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Investigation & Development of Voice Based Vehicle-2-Vehicle Communication System to Anticipate the Video Based Vehicle-2-Vehicle Communication System Problems

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ABSTRACT

The research work is investigating and developing a Voice based Vehicle-to-Vehicle (V2V) communication system to overcome the problems of video based V2V communication system. The Voice based V2V communication system enable a vehicle to predict and react to the different driving situations and then instantly warn the drivers using speech based warnings to avoid a possible accidents and deadly collisions as it has been investigated that video based accident warring systems are danger by their selves and creating distractions for drivers. The practical bed for Voice based V2V communication system has been proposed. For this purpose a specialized hardware has been employed .The proposed system is then tested in field for different road crash scenarios and its performance has been evaluated. It has been found that voice based systems can avoid efficiently road accidents as compare to the video based V2V communication systems. Two types of testing have been done to prove the efficiency of voice based V2V communication system. In first testing phase the functionality of voice based V2V communication system has been evaluated. After collecting data from field tests 2nd type of testing has been done using C# based simulator. The performance of voice based and video based V2V communication system has been compared for T and Y junctions. The simulation results show the dominance of voice based V2V communication system over video based V2V communication system.

KEYWORDS: Audio, Collision avoidance, Vehicle-Vehicle Communication, Video, T-Junction, Y-Junction

1 INTRODUCTION

In 2009 a report was published by world health organization, which declares road accidents as 9th major reason of deaths in the world. The report shows that only in 2009, 1.27 million died due to the road accidents [1]. To decrease this enormous ratio of deaths researchers started work on technology, which makes vehicles able to communicate with each other to avoid road accidents by exchanging information about their speeds, locations and headings. This research field is known as Vehicle–2-Vehicle (V2V) communication system [2]. In all technology advance countries like USA, Japan, and European countries, V2V communication system is in development phase. But in Pakistan this research area is very new and very few researchers are working in this field. V2V is a subfield of Intelligent Transport System (ITS). ITS is a very hot research area and the aim of this field is to improve the road commuters safety and comfort during driving [2].

In V2V communication system, vehicles are equipped with communication technology and on board sensors like ultrasonic radars and/or GPS receivers and are able to exchange their speeds, headings and locations to evade possible collisions. It helps passengers and drivers to increase their life security. Another approach to avoid the road accidents are autonomous vehicles and an effort by Pakistani researchers in this regard can be found in [3]. V2V communication system also helps drivers to save their time by avoiding

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road Jams by having road Jams alerts. [4]. Vehicles equipped with audio/video gadgets help the drivers to make their decisions. But it has been reported that video displays can create distraction for drivers and can be create dangerous situations for drivers and passengers. Also it has been found from a survey that drivers take long time to decide about which one safety maneuver is suitable to evade road accident due to video displays. In [6] it has been elucidated that video gadgets increase the driver reaction time to avoid the road accidents. However a quick response is necessary by the driver to avoid the possible collisions [5]. In this research paper we have first proved that video based V-2-V communication system creates distraction for the drivers. Then we have proposed a voice based V-2-V communication system test bed. Infield experiments and simulation results proved the effectiveness of proposed system. The remaining paper is arranged as follow. In section II drawbacks of video based V2V communication system are discussed. Section III elucidated the utilization of voice in V2V communication system. Section IV presents our proposed voice based V2V communication test bed. Section V discusses simulation and result. Performance analysis of proposed solution is made in section VI. In the last section VII concludes the paper.

2 Draw Backs of Video Based V2V Communication System

A video based V2V communication system can be explained as that all vehicles are equipped with on-roof cameras and video sending/receiving hardware and software. The proceeding car sends video alerts to the neighboring cars. The video contains information about the road hazards, road accident or road jam.

The concept of video based information system is not new and it is with us from many decays. But now new advancements in technology have made it far better than old video based information systems. To decrease the road accident possibility many V2V communication systems have proposed video based driver alert systems. The V2V com systems are using mostly IEEE 802.11 g/n for the exchange of video information.

To prove the driver distraction during the utilization of video based V2V communication system we performed infield tests. For this purpose a C# based video based V2V communication application was developed. The experimental topology includes two vehicles, one act as a server vehicle and other as a client vehicle. Server vehicle takes the video using 16 megapixel camera whereas client vehicle captures video data from the server and display it on the video LCD installed in the front of the driver. After deploying video based V2V test bed we conducted in field tests and surveys. For this purpose we select a technical crew, consist of five people. Two were sitting in server vehicle and two were in client vehicle. One other person was acting as a supporting staff.

