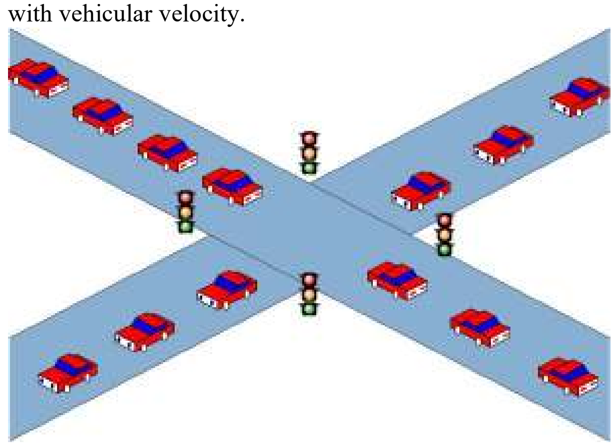

Figure 1 Figure Showing Vehicular Traffic

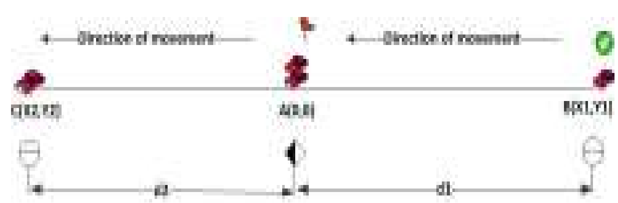

Figure 2 Geometrical Representation

Figure 3 captures the details of the GPS location update. The details of the location (latitude & longitude) of the vehicle are captured and periodically updated. The details of current Point of Attachment (PoA) is also captured. The Road Side Unit (RSU) is a type of PoA.

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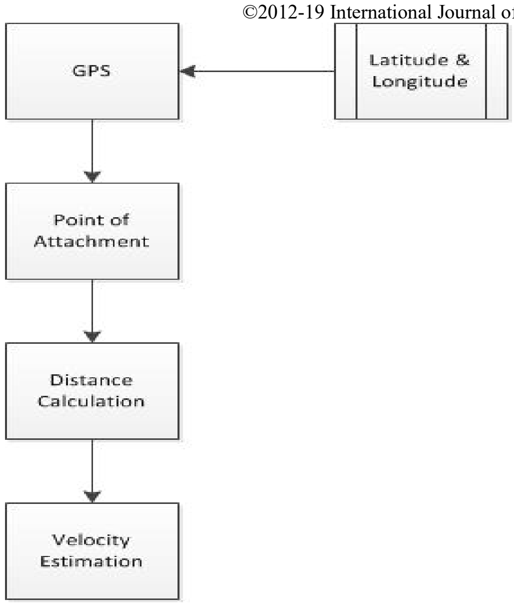

Figure 3 GPS Location Update

B. Triangular Membership Function for Fuzzy Inference System (FIS)

Fuzzy Logic can be termed as problem solving technique which is primarily based on approximation theory [7]. Figure 4 describes the Fuzzy Inference System.

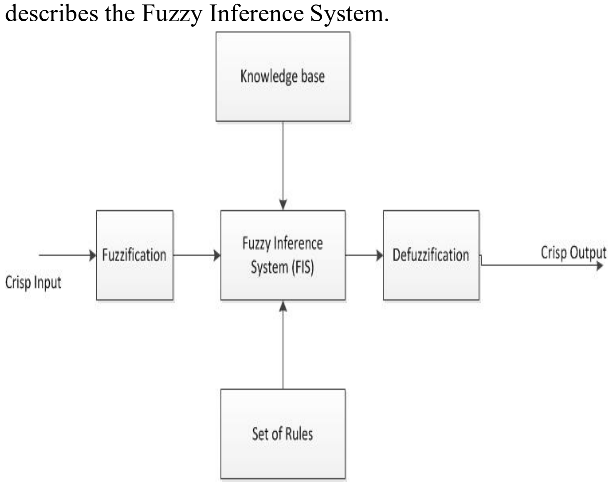

Figure 4 Fuzzy Inference System

The following equation describes the triangular membership function for three parameters [8] [9] [10]

$$\mu(x:p,q,r) = \begin{cases} 0, & x \leq p \\ \frac{(x-p)}{(q-p)}, & p \leq x \leq q \\ \frac{(r-x)}{(r-q)}, & q \leq x \leq r \\ 0, & x \geq r \end{cases} \quad (1)$$

3. DESIGN & IMPLEMENTATION

The block diagram for the Fuzzy Inference System (FIS) is captured in Fig 5. Fig 6 describes the condition of collision on the highway.

