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A Study on Surveillance System of Object's Abnormal Behavior by Blob Composition Analysis

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Abstract

Studied in this paper is an advanced detection system which activates emergency alert system to prevent the actual incidence, after computerized evaluation of danger-associated behavior captured in CCTV images. The detection of potential danger involves the ability to discern several steps that may ultimately lead to life-threatening event of an object. The system is designed with preset danger-zone within the zone of interest and analysis of blob composition, based on the assumption that probability of life-threatening event is directly correlated with the proportion of one overlapping with the danger zone. Subsequently, the danger level is evaluated accordingly to the range of encroachment into the danger zone of the targeted objects.

Keywords: *CCTV, blob segmentation, determination of danger level, analysis of blob composition*

1. Introduction

Lately, there has been increasing interest in social safety systems. This phenomenon is partly attributable to a dramatic elevation in sexual offenses that threaten social safety and also increase in suicide attempts and suicidal behaviors that are, perhaps, induced by stresses. Various forms of surveillance systems have been implemented for prevention of such incidents. One of them is the installation of CCTVs for its relatively low-cost and wide range of coverage, no need for man security. Currently, the CCTV records are pervasively used for post-incident investigations, yet there is still limitation in prevention of the incidents in advance. So, this study is proposed to incorporate intelligence to danger detection system for early detection of incidences [1]. In order to achieve such among some pedestrians, the system should be able to examine the severity of danger by detecting dangerous behavior beforehand and alert emergency by beeping or notifying the control center. It is not always the case that one individual is involved in danger. Therefore, this study takes accounts scenarios engaging multiple objects to increase effectiveness.

2. Related Research

For image recognition, in Section 2.1 the existing studies on technologies related to object detection and tracking and, in Section 2.2, the current status of surveillance systems, which is a case of application of image processing, were investigated.

Although currently CCTV surveillance systems are used a lot as security systems, it can be asserted that surveillance systems that provide information via intelligent image processing are almost nonexistent.

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2.1. Technologies Related to Object Detection and Tracking

As frequently used methods of object detection, there are the arithmetically simple background subtraction method and scene subtraction method. Background subtraction method detects moving objects based on the difference between the current frame and the background model. As methods of tracking detected objects, as in detection, there are methods that use differential images and methods that use background images, and other than these, there are methods that use block matching and minutiae. Methods that use background images, depending on the methods of extracting background frames, are divided into temporal smoothing method and temporal median method. Temporal smoothing method uses the method of averaging the pixel values, whereas temporal median method arranges pixel values in the order of size and uses values with high frequencies as the background image. Block matching method is a method that, within the present frame's navigation area, searches for the block that's most similar with the designated block of the previous frame. Tracking is possible even in cases where an object is motionless at first but later goes in motion, and the size of the block and the object to be tracked can be specified [6].

2.2. Cases of Action Detection Monitoring Systems

As cases of action detection monitoring system, in January 2013, the City of Seoul built "suicide detection rescue system" by installing 16 intelligent CCTVs and thermal detection cameras at the Mapo-Daegyo (Bridge) and Seogang-Daegyo (Bridge) [7]. By using intelligent image detection CCTV technology, etc., this system monitors suicide jumps occurring on the bridge and, by activating an alarm system when situations arose, the system dispatches a rescue team within 3 minutes. The system captures the occurrence signs of a suicide incident via the primary alert functionality; based on which, the functionalities of human tendency detection and sign determination that are connected with the 24-hour Emergency Response Command System of Seoul Disaster Management Center are enabled. As the country's first systemization of prevention of suicides and jumps from bridges, it is equipped with a multi-dimensional system responsible for suicide attempts: Prevention → Protection → Response → Follow-up.

In addition, at the central government level, in an effort to efficiently manage public image information resource, an integrated control center was established and is under operation. As of August 2013, there are 79 CCTV integrated control centers in operation in cities, boroughs and districts, and 41 new centers are under construction. For the installed CCTVs, by providing basic integrated control for services, such as security, illegal parking enforcement, prevention of littering, facility management, monitoring of disaster and fire, etc., which are classified based on the purpose, prompt actions can be taken in emergency situations. However, this cannot be viewed as an intelligent detection system of advance prevention.

As other monitoring systems, there are wildlife monitoring systems that are based on a real-time motion object segmentation method.[8] In this study, objects are detected through the combination of the shape information and movement patterns of objects, and humans and animals in the images acquired from the camera are distinguished, thereby improving the determination accuracy of objects.