In figure 1 it can be seen clearly that in daylight even a highest resolution cameras are failed to give the clear view of traffic flow or any road hazard. Drivers have to serve more time on video displays to understand the possibility of any dangerous situation.

These on road experiments of video based IVC system proved that, there is a need of some sort of new solution which relaxes the drivers from paying their attention on these gadgets and help them to achieve secure and comfortable driving. In figure 1 it can also be seen clearly that the driver on client side vehicle is not able to see the results of video stream sent from the server side vehicle. The reason is sunlight effect.

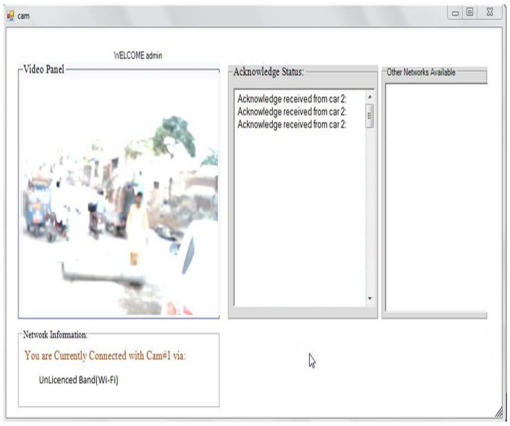

Figure. 1. Non-Cleared Client Side Video Display

3 When We Used Voice Based Warnings

When driver drive a car he/she manage multiple tasks, e.g. steering, monitoring speed and changing gears through visual channel then sounds channel can be used for intelligent warnings.

Omni directional antennas are used for to transfer information for voice communication. According to [7], sound warnings require little directional search and responses tend to be faster than visual displays. Authors also noted that human´s eyes have missing blocking ability as compared to ears, because he cannot shut his ears unlike the eyes.

4Proposed Voice Based Vehicle To Vehicle Communication Test Bed

Our Voice based V2V communication system has capability to share ((long, lat), speed, and heading) of vehicle to evade the accident possibilities. We develop this system to overcome the above mentioned problems of video based V2V communication system. The communication standard which we used as a communication medium is IEEE 802.11 N The functionality of V2V test bed is given as under.

The position of vehicles has been tracked using GPS (Global Positioning System) receiver. For this purpose Garmin eTrex legend GPS receiver has been utilized. Specialized V2V communication (peer to peer) software has been coded in Visual studio .NET using C# language. GPS (Global Positioning System) is the system able to show us our exact position on the Earth anytime, in any weather and in anywhere.

The longitude and latitude of both vehicle V1 and vehicle V2 are exchanged between each other using specialized GPS hardware mentioned above. To test the functionality of a proposed test-bed a wireless network of 3 kilometers range was deployed .For this purpose Wi-Fi (IEEE 802 n) TL-WA801ND wireless access point of TP-Link company has been used. The TP- LINK wireless N access point TL-WA801ND (is design or expands a scalable high speed wireless network.

After exchange of latitude and longitude between both vehicles distance, speed and heading of both vehicles computed in next step to measure the rate of expected collision danger.

On the bases of speed, distance, and heading the system will check the distance between two vehicles and it is less than 5m then it check the different directions either it is left, right, front or back side so it will generate audio based warning tone for driver to safe vehicles.

The alarm/audio warning is generated three times. After two warnings if driver does not response then a specialized module has been introduced in our test-bed and after third warning the ABS (automatic braking system) will be activated.

5 RESULTS OF TEST BED

Figure 2 shows that Vehicle 1 is connected with vehicle 2 and share latitude and longitude with vehicle 2. The Latitude and Longitude of vehicle 2 is 33.2700 and 73.1331 and Latitude and Longitude of vehicle 1 is 33.2701 and 73.1331 respectively. Distance between vehicle 1 and vehicle two is 0.0112 km .Whereas speed and direction of vehicle 2 are 10.536 and straight respectively. Speed and direction of vehicle 1 is 40.032 km/h and direction is straight as well according to the angle between both vehicles that is 0.

