

## Relative Position Dynamic Map for Driver Assistance Systems in Vehicular Networks

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### Abstract

Many traffic accidents happen because the driver misjudges the relative distance between vehicles. Active safety technologies and passive warning functions have been proposed for driver assistance systems in vehicular networks. Radar and cameras are sensors commonly used in active safety technologies. The global positioning system and dedicated short-range communication are suggested for the passive warning functions. However, the accuracy of position information is a challenge which can decrease the effectiveness of safety applications in driver assistance systems. This paper proposes a relative position dynamic map with a radar sensor for driver assistance systems in vehicular networks. The proposed method relies on the relative distance measured by the radar sensor to determine the position information of neighbouring vehicles by means of dedicated short-range communication and constructs a relative position dynamic map for the driver. The experimental results show that the proposed method should provide better performance than traditional global positioning system information.

Keywords: Relative Position; Dynamic Map; Vehicular Networks.

### 1. Introduction

Many traffic accidents, such as rear-end collision and overtaking crashes, happen because the driver cannot correctly judge the relative distance between neighbouring vehicles. Hence, many driver assistance systems have been proposed, such as active safety technologies and passive warning functions [1]-[6]. Radar (accurate) and cameras (cheap) are sensors commonly used in active safety technologies, such as forward collision warning and pedestrian collision warning. The sensors detect the shape and distance of front obstacles to support the

collision warning. Moreover, these sensors are used in advanced cars with autonomous cruise control systems and automatic driving. The vehicle automatically follows the one in front, allowing for speed and direction. The global positioning system (GPS) and dedicated short-range communication (DSRC) technology are helping to support understanding of the non-line-of-sight of neighbouring vehicles for passive warning functions, such as emergency electronic brake lights and intersection collision warning. Passive warning functions can reduce rear-end traffic accidents.

In our previous work [6], we implemented a radar map using GPS position information in vehicular networks. For the passive warning functions, GPS position information carries the risk of increasing false alerts and distracting drivers. The authors in [7] proposed a modified algorithm to correct the track. Those in [8] enabled non-GPS-adapted sensors to estimate their locations accurately by means of received signal strength indication information. An efficient real-time specific sign recognition scheme which can be applied in driver assistance systems, intelligent traffic systems, navigation systems and GPS correction has also been suggested [9]. A localisation algorithm based on a particle filter was verified and evaluated in an autonomous driving test [10]. However, the above methods did not broadcast self-position to the neighbouring vehicles to avoid a collision happening. Hence, the drivers still misjudged the relative distance between vehicles.

The accuracy of GPS position information is still a challenge, as noted above. The GPS position information has an error distance of three to ten metres in our experimental environment (city). For example, the neighbouring vehicle is located in the same lane as the self-vehicle but the original GPS position information places it in the other lane in our experimental environment. Hence, this paper proposes a relative position dynamic map with a radar sensor for driver assistance systems in

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vehicular networks. The proposed method relies on the relative distance measured by the radar sensor to correct the position information which from the neighboring vehicles by DSRC communication to construction the relative position dynamic map for the driver by the data fusion the GPS and radar map/distance map information. Moreover, the proposed method supplies the relative position dynamic map to the driver via a smartphone. This paper is structured as follows. Section 2 presents the proposed method. Performance evaluations are presented in Section 3. Conclusions and future works are given in Section 4.

## 2. Relative Position Dynamic Map

### 2.1 System Architecture

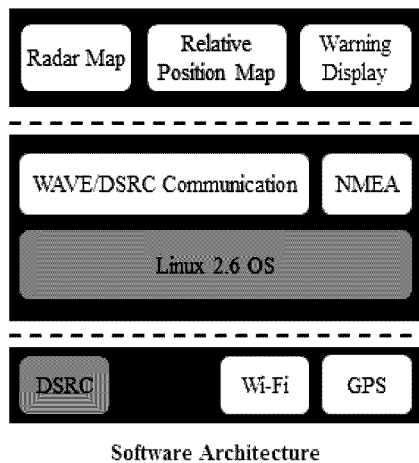


Figure 1: System architecture

The system architecture of the proposed method is shown in Figure 1. The GPS module is designed to obtain the position for each 100ms (10Hz). The GPS module has been used in recent years in car navigation and bus stations. The GPS information format follows the National Marine Electronics Association (NMEA) information protocol [11]. The protocol includes longitude, latitude, speed and heading information. The DSRC module broadcasts the position information to the neighbouring vehicles via a certain frequency. The communication protocol of the DSRC module is WAVE/DSRC [12]. The WAVE/DSRC communication protocol broadcasts the information to the neighbouring vehicles without beforehand handshaking which have very small latency. Hence, the DSRC module is suitable for safety applications in vehicular networks. The radar module can detect the distance around the neighbouring vehicles and so the application

layer obtains the radar map/distance map information. Many radar products are fitted in vehicles for safety reasons, such as forward collision warning and pedestrian collision warning [13]. The application layer needs to decide the vehicle or pedestrian shape and warning level according to the distance map. The relative position map information in the application layer organises the fusion of the GPS and radar map/distance map data to correct the relative position. A more detailed description is provided in the following sub-section. The relative position map information relies on Wi-Fi communication transmitted to a smartphone device. Hence, the driver can obtain a real-time relative position dynamic map information when the driver in the driving

