Design and Implementation of Auto Driving Algorithm with Lane and Speed Deciding Using GPS

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Abstract

In this paper, the technique to implement a fuzzy logic based interactive system and which will guide the vehicles using their GPS location based raw data has been described. A two lane system has been implemented. It is assumed that each vehicle has a GPS locator inbuilt and having the resolution of 1mt and capability to send its location via RF to the central based intelligent system remotely. This algorithm first place 5 vehicles randomly on the GUI based road that provide randomly speed to each of them. This algorithm will predict a new location for each vehicle according to the individual speed and also predict that there should have minimum of 1mt distance in between every vehicle. The vehicle will change its lane to avoid accident and otherwise will slow its speed. The main aim is to provide an advance algorithm based on GPS locator system so that it will provide a very good and advance precision based auto lane changing system which can be used for every type of vehicle.

Keywords: Fuzzy Logic, Auto Lane change, GPS locator, random location, random speed, central server

1. Introduction

As, many other technologies have been used in automatic vehicle driving till now. They include image processing based techniques, sensor based techniques. But there are some problems which are related to these techniques. As the image processing technique work when there is smooth traffic flow. When there is more congestion on the road, it doesn’t work well. In sensor based technology, noise effect arises, which creates a problem. Overheating of sensors is also a problem. A sensor installed in the vehicle can sense the vehicle to a very limited area. But these all problems have been removed in this new developed system. Because in this system, GPS has been used to predict the location of the vehicles, which has much accuracy. As, GPS has been used widely in vehicle tracking all over the world. Because it provide more accurate locations of the vehicles in comparison to other techniques.. Also it provides security to the vehicles. In this paper, according to the algorithm, the random locations will be allocated to the vehicles. Then random velocity is allocated to all the vehicles. And the central server will guide the vehicles using their GPS location based raw data .After that vehicles will move according to their individual speeds by maintaining at least 1mt distance between them .When a current vehicle in the first lane, going to collide with the other vehicle, it will change the lane, if it cannot, then the in front vehicle will try to change the lane. And the in front vehicle will change the lane if it cannot also change the lane then the current vehicle will slow its speed. Same strategy will be applied for the vehicles which are present in second lane.

2. Literature Survey

2.1 Daniel Chi Kit Ngai and Nelson Hon Ching Yung, Senior Member, "A Multiple-Goal Reinforcement Learning
In this paper, two algorithms Q learning and DAQL have been used under multiple Goal reinforcement algorithm. Q learning applies on the static environment whereas DAQL is applied when working on dynamic environment. Several goals have been accomplished by using DAQL algorithm. Sensors are used to capture the information of the vehicles.

2.2 Kakin K. Tsoi, Mark Mulder, David A. Abbink, "Balancing Safety and Support: Changing Lanes with a Haptic Lane-keeping Support System", IEEE 2010[7]. Previously the Haptic guidance system supports only in Lane keeping but not in Lane changing. But according to this paper, the haptic guidance was beneficial during lane keeping tasks with significantly increased performance and reduced steering activity. It showed that drivers could comfortably make lane changes and felt in control during the maneuver.

2.3 Ambade Shruti Dinkar and S.A Shaikh, “Design and Implementation Of Vehicle Tracking System Using GPS”, Journal of Information Engineering and Applications ISSN 2224-5758 (print) ISSN 2224-896X (online) Vol 1, No.3, 2011[13]. In this paper, it is explained that by installing GPS in vehicles, we can accurately track the vehicles. It increases the security of the vehicles. It tells about the communication process between server and GPS.

2.4 James Vernon: Visiting Consultant Scientist, "Fuzzy Logic Systems"[18]. In this paper, it is told that for which kind of applications, we should use fuzzy logic. Vehicle Automation is one of the applications of Fuzzy Logic. By having an uncertain input, we predict certain actions or outputs.

2.5 Li Ming-shun, LIU Dan-dan, "Study on Traffic Impact of Lane-changing at the Urban Intersection", IEEE 2011[2]. As both the characteristics of people and vehicle are different in real driving process. This paper studies the effect on road capacity, intersection delay and the rear-end collision probability by analyzing the mandatory and selectivity lane changing. VISSIM is only used for delay simulation.

2.6 Nazli E. Kahveci and Petros A. Ioannou, "Automatic Steering of Vehicles Subject to Actuator Saturation and Delay", IEEE 2011[6]. In many steering Applications, the actuator saturation nonlinearities and delay control are the big challenges. A control design with delay compensation and antiwindup augmentation schemes has been proposed in this paper.

2.7 Wei SHI, Hua KUANG, Li-yun DONG and Shi-qiang DAI, "Characteristics of Lane Changing Induced by Bus Stop and Deceleration Area", IEEE 2011, Fourth International Joint Conference on Computational Sciences and Optimization[3]. In this paper, two new traffic states are found in addition to the seven distinct traffic states with the variation of density. One of them shows that lane-changing occurs frequently whether in front of or behind the bus, the other shows the stop-and-go wave will appear simultaneously on both lanes. With increasing density, the lane changing region is alterable around the bus. The spatio temporal patterns of the different traffic states are presented.

