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Android Sensor Signal Processing using Acceleration Sensor for Smart Phone

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Abstract. Smart phones are equipped with various sensors, which can help realize user interfaces which are interesting and natural. In this paper, sensitivity and drift problems in the acceleration sensor are dealt with by using lowpass filter and Kalman filter, making the output stable and compliant. Besides, the study results can be applied to make new kinds of user interfaces. The experiment results of sensor signal processing revealed that the suggested methods are effective. The suggested methods can be useful for future researches on development of new interfaces on smart phone.

Keywords: sensor signal processing, acceleration sensor, filter

1 Introduction

Technologies in the areas of sensors, computing power, and interfaces have been advancing, enabling smart interactions between human beings and digital devices. Most of all, smart phones have been successfully realizing effective interactions between devices and human beings. Amongst various technologies, the touch technology on the smart phone, with its user-friendly and convenient interface, has contributed tremendously to the widespread use of the smart phones among people. Besides, various other technologies including ultra-speed wireless data communications technology(LTE), high performance computing capability of the mobile smart phone device, and other sensor technologies are expected to promote new kinds of interaction technologies between humans and devices.[1-8]

Especially, in the area of sensors, studies on gesture recognition based on sensor information are actively under way. To satisfy various other functions of the smart phone, many kinds of sensors have been added including acceleration sensor, magnetic field sensor, gyro sensor, proximity sensor, light sensor, temperature sensor, air pressure sensor, and etc. Among them, acceleration sensor and gyro sensor show numerical data about rotation and movement of the smart phone, so studies about these two are especially active. The motion gesture recognition method using smart phone sensor may be highly useful in certain situations or environment. The motion gesture recognition by the sensor allows immediate identification of the result when views are available, so this feature is a great advantage in the smart phone

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environment where screen is small. In addition, since each user registers his/her own motion gestures, it can ensure security and better utilization.[1-4]

In this paper, acceleration sensor motion data help recognize the directions of the gestures. To process the information, lowpass filter and Kalman filter are used for the sensor data. Through the features of the filtering and data process, we try to minimize the sensitivity and drift problems of the sensor, as well as extract the movement and directional information of the user.

2 Android sensor

Sensor is the part, device, gadget, or measurement which senses or measures the physical volume or changes of heat, light, temperature, pressure, sound, acceleration, or image, and turns them into certain signals. Sensors are electronic or mechanical imitation of the five senses of human beings which are necessary to sense the outside environment. Applications of sensors vary: registering movements, responding to sound, reacting to pressure, and etc.[3] Among the sensors which are frequently used for mobile gadgets like smart phones are camera, acceleration sensor, gyro sensor, magnetic field sensor, light sensor, temperature sensor, air pressure sensor, and etc. There are few cases where methods other than touch or button are used for input in mobile devices such as smart phones. These roughly include voice input, camera image input, and movement input. This paper uses the gesture recognition method which is based on sensor variations occurring when objects move or rotate. Here, the sensors measuring the user's movements should be able to get real time data on the user's movements. Acceleration sensor and gyro sensor are the ones with the relevant features.[2-4]

Gadgets using Android OS have sensors which can measure motions, directions, and various environmental factors. These sensors provide highly accurate raw data, and they can monitor three dimensional motions or positions, and provide information on relative changes in the environment nearby.[3-6]

3.1 Acceleration sensor

The acceleration sensor measures the variations in speeds. Considering speed represents the differences in movement distance, we can calculate the movement distance per unit time. However, the acceleration sensor does not simply measure the value in movement, but we also have to consider the acceleration effected by gravity. Gravity acceleration is constant at $9.8m/sec^2$ when the outward force is not applied, and the value is different depending on the slope of the sensor. Therefore, it is used to measure the slope of the mobile gadget. However, these data have many error factors such as noise, drift, and long response time, so we need to appropriately deal with data signals. Useful filters for smart phone sensors are lowpass filter, highpass filter, average filter, Kalman filter, and etc. When there is little need for modification afterwards, we can use lowpass filter or highpass filter. Kalman filter is only used when we need measured value and estimated value. For the purpose of this paper, lowpass filter and Kalman filter have been used in the experiments.[2-6]

4 Experiment

4.1 Experiment 1

(a) (b)

Fig. 1. Experiment 1 of Sensor Signal Processing

Experiment 1 shows the output value of the acceleration sensor in three ways. The first yellow square on top(R1, with the inner square pink) shows the direct output of the sensor. The second, black square(R2, the inner red square) is the output when Kalman filter has been applied to the sensor output. The third red square(R3, the inner blue square) is the output after lowpass filter has been applied to the sensor input. The upper left shows the right angle coordinate(x, y) for each respective square whose movement values have been modified depending on layouts. Figure(a) shows the filtered output at the motionless state(0,0) when there is no movement. Here, the coordinate for all the squares R1, R2, R3 shows (0,0). For squares R2 and R3 where Kalman filter and lowpass filter was applied respectively after time Δt elapsed, the movement is the same as the first at (0,0). On the other hand, for R1 square where the filter output was applied directly, constant slight movements are identified. Figure(b) shows the result. Through Experiment 1, we could confirm that the drift effect was great depending on time when the acceleration sensor output was applied directly. When the suggested lowpass filter or Kalman filter was applied, the sensitivity to the variations in the sensor output was ignorable, and the filtering effect helped maintain stable output value.

4.2 Experiment 2.

(a) (b)

Fig. 2. Experiment 2 of Sensor Signal Processing

In Experiment 2, the movements of the three squares R1, R2, R3 have been compared depending on the sensor output where the right bottom is sloped as in Figure(a) and where the left bottom is sloped as in Figure(b). Figure(a) is the result image of the case where there were movements in the right bottom. We could see that the most movements occurred in R1 which shows the sensor output. R2, where Kalman filter has been applied, and R3, which used lowpass filter, show almost identical movement responses. Figure(b) shows the result of the experiment where the left bottom movement is bigger than in Figure(a). Here, R1 square responds sensitively to the sensor output showing big movement just like in Experiment (a). R2, where Kalman filter was applied, shows the least response movement. The medium movement path behavior of R2 also reveals large sensor variations, but the movements are not sensitive and comply with the fixed variable condition. In R3 in which lowpass filter has been used, there were movements, but they were not as sensitive to sensor output as in R2, and they also showed good compliance with the fixed variable conditions. Both R2 and R3 were excellent in their adaptations to sensitivity of the sensor output. Displacement was greater in R2 in which lowpass filter has been applied than in R3.

5 Conclusion

Smart phones have various sensors, but their output values are not accurate and have large drift. Nevertheless, the important differentiation edge for the smart phone over the PC may be in using sensors, so we can create new functions by using these sensors. This paper tries to replace the conventional screen touch method by using the acceleration sensor on most of the smart phones. For this, we needed to solve the sensitivity and drift problems of the sensors. Lowpass filter and Kalman filter have been suggested for solution, and they were modified to be used on the smart phone. As shown in Experiment 1 and 2, we could confirm the stability of the output values when we applied the suggested filters to the sensitive output values of the sensors. Kalman filter was only appropriate when there were large horizontal(right and left) and vertical(up and down) movements. Lowpass filter can be used for prompt response time and displacement value.

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