Proceedings of International Conference on Technology and Social Science 2017
Invited Paper

Proposal of Condition Detection Method Corresponding to Brightness Change of Subject using Feature Quantity Obtained by Obrid-Sensor

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Keywords: Obrid-Sensor, condition detection, feature quantity, safety confirmation, privacy protection

Abstract. In Japan, lonely death becomes a social problem in recent years. In most cases, the causes of lonely death are the delays in finding the accidents or abnormal situations of elderly people who live alone. As a solution to the lonely death problem, condition detection using surveillance cameras are developed. However, the privacy of users is an important issue that we cannot ignore. To solve these problems, a system using a sensor named as One-dimensional brightness distribution sensor (Obrid-Sensor), which is able to detect a subject's condition without privacy offending, was proposed. The condition detection method to detect the subject's standing/falling-down is proposed in this research. This method uses the ratio of height and width obtained by feature quantity of two Obrid-Sensors. Therefore, it is effective even in the conditions with brightness changes of subjects, depth distance changes, or changes of height in sensors' setting.

1. Introduction

At present, the aging population in the world has been growing continuously [1]. Since the elders have weaker body functions, fall down accidents may occur frequently even when they are at home. Especially, for the elderly people who live alone, it is with high probability to have delays in finding their fall down accidents. Consequently, there is a risk that leads to the aggravation of symptoms or lonely death [2].

In order to detect accidents earlier, safety confirmation systems using surveillance cameras have been proposed. However, the system using a surveillance camera has several problems such as the violation of privacy, discomfort in using, and high cost. Thus, without violating the privacy, a system using a One-dimensional brightness distribution sensor (Obrid-Sensor) which can detect the condition of a person was proposed in our previous research [3]. Based on the sensor, the method to detect conditions of users, such as standing and falling down was proposed [4]. The height and width of subject can be estimated according to the feature quantity in vertical direction fetched by an Obrid-Sensor. Meanwhile, the subject's condition such as standing and falling down can be detected owing to the variation of height and width. However, some failures in detection may happen owing to the influence from background brightness variation.

In order to solve this problem, we propose the condition detection method using two Obrid-Sensor for detecting height and width of the subject, respectively. Meanwhile, to test the application in real

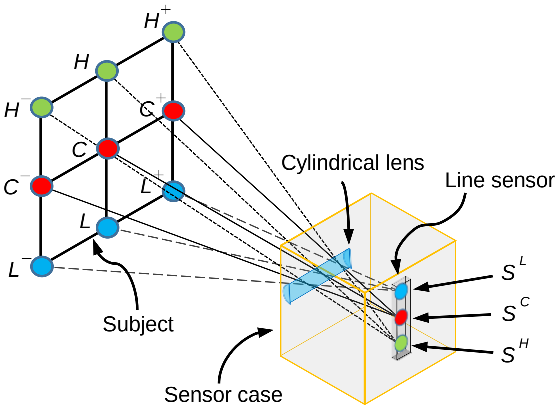
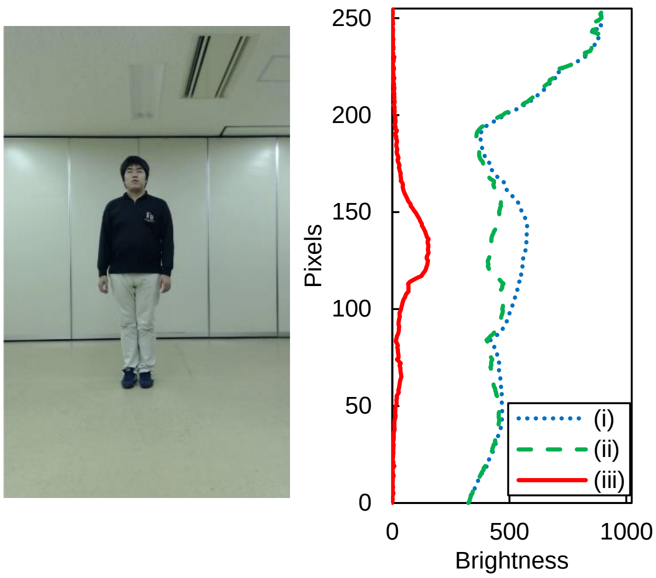


Fig. 1. Theoretical structure of Obrid-Sensor



(a) Camera image (b) Brightness distributions

Fig. 2. Acquisition of brightness distribution of subject

detect environment, the experiments under different conditions of sensor setting height and depth distance were implemented and studied.

