Emotion Enabled Cognitive Driver

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Abstract: A Smart Cognitive Driver has been implemented to overcome the human driving errors and utilizing Global Position System (GPS) for location detection of the vehicle. The proposed system has used cognitive agent for communication with a response time of one second. Additionally, the system shares the longitude and latitude after extracting it from the hardware to calculate the distance, speed and the direction of the vehicle, that are used in Stopping Sight Distance (SSD) formula which enable the system to decide its reaction to the situation. In the attempt to make the cognitive agent emotionally responsive to fear, different checks have been imposed on the system. Fear has been ranked on different levels (low, average and high). The cognitive agent responds immediately by applying brakes upon detecting the high fear condition.

Keywords: Accident, Collision, Cognitive Driver, SSD, longitude, latitude, V2V, GPS

I. INTRODUCTION

Ease of accessibility of luxuries leads to facilities availability to everyone, including the vehicles. Increased number of vehicles leads to increased number of road crashes as well. With the Referred to Annual Global Road Crash Statistics (AGRCS) nearly 1.3 million deaths are caused due to road accidents. 20 - 50 million of individuals were disabled or injured because of road collision. Moreover 400,000 people under the age of 25 die on the road. NHTSA (2013) claimed 10% of all fatal crashes and 17% of injury crashes happen due to the road accident. Many factors contribute to the road collision which includes vehicle, roads and human error.

The accidents caused by human driver can be due to over-speeding and loss of control, driver in the influence of toxin, not wearing seat belt, and being emotionally distress. According to Young and Salmon (2012) [4] [5, 6], distraction is a contributing factor in at least 23% of all accidents. With the innovation of vehicles, the ratio of casualties has decreased tremendously but human error has yet to be addressed effectively. Various Intelligent Transport System (ITS) are used around the globe to reduce vehicle collision.

With the advancement in the technological development of mobile computing, wireless communication and remote sensing, Intelligent Transportation System (ITS) has been progressing with each passing day. Interconnected Vehicles not only communicate with each other but extract the data about its environment [11]. Vehicle-to-Vehicle (V2V), also known as inter-vehicular communication (IVC), has been recognized by governments, corporations, and the academic community.

Timely exchange of information between the driver by inter-vehicular communication (IVC) and roadside-to-vehicle communication (RVC) might make the road system safer and efficient. IVC among the vehicles is mostly done using radio waves that allows the vehicles to exchange the position and speed information on one to one basis so a constant vehicle to vehicle distance can be maintained. For the communication between the vehicles the Global Positioning System has been used.

In the paper a simulation-based solution has been proposed addressing human-based accident. A cognitive agent is embedded with emotion of fear. Agent is expected to react to the stimuli in timely manner to avoid any possible collision. The fear has been activated by distance between the vehicles. To calculate the distance between the vehicles latitude and longitude is required. Global Position System (GPS) has been used for vehicles location identification.

Garmin Legend GPS receiver has been used to extract the Longitude and Latitude through which vehicle's speed, distance and time has been calculated. Stopping Sight Distance (SSD) has been calculated using reaction time and velocity to enable the agent to make a timely decision.

Specialized V2V communication (peer to peer) software has been coded in Visual studio .NET using C# language. SSD formula has been used for decision purpose. For this Reaction time and velocity (speed/time) will be required. The system will be tested at different velocities. Fig. 1 shows the block diagram of the proposed system.

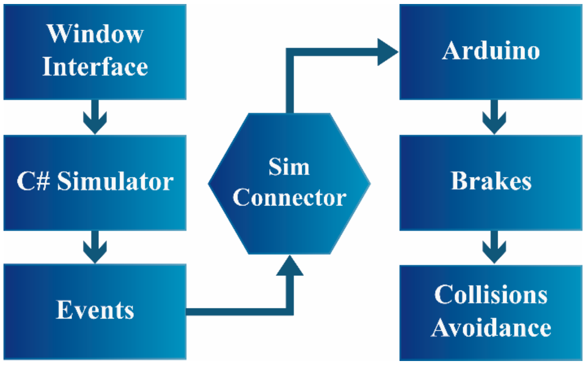

Fig. 1 SIM Connector

The remaining of the paper is organized as follows. Section II provide literature review, Section III the proposed solution, Section IV results and simulation and finally Section V conclude the paper followed by references.