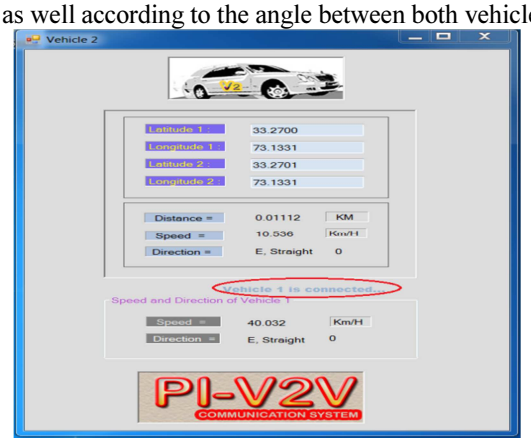

Figure. 2. Vehicle 1 Is Connected With Vehicle 2

When Vehicle 2 is connected with vehicle 1, it shares it latitude and longitude with vehicle 1 and calculates the distance from vehicle 1. After calculating the speed of vehicle2 it calculates the direction of vehicle2, according to the pervious calculations. Figure 3 highlights the direction of vehicle2 which is straight with respect to angle 0.

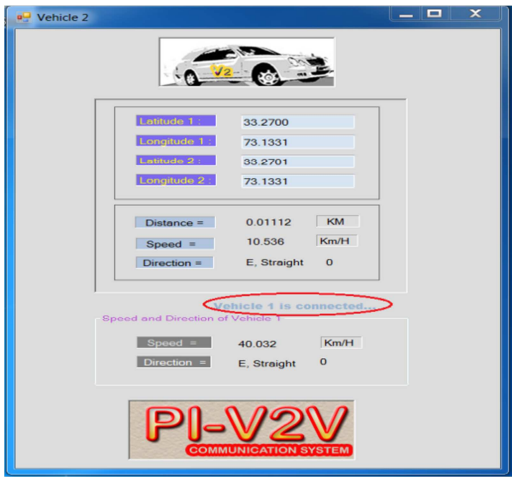

Figure. 3. Calculation of Direction by Using Longitude & Latitude.

Figure 4 shows successful communication and calculation of distance, speed and direction of both vehicles. The next step is generating a voice tone to warn the driver about the possible collision. Figure 3shows the direction and angle of vehicle1 and also vehicle 2 that is Right and Left respectively and the distance is less then danger threshold, so the voice based warning for the vehicle 1 is generated which is "Danger form Right side" .

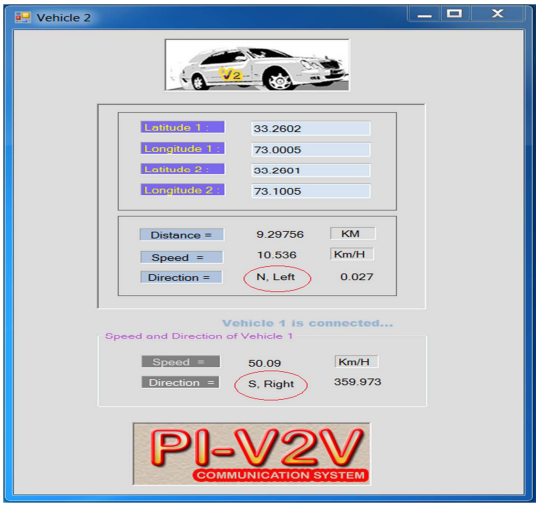

Figure. 4. Warnings Window

The proposed test-bed was tested in field. Figure 5 is showing research team setting up the test in the open ground. The system was tested in the Mirpur University of Science & technology. An ad-hoc Wi-Fi based network was established between Toyota and a Suzuki car. Two lane protocols was copied in open ground and total 6 team members took part in testing.

Figure. 5. Setting Up The Voice Based V2V Communication System Configuration Before Conducting Infields Tests

6Performance Analysis of Voice Based V2V Communication System

For the rigorous analysis of voice based V2V communication system on T and Y junctions a special C# based simulator was designed. Because testing crash scenarios on real roads can lead to the life and financial risk. 5 test cases were performed for the T- junctions and 5 for the Y- junctions. Due to the lack of space we are describing in details only two T-junction and two Y- junction collision scenarios and the effectiveness of proposed solution in avoidance of accidents. However all test results of both T and Y junctions are presented in table 1 and 2.

