A Pedestrian Collision Prevention Method Through P2V Communication

JinHyuck Park, ChoonSung Nam, JangYeol Lee and DongRyeol Shin

Abstract Today, research and commercialization about the autonomous vehicle are being progressed. Among them, the most popular issue is self-driving. To support self-driving, a vehicle has to know the pedestrian's location. Pedestrians have a smartphone with BLE communication. Thus, this paper proposes Bluetooth Lower Energy (BLE) communication-based service that recognizes the pedestrian and sends a warning message to the vehicle. It can be easily usable because it is easy to find a device that uses BLE communication such as a smartphone.

1 Introduction

While the research and commercialization for autonomous vehicles are in progress, the largest issue has been the research for safe driving. Autonomous vehicles must be able to sense the danger and be able to control the vehicle itself according to a pedestrian's location or expected motion. Therefore, it should receive external information from pedestrians [1].

The communication method needs network technology between vehicles and other devices, and Vehicular Ad hoc Networks (VANETs) are required to make it possible. VANETs can broadly be divided into two communication methods. First, through Vehicle to Vehicle (V2V) communication, one vehicle is able to predict

J. Park
Department of Cyber Security, Kyungil University, Gyeongsan, South Korea
e-mail: vkqxkr@gmail.com

C. Nam · J. Lee · D. Shin (✉)
Department of Electric & Electrical Computer Engineering,
Sungkyunkwan University, Suwon, South Korea
e-mail: drshin@skku.edu

C. Nam
e-mail: namgun99@gmail.com

J. Lee
e-mail: ljygo2005@skku.edu

V. S. Rathore et al. (eds.), *Emerging Trends in Expert Applications and Security*,
Advances in Intelligent Systems and Computing 841,
https://doi.org/10.1007/978-981-13-2285-3_65

other vehicles' movement so that it may recognize the danger in advance [2]. The second technology which is Vehicle to Infrastructure (V2I) is able to provide road conditions through information exchange between infrastructures such as vehicles or Road Side Unit (RSU) [3, 4]. However, the communication method of V2V and V2I of VANETs mainly consists of receiving safe messages as intersection movement assist and left turn assist between cars implying that there is no way to trace the position data of the pedestrian. Thus, to obtain the pedestrian's data, it is required to have the technology that is capable of both transmission and reception between a vehicle and a pedestrian.

Bluetooth Low Energy (BLE) communication can be used to provide the pedestrian's position data [5]. Basically, if a pedestrian possesses a smart device, the device will produce BLE and be used as the communication between the pedestrian and the vehicle based on the pedestrian's data. In addition, since BLE does not require a connection method through pairing, it is possible to transmit data through the broadcast. Yet, if the vehicle is operated carelessly based on random pedestrian's data, a traffic collision will occur by unnecessary vehicle operation. In other words, the communication between the pedestrian and the vehicle needs a method that can extract the pedestrian's data in the situation of vehicle operation.

Therefore, this paper proposes a method to set the safe zone according to the speed and position of the vehicle by using the BLE communication between the pedestrian and the vehicle to ensure both the danger detection and safe driving.

The remaining paper is organized as follows: Sect. 2 explains the current research in location recognition or service with related work. Section 3 suggests the communication method and algorithm between the pedestrian and the vehicle. Finally, Sect. 4 shows conclusion and future research directions.

2 Related Work

2.1 Communication Method Between the Pedestrian and the Vehicle

VANETs for the Communication Between Vehicles and Infrastructures

VANETs are actively being used in various application researches and commercial field starting from communication model. Among them, commercialization of V2V is proceeding mostly. V2V is defined as the communication between vehicles and aims to increase the safety between them and help drivers to drive safely. According to the report, "Vehicle-to-Vehicle communication: Readiness of V2V Technology for Application" [6] published by National Highway Traffic Safety Administration, V2V is capable of increasing both road and drivers' safety. Furthermore, the report defines some applications through scenarios, and it explains the importance and the necessity of V2V. However, the safe scenarios through V2V communication consist of merely the communication between vehicles, not environments, and more

importantly pedestrians. Moreover, although it defines application models such as P2V and Pedestrian in Roadway Warning (PRW), there is a weakness that it does not propose the definition of accurate communication and the technology that solves a danger between the pedestrian and the vehicle and other safety issues. Therefore, the communication method between the pedestrian and the vehicle is required.

iBeacon for P2V Communication

iBeacon [7] is a Near-Field Communication (NFC)-based service device introduced by Apple Inc. It is the service device using NFC between users and adopting the technology named Bluetooth Low Energy (BLE). BLE is a communication technology which consists of low packet parameter such as low transmitted power and received power to reduce energy consumption. The existing Bluetooth communication technology communicates NFC through the connection between Bluetooth enabled devices called pairing. iBeacon, on the other hand, is designed to allow devices capable of BLE communication to communicate rapidly using broadcast-type transmission without any kind of connection. BLE communication technology is the method that is able to provide vehicles with pedestrian's information without any connection. The method to measure distance with iBeacon can estimate the distance between the smart device and iBeacon by calculating Received Signal Strength Indication (RSSI) value and Tx power value. The communication method between iBeacon and the smart device is shown in Fig. 1.

