Abandoned Object Monitoring System

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Abstract **— The paper proposes a surveillance system to detect the abandoned objects in the region under surveillance. The CMOS sensor is used to acquire frames including the region to be kept under surveillance. The acquired frame is analysed by the proposed abandoned object monitoring algorithm. If any abandoned object is detected, a warning signal is issued to the monitoring center. Software simulations are also given to demonstrate its effectiveness including (i) the system renew the background frame adaptively and (ii) it can find the abandoned object correctly.**

Keyword **-- surveillance system, abandoned object, CMOS sensor, renew background**

1. Introduction

With the spread of terrorism, terroristic attacks prevail over the world. Terrorists often produce explosive incidents in the public place with a crowd of people to result in heavy casualties. Public space such as airport, station, sports complex is the major goal of attack. The time or remote-controlled bombs are left in the public place to produce terrible explosion. Hence, the detection of abandoned objects is an important issue.

To detect abandoned objects, many approaches [1-12] have been proposed. A kind of them is the tracking-based [1-3] approaches under the assumption that the scene is not crowded, occlusions are minimal, and moving objects can be accurately initialized using only motion information. Porikli [4] proposed a non-tracking-based system which detects the stationary objects with two backgrounds. Wand and Liu [5] use a background subtraction algorithm which updates two sets of background to extract objects, classified the extracted objects to be static or dynamic ones, and calculate a confidence score for the classification. Based on color richness, Li, etc. [6] introduce a unique combination of a new pixel-wise static region detector and a novel classifier.

2. Monitoring System for Movement of Driver's Head

To monitor whether there is any abandoned object in the region under surveillance, the abandoned object monitoring system (AOMS) is proposed. The schematic architecture of AOMS is shown in Figure 1. The frames including the region to be kept under surveillance are acquired by the CMOS sensor and analysed by the proposed abandoned-object monitoring algorithm. If any abandoned object is detected, a warning signal is issued to the monitoring center.

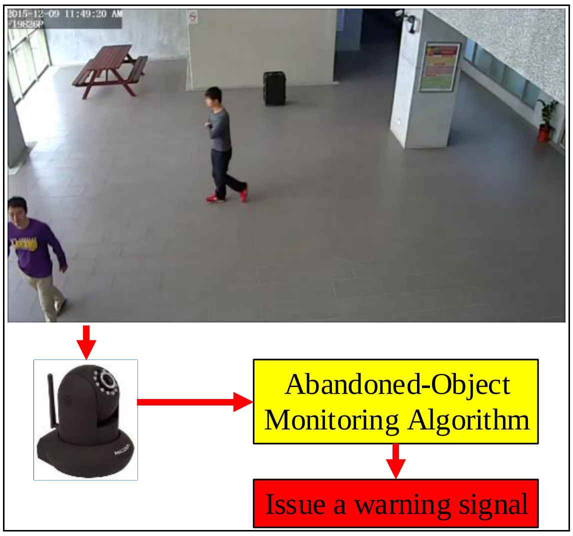


Fig. 1 The schematic architecture of AOMS

To quantitatively describe the AOMS, the following notations are adopted and defined:

- f_i: the ith frame of size 480×854,
- f_{is}: the ith resized frame of size 180×320,
- f_{bg}: the background frame of size 180×320,
- f_{out3D} and f_{out2D}: the processed three- and two-dimensional outputs in each step,
- f_{is}^H, f_{is}^S, and f_{is}^V: hue, saturation, and value components of f_{is},
- f_{bg}^H, f_{bg}^S, and f_{bg}^V: hue, saturation, and value components of f_{bg}.