2. Theoretical Structure of Obrid-Sensor and Method for Acquiring Feature Quantity of Subject using Background Subtraction Method

The theoretical structure of the one-dimensional brightness distribution is shown in Fig. 1. Based on Fig. 1, the light emitted by the subject passes through a cylindrical lens, then, it is incident on a line sensor. When viewing Fig. 1 from the top, there is no image formation effect of the property of the cylindrical lens. Thus, the light emitted from subject's horizontally arranged position entered one point of the line sensor (e.g. the light emitted from subject's point C^+ to C^- entered point S^C in Fig. 1). On the other hand, when viewing Fig. 1 from the side, the cylindrical lens becomes the shape of the plano-convex lens. Therefore, the vertical light emitted from the subject consecutively entered the corresponding point (e.g. the light emitted from the subject's point H to L consecutively entered the point S^H to S^L in Fig. 1).

By using the background subtraction method, the method to acquire the feature quantity is stated as below. Fig. 2(a) shows the camera image photographed in the detected range by the Obrid-Sensor. The brightness distribution acquired from the Obrid-Sensor is shown in Fig. 2(b). In line (i), the brightness distribution of the background when there is no subject is shown. Whereas in line (ii), the brightness distribution when a subject is the standing is shown. The differences between line (i) and line (ii) are shown in line (iii). Line (iii) is the feature quantity of the subject. From the changes of this feature quantity, condition of the standing or falling down can be detected.

3. Condition Detection Method Corresponding to Brightness Change of Subject using Feature Quantity

The proposed condition detection method uses the ratio R_l of height and width of subject's feature quantity obtained by two Obrid-Sensors, respectively. The condition detection such as standing and falling down is enabled by using the ratio R_l. The ratio R_l of the subject's feature quantity's height and width are derived on the following expression.

$$R_l = \frac{L_h}{L_w} \tag{1}$$

Where L_h [pixels] is the height of the subject's feature quantity acquired by Obrid-Sensor capable of detecting the movement in the vertical direction (the vertical width that there is the feature quantity); L_w [pixels] is the width of the subject's feature quantity acquired by Obrid-Sensor capable of detecting the movement in the horizontal direction (the horizontal width that there is the feature quantity).

In the proposed condition detection method, R_l of the standing and falling down condition satisfy the constant magnitude relationship of Table 1. This relationship doesn't depend on the setting height of the sensor and the depth distance between the sensor and the subject. In addition, by using the computer simulation, we confirmed that the proposed method could detect the standing or falling down condition of the subject.

4. Evaluation Experiments

4.1 Objective

As regards the ratio R_l of proposed condition detection method in this research, the measured value obtained by this experiment is evaluated by comparing with the theoretical value derived from the computer simulation.

4.2 Conditions and Methodology

The experimental conditions are shown in Table 2. Regarding the Obrid-Sensor's internal light receiving components, TSL1402R (produced by Ams) was used. Moreover, for the cylindrical lens, 12.5mm H x 25mm L x 12.5mm FL Uncoated, Cylinder Lens (produced by Edmund Optics) was used. In this experiment environment, the illuminance was 403 lx. The conditions of setting height H of the Obrid-sensor are 45 cm and 90 cm. The subject moved towards the depth direction in front of the sensor in the experiment. We decided the sensor position at 0 cm as the reference point. The depth distance between the sensor and the subject was measured from 100 cm to 500 cm at 50 cm intervals.

The subject's feature quantity was acquired in these measurement points and the ratio R_l of the feature quantity's height and width was measured.

