A Methodology for Managing and Intersection of Intelligent Highway Control System

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Abstract: This paper describes the control strategies for synchronizing the movement of the vehicles on the highway which has a narrow road linked to it using radio communication. The sensors detect the vehicles on the roads and the highway control scheme uses the Radio Communication measurements to broadcast the position of the vehicles on the highway to the vehicles on the narrow road. The narrow road vehicle takes the action whether to increase or decrease its speed based on the information broadcasted to it. The entire method of controlling the speed of the vehicle is based on the sensing of the vehicles and calculation of time required for the vehicle to reach from one point to another. This management scheme prevents the accidents on highway intersection and cross-roads and possible collisions due to negligence of the driver. It also reduces the time delay for the narrow road vehicle while entering the highway. This paper describes the Radio Communication, discusses key issues in system design, and provides experimental results.

Keywords: Highway, Cross Roads, Collision, Radio, Synchronizing.

Introduction:

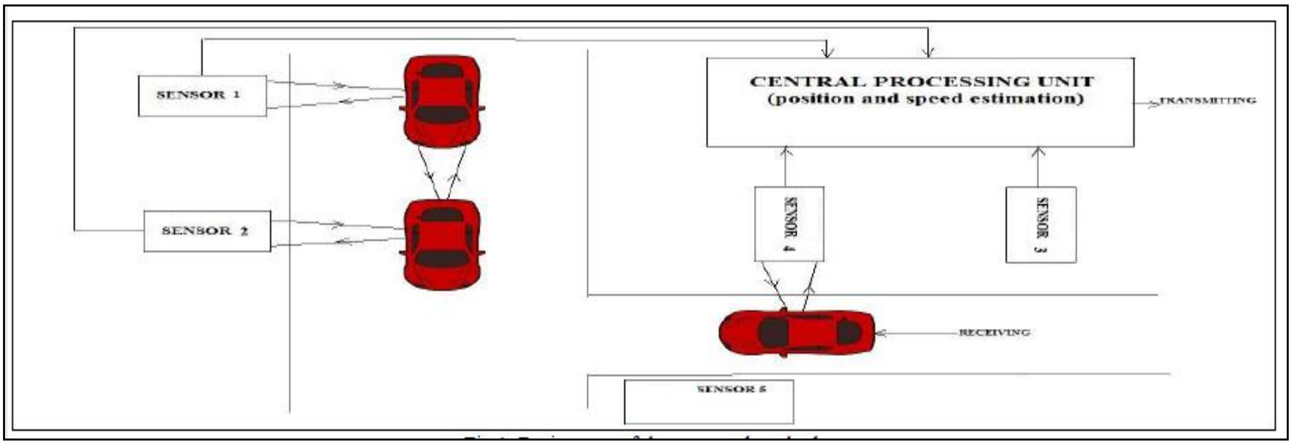
Extensive research has been focused on automated highway system in the past two decades. The highway control system extracts useful and accurate traffic information for traffic flow control, such as vehicle count, vehicle speed, and vehicle classification. The basic techniques involve detection and communication. In most of the automated highway systems, the intelligence is provided only to the vehicles, but in this case, the intelligence is provided to vehicles as well as the highway. This intelligence system will decrease the load effort on the drivers as a part of the intelligence is being provided to the road. In this paper we present a novel approach for vehicle etection, communication, synchronization, and control strategies. The basic framework of this system comprises of a highway and a narrow road linked to it. Here a vehicle on the narrow road wants to enter the highway and there is a possibility of another vehicle on the highway. This paper will present the control strategies for synchronizing the movement of these vehicles approaching the junction. These strategies can be applied to solve the problem of steering an autonomous vehicle on a highway and a narrow road. The aim of this system will be to control the speed of the vehicle on the narrow road (which wants to enter the highway) without affecting the speed of the vehicle which is on the highway. Thus we will strategize solutions in such a way that the vehicle on the narrow road will adjust itself without affecting any movement of the vehicle on the highway. The speed of both the vehicles will be calculated and based on that, the time required to reach the junction by each of them will be found out. The junction is the point of intersection of the highway and the narrow road. The following will be achieved with the help of sensors, a data transmitter and a receiver. The sensors will be placed on the roads which will be able to detect the position and the speed of the vehicles. There will be a data receiver on every vehicle. The central processing unit (CPU) will transmit the movement details (direction, position and speed) of both the vehicles. The narrow road will have its own private network which will receive the information transmitted by the CPU and then broadcast this information to every vehicle on the narrow road. Based on these data, action will be taken by the narrow road vehicle whether to slow down its speed or to increase its speed before entering the highway. There will be a complete synchronization between both the vehicles so that they do not collide with each other. Three cases can be seen when both the vehicles will be approaching the junction.

