A Simple Intruder Detection Using a Web Camera and an Image Processing

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A Simple Intruder Detection Using a Web Camera and an Image Processing

Naoyuki Tamaru* and Ayaka Yoshinami*

Abstract

This paper presents a simple indoor intruder detection system using a web camera and an image processing. There are many sensors for intruder detection and the remote surveillance. We selected the image sensor for this purpose because of the simplicity and the precision for the detection. The intruder is detected by comparing the test image with the template image that is standard. The both images are divided into small blocks. We clarify the relation between the slice level for the determination of the different blocks, the different block number and the divided block number. And to get the guide, we determine the ideal slice level and the effective block number. Moreover, we consider the computation method with less execution time while the system performance does not deteriorate.

Key Words: intruder detection, surveillance, security, web camera, crime prevention

1. Introduction

Recently, there have been many thefts, robberies, kidnappings and murders et al. in urban areas. Therefore, the demand for the intruder detection and the surveillance system is increasing for security purposes and for crime prevention.

Table 1 shows a classification of sensors for the intruder detection and the surveillance system. As the main sensors we select infrared sensors, laser sensors, ultrasonic sensors, pressure sensors, image sensors, radio wave sensors and MIMO sensors. In the table the reference number is noted on the right column.

A pressure sensor weighs objects, or measures the pressure of gas etc. In the reference (6) the pressure sensors that are set up on the chair measure the pressure distribution in order to identify a person sitting on the chair.

A laser sensor detects the light beams that are cut off the pass, or does the distance from the sensor to the target object. In the reference

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The MIMO (Multiple input multiple output) sensor with the wireless array antenna detects the change in the radio wave propagation characteristics. In the reference (15) to detect the intruder in a room the MIMO channel matrix is used. In the reference (14) to detect the indoor intruder the MIMO sensor using the FSK (Frequency shift keying) signal is stated. In the reference (13) to detect the wireless security and monitoring system is proposed. This system exploits the array antenna or the array sensor on the receiver side because of detecting the time change of the propagation characteristics. In the reference (12) the intruder detection system using the LCX (Leaky coaxial cable) is presented to improve the effect for the noise and disturbances.

An image sensor detects the still picture or the moving video using the CCD sensor, etc. In the reference (11) to detect the pedestrian the image sensor and the recognition algorithm is used. The processing system utilizes the special feature of the rhythm in walking. In the reference (9) to detect the moving objects in the image using the image sensors, the new background subtraction method is proposed when the background image changes under the varying illumination. In the reference (8) the remote surveillance system with omnidirectional image

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<th>Application</th>
<th>Principle</th>
<th>References</th>
</tr>
</thead>
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<tr>
<td>Infrared light sensor</td>
<td>Toilet lighting, Remote control panel</td>
<td>Detection for radiated infrared light</td>
<td>(1),(2)</td>
</tr>
<tr>
<td>Laser sensor</td>
<td>House security</td>
<td>Cutting off Laser light</td>
<td>(3)</td>
</tr>
<tr>
<td>Ultrasonic sensor</td>
<td>Anti-collision for car</td>
<td>Time difference for reflected sound</td>
<td>(4),(5)</td>
</tr>
<tr>
<td>Pressure sensor</td>
<td>Automatic door</td>
<td>Detection for weight</td>
<td>(6)</td>
</tr>
<tr>
<td>Image sensor</td>
<td>Surveillance camera</td>
<td>Image comparison</td>
<td>(7),(8),(9),(10),(11)</td>
</tr>
<tr>
<td>Radio wave sensor</td>
<td>Intruder detection</td>
<td>Radio wave detection from leaky coaxial cable</td>
<td>(12),(13)</td>
</tr>
<tr>
<td>MIMO sensor</td>
<td>Intruder detection</td>
<td>Detection for radio propagation change</td>
<td>(14),(15),(16)</td>
</tr>
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</table>

(3) the laser sensor installed on an indoor passage ceiling measures the distance from the person to the sensor in order to count up passing pedestrians along the passage.

An infrared sensor detects the radiated infrared rays, such as the temperature on a face or hand. It is difficult to detect the shape for the target object. In the reference (2) the infrared sensor array detects and tracks the person’s movement for the surveillance. In the reference (1) to detect the intruder at night, the detection system using the infrared laser camera is described. This camera radiates the near infrared wave (850 nm) and receives the reflected image. The system calculates the distance distribution and detects the object using the fuzzy algorithm. But this sensor has less resolution and detects small animals by mistake.

An ultrasonic sensor measures the time difference between the transmitted ultrasonic signal and the received that and calculates the distance from the sensor to the object. In the reference (4) the ultrasonic sensor array and the neural network algorithm estimates the objects position, the figure and the pose. In the reference (5) in order to decrease a pedestrian’s sense of crisis, such as snatching damages, the multiple ultrasonic sensors identify dangerous objects.
sensors is proposed instead of the conventional rotation camera. In the references (9) and (10) the image extraction method for the moving object is proposed. The influence of the noise in the image, such as small animals, is removed by the special algorithm.

Using a web camera several application software for the intruder detection (17) is opened to the public free. However, in these software the institute of the design parameters is almost fixed and flexibility lacking.