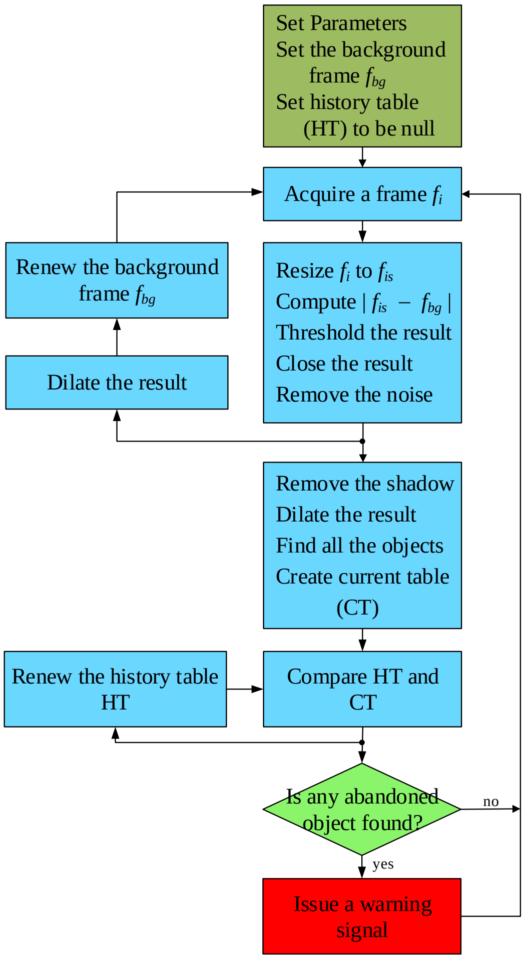


Fig. 2 The abandoned-object monitoring algorithm in AOMS.

Based on the defined notations, AOMA is proposed, shown in Fig. 2, and described as follows.

Compute $| f_{is} - f_{bg} |$

$$f_{out3D}(i,j,k) = | f_{is}(i,j,k) - f_{bg}(i,j,k) |$$

Threshold the result

$$f_{out2D}(i,j) = \begin{cases} & f_{out3D}(i,j,1) > 15 \\ 1 & \text{if } f_{out3D}(i,j,2) > 15 \\ & f_{out3D}(i,j,3) > 15 \\ 0 & \text{otherwise} \end{cases}$$

Close the result and remove the noise

Use morphology closing with a 5×5 kernel to f_{out2D}, remove the noise, and produce a new f_{out2D}.

Dilate the result and renew the background frame f_{bg}

Use morphology dilation with a 5×5 kernel to obtain the new f_{out2D} and then renew the background frame by the following equation:

If $f_{out2D}(i,j)$ is equal to zero, then

$$f_{bg}(i,j,1) = f_{bg}(i,j,1) \times \frac{19}{20} + f_{is}(i,j,1) \times \frac{1}{20}$$

$$f_{bg}(i,j,2) = f_{bg}(i,j,2) \times \frac{19}{20} + f_{is}(i,j,2) \times \frac{1}{20}$$

$$f_{bg}(i,j,3) = f_{bg}(i,j,3) \times \frac{19}{20} + f_{is}(i,j,3) \times \frac{1}{20}$$

Remove the shadow

Remove the shadow by the following scheme:

$$f_{out2D}(i,j) = \begin{cases} & -0.16 < f_{bg}^{S}(i,j) - f_{is}^{S}(i,j) < -0.24 \\ 1 & \text{if } \wedge -0.02 < f_{bg}^{V}(i,j) - f_{is}^{V}(i,j) < -0.28 \\ & \vee -0.6 < f_{bg}^{H}(i,j) - f_{is}^{H}(i,j) < -0.4 \\ 0 & \text{otherwise} \end{cases}$$

Dilate the result

Use morphology dilation with a 3×3 kernel to thicken the object.

Find all the objects

Find all the 8-connected objects. Then delete the person-object from the found objects. The criterion is that the ratio of square of object boundary to object area is larger than 16.

Create current table (CT)

The current table (CT) inclues features of the area, upper boundary, lower boundary, left boundary, right boundary, row and column coordinates of gravity, existing time, disappearing time, and matched index of all the objects.

Compare HT and CT

Compare all the items in the HT with the ones in CT. If the same object is found, mark the matched index in CT to be one, add one to the existing time, and copy the features of the object to the temporary table.

Examine the matched index of all the objects in CT. If it is zero, add one to the existing time and copy the features of the object to the temporary table.