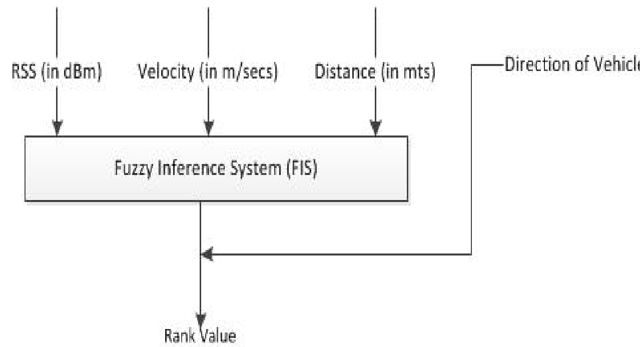

Figure 5 Block Diagram of FIS

Velocity of individual vehicles can be estimated from the rate of change of RSS. Dynamic calculation of the distance of each vehicle can be done through GPS.

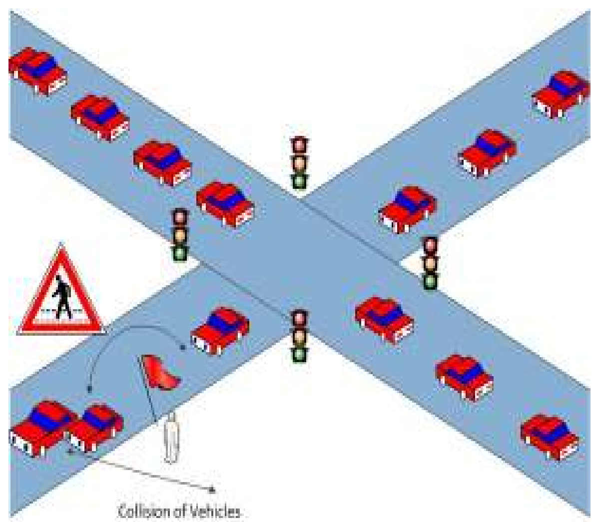

Figure 6 Condition of Collision

Table I denotes the value taken basis the direction of vehicle.

Table I Direction of Vehicle

Value	Direction of Vehicle
1	Vehicle coming towards the Accident site
0	Vehicle leaving Accident Site

Figure 7 captures the Algorithm for VANET.

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Algorithm ; Vehicular Congestion Avoidance using Fuzzy Logic

Input Data :

i. Location (Latitude & Longitude) of vehicle
ii. RSS (Received Signal Strength)
iii. v (Vehicular Velocity)
iv. Direction of Vehicle

Notations :

L_i – Latitude of Vehicle V_i
M_i – Longitude of Vehicle V_i
IP_i – IP address of Vehicle V_i
RSS_i – RSS of Vehicle V_i
V_j - Vehicle having accident / collision

Condition :
In case of accident / collision

Output :
Rank of Vehicle (Rank)

Steps to be followed :

1. For the condition of accident / collision, find the vehicle latched to particular RSU
2. Identify the RSU and identify the vehicles
3. For Vehicle Vi in Radius (R=400mts)
   Get_IPi of each vehicle
   Get_Long$_i$ (M_i): function to get longitude in Google API
   Get_Lat$_i$ (L_i): function to get latitude in Google API
4. Get L_i & M_i for each V_i (including accident vehicle)
5. For every vehicle, calculate
   Direction $_{ij}$ = (L_i – L_j) or (M_i – M_j)
   If Direction$_{ij}$ > 0
   Direction$_i$ = 1
   Else
   Direction$_i$ = 0
6. Filter out the Vehicles with Direction = 0
7. For every vehicle Vi in step above, get the following RSS_i, v_i (vehicular velocity), distance
   $$S_i = \sqrt{(L_i - L_j)^2 + (M_i - M_j)^2}$$
8. Velocity of Vehicle can be calculated as
   $$v_i = {\Delta Si}/{\Delta t}$$
   Where $\Delta t -$ $referεshing\ time\ (\ in\ secs)$
9. For every vehicle Vi, provide the inputs (as calculated in Step 7) to Fuzzy inference system
10. Calculate the Rank Value (RV_i) of each vehicle basis the inputs provided
11. Sort the vehicles based on the Rank Value of each vehicle
12. Select top 10 vehicles based on Rank Value (RV)
13. Sort the vehicles (from step 12) based on RSS
14. Send the emergency message to top 10 vehicles from step 13.

Figure 7 Algorithm for VANET

Table II captures the details of Universe of Discourse of the input parameters.