II. LITERATURE REVIEW

Humans have limited information processing abilities and must rely on some fallible mental functions. It has been proven to be a greater support to transport managers to maximizing the face validity of fatigue measurement [1]. The causes of the accidents can be perception failure accidents or comprehension failure accidents. Perception failure accidents involves a driver who failed to sense an obstacle that was about to cross its depth. Comprehension failure accidents involved driver who perceived the obstacle, but a judgment error result in intersecting the path of obstacle. The Perception Unit plays major role in defining how a driving model observes its environment and in shaping most of its later actions [2, 3].

Driver's exciting impact involve, firstly the frame of mind of driver in which he is not affected by object present in that situation and secondly emotional reaction to a particular entity present in situation itself. [7]. Driver's aberrant behaviors and violations of traffic rules also cause the traffic accidents [8]. SIM Connector Emulator approach has been used for the testing of real-world systems using agent-based simulations as a means of validation. It also uses agent-based modelling for the testing of a real-world disaster alerting system [9].

Deployment of emotions in Autonomous vehicles allows imitating human like behaviors to autonomous vehicles. Major concern of the framework is to make autonomous vehicles just like humans which take decision by influencing from their emotions [3].

A car driving a system (Xdriver) exist which uses an intelligent system of decision making (ISD). The design of the whole ISD system is result of a thorough modelling of human psychology base on an extensive literature study. The main goal of the Xdriver system is not to create another instance of an autonomously controlled car but to prove that a computational management system founded on the developed ISD model of human [10]. In existing literature, most of the autonomous vehicles have been designed by keeping in mind the cognitive part of human drivers, whereas the role of emotions like fear in avoiding road collisions has not been explored. Hence, this paper is an effort to design collision avoidance strategy using human emotions along with human cognition.

III. PROPOSED SOLUTION

In this paper a practical implementation of V2V communication system has been explored and improved, which enable vehicle to forecast and respond to the different situations. To empower the emotions of fear in cognitive agent different checks have been applied and the emotion fear is parameterized by (low, average, high). The proposed cognitive agent will take action on high fear by applying breaks. V2V communication system exchange longitude and latitude to calculate speed and distance of vehicle to evade the accident chances.

As depicted in Fig. 2, When GPS connection is established, and serial port is open then the longitude and latitude is displayed otherwise error message would be generated.

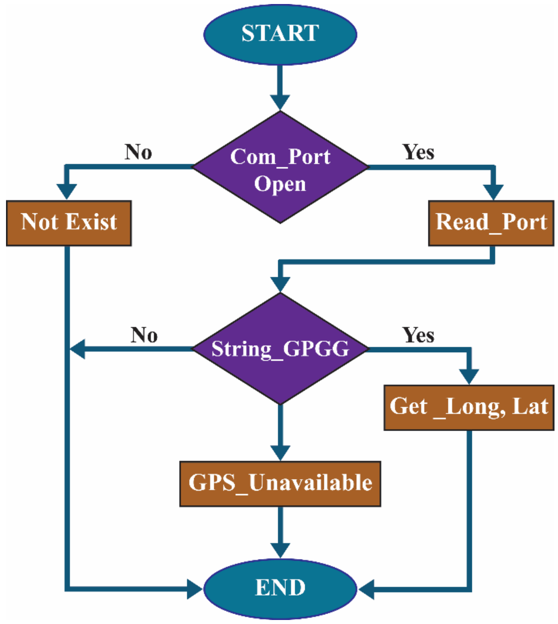

Fig. 2 Receiving longitude and latitude

To calculate speed of vehicles and the distance between two vehicles, the longitude and latitude of both vehicles (vehicle 1 and vehicle 2) are shared using Global positioning system (GPS) hardware.

As illustrated in Fig.3, if distance between the vehicles must be less than 5-meter, fear would be categorized. If the fear reaches high level, then action would be taken to avoid collision.

