# *A Novel Forward Vehicle Collision Avoidance Methodology through Integration of Information and Communication Technologies at Intersections*

Vivek Singhal
Centre for Transportation Systems (CTRANS)
IIT Roorkee
Roorkee, India
viveksinghal82@gmail.com

S.S.Jain
Department of Civil Engineering and CTRANS
IIT Roorkee
Roorkee, India
profssjain@gmail.com

***Abstract*—The enormous growth of vehicles on the roads increases the demand of different information and communication technologies to be extensively available over the road networks for better vehicle collision avoidance activities. The most occurring vehicle collision occurring in the present scenario is the forward vehicle collisions. The forward vehicle collision occurs when a vehicle tries to overspeed and therefore tries to overtake other vehicle to reach earlier at a particular intersection. Earlier works on vehicle collision avoidance systems did not enlighten about the integrated use of different information and communication technologies (ICT) for better collision avoidance activity. In this paper, we propose a novel, methodology which was implemented in programming language C++ for forward vehicle collision avoidance by integration of different information and communication technologies (ICT) i.e different geographical positioning and sensor based techniques at intersections like low cost camera, GPS, long range ultrasonic distance sensor and also does vehicle to vehicle communication through dedicated short range communication (DSRC) i.e bluetooth at intersections. Some trial test data was taken at roorkee city, intersection and was input to the C++ implementation of the methodology proposed. The method was found to be effective for collision avoidance at intersections.**

***Keywords- vehicle collision avoidance; sensor; intersection; global positioning system; information and communication technology (ICT)***

## I. INTRODUCTION

### *A. Information and Communication Technology (ICT)*

Information and Communication Technology (ICT) describes the information access through different communication technologies. The World Bank described ICT as " the set of activities which facilitate by electronic means the processing, transmission and display of information"[11].Therefore Information and communication technology (ICT) combines the use of different hardware and software technologies for electronic communication, data collection and processing in distributed networks. The attributes of ICT which included the extensibility, track ability, and intelligence i.e. speeding up, extending through spatial interaction, traffic management and speeding up data retrieval, processing and steering, and reorganizing the value chains with their spatial pattern respectively [13].

### *B. GPS Based Collision Avoidance System*

Collision avoidance system for a host vehicle includes a Global Positioning System (GPS) residing on the host vehicle for determining the host vehicle's location as the host vehicle travels based on signals received from one or more satellites, a map database having digital maps corresponding to an area including the location of the host vehicle as determined by the global positioning system, a vehicle-to-vehicle communication system residing on the host vehicle operative for receiving signals including location information acquired by global positioning systems residing on other vehicles directly from the other vehicles indicating the locations of the other vehicles, and a navigation system including a display residing on the host vehicle for displaying images to an occupant of the host vehicle showing the digital maps and indications of the locations of the host vehicle and the other vehicles on the digital maps. The navigation system also updates the images shown on the navigation. The GPS source may be the mobile phones of the automobile passengers, and the mobile phone of the bicyclist. The phones can even manage the collision avoidance.

### *C. Sensor Based Collision Avoidance System*

The system consisting of sensors is placed within a vehicle to warn its driver of any dangers that may lie ahead on the road. Some of the dangers that these sensors may observe is the one vehicle may be close to other vehicle surrounding it, how much speed it needs to reduce while going around a curve, and observe how close the vehicle is to going off track. The system uses sensors that send and receive signals from things like other cars; obstacles in the road, traffic lights, and even a central database are placed within vehicle and tell it of any weather or traffic precautions. A situation that provides a good example of how the system works is when a driver is about to change lanes, or car in its vicinity. The sensors will detect that car and inform the driver before he starts turning, preventing him from potentially getting into a serious accident. Collision avoidance systems are especially useful in bad weather conditions. Sensors in the vehicle may also be capable of detecting the poor conditions and inform the driver on how to drive in them. For example, because fog affects visibility, the sensors would recognize

this and alert the driver of any dangers that lie ahead, like a windy turn or another car, giving the driver enough time to slow down, allowing him to escape from what could have been a bad accident. Ongoing research also focuses on collision avoidance during night with aid from IR and long range ultrasonic sensors because of their low cost.