- When the vehicle in the highway is very close to the junction and the vehicle in the narrow road is far from the junction. In this case both the vehicles will be travelling in their normal speed and will pass the junction one after another without any collision.
- When the vehicle in the highway is far away from the junction and the vehicle in the narrow road is closer to the junction. In this case both the vehicles will be again travelling in their normal speed and will pass the junction one after another without any collision.
- When both the vehicles are close to the junction. In this case, if both the vehicles travel with their normal speed then it may lead to collision of both the vehicles near the junction.

To avoid this collision two actions can be taken:

- ✓ Increase the speed of the vehicle which is travelling in the narrow road so that it passes the junction easily and then the highway vehicle follows it.
- ✓ Decrease the speed of the vehicle which is travelling in the narrow road so that the vehicle which is in highway passes the junction and then the narrow road vehicle follow it.
- ✓ This increase and decrease of the speed will depend on how much time they would require to cross the junction from their respective positions.

In case if there is a chance of collision due to the negligence of the driver, then the sensor in front portion of the vehicle will detect if there is any obstacle in its path and then the vehicle will take the necessary actions to avoid the collision. So in a way it will be an intelligent vehicle which will avoid collision and will lead to customer satisfaction by providing safer means of travel.



Basic setup of the proposed method

Assumptions:

• The vehicles on the highway are travelling at a constant speed.

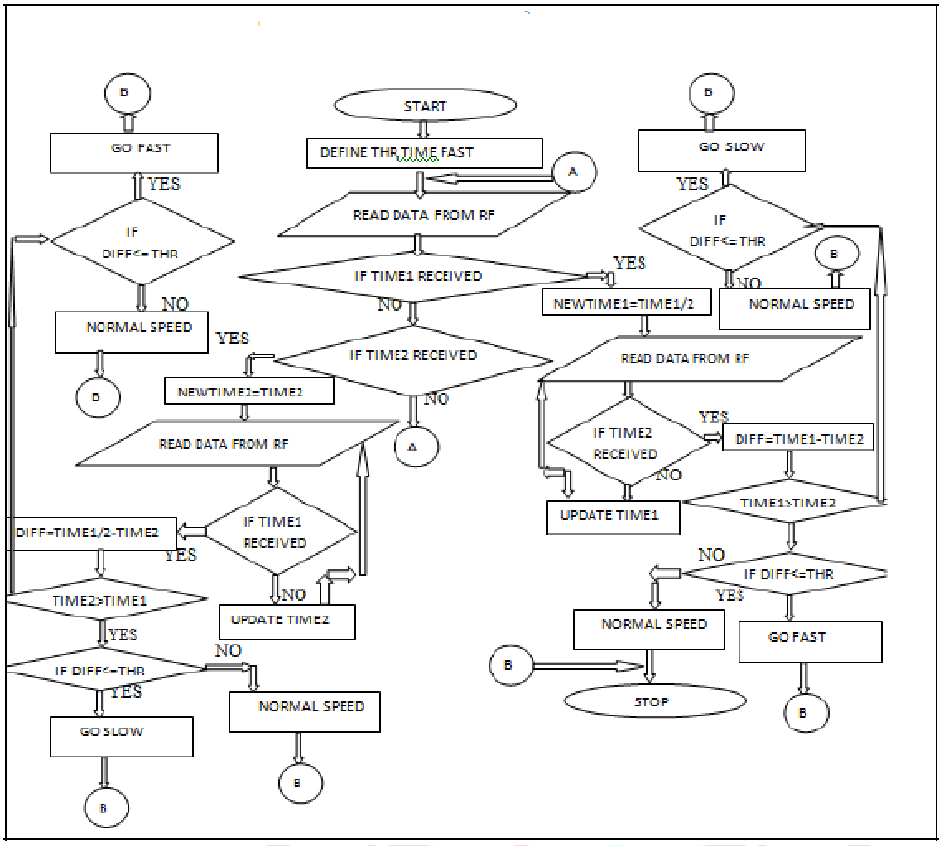
• The sensors are not affected by the environmental factors like rain, sunlight etc.

