A Method Using Same Light Sensor for Detecting Multiple Events on Window in Home Intruding Crime

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Abstract: Combining robots with many sensor nodes on the sensor network is important to improve the home security. From view of the cost of such system, it is desired that each sensor node is very cheap. The three events to the window and the key occurring when a thief attempts to intrude into the house are detected by the different sensors conventionally. This paper proposes a method detecting the three events by using the simple light-sensor consisting of an infrared LED and a photodiode. In the experiments, the light sensor shows the characteristic tendencies that can detect each event. This fact indicates that our proposal can realize a sensor node more efficiently instead of using different sensors.

Keywords: Light-sensor, detecting method, sensor node, multiple events, home security

I. INTRODUCTION

Combining robots with many sensor nodes on the sensor network is important to improve the home security [1][2]. From view of the cost of such system, it is desired that each sensor node is very cheap and small.

For the home intruding crime, three events mainly occur on the window [3]. First one is that the window is shocked. Next one is that the window is opened. Final one is that the key is opened. Traditionally, these three events are detected by using multiple sensors. For example, the magnetic sensor detects the window opened and the key opened [4]. The impact sensor detects the shock to the window [4].

This paper proposes new method that uses the same light sensor detecting three events mentioned above. By using the same light sensor, the cost buying many same sensors would be lower than buying the fewer number of different sensors. The light sensor is constructed by the trivial components which are an infrared LED and a photodiode. They are very cheap and can be obtained easily because many makers distribute them with the same characteristic.

The rest of this paper is organized as follows. Section II shows an organization of the sensor node that employs our method using the simple light-sensors. Also, how to detect the three events by our method is described. Section III performs the preliminary experiments to confirm whether the light sensor shows the characteristic tendencies that can detect each event or not. Finally, Section IV concludes our paper.

II. Proposed Detecting Method

1. Sensor Node Organization

Fig. 1 (a) shows a sensor node that employs our proposed detecting method using the light sensor. The proposed method uses two light-sensors (light-sensor A and light-sensor B) and two boards attached to the window as shown in Fig. 1 (a).

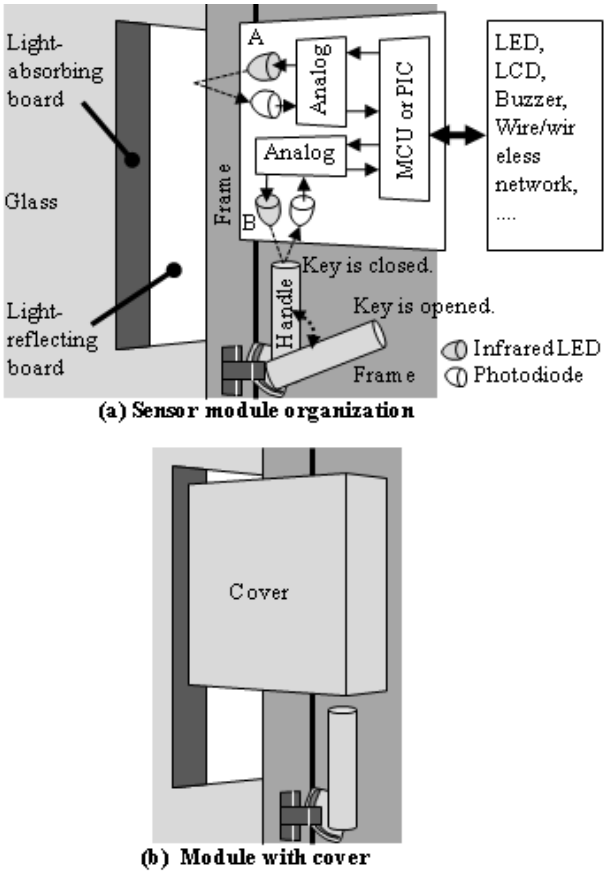

Fig. 1 Sensor Node Organization

In the light-sensor, the infrared LED irradiates a material and the photodiode detects the infrared light which is reflected by the material. The light-reflecting board and the light-absorbing board are attached to the