6.1Test Case 1(T-Junction)

The test case 1(possible collision scenario) is shown in Figure 6 in which Vs (skidding vehicle) is travelling with the speed of 50 km/h and Ts (Target vehicle) is moving with the speed of 50 km/h .The whole simulation for test case 1 works as. Vs is moving on road1 and Ts is moving on road2 of T junction. In this test case it has been supposed that driver of Vs suddenly changes its road due to any of the following reasons like drowsiness or due to tire blast. The collision level presented with yellow color is showing possible collision. The simulator calculates the distance between both vehicles and then using mathematical formulas calculates the time to collision (TTC) and time to avoidance (TTA). TTC in this case is 1.90 seconds and TTA is 0.771 seconds. Human driver needs 5. 678 seconds [6] to avoid this accident using video based emergency alerts, which is not possible in this case. Using audio based V2V communication system time of our crash sensing is 0.493 milliseconds; the possible collision can be avoided.

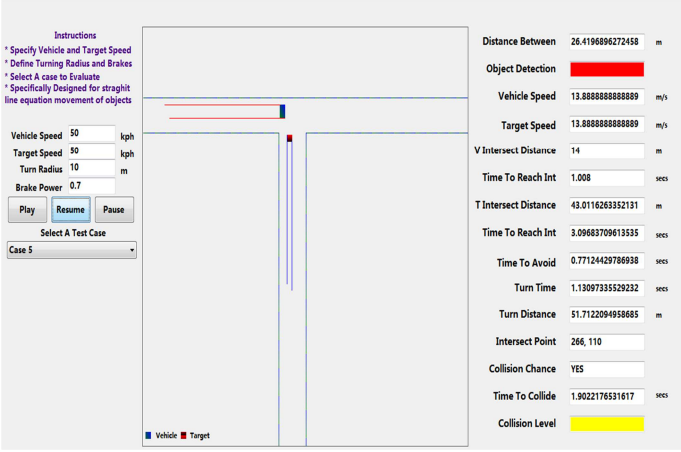

Figure. 6.T-Junction Test Case 1 Scenario

6.2Test Case 2(T-Junction)

The test case 2(possible collision scenario) is shown in Figure 7 in which Vs is travelling with the speed of 60 km/h and Ts is moving with the speed of 65km/h .The whole simulation for test case 2 works as Vs is moving on road1 and Ts is moving on road2 of shown T junction. In this test case it has been supposed that driver of Vs suddenly changes its road due to any of the following reasons like drowsiness or due to tire blast. The collision level presented with yellow color is showing possible collision. The simulator calculates the distance between both vehicles and then using equations 1 to 3 calculates the time to collision (TTC) and time to avoidance (TTA). TTC in this case is 2.37 seconds and TTA is 1.43 seconds. Human driver needs 5. 678 seconds to avoid this accident using video based emergency alerts, which is not possible in this case. Using audio based V2V communication system time of our crash sensing is 0.493 milliseconds; the possible collision can be avoided.

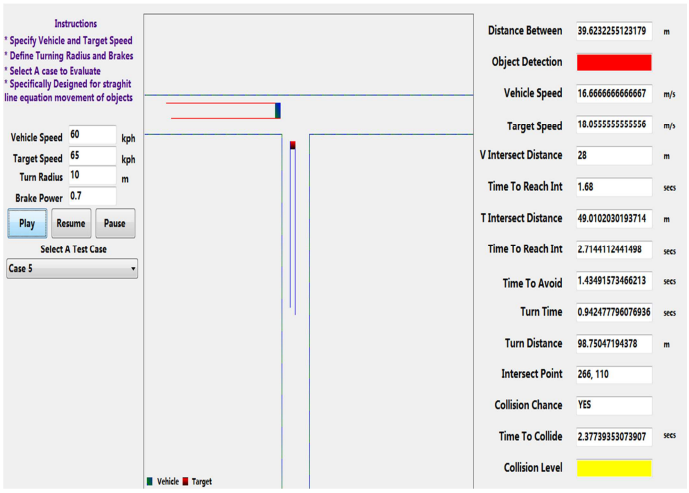

Figure. 7.T-Junction Test Case 2 Scenario

The results of T-Junctions tests are presented in table 1. The average TTA is 1.60 seconds. It means driver reaction time is 1.60 seconds on T-Junctions and it is 4.078 seconds faster than video based V2V communication system[6].

Intersection where three roadways connect and none of the roadways continue across the others. The roadways form a Y junction.

