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Integration of Background Removal and Thermography Techniques for Crowd Density Scrutinizing

Adnan Ghazi Abuarafah[1]and Mohamed Osama Khozium [2]

[1] Vice Dean for Academic Affairs, Faculty of Computer of and IS, UQU. Makkah, KSA.

[2] Department of Engineering and applied science - computers, MCC, UQU. Makkah, KSA.

[1&2] Center of Research Excellence in Hajj and Omrah (HajjCoRE), UQU, Makkah, KSA.

Abstract

Crowd Management is defined as techniques used to keep large crowds safe. The area of crowd management systems is currently of immense interest due to its implications in the field of security, avoiding crowd disasters and expediting procedures of special missions. Crowd detection is considered the initial and important step in crowd management systems. Many studies have been done for automatic crowd detection and monitoring methods based on computer vision technology. These studies include video sequences and thermography techniques. This paper proposes a new innovative technique by integrating the background removal technique and the thermography approach. Furthermore, the paper includes success results for integration of the two techniques experiments.

Keywords: crowd management, thermography, computer vision, average background model, secondary background model.

Introduction

Software modules in the crowd management system have been developed to analyze, monitor and control the crowd through calculation of density. The present study was undertaken to integrate background removal technique with thermography approach. The study was conducted on the titled caption “Integration of background removal and thermography techniques for crowd density monitoring."

Researchers discover that there are many advantages for the infrared thermal video sequences over the visual video sequences (not thermal) such as: [1, 2, and 3]

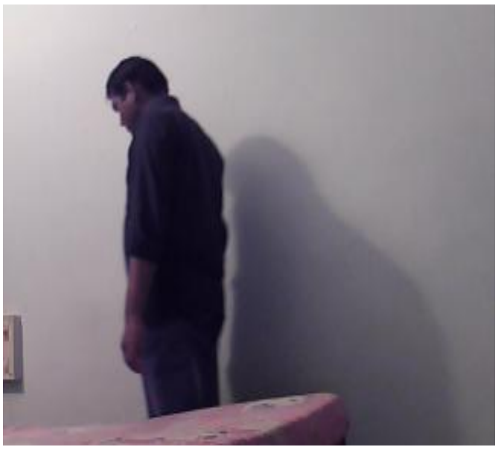
- Temperature of an object can be determined in a non-contact way.
- Privacy is reserved.
- Human becomes easily visible to the environment, day or night.

However, there are still some disadvantages in the thermal video sequences which cause faulty results in estimating the density of the crowd. The disadvantages include the interference between the temperatures of some of the background objects and the foreground objects (people) which gives inaccurate density of the crowd. So the removal of the background objects will solve this problem and get accurate results.

Background removal technique using normal video cameras gives inaccurate results in calculation of the density of a crowd due to the shadow effect as proved in this paper later, whereas background removal technique using the thermal camera gives accurate density of the crowd, and it is experimentally proven.
This paper is divided into five sections. The first section is this introduction. The second section discusses the related work. The third section is about the available background techniques. The fourth section illustrates the experimental work. And the last section concludes the work and discusses the future of the research.

Related Work

Priti P et al. 2012 present a novel algorithm for detecting moving objects from a static background scene that contains shadows using color images. Object tracking based on motion estimation and detection, background subtraction and shadow removal. A reference frame is initially used and considered as background information. While a new object enters into the frame, the foreground information and background information are identified using the reference frame as a background model. Most of the times, the shadow of the background information is merged with the foreground object and makes the tracking process a complex one used. Morphological operations are used for identifying and removed the shadow from the image. Video sequences have been captured and tested with the algorithm. [4]


(a)


(b)


(c)


(d)

Fig.1: Object tracking process (a) Video Sequences, (b) shadow detection and removal (c) Video Sequences, (d) shadow detection and removal

The author of this paper would like to conclude from the above images that due to the usage of a normal video camera, the shadow effect could not be removed perfectly from the image and this can be overcome by making use of the thermal camera as described in the experimental section of this paper. (Fig.1)

Anthony C. Davies et all.1995. Use a standard domestic camera (camcorder) to record scenes in a site of interest. The recordings are digitized and processed by a computer-based image processor under the control of a classic workstation. [5]

Fig. 2: Typical digitized image (Liverpool St. Railway Station, courtesy of Rail tracks East Anglia), 512 x 512 pixels, 256 gray levels.

