

Walking Security Alarm System for Mobile Phone Addicts

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Abstract. To handle walking safety problems for mobile phone addicts, a walking security alarm system based on android mobile platform is designed. According to movement features when someone is walking and when he falls down, this paper proposes a step counting algorithm and a fall-down detection algorithm based on SVM judging respectively. In addition, a graded alarm technology is designed, so that a complete security alarm and calling-for-help system is implemented. Test results indicate that the accuracy of core algorithms have reached over 96% in average, and functions of each module have reached the design objects.

Introduction

Along with the rapid development of smart phones and mobile technology, mobile phones have become people's indispensable portable devices in daily life. In recent years, using mobile phones when bowing down, therefore paying little attention to road traffic conditions, have produced lot of cases causing danger of life. Taking this into account, an APP that can run on mobile phones and issue warnings against users' walking security seems quite urgent. This paper aims at designing a kind of walking security alarm system based on android mobile platform, protecting the security of mobile phone addicts.

Analysis of current technology

The flaws and blank of current technology are as follows: lack of a real-time step counting algorithm which is easy to calculate and has both high precision and high accuracy; no way to judge whether users are using mobile phones only according to the increasing of step counts, which means we need more factors; lack of a graded alarm mechanism of walking security, and the security protection of mobile phone addicts is in a blank state; lack of an effective fall-down detection algorithm and calling-for-help mechanism when mobile phone users fall down accidentally.

In terms of step counting algorithms, essay[1,2] put forward a kind of step counting algorithm based on the plus and deduction window filter, reducing influences of multi-peak values, and the weak point is that accuracy reduces obviously when walking at variable speed. Essay[3,4,5] put forward a kind of step counting algorithm based on autocorrelation analysis, reducing influences of positions of phones and movement postures. The weak point is that the algorithm is relatively complex and sampling frequency is too low. Essay[6,7,8,9] put forward a kind of step counting algorithm based on calibration factors and delayed feedback, reducing influences of multi-peak values, and its robustness is relatively ideal. The weak point is that accuracy reduces when walking slowly. Essay[10] puts forward a kind of step counting algorithm based on amplitudes of SVM, achieving low power consumption and high accuracy. The weak point is that we need to adjust amplitude threshold due to users' practical movement characteristics, therefore inconvenient in actual use.

In terms of fall-down detection algorithms, essay[11] puts forward a kind of fall-down detection algorithm based on judging SVM and attitude feature thresholds, achieving relatively low missing rate and false rate. The weak point is that threshold parameters are fixed in certain age groups. Essay[12] puts forward a kind of fall-down detection algorithm based on Kalman filtering on body attitude angels, also achieving relatively low missing rate and false rate. The weak point is that the filter algorithm is

relatively complex. Essay[13] puts forward a kind of fall-down detection algorithm based on Hidden Markov Model training SVM and body attitude, achieving relatively low missing rate and false rate. The weak point is that the training process will take extra time. Essay[14] puts forward a kind of fall-down detection algorithm based on SVM and extracting SMA peaks. The data are easy to collect, but missing rate and false rate are not low enough. All of the above four algorithms use external accelerometer to collect data, and the missing rate and false rate will increase in actual detection, which is harmful to the detection in this part, considering the restriction of built-in accelerometer.

Against deficiencies of current technology and flaws of algorithms, this paper proposes a step counting algorithm and a fall-down detection algorithm based on SVM judging. Both algorithms are simple and efficient, achieving relatively high precision and high accuracy. In combination with the algorithms, we use built-in face detection technology of android mobile phones, implementing real-time and accurate judgment of mobile phone addicts, locking targets efficiently. Also, a graded alarm technology is designed creatively, reflecting humanize designing concept.

System module division

Module 1: step counting module, responsible for judging whether the user is walking.

Module 2: Face detection module, responsible for judging whether the user is using the mobile phone, therefore judging whether the user is a mobile phone addict right now.

Module 3: Graded alarm module, responsible for issuing warnings to users according to their personal information and current statement.

Module 4: fall-down detection module, responsible for monitoring if the user happens to fall down, calling for help timely when fall-down occurs.

Core algorithm and technology

Step counting algorithm

According to the movement characteristics of human walking, we choose SVM (Signal Vector Magnitude, $SVM = \sqrt{A_x^2 + A_y^2 + A_z^2}$) as evidence of judging whether steps increase or not, so that the interference from phone movement angle can be excluded.