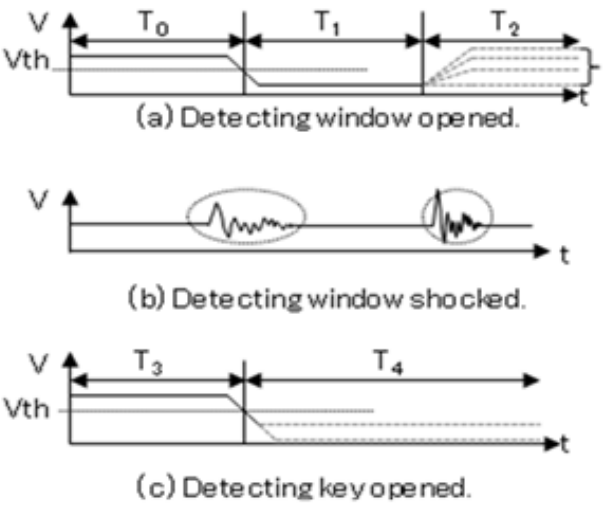

Fig. 2 Detecting Method

window as shown in Fig. 1 (a). The light-sensor A irradiates the light-reflecting board when the window is closed. Thus, when the window is opened, the infrared light irradiated by the light-sensor A crosses the light-absorbing board. The light-sensor B irradiates the light-reflecting board when the window is closed. The other irradiates the top of the handle of the key when the key is closed. The size of the two boards is enough large to hide the sensor node from the outside light as shown in Fig. 1 (b). In addition, the cover wrapping the sensor node is used to obstruct the outside light as much as possible.

In the sensor node, the output voltage of the photo diode passes through the analog circuits like an amplifier, a filter circuit, and an A/D converter. The output voltage that has passed the analog circuits is processed by the microcontroller. Then, the microcontroller drives some devices like the buzzer, LED and so on for alert. You can connect this sensor node to a sensor wire/wireless network to realize more intelligent security system.

2. Detecting Method

When the closed window is opened, the output voltage of the light-sensor A will change like Fig. 2 (a). The T0 means the period of which the window is closed and the light-sensor A irradiates the light-reflecting board. The T1 means the period of which the window is being opened and the light-sensor is crossing the light-absorbing board. The T2 indicates the period of which the window has been opened and the light-sensor A irradiates the outside through the window. The change of the output voltage from T0 to T1 can detect the window opened. In T2, the output voltage of the light-sensor A may be uncertain according to the outside situation like the weather and the time (day or night). Thus, we prepare the T1 by using the light-absorbing board to make the drop of the output voltage clear.

When the closed window is shocked, the window would wave [5]. By waving, the distance between the light-sensor A and the light-reflecting board will change. Consequently, since the amount of the reflected light varies, the output voltage of the light-sensor A changes as shown in Fig. 2 (b). Compared with the constant voltage without the shock, the window shocked can be detected by the differences of the output voltage.

