Design and Implementation of Vehicle Collision Detection and Alarm System Based on Smartphone

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Abstract. Every year, there are a large number of people died in traffic accidents in our country. If people can get help in time after a traffic accident, the survival rate of the people who are treated can be greatly increased. Therefore, it is very necessary to have a system that can detect traffic accidents and call the police or notify the rescuers in time. According to the survey and analysis, the functions of some similar systems in China are not perfect and most of the cost are high, which cannot be widely promoted in China with a high private car base. Based on the acceleration sequence value obtained by the smartphone accelerometer, this project designs the vehicle collision detection algorithm and realizes the collision detection during the driving process of the vehicle in the android environment. When a collision event is detected, the system can promptly send the collision information to the preset phone number and drive the camera function of the mobile phone, perform instant photo forensics on the scene, and finally send the help information and the accident photo to the preset phone number. The project system can realize the detection and alarm function of automobile collision accidents in time, and provide timely rescue after the collision accident.

1. Introduction

With the rapidly development of the automobile manufacturing industry, the number of motor vehicles in the world has increased substantially. Road traffic problems have become increasingly prominent, traffic accidents have continued to rise, and the number of people who lost their lives due to traffic accidents has increased year by year. Road traffic safety has become a common concern in society. Road traffic accidents have become a serious problem that threatens the safety of national life property. It is particularly necessary to effectively reduce the loss of traffic accidents. Looking up the Statistical Bulletin of the People's Republic of China of the past decade, we can see that the people killed by traffic accidents is increasing every year. The results are shown in the figure 1.

According to the relevant investigations, the following two points can be known. First, most of the victims in traffic accidents dead before they get effective rescue. Second, if the injured person who is equally injured can be sent to the hospital within 30 minutes for treatment, the survival rate can reach 80%. If they have not been effectively treated in more than 90 minutes, the hope of survival is very slim. From this, we know that reducing the waiting time of the injured after the traffic accident is the key to reducing the death rate of traffic accidents [12][3]. Therefore, it is very necessary to develop a system that can report the accident and provide the location of the accident after a traffic accident. It can effectively reduce the waiting time for the injured person after the accident and has good practicability for reducing traffic accident losses.
2. Vehicle crash accident characteristic parameters

How to accurately determine the occurrence of collision accidents is the primary task of the whole system and it is also the most important part of ensuring the practicability of the system. After reviewing the relevant literature related to automobile collision accidents, it is found that the following rules existed in the operation of the car, as shown in table 1.

| Collision speed (km/h) | Time spent (ms) |
|------------------------|-----------------|
| 60                     | 80              |
| 70                     | 70              |
| 80                     | 50              |
| 120                    | 40              |

It can be seen from the table that the time spent by the car in the collision process is between 40 and 80 ms, and gradually decreases with the increase of the collision speed. From the acceleration formula $a=(v-v_0)/t$ can be seen that the greater the collision speed, the greater the acceleration will be at the time of collision, and the greater the threat to the collision of the car. Therefore, according to the speed of the car, there should be an acceleration threshold during the collision of the car, which can be used as the basis for the collision. For example, the acceleration value generated by collision will be large when the vehicle is in a fast speed, and small when the vehicle is in a slow speed. Therefore, it can be comprehensively judged whether the car collision accident occurs according to the driving speed and the acceleration value of the car. According to the relevant research on the theory of automobile collision, it can be known that when the car collides at a speed of 60km/h, the peak value of the acceleration of the car can reach 30g, but the average acceleration value is about 11g. Therefore, 11g acceleration value and the speed of 60km/h can be used as two thresholds to judge whether a collision accident occurs. Correspondingly, when the vehicle speed is low, the acceleration threshold as the basis for judgment will be correspondingly reduced. When the vehicle speed is high, the corresponding acceleration threshold should be appropriately increased. The system should increase the frequency of detection when the vehicle speed exceeds a certain maximum value (because the probability of an accident at this time increases). Check the relevant information to know the magnitude of the collision acceleration when a traffic accident occurs at a certain speed.

