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Alarm System for Pedestrians Safety Against Hybrid/PHEV/EV Vehicle on Minor Road

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Abstract

This paper presents an alarm system for pedestrian safety against hybrid vehicle/PHEV/EV on minor roads. Recently, the interest and production of the hybrid/PHEV/EV vehicles have been rising in the automobile market, and a number of such vehicles are already driving on the road. One of their salient features is that they are very quiet and the exhaust sound is scarcely audible. So the pedestrians on minor roads are difficult to recognize those vehicles when the vehicles are coming behind them. This situation has emerged as a serious problem in the matter of ensuring the safety of pedestrians. Therefore the alarm system to notify the approaching vehicles to pedestrians on minor roads should be developed.

The proposed alarm system in this paper informs pedestrians with a vibration or sound through the smartphone when the vehicles are closing in to the pedestrians from behind on minor roads. And this alarm network system consists of a few smart access agents, some smartphones and RFID tags that are equipped with the vehicles. The smart access agent recognizes the direction of driving vehicles on minor roads and informs it to the pedestrian's smartphone, and the RFID tag equipped with vehicles sends an approaching signal to the smartphone. Thus, the proposed alarm system concept can support the pedestrians' safety on minor roads against hybrid vehicle/PHEV/EV simply and effectively.

Keywords: *Connected vehicle communication network, Pedestrian Safety, Smart access agent, Electrical powered vehicle, RFID*

1. Introduction

Recently, the development of automobile industry through combining vehicle, electric energy, computer and wireless communication technology is making great progress. Such convergence for smart (connected) vehicle and ICT technology can establish connected-smart vehicle network and ITS (intelligent transportation system) network. Thus, intelligent connected-smart vehicle network can provide more comfortable, pollution-free environment without CO2 emission and ensure safe driving on the roadway because it supports real-time communication of vehicle-to-pedestrian (V2P) and vehicle-to-everything (V2X) such as V2V(vehicle-to-vehicle), V2I(vehicle-to-infrastructure), V2N (vehicle-to-nomadic devices) and vehicle-to-traffic facilities. Therefore, the researches of electrical powered vehicle and autonomous vehicle have been progressed widely at the present day [1-6].

The hybrid vehicle, PHEV(plug-in hybrid electric vehicle) and electrical vehicle(EV) are extensively developing in the automobile market including Tesla motors as well as the conventional automobile company during the past 5 years. Especially, PHEV and EV

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have accelerated its pace in the vehicle development. Because these vehicles use charged electric power instead of gasoline and diesel, they support pollution-free environment which creates no dangerous gases like carbon dioxide(CO2) generation [5-8].

Another advantage of the hybrid vehicle, PHEV and EV is little noise during driving, especially at low speed driving. Such little driving noise provides pleasant driving environment, but this can be dangerous and may lead to a serious problem to pedestrian's safety. These days people without distinction of age or gender use smartphones or mobile devices on the street and this leads to the lack of recognition of vehicle approaching that has little driving noise. This kind of situation can happen to kids and young people more frequently.

Many pedestrians who collide with vehicles are given impact twice in vehicle accidents including cycles and motor-cycles. The first impact by those accidents is due to the speed and collision strength that crashed them. Due to this, the pedestrians who had a vehicle accident suffer from broken bones, brain injury, bruising, scratch or psychological trauma of the vehicle accident if not death. And pedestrians are injured frequently by a bumper, hoods or windshield area when they are crashed with vehicles on a minor road. The second impact by those accidents can be caused by conflict with the ground, this can also lead to aforementioned serious problems [9]

Although some modern vehicles equipped with collision avoidance system are braked when they detect pedestrians, the effectiveness of this technology in real driving on the road has not been proven.

Pedestrian fatalities have decreased rapidly since 1975 (down 35 %; year 1975: 7516, year 2014: 4884). Even if the absolute numbers of pedestrian fatalities have decreased, recently those are increasing nearly every year. The U.S. Department of Transportation's Fatality Analysis Reporting System (FARS) announces that 15 percentages of vehicle crashes fatalities is pedestrian deaths. The pedestrian fatalities in vehicle crashes have been increasing since 2009 except 2013 and increased 2 percent from 2013 to 2014 [10].

