Real-time Detection System for Smartphone Zombie Based on Machine Learning

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Abstract:

In this paper, we propose a real-time detection system for smartphone zombie (smombie) based on machine learning. The feature of this study is that it does not use cameras and external devices, which are often seen in studies focused on smombie. The proposed system uses four kinds of brightness, acceleration, gyro and motion sensors. We find the effectiveness of the proposed system by experiments for 10 examinees. We show it can detect smombie with 93\% accuracy.

Keywords: Smartphone zombie, Machine learning, Real-time detection

Classification: Sensing

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1 Introduction

The number of traffic accidents had been increasing until 2004, but has been decreasing in recent years due to the development of safe driving support technology and the voluntary return of licenses by aged people. However, there are still more than 400,000 accidents per year. Many fatal accidents occur between vehicles and pedestrians. In order to reduce such accidents, many studies on pedestrian detection using infrared radars and cameras [1, 2] have been conducted. However, the methods using radar and camera are effective only in a situation where visibility is good. This is because if there is an obstacle between the vehicle and the pedestrian, the pedestrian cannot be recognized.

Therefore, it is necessary to develop a new system that enables collision avoidance outside of line of sight. Wada et al. have been studying the Pedestrian-Vehicular Collision Avoidance System (P-VCASS) [3]. In P-VCASS, information on the position, speed, and direction of travel obtained from GPS is exchanged between pedestrians and vehicles via Wi-Fi, and the relative distance between pedestrians and vehicles is recognized. Then, P-VCASS estimates the relative distance after a few seconds. If there is a possibility of collision with a pedestrian, a warning is given to the driver. P-VCASS is effective for avoiding traffic accidents involving pedestrians because it exchanges information for both pedestrians and vehicles. Pedestrian behavior estimation is important in P-VCASS to estimate collision.

In this paper, we focus on smartphone zombie (smombie) which is the motion that the person operates the smartphone with walking. In 2017, the ownership rate of mobile terminals in households exceeded 90%. According to a survey by the Telecommunications Carriers Association, about half of people who own a smartphone answered that they have been smartphone zombie. When the smartphone zombie, the field of view becomes narrower because he concentrates on the screen [4], and the safety confirmation of the surroundings becomes sparse. Such pedestrians are one of the causes of troubles and accidents in every situation, not to mention under the road traffic environment. In recent years, accidents related to smartphone zombie have frequently occurred, and have become a serious social problem.

Various studies have been conducted to improve the safety of pedestrians while walking so far. These studies are classified into pedestrian-surrounding safety and pedestrian-behavior safety. The pedestrian-surrounding safety includes Ultra See [5] and Smombie Guardian [6]. There is SafeWalking [7] in pedestrian-behavior safety. Many of these studies use cameras built in smartphones. However, the system using the camera may not work well due to the difference in the brightness of the surrounding situation.

Hence, we propose a new smartphone zombie detection system that does not use a camera. Since no camera is used, smartphone zombie can be detected regardless of the surrounding environment. We detect a smartphone zombie by using sensors built in the smartphone and machine learning.
2 Proposed method

This method does not use an external device and a camera, and only uses a terminal to detect smartphone zombie. Fig. 1 shows the flowchart of the proposed method.

The proposed method consists of the following four steps.

Step 1: Motion and stop judgment
We determine whether the smartphone holder is in motion state or stop state.

Step 2: Possession position estimation
We estimate the possession position of the smartphone.

Step 3: Brightness judgment
We judge whether the smartphone screen is ON or OFF.

Step 4: Smartphone zombie judgment
The terminal judges whether the smartphone zombie is detected or not.
In Step 1, the three-axis composite acceleration is calculated from the values acquired by the acceleration sensor, and then the motion and stop of the terminal holder are determined. If the three-axis composite acceleration continuously exceeds a certain value for one second, it is determined to be motion, otherwise it is determined to be stopped. The three-axis composite acceleration is calculated by excluding the gravity component. This judgment is necessary in order not to give warning when operating the smartphone in a stop state such like sitting.

In Step 2, possession position estimation is performed using random forest (RF) with three-axis composite acceleration, three-axis composite angular velocity, and each axis gravity component as inputs. We perform machine learning on a smartphone using Core ML. The two kinds of outputs by RF are "chest pocket" and "other". The assumed positions of the smartphone are “hand-held”, “trouser pocket”, and “chest pocket”. But, because the way of the terminal posture change during walking or when starting smartphone zombie was different between “chest pocket” and “other”, we classified into the two kinds. Since the smartphone attitude in “bag” differs depending on the shape and the amount of contents, it is difficult to group the "bag". Hence, we do not consider its possession position.