### *D. Vision Based Collision Avoidance System*

Vision-based systems make use of complex algorithms to ensure detect obstacles and lane markers in front of the vehicle. This type of lateral collision avoidance system uses an on-board computer and employs binocular stereosis to locate lane markers and obstacles that fall within the field of vision. The forward movement of the vehicle would continually update the information stored by the computer, which transforms obstacles and lane markers into geometric shapes that exist in the vehicle's field of vision. These vision-based systems are intended to work in conjunction with non-visual sensing techniques, such as magnetic sensors for lateral position measurement and active range sensors, for a more integrated approach to vehicle control.

### *E. Problem Identification*

Road Network involved the problems of overutilization of roads, over speeding and overtaking of vehicles which leads to the road accidents. GPS based technology had the problems of accuracy in determining the position of vehicle whereas sensor and vision based technology could only detect the vehicle in its vicinity at intersections. Therefore the problems identified are the limited use of integration of these different geographical positioning, sensor and vision based techniques at intersections**.**

### *F. Paper Organization*

In this paper, we have organized it in sections. Thus, in section-I introduction has been discussed. Based on literature review, some problems were found in this mechanism that has been discussed in section-II entitled related work. In section–III solution is proposed for the problems under the heading of the proposed methodology and implementation. Section-IV provides the results and analysis. Section-V provides the conclusions and future scope.

## II. RELATED WORK

A future trajectory predictable cooperative-driving-based collision detection [12] was proposed using low cost DGPS with extended KF (EKF) i.e AshTech G12 receiver (0.4–0.5-m STD7) operating at 5 Hz which was a location observer and motion sensors like Donner MEMS gyro and 47-tooth wheel speed sensors. The objective of this system was to study the feasibility and methodologies of cooperative driving where either vehicle to vehicle communication, vehicle to infrastructure communication is done through use of in vehicle sensors.

Eaton Corporation [3],[4] developed collision avoidance system which was called Bendix VORAD (vehicle on-board Radar) system for commercial trucks and heavy military vehicles. The model VORAD VS-400 system detected vehicles and obstacles through a forward looking 77GHz radar (detection range of 3 to 500 ft and speed of 0.5 to 120 mph). The VORAD system also detected side competing vehicles and obstacles through a side object detection system called Blind Spotter.

A safety crash warning system [2] to minimize the number of crashes on the road that avoids rear end crashes and also take over the control of the vehicle when the threat is at the highest level, but here properties of system like feasibility, robustness and reliability of system were maintained using temporal logic with implementation in a synchronous programming language named ESTEREL [1],[5],[6],[7] which allows the synchronous communication of parameters between modules that models real time behavior of system and simplifies these modules in relation to hardware circuitry. This implementation responds faster as ESTEREL [8], [9], [10] logically takes no time as compared to other existing systems. In this Mechanism the Forward Looking automotive radar sensor which was specially built sensor for intelligent cruise control and forward looking collision warning systems was used which gathered data at each time instant from parameters vehicle's ambience. Thereafter formal verification was done to check properties i.e. feasibility, robustness, reliability etc.

## III. PROPOSED METHODOLGY AND IMPLEMENTATION

In this paper a methodology which was implemented in programming language C++ for forward vehicle collision avoidance through integration of information and communication technologies (ICT) at intersections is proposed. This methodology does the forward vehicle to vehicle collision avoidance through integration of low cost camera, GPS, long range distance sensor and also does vehicle to vehicle communication through dedicated short range communication (DSRC) i.e. bluetooth at intersections and describe how it behaves in different situations of forward collision avoidance. The methodology makes use of a low cost video sensor e.g video camera for detection of color of traffic lights at intersection and also for detection of forward moving vehicles, low cost GPS with antenna for finding the location of the vehicle and bluetooth for vehicle to vehicle communication. The long range ultrasonic distance sensor with range of about (0.5m to 15 m) and a speed radar gun are meant for measurement of relative distance and relative speed from intersections or from other vehicle respectively. The methodology for ICT based forward vehicle collision avoidance through integration of different sensor and GPS techniques is shown in Figure1. The cost of various components along with their cost are shown in Table I.