3. System overall framework and module design

Based on the acceleration sensor of the smartphone, the system uses the obtained acceleration sequence value as a parameter to design the vehicle collision detection algorithm, and realize the collision detection during the driving process of the vehicle in the Android environment. When a collision event is detected, the collision information can be sent to the preset phone number in time. At the same time, the mobile phone camera is driven to take a photo, and the photo is sent to the reserved mobile phone.
number. The collision detection and alarm function is realized to provide timely support for the alarm when a car collision accident occurs. The smart phone-based vehicle collision accident detection and alarm system should have modules: distress information editing and control module, integrated positioning and position display module, acceleration monitoring module. The system framework is shown in Figure 2 below.

3.1. Acceleration monitoring module
The main way to judge the occurrence of automobile collision accident is to detect whether the acceleration value of automobile is equal to the preset threshold \( G \) in real time. If it exceeds, it is judged that the accident occurs. The value of the acceleration can be obtained by calling the acceleration sensor of the smartphone. The \( x \)-axis, \( y \)-axis, and \( z \)-axis acceleration sequence values are represented by \( A_x \), \( A_y \), and \( A_z \) respectively. The \( z \)-axis in the acceleration sensor called by this system defaults to 1g \( (9.8\text{m/s}^2) \) in the horizontal and stationary state of the mobile phone. Therefore, before the synthetic acceleration model is established, the obtained \( z \)-axis acceleration value is subtracted from 9.8. For the synthesis of acceleration, the following mathematical model is established:

\[
A = \sqrt{A_x^2 + A_y^2 + A_z^2},
\]

where \( A \) is a parameter directly judged with the threshold \( G \) (take 11g). Corresponding to this model, system need to call the mathematical function of JAVA language, where the square operation calls the function: ‘Math.pow()’; the square root operation calls the function: ‘Math.sqrt()’. To obtain the acceleration value in the smart phone, the API of the acceleration sensor needs to be called. The obtained acceleration values of the \( x \), \( y \), and \( z \) axes are used to calculate the combined acceleration and compared with a preset threshold. The implementation process of the acceleration detection module is shown in Figure 3.

3.2. Integrated positioning and position display module
The acquisition of location information is a key step to improve the rescue efficiency. The positioning and location display function of the system is mainly realized by calling the Baidu map API. It can be divided into two parts: latitude and longitude acquisition and map display. Before calling Baidu map, you need to apply for Baidu map AK code and download Baidu map Android positioning SDK package. The SDK parameters used in the positioning process are shown in table 2. The obtained location information is displayed in the form of a map, which helps the user to more intuitively understand where he is. First, add the Baidu map control in the layout file (com.baidu.mapapi.map.MapView). Then obtain the management permission of Baidu map in the main program through ‘getMap’, and judge the positioning method before displaying the positioning. Finally map will be displayed at a certain multiple of the location.
Table 2. Baidu map SDK parameters.

| Call function                | Features                                      |
|------------------------------|-----------------------------------------------|
| setLocationMode              | Set positioning mode                         |
| setCoorType                  | Set back to latitude and longitude coordinate type |
| setScanSpan                  | Set the interval to initiate a location request |
| setIsNeedAddress             | Set whether you need address information       |
| setIsNeedLocationDescribe    | Set whether you need a simple location description |
| setOpenGps                   | Set whether to use GPS                        |
| setIsNeedLocationPoiList     | Set whether you need peripheral POI information |

After the Baidu map SDK is arranged, the latitude and longitude coordinates can be obtained only by calling the corresponding function. The latitude and longitude and position information are displayed on the system interface through ‘setText’. Then call the save method declared in advance to save it to the specified txt file.

3.3. Distress information editing and control module

After the acceleration detection module detects that there is a collision accident, the system will enable the distress information editing and control module. The implementation process of the whole module is shown in figure 4.

The input of the emergency contact should have very clear prompting and editability, so the form of pop-up input should be added to the main thread. After entering the program, call ‘AlertDialog’ to get the mobile phone emergency contact mobile number, then display the ‘EditText’ in the main interface, which is called by ‘getText.toString’ when a message needs to be sent using an emergency contact.

The content of the help message should mainly include the call for help notification, latitude and longitude coordinates and location information. The implementation of the SMS function in Android needs to call ‘smsManager’, then use ‘sendTextMessage’ to edit the content of the SMS and the phone number to complete the sending of the SMS.