Fig. 3: A “background-only” image for the site in Fig. 3. This is used to isolate pedestrians from images by removing the surrounding background.

Fig. 4: An image where the background has been removed.

In the figures 2, 3 and 4, the authors (Anthony C. Davies, et al. 1995) use the normal camcorders which give inaccurate density of the crowd due to the shadows of the people in the image [5]. This shadow effect can be overcome by using the thermal camera as done in this paper.

Yi Lu presents a research in an image content-based indexing and retrieval, a key technology in digital image libraries. In most of the existing image content-based techniques, image features used for indexing and retrieval are global, features computed over the entire image. The major problem with the universal image feature-based retrieval method is that background features can be easily mistaken as object features. When a user attempts to retrieve images using color features, he/she usually means the color feature of objects of interests contained in the image. The approach we describe in this paper utilizes color clusters for image background analysis. Once the background regions are identified, they are removed from the image indexing procedure, and therefore, no longer interferes with the meaningful image content during the retrieval process. [6]

Some common models for the available background techniques …. [7, 8]

Average Background model

A standard approach for finding moving objects in still-camera video data is to create a model for the background and compare that model with the frame in question to decide which pixels are likely to be the foreground (moving objects) and which the background. Our approach is to use a simple average model where the average gray values for each pixel over a window of N (typically 200 frames) is regarded as the background model. The entire background modeling and segmentation process is carried out on grayscale versions of the images.

Secondary Background model

It was observed that the intensity level of a background pixel changes very little from frame to frame. The value of the background in the previous frame can be considered as the background in the current frame not the average value over N frames.

Experimental work

During the experiment, we use two kinds of video cameras. The first one is a normal digital camera which produces colored videos of average quality (called in the paper normal video and normal image) …the second camera is a FLIR camera (Forward looking infrared camera) which produced thermal colored video (called in the paper thermal video and thermal image)

Video screenshot from a Normal Camera.

Consider a screenshot from a normal video captured by a digital camera. It results in the inaccurate calculation of the density of the crowd due to the following issues...

A. Shadows

C. It is difficult to distinguish people from the background due to the same resemblance (colors) of parts of people and background.

Fig.5: Sample screenshot from a video using normal camera

Thermal Video screenshot

Consider the same screenshot as used above but it is a thermal video captured by a FLIR thermal camera.

In the below image the problem of shadows does not occur, however the problem exists in matching colors between the people and the background due to which it is unmanageable to distinguish people from the background.

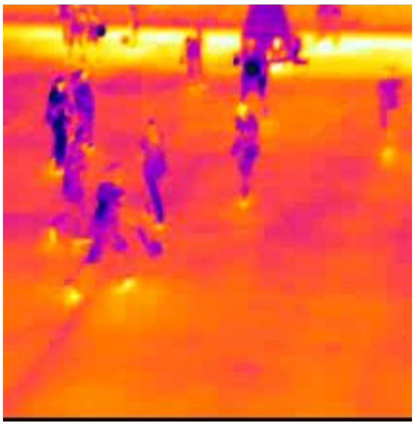


Fig. 6: Sample screenshot from a thermal video using FLIR camera

Thermal Video frame with ruler

A full snapshot from the FLIR camera with the Temperature ruler to the right is shown below.

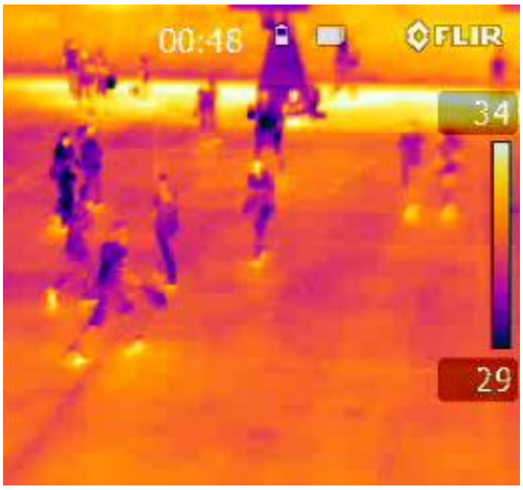


Fig. 7: Sample screenshot with a ruler from a thermal video using FLIR camera

CMINS program screenshot to calculate density from image according to temperature