2.8 XUE Guoxin, SUN Yuqiang, SHI Guodong and Wang Yue, "One-lane Traffic Flow Simulation Model based on Imaginary Slope with Changing Tail Length", IEEE 2011[4]. In recent years, cellular automaton method has been widely applied in modeling of traffic problems. Cellular automaton models could simulate acceleration, random deceleration and determined deceleration characteristics and lot of traffic phenomenon. Simulation results showed that this kind of model could avoid colliding with each other when the cars run fast and the cars could approach their leading cars sufficiently when the cars run slow.

3. Problem definition

To create a system based on central server, in which a central server can control all the vehicles. Only the central server can have the information about vehicles, no intervehicle communication should be there. Only server and vehicle communication should occur.
4. Research Methodology

The most important about this algorithm is that it is centrally based. That is, a central system is controlling all the vehicles. Algorithm is executing simultaneously on all the vehicles, placed on the road. We designed a two lane system in MATLAB 2011b. We are running two auto driving systems, which are two lane. One is running without Lane Changing Algorithm and second system is running with Lane changing Algorithm. In the first one, the vehicles move according to the random speed allocated to them, in which several cases can be arise. In the first case, we can consider that All of them may have almost constant velocity with a minor difference in their velocities. In this case, there may be no situation of accident. The other case can be like that we consider a current vehicle which may have less speed than the infront vehicle which is moving infront of it. In this case also, there will also be no situation of accident because the vehicle which is at the front have more speed and it will be having no interruption in its way. It will reach at the target without any interruption and without any collision. And the vehicle moving at its back has slow speed than the vehicle, which is moving infront of it. It will also move without any interruption because it has slow speed and it will reach the target also without any collision. The other case can be like that when there is a current vehicle and a infront vehicle. And the current vehicle has more speed than the infront vehicle, which is moving infront of it. Then, surely there will be chance of collision in this case. And in this case, the auto driving system which is running without auto lane changing algorithm, the collision will occur and alarm will occur. The system will stop executing.

But in the second case, where we are applying the Lane changing algorithm, this system will also run simultaneously with the previous system. Here also several cases generates like in the previous case. When the vehicles have almost constant velocity with little variation, the vehicles in this case also will move same as that of previous case, where we are not applying any lane changing algorithm i.e. that system is running without this Lane changing algorithm. When there is less variation in the velocities of the vehicles, the vehicles will reach the target without any accident and without any interruption because a gap will always be maintained in them from starting to target and all the vehicles will move very smoothly. But when there is big variation in the velocities in this algorithm then there are further two cases generate in this case. When the infront vehicles have more speed and the vehicles at the back, have less speed. Then, the vehicles will also move as same as they move in the system, where we did not apply lane changing algorithm. Because, here also no case of accident will arise. But, here when the current vehicle going to collide with the infront vehicle, i.e. the current vehicle has more speed than the infront vehicle, then the case of accident arise. In this case, as it is a two lane system, if the vehicle is in 1st lane and it wants to change lane to avoid accident, it will change the lane and come to the second lane. But what will happen, if some other vehicle is already moving parallel in the second lane?

Here also three cases arise, if the parallel moving vehicle will have less speed, it will lack behind in the second lane than the current vehicle in the first lane, then it will have no problem in changing lane. And if the vehicle in the second lane parallel to the current vehicle in the first lane moves fast, than it will cross the current vehicle in the first lane, in this case also the current vehicle will also change lane from first to second easily. There will be no big issue for these cases. But if the any other vehicle is moving exactly parallel in the 2nd lane to the current vehicle in the first lane with the same velocity, then the current vehicle can not change the lane. In this case, we will make the infront vehicle of the current vehicle to change the lane to avoid accident. The same conditions apply for the infront vehicle also. That is in some cases, it may be able to change the lane and in some other cases, it may not be able to change the lane. That is, when any other vehicle is moving exactly parallel in the other lane to the infront vehicle in the first lane. That time, it will not change the lane. And, if any other vehicle is not moving exactly parallel to the infront vehicle in the first lane, then it can change the lane. The case arises in which the infront vehicle can also not change the lane, in that condition, the current vehicle in the first lane will slow its speed.
Here, we created a matrix which is acting as a central server. In this, we have six columns and five rows. First column in the matrix provides no of vehicles. Second column provides the row locations of all the vehicles on the road. Third column provides the column locations of all the vehicles on the road. Fourth column provide the random speed of all the vehicles in km/hr. Fifth column provides the random speed of all the vehicles in m/sec. The sixth column provide the time which each vehicle will take to move to the next pixel.

### Lane Changing Algorithm

**Main Algorithm**

1. Create Road_image, which is a rgb image.
2. Create vehicle_images, which are also rgb images.
3. Get random locations for the vehicles.
4. Allocate random speed to the vehicles.
5. To check for collision, **collision check subroutine** is called.