Renew the history table HT

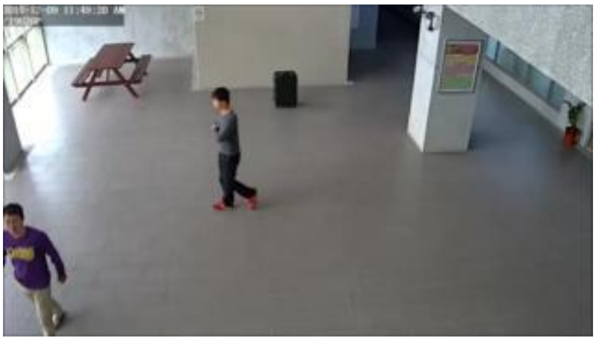
Replace the HT by the temporary table.

Find abandoned objects

Examine all the object in the renewed HT. If the existing time is larger, it is an abandoned object and issue a warning signal to the object.

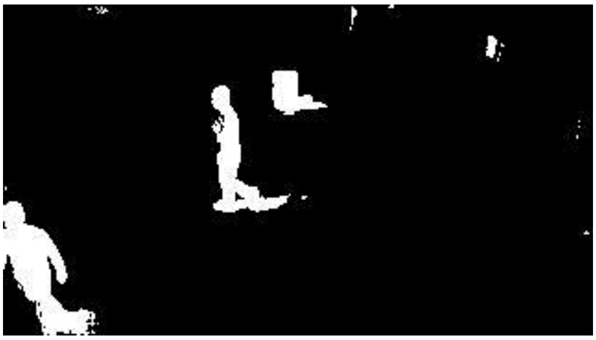
3. MATLAB Simulation Results

To demonstrate the performance of AOMS, the system is set up in the lobby of our department. The IP camera is used to record the region under monitoring. The adopted video of length 58 seconds and 1740 frames are extracted from the video. According to AOMA, MATLAB simulation result of f_{1606} is shown in Fig. 3.

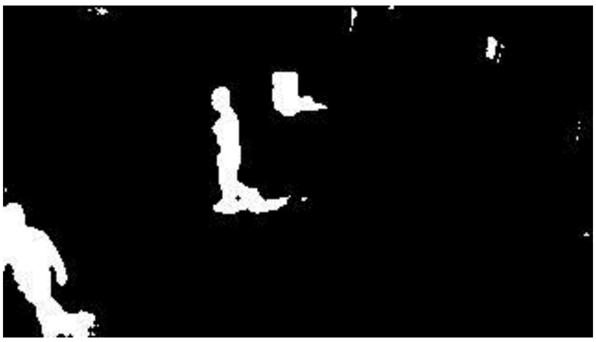


(a)

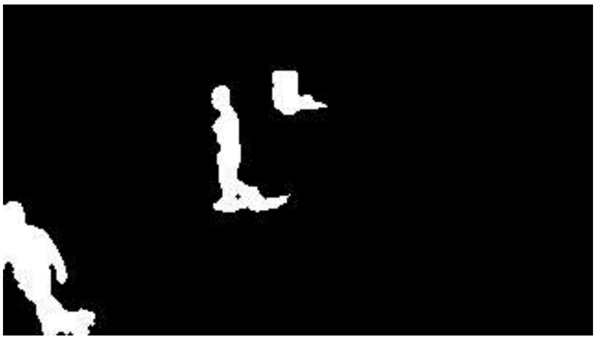
(b)



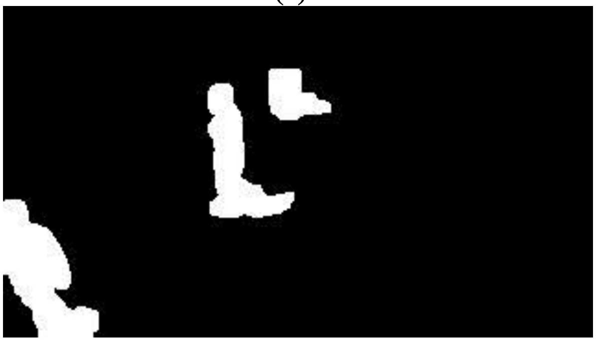
(c)



(d)