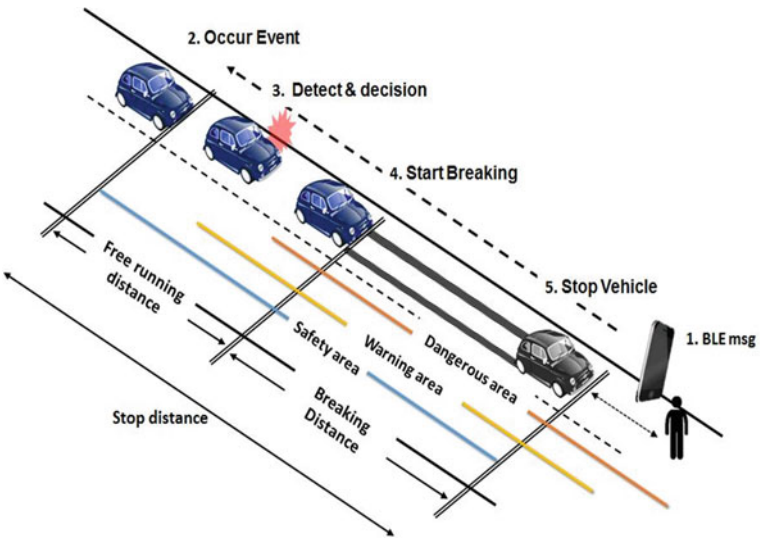

Fig. 1 Safety area architecture through BLE

When the smart device enters the transmission area of the iBeacon, the smart device can receive the iBeacon data and check the information of the device. Therefore, this communication is possible if a Bluetooth device is installed in a vehicle.

3 Danger Recognition Method

To provide a hazard signal between the pedestrian and the vehicle, they must be able to perceive their relative data with respect to their current position, speed, and direction. In order to do it, they should be able to exchange communication in the form of P2V as shown in Fig. 2. The vehicle finds the point where it can brake by itself by calculating its own speed, the distance between pedestrians based on the pedestrian's location. This point includes a safe area where the vehicle can maintain its existing driving without special actions, a warning area where speed reduction and a change of direction must be made within certain time, and a danger area where the vehicle control itself immediately without the driver's decision. Depending on the area, the vehicle generates events such as driving, warning, braking, etc. The pedestrian is able to detect a situation in advance in which the pedestrian is located on the roadway based on the data of the vehicle received, and deal with it. Therefore, both the pedestrian and the vehicle prevent traffic collision by providing danger recognition.

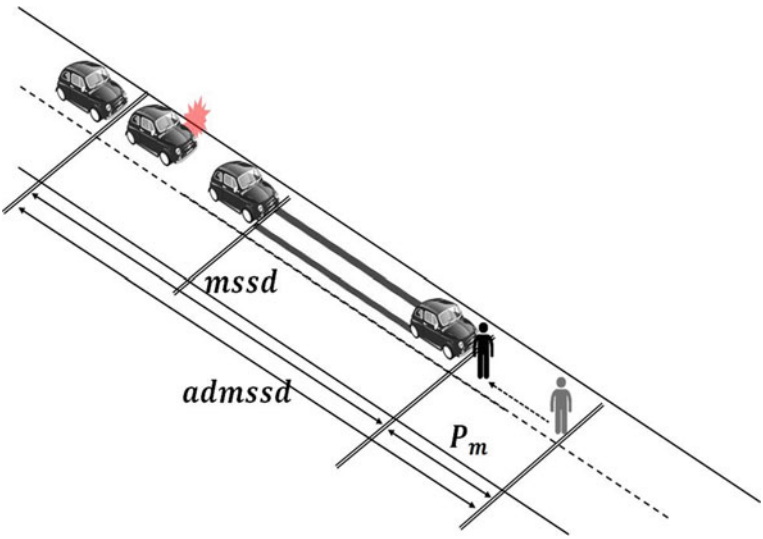

Fig. 2 Braking distance: admssd for preventing collision

3.1 Setting up Safety Area

The safe driving zone is defined as the area outside the distance until the vehicle in motion comes to a complete stop at its current speed. When the vehicle receives a message from the pedestrian through the smart device, a total of the distance traveled by the vehicle until it receives the message, until the driver steps on the brake from receiving the message, and for speed reduction from applying the brake should be less than the distance between the pedestrian and the vehicle.