After detecting a vehicle collision accident and sending a help message, the system will jump from the main program to the shooting thread that drives the camera. In the jump process of the program, the ‘startActivity’ is mainly used to realize the jump between activities. After entering the camera activity, the program will drive the mobile phone’s own rear camera and automatically save after 6s. The time-lapse shooting is to avoid the blurring of the photos caused by the impact of the collision, and the function used for time-lapse shooting is ‘sleep’. Pictures taken by the phone will be saved in the default directory.
In order to let the rescuers know more about the situation of the accident scene, the system will send the photo to the emergency contact through the MMS function after the collision accident is detected. The emergency contact phone is obtained by ‘getText.toString’. Different from sending a text message, sending a multimedia message requires defining more parameters through ‘putExtra’, such as defining a MMS subject through the subject and defining the storage address of the attachment through the ‘Intent.EXTRA_STREAM’. The attachment of the MMS is the photo of the accident scene just taken. Its address is obtained by ‘getContentResolver().insert’ and ‘Media.EXTERNAL_CONTENT_URI’.

4. System function test
Due to the constraints of the actual situation, it is impossible to test the system in the real situation of car collision. Therefore, the collision detection of the car is tested in a simulated environment, and the electric toy car is used to simulate the collision of the vehicle. Because the speed of the car is slow, the acceleration threshold is lowered, part of the test results are shown in table 3. The test results show that the system has a correct alarm rate of more than 97% when the simulated vehicle collides, and can accurately send help information and accident photos. The interface when the system is running is shown in figure 5, the help information is shown in figure 6.

| Time (year, month, day, hour, minute, second) | Simulated vehicle operating status | Acceleration value (m/s²) | Synthetic acceleration value (m/s²) | Whether to trigger an alarm |
|-----------------------------------------------|----------------------------------|---------------------------|-----------------------------------|-----------------------------|
| 2019.5.30-11:15:27 normal                     | 2.652 5.099 9.127               | 5.786695                  | no                                |
| 2019.5.30-11:15:29 collision                  | -19.211 -3.567 3.811            | 20.43659                  | yes                              |
| 2019.5.30-11:16:03 normal                     | 4.276 -4.74 19.614              | 11.70753                  | no                                |
| 2019.5.30-11:17:05 collision                  | 17.909 -10.472 12.502          | 20.92118                  | yes                              |
| 2019.5.30-11:17:55 normal                     | -5.3 -6.574 10.515             | 8.474591                  | no                                |
| 2019.5.30-11:18:17 collision                  | 18.68 -9.826 12.536            | 21.28329                  | yes                              |
| 2019.5.30-11:19:42 normal                     | 7.676 1.307 11.597             | 7.991147                  | no                                |
| 2019.5.30-11:19:50 collision                  | 17.641 -5.056 4.711            | 19.04379                  | no                                |
| 2019.5.30-11:20:01 normal                     | 13.901 -1.915 6.569           | 14.39946                  | no                                |
| 2019.5.30-11:20:12 collision                  | 15.725 -15.208 19.614         | 23.97652                  | yes                              |
| 2019.5.30-11:21:08 collision                  | 16.75 1.647 -0.924           | 19.95694                  | yes                              |
| 2019.5.30-11:22:00 normal                     | -6.56 6.814 6.574              | 9.993562                  | no                                |
| 2019.5.30-11:22:22 collision                  | -19.048 -14.111 1.915        | 24.98239                  | yes                              |
| 2019.5.30-11:23:08 normal                     | 7.714 4.616 8.585            | 9.071355                  | no                                |
| 2019.5.30-11:23:15 normal                     | 6.522 4.352 6.569            | 8.480315                  | no                                |
| 2019.5.30-11:23:28 collision                  | 1.508 4.089 -11.712          | 21.94903                  | yes                              |
5. Conclusion
The designed system monitors the acceleration value of the mobile phone in real time, and then designs the vehicle collision detection algorithm to realize the collision detection during the running of the vehicle. When a collision event is detected, the alarm message and the live photo can be sent in time. Through the experimental verification in the simulation environment, the system basically realized all the functions designed. The algorithm of automobile collision detection is a very meaningful and complicated topic. In this paper, there are many imperfections in the car collision algorithm. In the future research process, the related research will continue to be improved.

Acknowledgments
Thanks to the support of the Natural Science Foundation of Jiangxi Province (No.20142BAB201015) and the Research Project of Jiangxi Provincial Department of Education (No. GJJ160476).

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