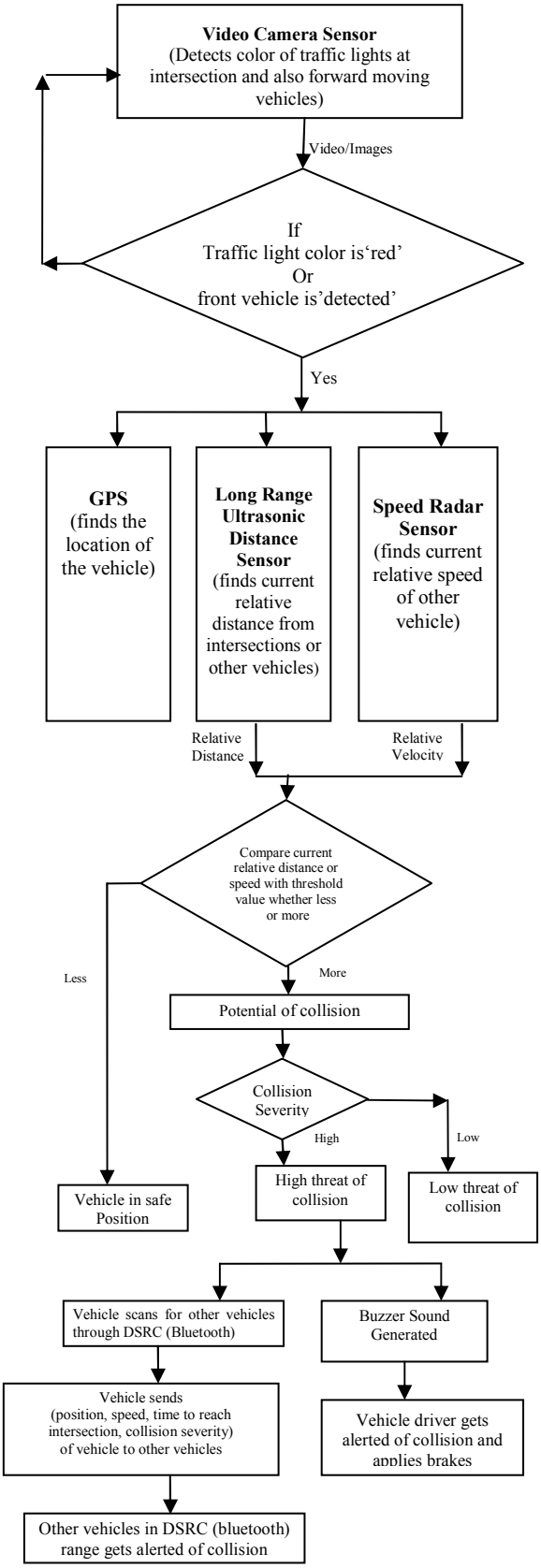


Figure 1. Methodology for ICT based forward vehicle collision avoidance

TABLE I LIST OF VARIOUS COMPONENTS ALONG WITH THEIR COST

| S. No. | Components | Approx. Cost ( Rupees) | Purpose |
|---|---|---|---|
| 1. | GPS receiver with antenna | 2,50,000=00 | To acquire position of vehicle (latitude and longitude) |
| 2. | Long Range Ultrasonic Distance Sensor | 3,000 =00 | Acquire distance from other vehicle |
| 3. | Speed Sensor ( Speed Radar Gun) | 1,00,000=00 | To acquire speed of front moving vehicle |
| 4. | Video Camera sensor | 60,000=00 | To acquire front or surrounding view around the vehicles. |
| 5. | Buzzer/Alarm | 1,000 = 00 | To indicate vehicle driver of the danger |
| 6. | Laptop with Bluetooth, Wi-fi | 50,000=00 | To display data, store data and broadcast collision information |

## IV. RESULTS & ANALYSIS

The trial test data was taken from different instruments described above from an intersection in roorkee city as shown in Table II.

TABLE II TEST DATA

| Test Da--ta | Traffic light color | Front vehi--cle status (1 or 0) | Current relative distance from intersect--ion or from other vehicle (m) | Current relative speed from intersec--tion or from other vehicle (km/hr) | Location of vehicle (Latitude, Longitude) (aa°bb'c c.dd,ee°f f'gg.hh) |
|---|---|---|---|---|---|
| 1. | Red | 1 | 2 | 70 | (29°51'28 .14"N, 77°53'23. 21"E) |
| 2. | Red | 1 | 6 | 50 | (29°51'15 .64"N , 77°53'16. 52"E) |
| 3. | Yellow | 1 | 8 | 32 | (29°51'16 .30"N, 77°53'16. 67"E) |
| 4. | Yellow | 0 | 18 | 47 | (29°51'28 .13"N , 77°53'23. 20"E) |
| 5. | Green | 0 | 9 | 45 | (29°51'28 .10"N , 77°53'23. 11"E) |
| 6. | Green | 1 | 11 | 12 | (29°51'16 .73"N, 77°53'16. 57"E) |