Table 1. Test Results of Proposed System on T-Junction

Test	Distance	V speed	T speed	TTA	TTC	Sound	Video
1	26.41	50	50	0.771	1.90	0.493	5.678
2	39.62	60	65	1.43	2.37	0.493	5.678
3	77.10	85	100	2.60	3.26	0.493	5.678
4	116.49	100	80	-	-	0.493	5.678
5	59.41	80	90	1.61	2.67	0.493	5.678

6.3 Test Case 1 (Y-Junction)

The test case 3(possible collision scenario) is shown in Figure 8 in which Vs is travelling with the speed of 80 km/h and Ts is moving with the speed of 90km/h .The whole simulation for test case 1 0f Y junction works as. Vs is moving on road1 and Ts is moving on road2 of Y junction. In this test case it has been supposed that driver of Vs suddenly changes its road due to any of the following reasons like drowsiness or due to tire blast. The collision level presented with green colour is showing safe scene.

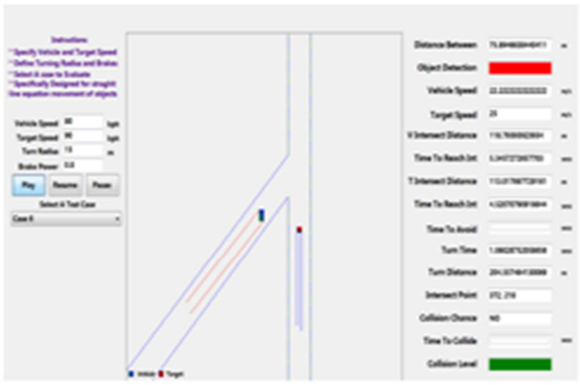

Figure. 8.Y-Junction Test Case 1 Showing Safe Scenario

6.4Test Case 4 (Y-Junction)

The test case 2(possible collision scenario) is shown in Figure 9 in which Vs is travelling with the speed of 80 km/h and Ts is moving with the speed of 90km/h .

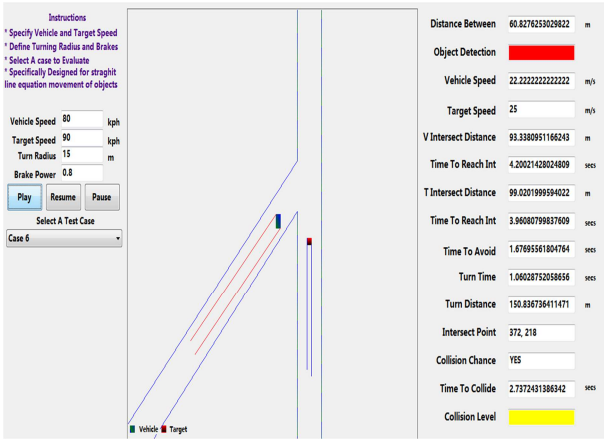

Figure. 9.Y-Junction Test Case 2 Scenario

The whole simulation for test case 2 works as Vs is moving on road1 and Ts is moving on road2 of Y junction. In this test case it has been supposed that driver of Vs suddenly changes its lane due to any of the following reasons like drowsiness or tire blast. The collision level presented with yellow colour is showing possible collision. The simulator calculates the distance between both vehicles and then using equations 1 to 3 calculates the time to collision (TTC) and time to avoidance (TTA). TTC in this case is 2.73 seconds and TTA is 1.67 seconds. Human driver needs 5. 678 seconds to avoid this accident using video based emergency alerts, which is not possible in this case. Using audio based V2V communication system time of our crash sensing is 0.493 milliseconds; the possible collision can be avoided.

The results of Y-junctions tests are presented in table 2. The average TTA is 1.31 seconds. It means driver reaction time is 1.60 seconds on Y- junctions and it is 4.368 seconds faster than video based V2V communication system [6].

Table 2. Test Results of Proposed System on T-Junction

Test	Distance	V speed	T speed	TTA	TTC	Sound	Video
1	26.41	50	50	0.771	1.90	0.493	5.678
2	39.62	60	65	1.43	2.37	0.493	5.678
3	77.10	85	100	2.60	3.26	0.493	5.678
4	116.49	100	80	-	-	0.493	5.678
5	59.41	80	90	1.61	2.67	0.493	5.678

7Conclusion

Video based V2V communication systems can cause distraction for the drivers instead of facilitating them. Our proposed voice based V2V communication test-bed has proven its efficiency and can be used as a guideline for the automakers which are working on V2V communication enabled vehicles.

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