In Figure 1, the blue bar graph shows total fatalities(the left-handed y-axis) and red band graph shows pedestrian fatalities(the right-handed y-axis) by year 2000 to 2014 that published annual report of National Center for Statistics and Analysis. As shown in Figure 1, although the total number of fatalities has gradually decreased in the period of the year of 2000 to 2014, the pedestrian fatalities have been increased gradually since 2010. And the recent(the year of 2015 and the mid-2016) statistics of fatalist include pedestrian one has not been released to the public, the pedestrian accidents on the minor road and the crosswalk pedestrian accidents would have been increased [10].

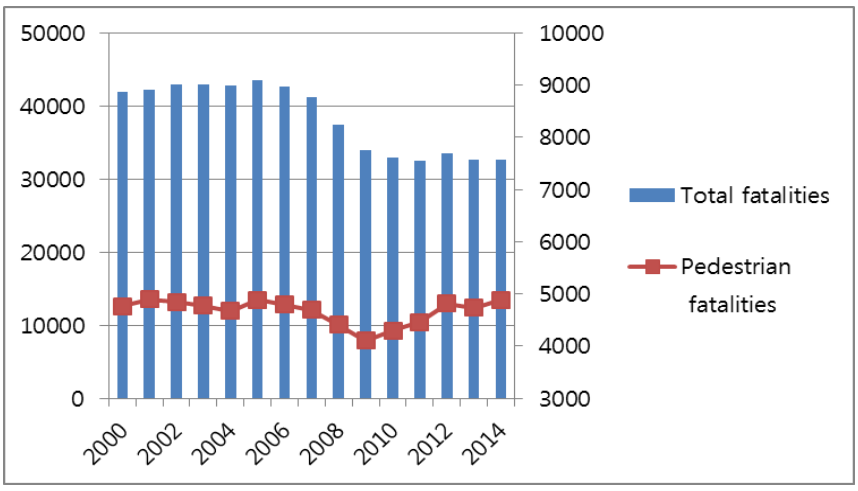


Figure 1. Source: FARS 2000-2014 ARF and National Automotive Sampling System(NASS) General Estimates System(GES) 2014 [10]

The pedestrian accidents on the minor road would certainly be increased in a few years because the hybrid vehicle/PHEV/EV will increase on the street and they have little exhaust sound and the noise of motor. Also, the rapid increase of the concentration of fine dust is becoming a serious issue as the critical social problem in the recent. Because of issues like this social problem, the development and production of the hybrid vehicle/PHEV/EV are expected to increase significantly for the present in the vehicle market. Therefore, the research about pedestrians' safety should be necessary because recently the pedestrian fatalities increased as mentioned above and the pedestrian accidents could increase on the minor roads.

The Figure 2 indicates total number of injured persons and pedestrians injured by vehicle accidents according to age: under 14's to over 80's. In Figure 2, the blue bar graph shows the total number of injured persons(the left-handed y-axis) and red band graph shows pedestrian injured(the right-handed y-axis) by vehicle accidents according to age that published annual report of National Center for Statistics and Analysis [11]. The research that notifies pedestrian on vibration through the smartphone when the vehicles are approaching behind should be necessary because pedestrians under 14-year-olds and senior over 65's are injured relatively many in comparison to other age groups as shown in Figure 2. Especially, these age groups do not pay attention or can't hear well to coming vehicles. Also, the pedestrian accidents would be increased obviously because a large number of pedestrians use smartphone or mobile device while walking, particularly young persons.

This paper presents algorithms(smart access agents(SAA), Hybrid/PHEV/EV and pedestrians) on alarming system for pedestrian safety in minor roads against electrical powered vehicle including hybrid/PHEV/EV, and this concept would be an essential part of safe driving in CVCN network that published already in 2015 or in the autonomous driving vehicle system [3-4] and [12].

The rest of this paper is as follows: Section 2 presents the structure of alarm system for pedestrians' safety against Hybrid/PHEV/EV. Section 3 proposes algorithms to support alarm system for pedestrians in alleyways. And finally, we discuss our conclusion.