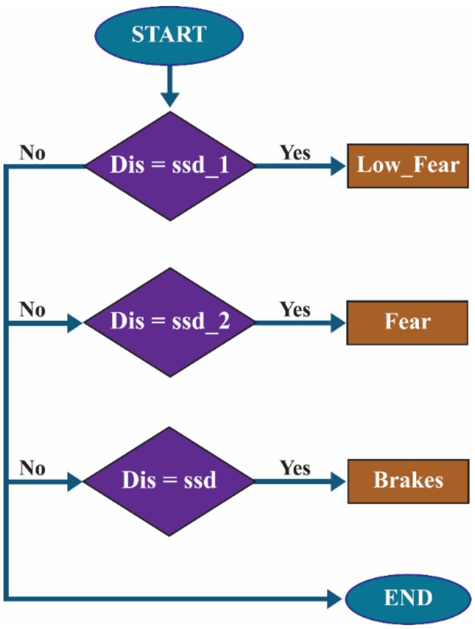

Fig. 3 Evaluation of fear on distance

Pseudo code for distance and fear by using Latitude and Longitude is:

```
START
Get (positions_of_Vehicles)
 Calculate dis, speed
  WHILE DIS< 5m DO
       Establish_connection
       Calculate SSD
  ENDIF
    IF DIS < 4m && DIS > 2m THEN
      Low_fear
        IF DIS >=1m && Dis <= 2m
        THEN Fear
          IF DIS <1 THEN
            High_ fear
         ENDIF
     ENDIF
   ENDIF
              IF DIS= SSD     THEN
              Auto brake
              ENDIF
ENDWHILE
END
```

In V2V communication network, the server request to client for connection, the client wait for request. When client accepts request the connection would be established between client and server, so the exchange of longitude and latitude can take place. When both vehicles exchange their longitude and latitude, distance has to be calculated between the vehicles. Speed has been calculated by time difference. Direction formula has been used to calculate the angle through with the direction of vehicle can be perceived. General formula for the respond time that has been used to calculate SSD (Stopping Sight Distance) is:

$$SSD = 1.47Vt + \frac{1.075V^2}{a}$$

Where, V is the design speed, which is measured in miles per hour mph, t is the brake reaction / respond time, it is measured in seconds and ‘a’ is the deceleration rate. 11.2 ft/s. The proposed system has been tested with different speeds, where the respond time of the system remain one second throughout. Lastly to ease the further validation of results standard agent-based modeling tool NETLOGO has been used. Its details are giving in the next section.

IV. SIMULATIONS AND RESULTS

The main simulation screen is presented in fig. 5. Setup and Go buttons are used to setup and run the simulation respectively. The Emotion Enabled agent label helps in testing the experiments in human driven and emotion enabled agent modes. The number of cars label helps in adjusting the number of vehicles being used in simulation, whereas acceleration and declaration labels are being used to set the acceleration and declaration rates of the vehicles. In the last the collision graph helps in viewing the results in the shape of collisions avoided between both vehicles.

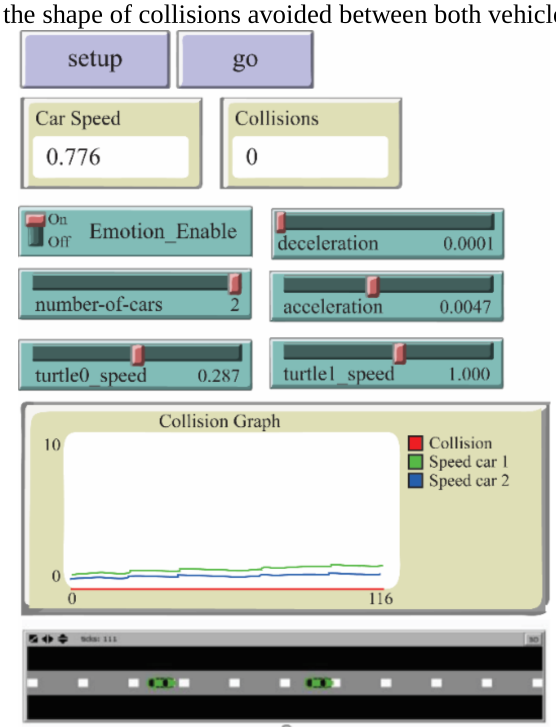

Fig. 5 Main Simulation Screen

The tables given below, illustrates the tested parameters of speed, reaction time, break time, stopping sight distance and save distance accordingly.

Table 1 Stopping sight distance of Human Driver calculated using Long route with reaction time = 2.5 sec

SR#	Speed	Break Reaction Distance	Breaking Distance	Minimum SSD calculated
1	15	22.05	21.60	43.65
2	20	29.4	38.39	67.79
3	25	36.75	59.99	96.74
4	30	44.1	86.38	130.48
5	35	51.45	117.58	169.03
6	40	58.8	153.57	212.37
7	45	66.15	194.36	260.51
8	50	73.5	239.96	313.46
9	55	80.85	290.35	371.20
10	60	88.2	345.54	433.74

In humans' driver reaction time is always 2.5 second. It is also notice that when speed increases the, break reaction time, stopping side distance and save distance also increase.