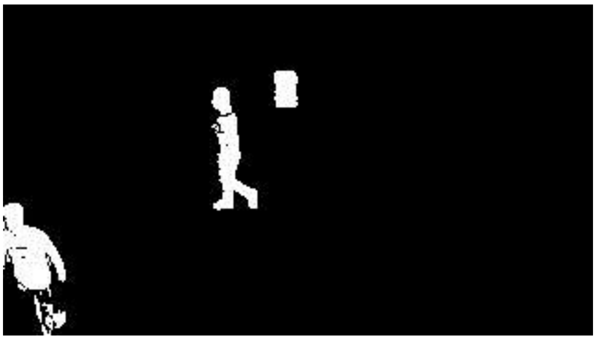


(e)

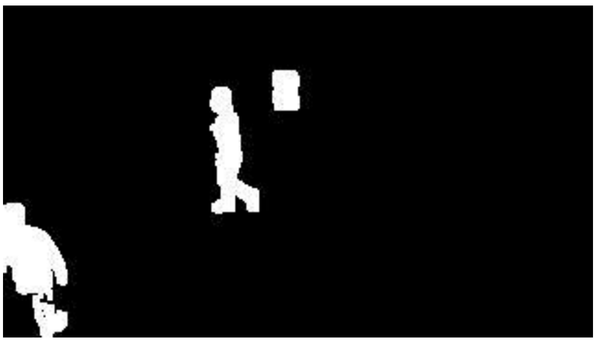


(f)

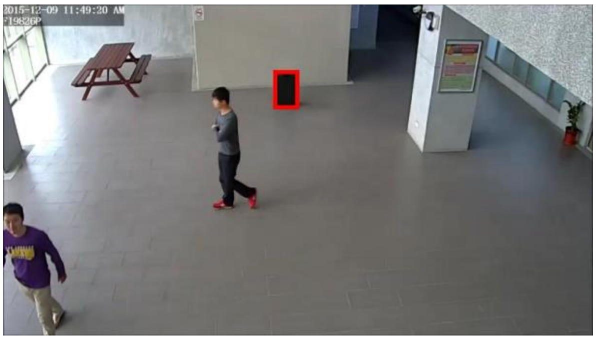
(g)



(h)



(i)



(j)

Fig. 3. MATLAB simulation result of f_{1606} after we (a) resize f_{1606} to f_{1606s}, (b) compute | $f_{1606s} - f_{bg}$ |, (c) threshold f_{1606s}, (d) close the result, (e) remove the noise, (f) dilate the result, (g) renew f_{bg}, (h) remove the shadow, (i) dilate the result, (j) issue a warning signal to the frame.

The complete simulation results of all the 1740 frames are concatenated to a video again. The video is uploaded to YouTube [13] and can be played in Fig. 4.

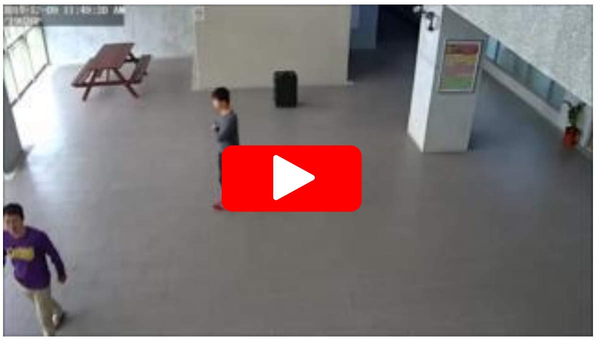


Fig. 4. Video of MATLAB simulation result [13]

According to the MATLAB simulation result shown in Fig.3, the effects of each steps in AOMA are clearly demonstrated and the abandoned object is identified exactly. Inspecting the video shown in Fig. 4, all the abandoned objects are detected exactly. The video demonstrates the features of the proposed AOMS clearly.

4. Conclusions

In the paper, the high-performance surveillance system for monitoring abandoned-object has been proposed. The features of the proposed system are as follows. (i) The system renew the background frame adaptively. (ii) It can find the abandoned object correctly.

Finally, we believe that the abandoned-object surveillance system can greatly benefit by adopting the proposed system.

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