In Step 3, it is determined whether the screen of the smartphone is ON or OFF from the brightness sensor of the screen. The reason for judging the brightness is that the screen is always ON when smartphone zombie.

In Step 4, the smartphone zombie is detected by using the threshold according to the possession position in Step 2. If the equation (1) is satisfied in the case of “chest pocket” and the equation (2) is satisfied in the case of “other than chest pocket”, it is determined that the smartphone zombie has started. This judgment is continued as long as the condition of the equation (3) is satisfied. When the smartphone zombie is detected, the pedestrian is given warning on the screen.

\[
\begin{align*}
\text{pitch}_{\text{diff}} &\leq -15 \\
g\text{ravityX} &\leq -0.14 \\
g\text{ravityY} &\leq 0.69 \\
g\text{ravityZ} &\leq -0.71 \\
\end{align*}
\]

\[
\begin{align*}
\text{pitch}_{\text{diff}} &\leq -300 \\
g\text{ravityX} &\leq -0.22 \\
g\text{ravityZ} &\leq -0.66 \\
17 &\leq \text{pitch} \leq 48.8 \\
\end{align*}
\]

where \( \text{pitch} \) is pitch angle [degree], \( \text{pitch}_{\text{diff}} \) is the difference of the pitch angle [degree] between current and previous 0.1 second time, \( \text{gravityX}, \text{gravityY}, \) and \( \text{gravityZ} \) are gravity of X, Y and Z axes [G], respectively. These conditions are set from behavior experiments of ten examinees. The detection in Step 1 to 4 is done every 0.1 second.

3 Performance evaluation

3.1 Overview

An experiment was performed to show the effectiveness of the proposed method. We used the iPhone 6s smartphone. The evaluation indices are detection accuracy.
and time from start of smartphone zombie to warning. The examinee first presses the start button, then walks for five seconds, and then starts smartphone zombie for five seconds. The accuracy evaluation uses four seconds of each movement. At the time of the experiment, a sound is emitted so that the timing of switching the operation can be understood. Since the examinee performs motions after hearing the sound, there is a slight delay. It takes one second to determine whether to move or stop. Therefore, data for four seconds excluding the first one second of each operation is used for performance evaluation. Since the system judges every 0.1 second, there are 40 judgment results for one motion per person. We assume three positions of the smartphone are hand-held, trouser pocket, and chest pocket when stopping and walking.

3.2 Detection accuracy of smartphone zombie
The detection accuracy is evaluated based on the display of smartphone zombie warning. Table 1 shows the detection results of the conventional smartphone zombie application on the Android OS [8] and the proposed application. We evaluate the display warning 12 times per person for 10 examinees, total 120 times. No smartphone zombie means walking in this experiment. The detection accuracy of the application [8] and the proposed application are 63 % and 93 %, respectively. We find the proposed application can improve the detection accuracy drastically. When smartphone zombie in real motion, there is detection case of no smartphone zombie. This is thought to be due to errors in motion or stop judgment and smartphone zombie judgment. This is a future work to further reduce these errors.

| Real motion | Detection |  |
|-------------|-----------|---|
| Smartphone zombie | 72 | 48 |
| No Smartphone zombie | 41 | 79 |

| Real motion | Detection |  |
|-------------|-----------|---|
| Smartphone zombie | 103 | 17 |
| No Smartphone zombie | 0 | 120 |

3.3 Time from start of smartphone zombie to warning
We evaluate the time from the start of the smartphone zombie to the warning. The same experiment as in the previous section was performed on 10 examinees, and we compare the proposed application with the conventional smartphone zombie application [8]. Fig. 2 shows the comparison of time from start of smartphone zombie to warning between the conventional and the proposed applications. Three cases show each possession position before the smartphone zombie. The upper and lower lines represent the maximum and minimum values, respectively. The points are the mean values. “With reaction time” means the time when 0.3 seconds is subtracted from the measurement time. Since there is a slight delay from the
display to the recognition, we subtracted 0.3 seconds which is the average reaction time of people. From these results, it is found that the proposed application gives warning more than one second earlier than the conventional application.

![Figure 2](image)

**Fig. 2.** Time from start of the smartphone zombie to warning

### 4 Conclusions

We have proposed a real-time detection system for smartphone zombie based on machine learning without using external devices and built-in camera. From the performance evaluation, it was shown that this system can detect smartphone zombie with 93% accuracy. As a future work, we need to verify the judgment result when the smartphone is taken out of the possession position in the stop state.

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