• There are no other objects on the roads except the vehicles.

• There is no signal interference in the radio signals.

Research Methodology:

The research idea is implemented in a small scale model using infra-red sensors and a RF transmitter and receiver for communication. The CPU is an 8-bit microcontroller. Below is a detailed description of how this model works. The total system consists of five sensors, two of which are placed on the highway and two is placed on the narrow road. The remaining one sensor is placed near the junction. In figure the distance between the sensor 1 and sensor 2 is twice the distance between the sensor 2 and the junction, so we can say the time required by the vehicle to reach from the sensor 2 to the junction is half the time required to reach from sensor 1 to sensor 2. The distance between the sensor 3 and sensor 4 is same as the distance between the sensor3 and the junction, so we can say the time required by the vehicle to reach from the sensor4 to the junction is nearly same the time required to reach from sensor 3 to sensor 4. The sensor 5 which is placed near the junction tells the vehicle on the narrow road that the vehicle on the highway has passed the junction and the vehicle on the narrow road can now run in its normal speed. The next figure shows the working of the CPU. The CPU takes the value from the two sensors which are placed on the highway or on the narrow road and calculate the time required by the vehicles to cover the distance between these two sensors. A timer is initially set on. As soon as the vehicle reaches the 1st sensor the timer value is noted and again when the same vehicle reaches the 2nd sensor the timer value is again noted. The difference of both the timer is done to calculate the time required by the vehicles to cover the distance between these two sensors. The receiver will be placed in the narrow road vehicle and will receive the data transmitted by the transmitter which is interfaced with the microcontroller on the roads. The time will be received twice by the receiver, once for the highway vehicle (T1) and the other for the narrow road vehicle (T2).

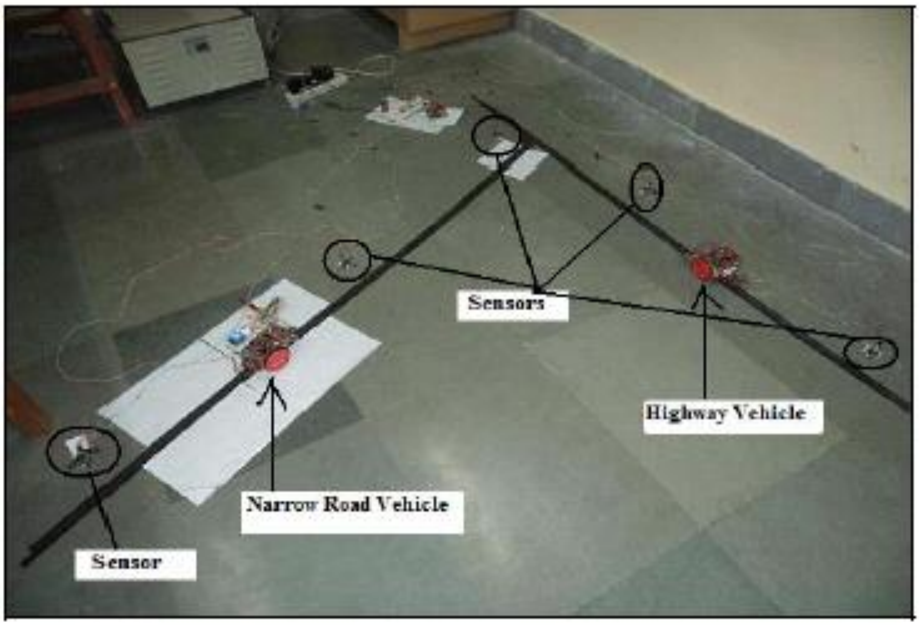


(Flow chart showing the speed control mechanism of the vehicle)

The receiver will thus receive the information about both the vehicles and the actions will be taken based on this information by the narrow road vehicle. figure shows the speed control algorithm of the narrow road vehicle. Once the time needed by the highway vehicle to reach the junction is calculated and is broadcasted to the vehicles of the narrow road. The narrow road vehicle will also know the time required by it to reach the junction. So, the narrow vehicle will have the information of both the vehicles. Now the time required for both the vehicles to reach the junction will be compared and based on that the decision will be taken by the narrow road vehicle whether to increase or decrease its speed so that it can enter the junction and avoid the collision. Now let us suppose T1 is the time required by the highway vehicle to reach the junction and T2 is the time required by the narrow road vehicle to reach the junction. Then following observations and actions can be taken.