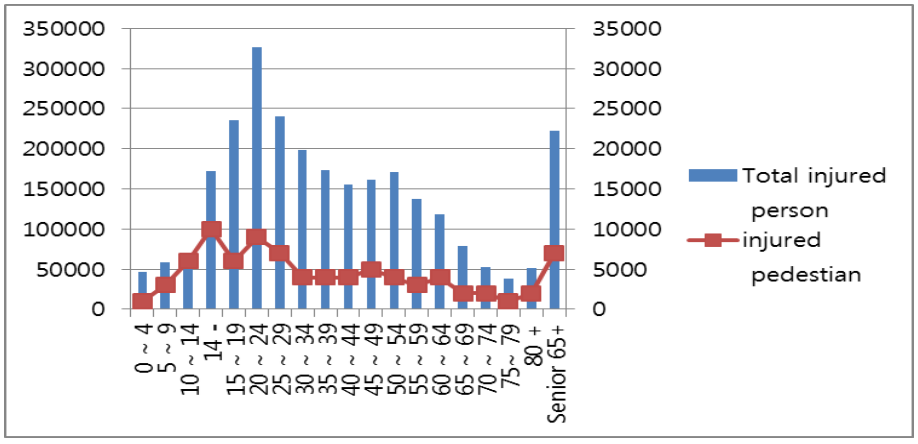


Figure 2. Source: FARS 2013 ARF and National Automotive Sampling System(NASS) General Estimates System(GES) 2013

2. The Structure of Alarm System for Pedestrians Safety against Hybrid/PHEV/EV

This paper proposed the connectivity in CVCN(connected vehicle communication network) network to support safe and comfortable driving. The modified diagram of connectivity in connected vehicle communication network(CVCN) is shown Figure 3 described in reference paper no. 1. This modified schematic diagram of connectivity that

composing CVCN network adds the pedestrian safe, autonomous driving system and environmental protection components [12].

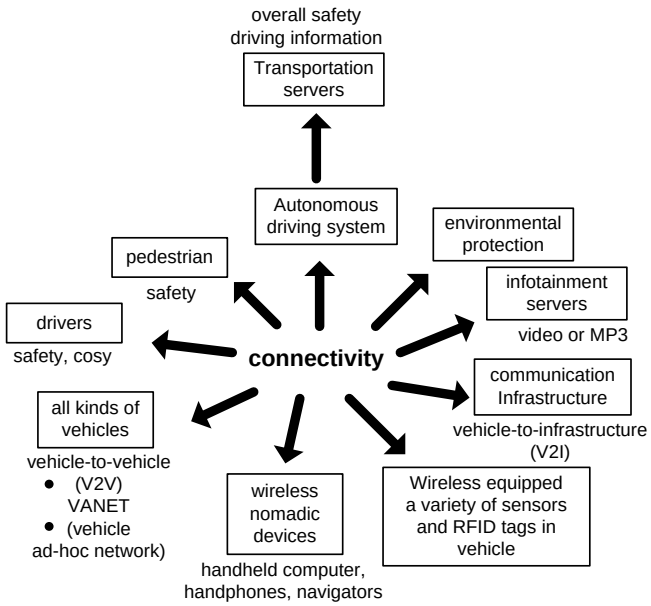
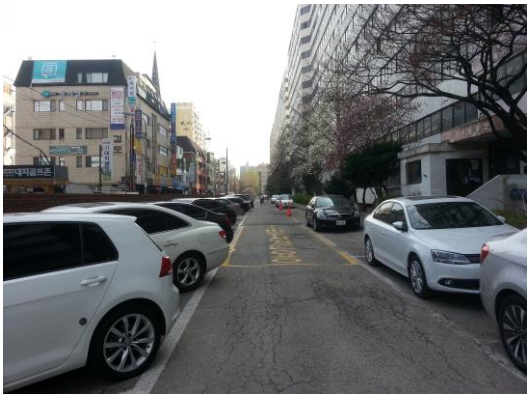