Acquire acceleration data of X/Y/Z axis, named $A_x/A_y/A_z$, calculate SVM, mean filter with the window length of 3, and draw the waveform.

According to periodic characteristics of the waveform, we try to find out the repeated parts of every period, namely the part where SVM decrease from A_1 to A_2 , judge whether the user actually takes a step according to T_1 , which refers to the time length this part occupies. With this method we can avoid interference from sensor data jitter or other external factors. As normal walking speed of human stays within a certain range, we should calculate the time interval between two adjacent steps, namely T_2 . After repeated test and revise, we decide the value of A_1 as $10.5m/s^2$, A_2 as $9.1m/s^2$, T_1 as $0.03s$, T_2 as $0.40s$. Each time when SVM meets the conditions above, the total steps increase 1. When the total steps increase from 0 to 5, we judge that the user begins to walk. When the total steps no longer increase over 3 seconds, we judge that the user stops walking, and the total steps will be set zero.

Face detection

Step1 When the user is detected walking by using the step counting algorithm above, we initialize the front camera, and take a picture every second.

Step2 Store the data obtained from the picture into a temporary bitmap, rotate 90 degree counterclockwise and zoom the bitmap with the proportion of 1:0.3.

Step3 Transfer the bitmap to the format of RGB_565, use the default FaceDetector class to detect the bitmap. When there's complete outline of human face, and the angle between the face and the mobile phone stays within the range of $\pm 45^\circ$ on the X axis, $\pm 30^\circ$ on the Y axis, $\pm 30^\circ$ on the XOY plane, then the face will be detected, and the user is judged using the mobile phone.

Graded alarm

Step1 Turn on the timer to record the duration. When the user use the mobile phone while walking for more than 15 seconds, start alarm of level 1, pop up a line of warning word with a warning sign: Use the mobile phone while walking for too long may cause danger, please be careful.

Step2 When the user use the mobile phone while walking for more than 30 seconds, start alarm of level 2, pop up a line of warning word with a warning sign: You are walking in the state which may cause danger, please be careful. Then start the vibration function, broadcast the warning voice circularly.

Step3 When the user use the mobile phone while walking for more than 2 minutes, start alarm of level 3, pop up a line of warning word with a warning sign: You've been use the mobile phone while walking for over 2 minutes, the screen will be turned off for your safety in 10 seconds. Then pop up a countdown dialog box, start the vibration function, and broadcast the warning voice circularly.

Step4 When the user stop using the mobile phone while walking for over 5 seconds, then stop alarming, record the level and duration of this alarm, store the data into the database in the mobile phone. When level 3 alarm is triggered three times within 30 minutes, then start 10 seconds countdown, turn off the screen in 10 seconds by controlling the phone power management.

Note: For women users, users aged under 18 or over 60, and users with movement disorder, level 1 alarm trigger time will be 10 seconds, level 2 alarm trigger time will be 20 seconds, level 3 alarm trigger time will be 60 seconds.

Fall-down detection

Choose SVM as evidence to judge the mutation of movement state, so that the interference from phone movement angle can be excluded.

Acquire acceleration data of X/Y/Z axis, named $A_x/A_y/A_z$, calculate SVM, mean filter with the window length of 3, and draw the waveform.

According to the waveform characteristics of sudden fall-down in walking process, there will be a short peak in SVM waveform, and the mobile phone will stay still in the next several seconds after the fall-down.

Firstly, according to the feature of SVM be greater than the threshold A_1 within a continuous interval T_1 , mark out the time point where a fall-down is suspected to occur. Then check whether SVM stays within the range between A_2 and A_3 in the time interval between T_2 and T_3 , judge if the mobile phone stays still during the interval, further judge if a fall-down occurs. After repeated test and revise, we decide the value of A_1 as 15.6m/s^2 , A_2 as 8.8m/s^2 , A_3 as 10.8m/s^2 , T_1 as 0.20s, T_2 as 3s, T_3 as 6s. Each time when SVM meets the conditions above, then the user is confirmed to have fallen down unexpectedly. A dialog of inquiry for asking for help will be popped up, and a 5-second countdown will be started at the same time. If the user hasn't cancel the inquiry manually, then begin to alarm by playing the default tone of the mobile phone, and start to vibrate with a short interval. Afterwards, send a message to the emergency number with user's current location information, and call the emergency number or 120 for help.