3. Surveillance System of object's Abnormal Behavior

3.1. General Conception

The proposed CCTV based surveillance system particularly aims for detection of suicide attempts on the bridge where normal and abnormal behavior are relatively discernable. Low variability in situation, like on the bridge, is taken advantage to detect one's abnormal behavior. Process of the system are as follows. First, on the CCTV bridge footage, the area of interest for detection is set, and the danger zones are selected within the area of interest. Then, the selected background image and the current image are binarized to acquire images and set up certain degrees of threshold to filter out insignificant signals due to slight shakings of structures. The object is detected by using blob labeling and the empty space of an object is filled using morphology calculation. The detected blobs are analyzed to find out which object they are originally belonged to in current image. This step is necessary to sum up area of all blobs in endangered parts of each object. This alert system is activated when the system recognizes dangerous abnormal behavior by the ratio of endangered part to whole part of each object. Figure 1 is a flow diagram of the detection and evaluation of danger level.

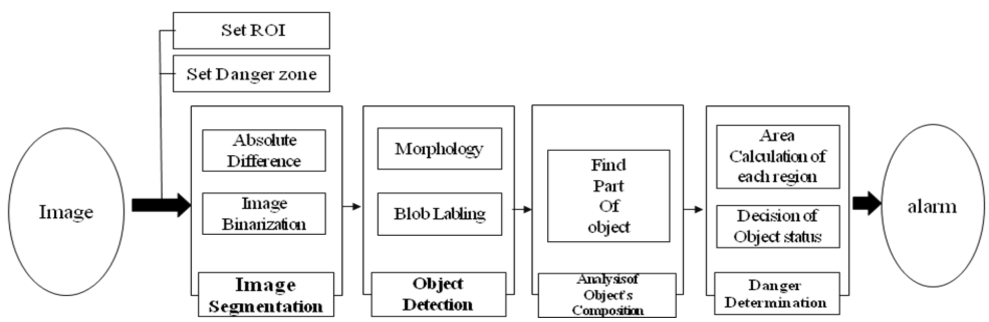

Figure 1. General Conception

3.2. Image Segmentation Unit and Object Detection

In a CCTV-based detection system for prevention of bridge suicide, the background image, which is extracted from the rows of sequential images, is constant once the CCTV has been installed. Here, the ROI (region of interest) is artificially selected to exclude roads and nearby buildings that are unrelated to dynamics of one's movement, as shown in Figure 2. Furthermore, within the ROI, the boundary of river and bridge is selected as the danger zone, drawn as solid lines in Figure 2. The detections of the shaking induced by wind and patterns of water current movements were inevitable. So, the threshold values, approximately 20 to 30, are set in the system to compromise the effect of unwanted components in the captured images.

With a morphological filtering of the original image the empty spaces in the object are filled white spaces by connecting contours of objects.

(a) Current frame (b) Binarized frame

Figure 2. Object Segmentation by ROI and Danger Zone

3.3. Analysis of Object's Composition

To examine severity of potential danger, multiple blobs are analyzed to determine to which object's components individual blob corresponds. So, this study includes an analysis of object's composition to evaluate danger level for each blob. The system, specifically, analyze blobs that perpetrate the preset boundary of the danger zone. Each blob consisting of an object is categorized by the physical location relative to the danger zone and an object is regarded as two different blobs based on whether they are included or excluded from the boundary. This is to evaluate a danger-level by calculating the areas of encroachment and analyzing object's composition to connect the contours of distinguished blobs as to reduce systematic errors of recognizing blobs as two different objects. It is an important task to identify of which anatomical composition the blobs consist. Thus the system compares images of an object in two different conditions with and without the danger zone and analyzes the object's composition by connecting the blobs. Two methods of comparison have been attempted: analysis of object's composition using contour and bounding box.

3.5. Danger Level Determination Unit

Determination of danger level depends on the level of perpetration of an object onto the danger zone, and also how much, in percentage wise, of the object's composition overlaps with the zone. Especially, situations involving multiple objects are highly variable. The system may activate false positive alarm in situations where objects simply putting their hands on the fence. To prevent such, based on the object's composition, the system distinguishes between the area of the blobs in the danger zone and that of outside the zone and adds two values, and then takes the percentage of the area in the danger zone out of added values.

$$\text{Danger level(\%)} = \frac{\sum_{i=0}^{n} Area\ (A_i)}{\sum_{i=0}^{n} Area\ (A_i) + \sum_{j=0}^{m} Area\ (B_j)} \times 100 \qquad \text{(eq.1)}$$

A_i : Blobs in the danger zone in an object, B_j : Blobs outside of the danger zone in an object

$A_i + B_j$: the entire blobs of an object without danger zone

Thus, the danger level can be determined in the following order:

1) Within the area of interest, the danger zones and safety zones are preselected.
2) The zone-specific areas of the object are calculated.
3) Depending on the situation of where the area of the object is located, the situation is separated into a "safe state," "warning state," and "emergency state."