### 2.2 Radar Map

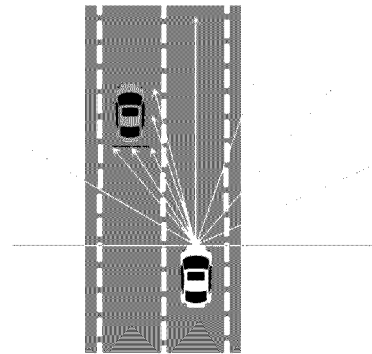


Figure 2: Radar map

The radar device is used to assess a straight line in front in order to warn the driver. The radar device is fitted in the front bumper and detects obstacles less than 30 metres away. The detection range can be increased when the radar device is enhanced in the future. The radar device scans the 190 degree of front distance of obstacle in 100ms and each 0.5 degree report one distance of obstacle value. The report value is zero when the vehicle has no obstacles in front and is not zero when the vehicle does have obstacles in front. Hence, the radar map obtains 380 fields of array per 100ms. The proposed method uses a right-angled curve based on the arrays of the radar map in order to identify neighbouring vehicles. An example of the radar map is shown in Figure 2.

### 2.3 Relative Position Map

The neighbouring vehicles broadcast position information, relying on DSRC communication in the vehicular networks. Hence, each vehicle will

receive multiple position information from neighbouring vehicles. However, the accuracy of the GPS position information is a challenge, as noted above: for example, when the neighbouring vehicle is located in the same lane as the self-vehicle and the GPS position information is located in the other lane of the self-vehicle. Figure 3 gives a relative position map example including the GPS position information and right-angled curve of a neighbouring vehicle. The neighbouring vehicle is on the left of the yellow vehicle, but its position may be the same lane as the yellow car. This paper's proposed method will correct the position information when it is in the tolerance range of the right-angled curve centre. The tolerance range is set at three metres in this paper. The position information will correct in the left lane of yellow vehicle in the Figure 3. The right-angled curve centre has a radius of three metres. The GPS position information will be corrected become this value of right angle curve/ radius circle center when the GPS position information falls within this radius.

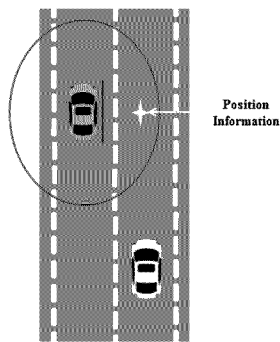


Figure 3: Relative position map

### 3. Performance Evaluation

The experimental setting used in the performance evaluation is shown in Figure 4. The front vehicle is equipped with a DSRC communication device which broadcasts the GPS position information in 10Hz. The self-vehicle is equipped with a DSRC device which also broadcasts the position information in 10Hz and receives information from neighboring vehicles. Moreover, the radar device is fitted in the front bumper of the self-vehicle in order to correct the position information of neighbouring vehicles. The smartphone device displays the relative position map in the self-vehicle. The proposed method is compared with previous work [6] in the experimental results.

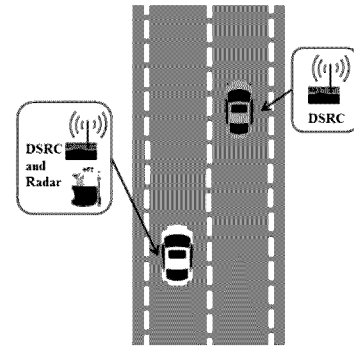


Figure 4: Experimental setting

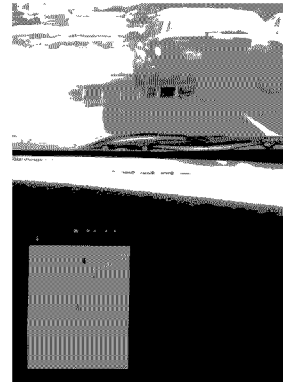


Figure 5: Front vehicle in the right side

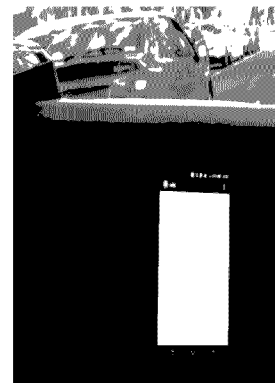


Figure 6: Front vehicle in the left side

The experimental results are shown in Figure 5 and Figure 6. The centre point of the smartphone is the self-vehicle position. The red point is the original GPS position information (previous work) and the other point is the method proposed in this paper. In Figure 5, the front vehicle is located on the right side of the self-vehicle. In this case, the original GPS position information has drifted to the other position. The proposed method will correct the original GPS position information to make it more accurate. In Figure 6, the front vehicle is located on the left side of the self-vehicle. In this case, the original GPS position information has

been drifting to the same lane as the self-vehicle. The proposed method will move the original GPS position to a more accurate position in the lane on the left side. The experimental results in Figure 5 and Figure 6 show that the proposed method will provide better performance than the original GPS position information in terms of supporting the relative position dynamic map in vehicular networks.

#### 4. Conclusions

Because drivers cannot correctly judge the relative distance between neighbouring vehicles, many traffic accidents happen. A relative position dynamic map with a radar sensor for driver assistance systems in vehicular networks is proposed in this paper. The proposed method relies on the relative distance measured by the radar sensor to correct the GPS position information on neighbouring vehicles by means of dedicated short-range communication to construct a relative position dynamic map for the driver: the map uses a fusion of data from the GPS and radar map/distance map. The experimental results show that the proposed method provides better performance than the original GPS position information and displays the relative position dynamic map to the driver. We believe the relative position dynamic map will become a basic technological requirement for automatic vehicles. Hence, our aim in future work is to control the speed and direction of the self-vehicle as it follows the vehicle in front.

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