Experimental evaluation

Mobile phone used for testing: Huawei 5A

Testing of step counting algorithm

Horizontal test: Multiple users, hand hold, walking at stable speed(about 95 steps/min)

Longitudinal test: Fixed one user, different posture to hold the phone

Horizontal Test

Tester	Steps measured	Steps in fact	Steps measured	Steps in fact	Average accuracy
Student 1	52	51	46	50	95%
Student 2	50	50	51	50	99%
Student 3	50	50	51	50	99%
Student 4	50	50	50	50	100%
Student 5	50	50	50	50	100%
Student 6	50	50	50	50	100%
Student 7	51	50	50	50	100%
Student 8	50	50	50	50	100%

Table 1

Longitudinal Test

Walking posture	Steps measured	Steps in fact	Steps measured	Steps in fact	Average accuracy
Upstairs	48	50	50	50	98%
Downstairs	48	50	49	50	97%
55 steps/min	50	50	50	50	100%
Variable speed	49	50	48	50	97%
135 steps/min	49	50	47	50	96%
In coat pocket	52	50	52	50	96%
In pants pocket	51	50	50	50	99%

Table 2

Analysis: Average accuracy of all users when walking at 95 steps/min is 99.1%, while overall accuracy of different posture is 97.6%.

Face detection

Margin test: The user's face can be detected only when the whole face contour is located in the picture.

Max deflection on X axis is $\pm 45^\circ$ (with no rotation in XOY plane, no deflection on Y axis)

Max deflection on Y axis is $\pm 30^\circ$ (with no rotation in XOY plane, no deflection on X axis)

Max rotation in XOY plane is $\pm 30^\circ$ (with no deflection on X axis, no deflection on Y axis)

Fall-down detection

Horizontal test: Multiple users, hand hold, fall down forward when walking at stable speed

Longitudinal test: Fixed one user, different posture to fall down

Horizontal Test

Tester	Fall-down times tested	Fall-down times in fact	Average accuracy
Student 1	19	20	95%
Student 2	20	20	100%
Student 3	20	20	100%
Student 4	20	20	100%
Student 5	19	20	95%
Student 6	19	20	95%
Student 7	20	20	100%
Student 8	20	20	100%

Table 3

Longitudinal Test

Behavior	Fall-down or not	Correct times	Total times	Average accuracy
Lying down still	No	20	20	100%
Sitting still	No	20	20	100%
Standing still	No	20	20	100%
Uniform walking	No	20	20	100%
Sit down quickly	No	20	20	100%
Fall forward	Yes	20	20	100%
Fall Laterally	Yes	19	20	95%
Fall backward	Yes	19	20	95%
Stand up quickly	Yes	19	20	95%

Table 4

Analysis: Average accuracy of all users falling down forward when walking at stable speed is 98.1%, while overall missing/false rate of different posture is 0/3.75%.

Conclusions

This paper elaborates a kind of design of walking security alarm system for mobile phone addicts in detail. In the part of step counting algorithm, the quantity of data collection is reduced, while high precision and high accuracy is maintained. In the part of face detection, we choose default face detecting technology from Google, providing real-time and precise judgement of whether the user is using the mobile phone while walking, so that the target can be locked effectively. According to how long the user has been using the mobile phone when walking, a graded alarm technology is creatively designed, meanwhile special care is given to women, elders, juveniles and users with movement disorder, reflecting humane design concepts while protecting users' walking safety. In the part of fall-down detection, the quantity of data collection is reduced, while high precision and high accuracy is maintained. The whole system has a clear structure and clear division of labor, while every module can play their role according to the designing demand, so that the walking safety of mobile phone addicted users can be fully guaranteed.

The system designed in this paper is part of walking security protecting plan, meanwhile the base of the whole project. We are planning to store real time motion data and location information of every

user in the cloud, so that we can monitor the user's walking status more effectively, and provide more safeguard. At the same time, we'll do real time image processing for the front road in the user's direction, develop the road image feature database by machine learning, and realize intelligent analysis for the front road condition in the user's direction, so that every user's walking security can be further protected.

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