This also can be viewed in Table 1 that when speed is 15 then the reaction time is 2.5, break time is 55.125, SSD is 21.6 save distance is 76.7. When speed is 20 then the reaction time is 2.5, break time is 73.5, SSD is 38.39, and save distance are 111.78. When speed is 25 then the reaction time is 2.5, break time is 91.87, SSD is 59.99, and save distance are 151.86.

Table 2 Stopping sight distance of Cognitive Agent calculated using Long route with reaction time = 1 sec

SR#	Speed	Break Reaction Distance	Breaking Distance	Minimum SSD calculated
1	15	55.125	21.60	76.72
2	20	73.5	38.39	111.89
3	25	91.875	59.99	151.86
4	30	110.25	86.38	196.63
5	35	128.625	117.58	246.20
6	40	147	153.57	300.57
7	45	165.375	194.36	359.74
8	50	183.75	239.96	423.71
9	55	202.125	290.35	492.47
10	60	220.5	345.54	566.04

In our system reaction time is always 1 second. It is also notice that when speed increases the, reaction time, break time, stopping side distance and save distance also increase but the reaction time will remain the same. This also can be viewed in following table 2 that when speed is 15 then the reaction time is 1 sec, break time is 22.05, SSD is 21.6 save distance is 43.64. When speed is 20 then the reaction time is 1, break time is 29.4, SSD is 38.39, and save distance are 67.79. When speed is 25 then the reaction time is 1, break time is 36.75, SSD is 59.99, and save distance are 96.74.

As depicted in Table I, II, speed is directly proportional to break time, SSD and safe distance. But the reaction time remains constant throughout the experiment. As compared in the tables above the response time in human remains 2.5 and for emotionally cognitive driver 1 second. From the tables it can be concluded that the emotionally cognitive driver is more efficient and responsive than human driver. As it has been illustrated in the graph below.

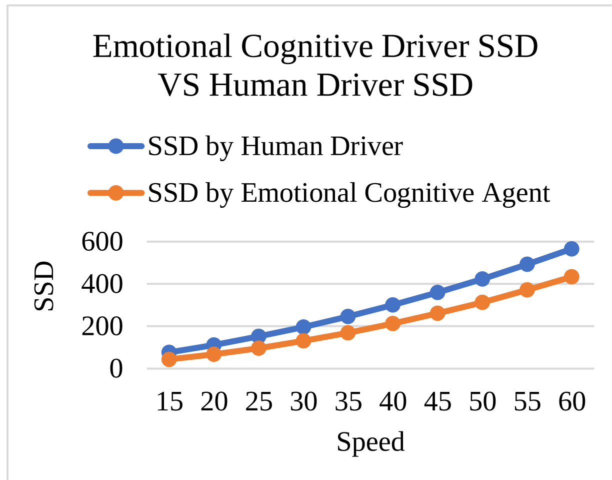

Fig. 5 Positive relationships between speeds and break time, save distance and SSD.

V. COMPARISON

In the existing literature, Riaz et. al [12] has proposed Emotion Enabled Cognitive (EEC) Agent to avoid the road crashes, occur due to perfunctory decisions by human drivers. However, no standard equation has been utilized in [12] to compute the performance of EEC Agent to rear-end collisions. Though, EEC Agent proposes fear-based mechanism to avoid lateral collisions, however, fear incorporation algorithm has not been presented [12]. Another main contribution as compared to the existing state-of-the-art [12] is that, standard agent-based modeling tool Net logo has been used to simulate and test the performance of the Emotion Enabled Cognitive Agent. However, the existing state-of-the-art [12], EEC_Agent has been implemented using C#. It means that the existing EEC Agent has not been implemented and tested in real a sense because C# does not provide any functions or libraries for the simulation/ testing of the agent-based modeling.

VI. CONCLUSIONS

An emotional cognitive driver has been proposed in the paper to overcome the accidents caused by human driving factor. The proposed system is empowered with emotion of fear, so the system can respond to avoid accident. To evaluate fear the parameter has been established (low, average and high). SSD formula enable the system to decide its reaction to the situation. Furthermore, comparison between the emotional cognitive driver and human driver has been done. SSD of emotional cognitive driver has always been more effective and efficient than human drivers and reaction time always remain 1second, but the reaction time of humans is 2.5 seconds.

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