- If T1>>T2 then we can say time required by the highway vehicle is more than the time required by the narrow road vehicle to reach the junction. In this case both the vehicles will travel in their normal speed and will reach the junction one after another.
- If T2>>T1 then we can say time required by the narrow road vehicle is more than the time required by the highway vehicle to reach the junction. In this case both the vehicles will travel in their normal speed and will reach the junction one after another.

- If T1 is slightly more than T2 (T1>T2) then the difference (diff.) will be compared with the certain threshold value which is already defined (let us say 2sec).Now since (T1>T2) we can say that narrow road vehicle is closer to the junction. If the diff. is smaller than the threshold then the narrow road vehicle will have to increase its speed to enter the highway without any collision else if greater than threshold they can travel with their normal speed and cross the junction.
- If T2 is slightly more than T1 (T2>T1) then the difference (diff.) will be compared with the certain threshold value which is already defined (2sec).Now since (T2>T1) we can say that highway vehicle is closer to the junction. If the diff. is smaller than the threshold then the narrow road vehicle will have to decrease its speed to enter the highway without any collision else if greater than threshold they can travel with their normal speed and cross the junction.



(Basic set up of Highway Control System)

(T1>>T2)

(T2>> T1)

In these figure one vehicle was closer to the junction and the other vehicle was far away from the junction, so there was no chance of collision and hence both the vehicles travelled with their normal speed and crossed the junction one after another, whereas 8 both the vehicles were closer to the junction so there was a chance of collision. In order to avoid this collision the speed of the narrow road vehicle was increased as the time required by it to reach the junction was slightly less than the time required be the highway vehicle to reach the junction (T1>T2) and in Fig. 8 the speed of the narrow road vehicle was decreased since the time required by it to reach the junction was slightly more than the time required by the highway vehicle to reach the junction (T2<T1).

Conclusion:

If this control system is implemented in the real world, then the accidents on the highways can be reduced to a great extent. Also the wastage of time due to long waiting in traffic can also be reduced. This system will be of great help in designing the fully autonomous traffic control system which includes both intelligent vehicles and highways. This small scale model when implemented in large scale in real world with better communication, sensors, tracking device and with more optimized algorithm will prove much more efficient. There is a wide range of benefits that can be obtained from ITS deployments. For example, fuel consumption, travel time, and delay can be reduced. ITS deployments can also result in higher travel speeds, improved traffic flow, and more satisfied travelers for all modes.

References:

1) G. Lu, Masayoshi Tomizuka, "LIDAR Sensing for Vehicle Lateral Guidance: Algorithm and Experimental Study", Mechatronics, IEEE/ASME Transactions on, On page(s): 653 - 660, Volume: 11 Issue: 6, Dec. 2006.
2) W. Zhang, Q. M. J. Wu, G. Wang, X. You, “Tracking and Pairing Vehicle Headlight in Night Scenes”, IEEE Transactions on Intelligent Transport Systems, Volume: PP Issue: 99, On page(s): 1-14, September 2011.
3) Optimization. November 2004, DKS Associate Transportation Solutions and Siemens Intelligent Transportation Systems.
4) Varaya P. “Smart cars on Smart roads. Problem of control”,IEEE trans automation control,vol.38 no.2,1993.
5) W. W. Chen, H. T. Sin, D.C.H, Q. R. Wang, J. Li, “Tracking control of automatic guided vehicle based on lane marking navigation”. Chinese journal of mechanical engineering, vol. 42 of 4-170, 2006.
6) Regan, M., Langford, J., Johnston, I., & Fildes, B. (2006). Intelligent Transport Systems and safer vehicles. Clayton, Australia: Monash University Accident Research Centre.

7) Lappin, J. E., Chapter 4: What Have We Learned About Advanced Traveler Information Systems And Customer Satisfaction, John A. Volpe National Transportation Systems Center.