In order to obtain the stopping distance, the definition of the previously defined stopping distance of the vehicle should be considered. The description of the stopping distance is shown in Fig. 2. The stopping distance can be divided into two categories: free running distance, braking distance. Free running distance means the amount of time either the driver or the vehicle decides to stop and starts to apply the brake when the vehicle detects a dangerous object or the pedestrian to appear on the roadway. Breaking distance is the distance from the point where the vehicle starts to work the brake to stopping completely. The sum of these two distances is the vehicle's stopping distance.

Equation (1) is the expression for calculating the basic breaking distance. *mssd* stands for Minimum Stop Sight Distance. This allows the total stopping distance of the vehicle to be calculated. In Eq. (1), V is the design speed of the road (or vehicle speed) and t is the driver's recognition response time (or computation time) and f is the coefficient for the road friction.

$$\text{mssd} = \frac{tV}{3.6} + \frac{V^2}{256f} \tag{1}$$

Equation (2) is the formula for the distance that the vehicle travels relative to the time when the pedestrian enters the road. Because the formula above shows the total stopping distance, the hazardous area can be established.

$$\text{Pm} = \left(\frac{\frac{mssd}{V}}{3600} \times 1.8\right) + 1 \tag{2}$$

$$\text{admssd} = \text{mssd} + \text{Pm} \tag{3}$$

3.2 Results Analysis

Figure 3 shows minimum safety distance between a pedestrian and a vehicle by vehicle's speed, when the driver's cognitive response time is set to a maximum of 1.5 s. If the speed of the vehicle is more than 100 km, the driver has to know

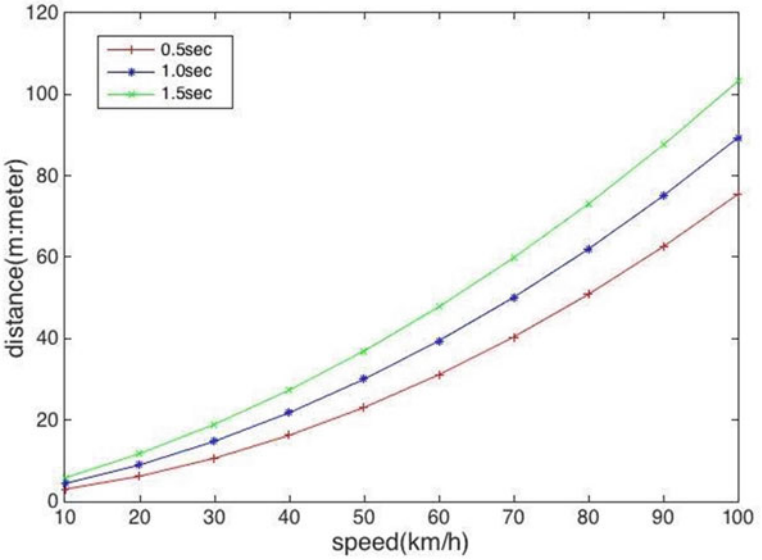

Fig. 3 Safety distance by cognitive response time of accident alarm

accident alarm before 100 m from a pedestrian. However, if the cognitive response time of the driver is shortened to 0.5 s, the safety distance is about 70 m. Thus, it is possible to prevent a vehicle accident by constructing the proposed safe area system using BLE communication.

4 Conclusion and Future Research Plan

This paper presented a method to prevent accidents of vehicles and pedestrians using BLE communication. To achieve this, the distance is measured by exchanging the location information of the vehicle and the pedestrian, and the drivers know the alarm about the stopping distance.

Future research will measure the possible distance for accident prevention through simulation.

Acknowledgements This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korean government (MSIT) (No. R0113-15-0002, Automotive ICT-based e-Call standardization and after-market device development).

References

1. An KH (2013) Technology trends of self-driving vehicles. Electron Telecommun Trends (ETRI) 35–44
2. Lin YW (2010) Routing protocols in vehicular ad hoc networks: a survey and future perspectives. J Inf Sci Eng (IIS) 26:913–932
3. Qian Y (2008) Design of secure and application-oriented. In: Vehicular technology conference 2008. IEEE, pp 2794–2799
4. Karagiannis G (2011) Vehicular networking: a survey and tutorial on requirements, architectures, challenges, standards and solutions. Commun Surv Tutorials. IEEE, 584–616
5. Frank R (2014) Bluetooth low energy: an alternative technology for VANET applications. In: Wireless on-demand network systems and services 11th annual conference. IEEE, pp 104–108
6. Harding J (2014) Vehicle-to-vehicle communications: readiness of V2V technology for applicaiton. U.S. Department of Trasportation, National Highway Traffic Safety Administration
7. Cavallini A (2014) iBeacons Bible 2.0. http://meetingofideas.wordpress.com/