A. If the entire area of the object is in the safe zone, then the situation is a safe state; whereas, if the entire area of the object is in the danger zone, then the situation is an emergency state.

B. If parts of the object are across the safe zone and the danger zone, then determination is made as a safe, warning or emergency condition and measures are taken, in accordance with the amounts of the areas.

Figure 3 shows alarm operating conditions of the system, in accordance with the safe state, warning state, and emergency state.

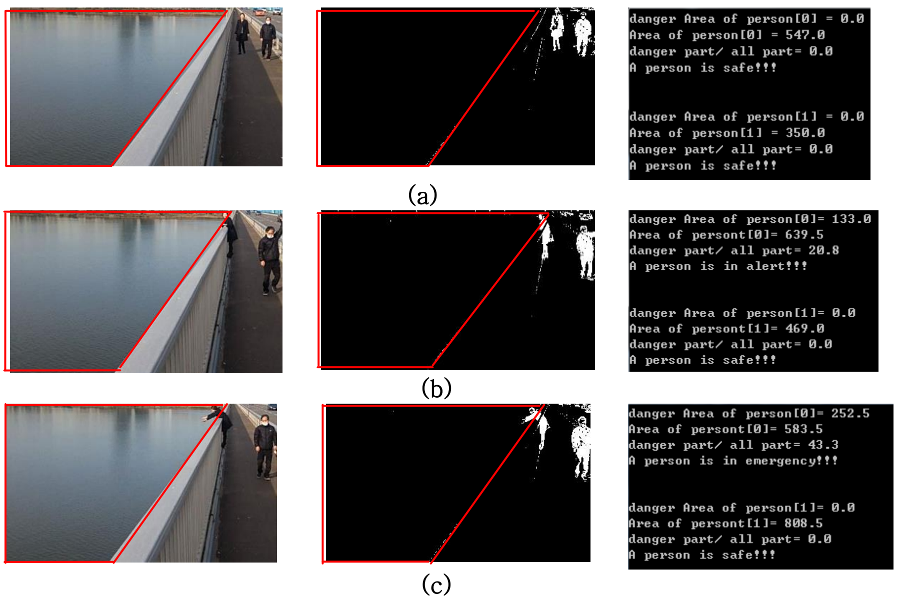

Figure 3. Alarm Operating Condition in (a) Safe State (b) Warning State (c) Emergency State

4. Experiment Results and Analysis

It is the proportion of the endangered area over the entire size of an object that matters, so an accurate measurement of the size of an object is a core criteria of the detection system. In addition, in order to test the accuracy of the system, this chapter includes an analysis of the ability to accurately recognize the number of objects based on analysis of object's composition. Furthermore, under the assumption that the object size has been correctly measured, accuracy in determination of danger level is analyzed.

Consequently, the results depending on various positions of the object were fairly accurate in the case when the size of an object was larger than 800. Detections of other unwanted structures such as cars overlapping with the ROI attributes for low accuracy in small objects. This condition can be compromised by eliminating the background of the street from the ROI, yielding more accurate results. Even so the object size may vary depending on the distance between the camera and the object.

Table 2. Success Rate of Object Size versus Various States

Object Size(Area)	Safe State (total)	Safe State (part)	Warning State	Emergency State (part)	Emergency State (total)
Small (less than 800)	75%	55.5%	87.5%	87.5%	87.5%
Medium (800 ~ 2500)	100%	80%	100%	80%	87.5%
Large (larger than 2500)	100%	100%	100%	100%	100%

5. Conclusion and Future Challenges

Proposed in this paper is an advanced detection system to alert the integrated control center regarding any potentially dangerous behavior of individuals among some pedestrians, such as bridge suicide, from CCTV-based images. As mentioned previously, it may not always be the case that the dangerous events involve one person, but multiple individuals. Thus this paper included the analysis of object composition. Also, this study closely measures danger levels using encroachment rates of the danger zone divided into three categories; safe, warning, and emergent. Here, we are assuming higher the rates of encroachment of the danger zone is more probable that one is likely to commit life-threatening actions. Future research on different scenarios, for instance group assault and fighting which involves multiple objects, will be encouraged. The detection system is not limited to basis on the difference in visible light spectrum, but detecting dangerous act after dark using infrared CCTVs is also viable for future research topics.

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