In order to detect indoor intruders, we selected image sensors because of the easiness for getting them. Recently, digital cameras using image sensors are generally equipped into notebook computers. Moreover, simple and small USB (Web) cameras are sold at an inexpensive price.

We take pictures of the template image and the test image using the USB camera that is set up on the tripod not to move the camera. In the template image there are not any intruders, but in the test image there is. These images are stored in the file memory using the camera’s application software. The computer reads out both images and divides into the small blocks. Next it compares the two blocks at the same position of both images, and computes the number of the different blocks. If this different block number is larger than the particular value, we assume that the indoor intruder is detected this time.

As we have effective results from the experiments, we show the method and the results.

In Section 2, we describe the method for the intruder detection including the experimental apparatus and the program flow chart. The experimental results by the computer are shown in Section 3. Finally, the paper is briefly summarized in Section 4.

2. Method For Intruder Detection

2.1 Experimental Apparatus

Table 2 shows the specification for the experimental apparatuses, such as the CPU in the computer and the digital camera. The web camera is the HD Webcam C615 sold by the Logicool Inc. The camera resolution is 1920×1080 pixels, and it is set to the tripod not to move at all. As the image processing program the Microsoft Visual Basic 2008 Express Edition is used.

<table>
<thead>
<tr>
<th>CPU</th>
<th>Intel Core i5 2.40 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS</td>
<td>Windows 7 Professional 64 bit</td>
</tr>
<tr>
<td>Main Memory</td>
<td>4.0 GB</td>
</tr>
<tr>
<td>SSD</td>
<td>225 GB</td>
</tr>
<tr>
<td>Camera Resolution</td>
<td>1920 × 1080</td>
</tr>
</tbody>
</table>

2.2 Method

At first we divided the images into small rectangle blocks. We calculated the grey levels at each color pixel in the block by summing the pixel levels of the R, G and B segment of the color image, and by dividing the sum by 3, that is to say we derive the average pixel level among three elements.

Next, we computed the average grey level in the block, and compare the block average level between the template image and the test that. When the difference for both images is larger than the predetermined slice level (slice 1 in Fig. 1), we suppose that the both blocks are different. The selection of the slice level is important. The less slice level becomes, the more blocks differ between both images, conversely the larger does that the every block is the same.

Next, the different blocks are counted up among all blocks, and when the different block
number is greater than the particular value (slice 2 in Fig. 1), we decide that the intruder exists in the test image. The particular value is depended upon the intruder size, the distance between the camera and the intruder, and the division block number.

Figure 1 roughly displays the program flow chart for the detection method. In the figure the loop1 repeats toward the blocks for the horizontal direction and those for the vertical that. Also the loop2 does toward the pixels for the horizontal direction and for the vertical that.

2.3 Window Display

Figure 2 shows an example of the displayed window immediately after the program starts to run. The left image is a template one and the right is a test one where an intruder is seen. The
3. Experimental Results

3.1 Different Block Number

Figure 6 shows a relationship between the different block number and the slice level for the near distance. If the difference between the average pixel level in the template image and that in the test image is larger than the slice level, we assume that the both blocks are different from each other because of the intruder. The vertical axis represents the different block number, and the horizontal that does the slice level for the average pixel level inside the block. The solid line with the diamond plots displays the different block number with the 10×10 division, the broken line with square plots does that with the 15×15 division and the dotted line with circle plots does that with the 20×20 division. From this figure the different block number decreases gradually when the slice level changes from 8 to 28. When the slice level is at about 40, the different block number keeps a constant value and almost coincides with the measured value of 13, 26 and 48 for the division of 10×10, 15×15 and 20×20, respectively. In regard to the measured value we count up the block that occupies the intruder in the test image.

Figures 4-(a) and 4-(b) show the divided test images for 15×15 blocks and 20×20 blocks, respectively.

Figures 5-(a) and 5-(b) show the test images that an intruder appears for the middle distance from the camera and the far distance, respectively. The distance to the intruder is about 2.2 m, 3.5 m and 5.5 m for near, middle and far, respectively.
3.3 Execution Time

Figure 10 shows a relationship between the step number and the execution time. The step number for the horizontal axis is explained by the pixel interval of the horizontal direction and the vertical that at comparing among two images, and is expressed by the logarithmic scale. The vertical axis represents the logarithmic time measured by seconds using a stop-watch. The solid line displays the execution time from clicking the “START” button to the appearance of the pop up window for the intruder detection. The EXE format program is made by debugging the VB (Visual Basic) program, and stored in the debug folder of VB. The EXE program is capable to run without the VB system.

From this figure the EXE time decreases when the step number increases because the comparing number among pixels of both images decreases. Theoretically at doubling the step number the execution time becomes smaller by 1/4. But the execution time does not decrease to the limit because there are many processes except for the comparing process. Over the step by
4. Conclusion

This paper presents a simple indoor intruder detection system using a web camera and an image processing. There are many sensors for the intruder detection and the remote surveillance. We selected the image sensor for this purpose because of the simplicity and the precision for the detection. The intruder is detected by comparing the test image with the template image that is standard. The both images are divided into small blocks. We clarified the relationship between the slice level for the determination of the different blocks, the different block number and the divided block number. And to get the guide we determined the ideal slice level and the effective block number. Moreover, we considered the computation method with the less execution time while the system performance does not deteriorate.

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