Figure 3. The Modified Schematic Diagram of Connectivity [12]

The examples of the minor road that is applying the proposed alarm system for pedestrians' safety against the hybrid/PHEV/EV are shown in Figure 4 [13-14]. The minor roads in this paper as shown in Figure 4 are roads without distinction of sidewalk and the trafficway. Those are the narrow street (Figure 4 a) without distinction of the sidewalk and traffic way, parking lot (Figure 4 b) and narrow alleyway (Figure 4c). These type of roads are often congested with vehicles and pedestrians. And the pedestrian should be careful because they cannot decide precisely where they pass through in such minor roads. Especially, the drivers should lower their speed of vehicles and pay close attention to kids and senior persons because they cannot hear the sound of vehicles very well that are coming from behind. And this situation happens very often in alleyways in the city, near the school zone, parking lots, pedestrian crossing and not busy roads in suburb. And the driving in those minor roads is more dangerous in nighttime. We think this situation is a very critical hazard for electrical powered vehicles such as hybrid vehicles, PHEV and EV.



(a)

(b)

Figure 4. The Type of Minor Roads (a) Narrow Street (b) Narrow Alleyway (c) Parking Lot (d) Street [14]

The schematic diagram of minor road for the proposed algorithm applied in this paper is shown in Figure 5. We suppose this minor road has one alleyway and there are 5 smart access agents in that road.

The smart access agents(SAA_#000) and SAA_#100 may become the starting SAA or the last SAA according to the entering direction of pedestrians and vehicles in minor road. Thus, SAA_#000 and SAA_#100 perform the assigning pedestrians' ID, vehicles ID and the direction bit(1-bit) for represent forwarding direction on the minor road with 0 or 1. And they get return the pedestrians' ID and vehicles ID when the pedestrian and vehicles passed through the minor road. Other 3 SAAs check some pedestrians that did not pass through the minor road during assigned time or having some business within that road. Thus, SAAs have a timer for pedestrian and vehicles when they are entered this road.

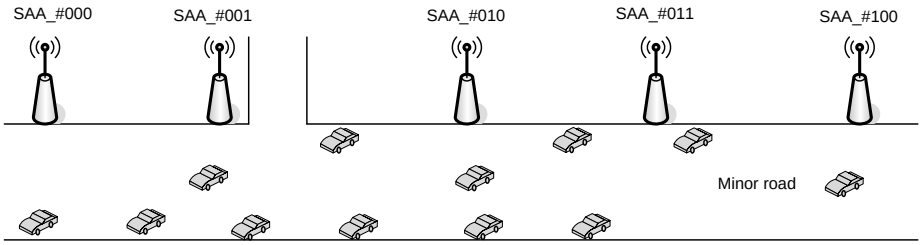


Figure 5. The Minor Road that Applied in Minor Road in this Paper

3. The Operation Mechanism for the Alarm System for Pedes-trians Safety against Hybrid/PHEV/EV in CVCN

The shape of the minor road applied in the proposed alarm system for pedestrians safety shows in Figure 5.

The operation mechanism for some smart access agents(SAA) in the minor road

i) The starting SAA(smart access agent) recognizes pedestrians and vehicles entering into the minor road and assigns pedestrians and vehicles the direction bit of forwarding on the minor road with 0 or 1.

ii) The starting SAA_#000 assigns the pedestrians 7-bit identification code and the entering vehicle a specific address(6-bit).

iii) The starting SSA_#000 sends the information of the pedestrians and the vehicles, and notifies to initialize timer for each of them to the other SSAs(SAA_#001 ~ SAA_100 in Figure 5).

iv) The starting SSA_#000 notifies the vehicle assigned in step (i) and step (ii) to operate active RFID tags equipped within the vehicle according to the speed of vehicle.

v) The other three SAAs(SAA_#001 ~ SAA_011 in Figure 5)including the last SAA checks the assigned time to both the pedestrians and the vehicles according to the length of the minor road and the speed of vehicles to recognize whether they pass through the position of each SAA.