This data was input to the C++ code developed for the methodology. Different parameters i.e. traffic light color, front vehicle status (1 for front vehicle present, 0 for front vehicle not present), current relative distance in (meters) from intersection or from other vehicle, current relative speed in (km/hr) from intersectionor from other vehicle and location of vehicle (latitude, longitude). Test data 1 and 2 when applied to the methodology C++ code, it gave the results of high threat of collision and thereafter vehicle sends the speed, position, speed, time to reach intersection, collision severity of vehicle to other vehicles through DSRC (bluetooth) and other vehicles are being alerted of being in danger and gets alerted. Test data 3 showed the results of vehicle being in low threat of collision. Test data 4, 5 and 6 when implemented on methodology C++ code, showed the results of being in no danger to the vehicle.

## V. CONCLUSIONS AND FUTURE SCOPE

In this paper we have proposed a Information and Communication technology (ICT) based integration of different geographical positioning and sensor based techniques at intersections like low cost camera, GPS, long range ultrasonic distance sensor with vehicle to vehicle communication through DSRC i.e. bluetooth for forward vehicle collision avoidance at intersections. The implementation of the methodology is done in programming language C++. The parameters used in the C++ implementation are the traffic_light_color, relative distance, relative speed, latitude, longitude for collision avoidance mechanism.

The proposed methodology for collision avoidance is efficient and effective over road network of vehicle competing to get earlier to the intersection. It may be improved by implementing it in real time rigorously and for enough time to prove its usefulness. Therefore, the comparison with other forward collision methodologies can also be made easily. The other improvement may be of implementation of effective DSRC techniques for vehicle to vehicle communication in future.

## REFERENCES


[1] A. Bouali, J. paul Marmorat, and R. D. Simone. Verifying synchronous reactive systems programmed in ESTEREL, Jan. 13 1996.

[2] A. Jagannath ,and T. Ashwin,"Design and Validation of Safety Cruise Control Automobiles," International Journal of Computer Science, Engineering and Applications (IJCSEA),vol.1, no.5, pp.139-153, October 2011.

[3] Eaton Corporation VORAD Collision Warning System for Military Vehicles,2007.

[4] Eaton Corporation VORAD VS-400 System Packages,2008. URL:http://www.roadranger.com/ecm/groups/public/@pub/@eaton/ @ roadranger/documents/content/ct_063188.pdf.

[5] E. Technologies. Official Website of Esterel Technologies, 2010.

[6] F. Boussinot and R. De Simone. The ESTEREL language. *Proc. IEEE*, 79(9):1293–1304, Sept. 1991.

[7] G. Berry, P. Couronn´e, and G. Gonthier. Synchronous Programming of Reactive Systems: An Introduction to ESTEREL. Technical Report 647, INRIA, 1986.

[8] G. Berry and G. Gonthier. The ESTEREL Synchronous Programming Language: Design, Semantics, Implementation. Technical report, INRIA, 1988.

[9] G. Berry. The Esterel v5 Language Primer Version v5 91. June 2000. Centre de Math`ematiquesAppliqu`ees, Ecole des Mines and INRIA, Sophia-Antipolis.

[10] G. Berry, M. Kishinevsky, and S. Singh. System Level Design and Verification Using a Synchronous Language. In *ICCAD*, pages 433–440. IEEE Computer Society / ACM, 2003.

[11] R. Francisco and W. J. Ernest, III, ”Are Poor Countries Losing the Information Revolution?,” Report of Department of Economics Center for International Development and Conflict Management , University of Maryland, pp. 1-85, 2000.

[12] Tan Han-Shue and Huang Jihua,” DGPS-Based Vehicle-to-Vehicle Cooperative Collision Warning: Engineering Feasibility Viewpoints”, in IEEE Transactions on Intelligent Transport Systems Vol. 7, No. 4, pp.415-428, Dec. 2006.

[13] W. R. Black and M.V.Geenhuizen,“ICT Innovation and Sustainability of Transport Sector,”, vol no.6, pp. 39-60, 2006.