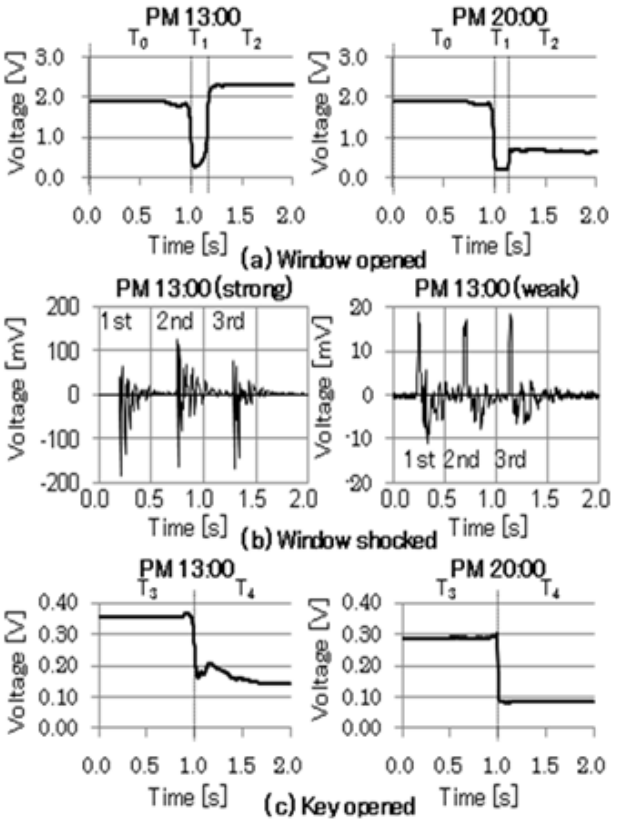

Fig. 3 Experimental Result

When the closed key is opened, the output voltage of the light-sensor B will change like Fig. 2 (c). The T3 means the period of which the key is closed. The T4 means the period of which the key has been opened. Compared with the period of which the key is closed, the distance between the light-sensor B and the handle of the key becomes longer. Thus, the output voltage of the T2 is smaller than that of the T1. By using this drop, the key opened can be detected.

III. Experimental Result and Discussion

1. Experimental Environment

To confirm that proposed method can really detect the three events in the house intruding crime, we have developed a prototype.

In the prototype, we have used the TLN110 of the infrared LED and the TPS611 of the photodiode. The light-reflecting board is a corrugated paper whose surface is shiny white. The light-absorbing board is constructed on the same corrugated paper by painting its

edge black.

The prototype is set to the southern window in the lab room. We have set the distance between the light-sensor A and the light-reflecting board to about 0.8cm. T The distance between the light-sensor B and the top of the handle of the closed key has been set to about 1.5cm.

We have made a cover by the corrugated paper and painted the inside of the cover black. The chink between the cover and the light-reflecting board is about 0.2cm. The chink between the cover and the handle of the closed key is about 1.0cm.

We have measured at 8:00am, 13:00pm, 17:00pm, and 20:00pm in sunny day. For the case shocking the window, we have extracted only the differences to the c onstant voltage, removing the DC by the capacitor.

2. Result and Discussion

A. Window Opened

Fig. 3 (a) shows a part of the results of which we have opened the window 10 times. The output voltages of the light-sensor A when the window is closed are 1.97V to 2.03V. In contrast, the output voltages when the light sensor A crosses the light-absorbing board are decreased until 0.19V to 0.26V. This fact indicates that the window opened can be detected by using this difference.

B. Window Shocked

Fig. 3 (b) shows a part of the results of which we have shocked the window 10 times at each time. Most thieves break the window around the key when intruding to the house. Thus, we have shocked around the key from outside the window. The shocked area is within about 20cm radius from the key.

As shown in Fig.3 (b), you can see the clear differences of the output voltage between two cases. For example, when the window is not shocked, the peak-to-peak voltages of the light-sensor B are lower than 0.5mV. In contrast, when the window is shocked, they are 12 mV to 310mV. Thus, the shock to the window can be detected by using the differences to the constant voltage.

C. Key Opened

Fig. 3 (c) shows a part of the results of which we have opened the key 10 times. The output voltages of the light-sensor B are 0.29V to 0.37V when the key is closed. In contrast, they are 0.08V to 0.14V when the key is opened. By using this voltage drop, the key opened can be detected.

IV. Conclusion

We have proposed the detection method of three events to the window and the key in the intruding crime using the simple light sensor. Through the preliminary experiment, it has been confirmed that the simple light-sensor can detect three events actually as expected. This fact indicates that our proposal can realize a sensor node more efficiently instead of using different sensors.

As future work, for putting our method to practical use, we will decide the threshold voltages and signal processing methods, giving stimulus corresponding to the real crime to the window.

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