vi) The last SAA_#100 checks the pedestrians whether they passed through the minor road.
And if they passed through the minor road,
then its time switch terminates the allotted time for pedestrians
else, goto step (v)

vii) The last SAA_#100 sends the 8-bit identification code of the pedestrian and a specific address assigned vehicle to the starting SSA_#000 if the pedestrian and vehicle through the minor road
else goto step (vi)

viii) The starting SSA_#000 initializes the information related to pedestrians and vehicles passed through the minor road or pedestrian expired elapsed time

The minor road shown in Figure 5 has one alleyway and 5 smart access agents(SSA). Thus, these five SSAs in the minor road are assigned SSA_000 to SSA_100, the SSA_000 and SSA_100 are located in the start and last point of the minor road, respectively. The SSA_010 of three remaining SSAs is located in the start position of the alleyways, the SSA_001 and SSA_011 are located in appropriated position of the minor road.

In step (iv), the reason to send the information of the pedestrians and the vehicles to the other SSAs is to identify whether they passed through the specific position of the minor road. As an example when the vehicle_000001 that operated a RFID(5m ranged) passed SSA_001 but a specific pedestrian_1010011 has not yet passed that position, the pedestrian_1010011's vibrator does not need to operate about the vehicle_000001.

The Operation Mechanism for Entering Vehicles into the Minor Road

i) The vehicles access the starting SSA(SAA_#000 or SAA_#100) when they enter the minor road

ii) The vehicles acquire identification code(6-bit) from the starting SSA

iii) The vehicles receive information of pedestrians identification code(8-bit) assigned in the minor road and make up working table for them.

iv) The vehicles work one of their active directional-RFID tags according to the speed of vehicles

v) The vehicles check the identification codes of pedestrians in the working table whether the pedestrians are passed through one of the remaining four SSAs in the minor road.

vi) The vehicles eliminate pedestrians ID in working table if pedestrians are not passed through a specific SSA
else goto step (v)

vii) The vehicles work continuously their active directional-RFID tags according to the speed of them if there are any pedestrian IDs in the working table
else goto step (v)

*viii) The vehicles stop their active directional-RFID tag that is working when they are passed through thoroughly the minor road or p*arked on that minor road.

The Operation Mechanism for the Pedestrians

i) The pedestrians access the starting SSA(SAA_#000) when they enter the minor road

ii) The pedestrian acquire identification code(8-bit) from the SAA_#000

iii) The pedestrians recognize driving vehicles from the behind if their smartphone is vibrated when it sensed signal from one of the active directional-RFID tags equipped in vehicles.

iv) The pedestrian's smartphone stops vibration if the vehicle passed the pedestrian
else goto step (iii)

v) The pedestrians remove their ID assigned from the SSA_#000 whenever they are passed the last SSA_100 in the minor road.

vi) The pedestrians eliminate their identification code(8-bit) when they are passed through thoroughly the minor road or their allotted time that assigned from the SAA_#000 is expired.

In step (v) the reason that pedestrians have the allotted time that assigned from the starting SSA_#000 is that the pedestrians do not need to care about driving vehicles forwarding from behind. This means that pedestrians have their business within the minor road such as enter the indoor. The reason is to protect a cumbersome situation that vibrates smartphone of pedestrians when they are in the indoor.

4. Conclusion

Pedestrian safety issue will be emerged as a key figure in the automobile industry because the little noised green cars including electrical powered vehicles as hybrid vehicle/PHEV/EV have greatly increased. The little noised green cars that are caused by the environmental contamination due to fine dust and depletion of fossil fuels can be very threatening to the pedestrian safety. This paper proposes the mechanism on the alarming system for pedestrian safety in minor roads against hybrid vehicle/PHEV/EV. The proposed new alarm system for pedestrians' safety is not limited to the forthcoming future vehicles that have no sound of engine and exhaust but can apply easily in the conventional vehicles that use fossil fuel. And the proposed mechanism can support easily and inexpensively because it uses vibration or sound-effects function smartphone through wifi network. Thus, this proposed mechanism should be adopted essentially in the autonomous driving vehicles. And the research for implementation of alarming system for pedestrians in a variety of minor roads is in progress.

Acknowledgments

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