**Checking for Collision subroutine**

1. If the vehicle is going to collide.
2. **Lane change subroutine** is called.
3. Increment vehicle position by 1 pixel.
4. If reached the target, stop the algorithm.
5. Else, goto step 5 of Main Algorithm

### Lane change subroutine

1. Check desired no.of columns parallel to the current vehicle to change lane.
2. If the columns are available, change the lane.
3. Elseif, infront vehicle will change lane.
4. Else, Current vehicle will slow its speed.
5. Go to step 3 of Checking for Collision subroutine.

### Results and Discussions

This is one of the simulation result,where according to the graphical image 2.1, initially, v1, v2, v3 are in the 1st lane and v4, v5 are in the 2nd lane. But then, v2 collides with v3 in the lane system in which we have not applied the lane changing algorithm. That means v2 have higher speed than v3. But in the proposed system, it changes lane to avoid collision. According to the graphical image, it has changed its lane. v1 also changes the lane from 1st lane to 2nd lane. No other vehicle changes the lane.
In the graph, it is shown that, only v1 and v2 vehicles changes its position from 1\textsuperscript{st} lane to 2\textsuperscript{nd} lane. According to the graph, firstly the vehicle v1 changes its lane from 1\textsuperscript{st} lane to 2\textsuperscript{nd} lane before it reaches the mid of the lane whereas v2 changes its lane almost at the end of the lane. But all the other vehicles were in the same lane as they were. No other vehicle change the lane.

In this table 1, the actual and attained speeds of all the vehicles are given. It is given that what was the initial speed of each vehicle. And then, it is given that what speeds they attained through all the way to change lane or to avoid collision. The difference in the actual and attained speeds is calculated. The no. of collisions occurred by the vehicle is given. At the last, safety index is calculated.

According to this table, only the v1 and v2 has different actual and attained speeds. Its actual speed is 17 and attained speed is 14.3165. And the difference in the actual and attained speed is 2.6835. The actual speed of vehicle two is 18 and attained speed is 11.0557. And the difference in actual and attained speed is 6.9443. All the other vehicles has same actual and attained speeds. And the no of collisions by every vehicle is 0 throughout its path.

This is another simulation case, where it is shown in the graphical image 3.1, that there is no collision of any vehicle with any other vehicle. All the vehicles have enough space difference between them to move smoothly. Also, there is no change lane by any of the vehicle. They all are in the same lanes as they were initially.

![Figure 2.2 Lane Change by v1 and v2](image)

![Figure 3.1 Vehicles with suitable difference in location](image)

### Table 1 v1, v2 with difference in actual & attained speed

<table>
<thead>
<tr>
<th>Actual speed (km/h)</th>
<th>Attained speed (km/h)</th>
<th>Difference in speed</th>
<th>No of collision</th>
<th>Safety index</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>14.3165</td>
<td>2.6835</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>11.0557</td>
<td>6.9443</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

![Available online@www.ijcta.com](image)
As the vehicles were having enough space to move smoothly, shown in the graphical image. Any of the vehicle did not change lane, shown in the graph 3.2.

Table 2 Vehciles with the same actual & attained speed

<table>
<thead>
<tr>
<th>No. of vehicle</th>
<th>Actual speed (km/h)</th>
<th>Attained speed (km/h)</th>
<th>Difference in speed (km/h)</th>
<th>No. of collisions</th>
<th>Safety index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>27</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

As there was enough space in the vehicles, shown in the graphical image. And no vehicle change its lane, shown in the graph. That's why, there is no difference in the actual and attained velocities, every vehicle have same actual and attained speed in the table 2. The no of collisions by all the vehicles is 0. And the safety index is 1.

6. Comparison study

The parameter Safety index (SI) = c, which represents the percentage of simulation episodes for the simulation task in which the vehicle successfully reached the target without collision.

It is given by \( c = \frac{m}{k} \) where \( m \) is the total simulation episodes without a collision, and \( k \) represents the total number of simulation episodes.

According to the Multiple-Goal Reinforcement Learning Method, its value is 0.99 when five vehicles are present on the road.

But according to the Auto driving Algorithm with Lane and speed deciding using GPS locator, is 1 when five vehicles are present on the road, which is better than Multiple-Goal Reinforcement Learning Method. And also there are no collisions in case of Auto driving algorithm with lane and speed deciding using GPS.

6. Conclusion and Future Work

The purpose of this paper is to implement a fuzzy logic based interactive system and which will guide the vehicles using their GPS location based raw data. In this, the auto-driving algorithm running on the centrally based system will guide a new location for each vehicle according to its individual speed. Most importantly, it consider the real time motion of the vehicles. That is, it has applied on dynamic environment. According to this work, the vehicle is changing its lane successfully to avoid collision and the vehicle can also vary its speed to avoid collision if it cannot change lane. All these goals like Lane following, Lane changing has been achieved successfully without collision by implemented the Algorithm i.e Auto driving Algorithm with Lane and Speed deciding using GPS Locator. This work has been implemented on the straight road. But in the future, we can try to implement the same algorithm on the curve road.

References


Conference on Computational Sciences and Optimization.