Table II Universe of Discourse

S. No	Parameter	Unit of measurement	From	To	Max Value
1	RSS	In dBm	-100	-59	-
1.1	Low	In dBm	-100	-80	-100
1.2	Medium	In dBm	0	-100	-80
1.3	High	In dBm	-80	-59	-59
2	Velocity	In m/sec	0	36	-
2.1	Low	In m/sec	0	18	0
2.2	Medium	In m/sec	0	36	18
2.3	High	In m/sec	18	36	36
3	Vehicular Distance	In mtrs	0	400	-
3.1	Low	In mtrs	0	200	0
3.2	Medium	In mtrs	0	400	200
3.3	High	In mtrs	200	400	400
4	Rank Value	No Units	0	10	-
4.1	Worst	No Units	0	2	0
4.2	Worse	No Units	0	4	2
4.3	Bad	No Units	2	6	4
4.4	Good	No Units	4	8	6
4.5	Better	No Units	6	10	8
4.6	Best	No Units	8	10	10

Rule base follows the triangular membership function given by equation 1.

4. SIMULATION & RESULTS

The simulation has been done for 40 vehicles at different velocity, distance and direction. Figure 8 captures the GPS location update for these vehicles.

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Figure 8 GPS Location Update

Figure 9 captures the latitude & longitude of two vehicles and inter-vehicular distance.

Location Details of Vehicle 1 :
Latitude 19.229086 ,
Longitude 72.8423263

Location Details of Vehicle 2 :
Latitude 19.0728 ,
Longitude 72.8826

Distance between the vehicles (in mtrs) – 161.3917120

Figure 9 Calculation Of Inter Vehicular Distance

Table III captures the vehicle numbers along with the various parameters. Table IV captures the rank value of various vehicles moving towards the accident -site (based on duration).

Table III Vehicle & Parameters measurement

Vehicle No	RSS	Velocity	Distance	Direction
V0	-100	36	400	0
V1	-76	19	290	1
V2	-79	16	140	1
V3	-81	14	307	1
V4	-95	11	234	0
V5	-99	7	394	0
V6	-90	32	380	0
V7	-80	26	391	0
V8	-70	20	400	1
V9	-65	12	400	1
V10	-60	6	400	1
V11	-98	35	298	0
V12	-90	29	295	0
V13	-83	24	333	1
V14	-74	18	297	1
V15	-67	15	300	1
V16	-60	6	300	1
V18	-82	29	202	0
V19	-80	23	200	0
V20	-70	17	210	0
V21	-65	12	198	0
V22	-60	6	200	0
V23	-100	36	110	1
V24	-90	30	105	1
V25	-80	24	95	1
V26	-70	18	90	1
V27	-65	12	92	0
V28	-60	6	104	0
V29	-91	36	51	0
V30	-83	30	50	0
V31	-71	24	45	1
V32	-64	15	49	1
V33	-65	12	45	1
V34	-60	6	50	0
V35	-62	23	10	0
V36	-74	21	5	0
V37	-76	19	190	0
V38	-79	16	160	1
V39	-81	14	295	0

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Table IV Rank of Vehicles

Vehicle No	Rank
V1	4.825
V2	4.697
V3	4.862
V8	5.000
V9	5.000
V10	5.000
V13	4.940
V14	4.834
V15	4.932
V16	5.000
V17	4.666
V23	4.361
V24	4.456
V25	4.666
V26	4.839
V31	4.729
V32	4.987
V33	4.978
V38	4.697

Table V captures the vehicles with high ranking values.

Table V Vehicles with Top Ranks

Vehicle No	Rank
V16	5.000
V8	5.000
V9	5.000
V10	5.000
V32	4.987
V33	4.978
V13	4.940
V15	4.932
V3	4.862
V26	4.839

Below table VI captures the high ranking vehicles with descending order of RSS.

Table VI Vehicles (with Top Ranks) in descending order

Vehicle No	RSS	Rank
V16	-60	5.000
V10	-60	5.000
V32	-64	5.000
V9	-65	5.000
V33	-65	4.987
V15	-67	4.978
V8	-70	4.940
V26	-70	4.932
V3	-81	4.862
V13	-83	4.839

As shown in Table VI, the message about the accident / collision of vehicles is send to the particular vehicles only. This will avoid flooding of messages and congestion in the network. The above ranking is an indication of the vehicles which will benefit from the traffic information and accordingly they can be kept informed of the congestion details on priority.

5. CONCLUSION & FUTURE SCOPE

This paper captures the design and implementation of algorithm for emergency response to prevent road congestion in case of accidents and vehicular collision using VANETs. We have considered all important parameters in practical scenarios. This algorithm can be used for traffic management in highways and smart cities. The algorithm can also be used for emergency situations like creating a green corridor for ambulances, fire engines etc.

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