4.3 Results and Discussion

The result of the setting height of H = 45 cm and 90 cm is shown respectively in Fig. 3 and Fig. 4. From the results, the measured values were similar to the theoretical value of the computer

Table 1 Magnitude relationship of R_l

Condition	Standing	Falling down	
		Back-to-front direction	Left-to-right direction
R_l	Large value	Medium value	Small value

Table 2 Experimental conditions

Sensor A for L_w	Horizontal movement detection angle		55.29 deg
	Vertical integration detection angle		55.29 deg
	Setting direction		Horizontal direction
Sensor B for L_h	Vertical movement detection angle		55.11 deg
	Horizontal integration detection angle		38.36 deg
	Setting direction		Horizontal direction
Subject	Height (body height)		178 cm
	Width		60.0 cm
	Color of clothes	Tops	Black
		Bottoms	White
Color of Background			White

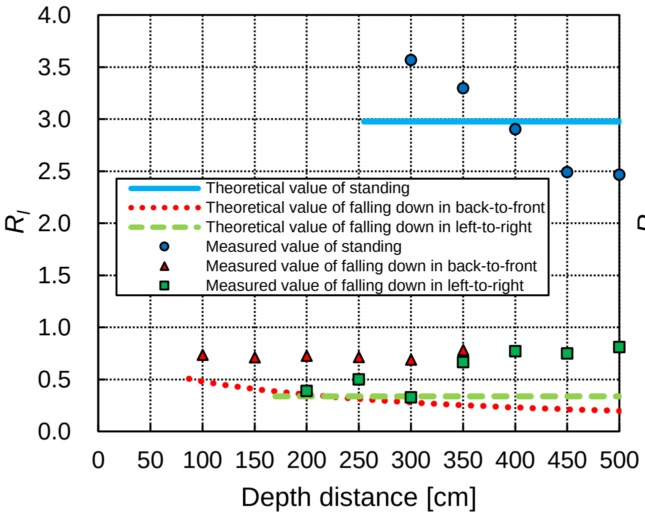


Fig. 3. Comparison of experimental results with computer simulation of H = 45 cm

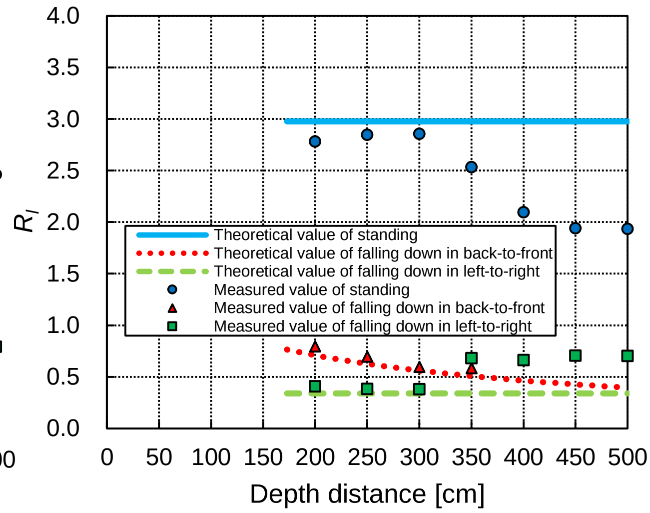


Fig. 4. Comparison of experimental results with computer simulation of H = 90 cm

simulation can be confirmed. From this, for the range of the R_l value between standing and falling down, the standing or falling down condition can be detected by setting a threshold.

5. Conclusion

In this research, we proposed a condition detection method corresponding to brightness change of subject using feature quantity obtained by Obrid-Sensor. The proposed method is confirmed in condition (standing/falling down) detection experiments. According to the experimental results, it is verified that the mechanism of detection using the ratio of height to width is effective in the proposed method. In the experiments, there were almost no influence owing to detection conditions of subject's brightness, depth distance, and setting height of sensors.

The proposed condition detection method can be expected to expand applications of the safety confirmation system using Obrid-Sensor. It is also confirmed effective in early detection of fall down accidents in daily life.

Acknowledgements

This research was supported by JSPS KAKENHI Grant Number 15K21197.

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