Khozium, 2012 proposed CMINS which had a Hybrid Intelligent Information System for the Administration of Massive Mass of Hajjis.[1,2,3]

The land area in the screenshot shown below which used in this experiment is 6 m * 8.5 m (50 m^2) and there are 13 moving persons. The average capacity rate is 2 persons per each 1 m^2. So the 13 person's dense ratio is about 13 % to the total land area. However, when we use temperature rules and colors to calculate the density, we will get a percentage which is not accurate (about 14.8 %) due to the interference between colors of the people and the background. (Fig.8)

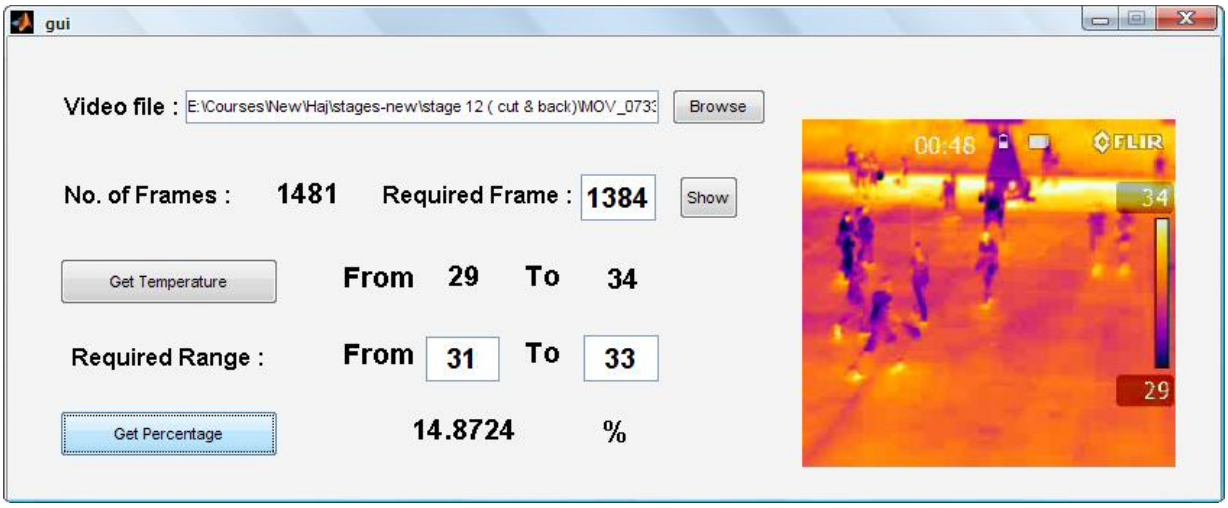


Fig. 8: CMINS program screenshot using thermal camera (without background removal)

Background image from Thermal video

We will make use of an innovative method by removing the background from the thermal images.

First, we extracted the background image as an average of all the frames of the captured thermal video.(Fig.9)

Fig.9: Background image from Thermal video

If $I^k(y, x)$ is the intensity level at coordinates $Y = y$ and $X = x$ of the k^{th} frame in the sequence and $bg^k(y; x)$ is the average background model value at (y, x), then

$$bg^k(y,x) = \frac{1}{N} \sum_{j=k-(N/2)}^{k+(N/2)} I^j(y,x)$$

Thermal image after background removal

Then after subtracting this background from the thermal screenshot, we will get the following binary thermal image for the moving objects only in white. (Fig. 10)

Fig.10: Thermal image after background removal

The segmented output is:

$$seg1^k(y,x) = \begin{cases} 1 & , \text{if } |bg^k(y,x) - I^k(y,x)| > T1 \\ 0 & , \text{otherwise} \end{cases}$$

Where $T1$ is a predetermined threshold usually 10.

The white pixels in the image are the regions that have been segmented as moving pixels in the current frame.

CMINS program screenshot to calculate density from thermal image without background

Now the CMINS program is used again to calculate the density from the thermal image after removing the background.

We get a density of about 12.8 % which is accurate when compared to the exact crowd density ratio (i.e., 13) in the sample thermal image used in the experiment. (Fig.11)

This method is more accurate as it uses the thermal images and doesn't depend on temperature ruler and colors of the body parts and doesn't get affected from color's interferences.

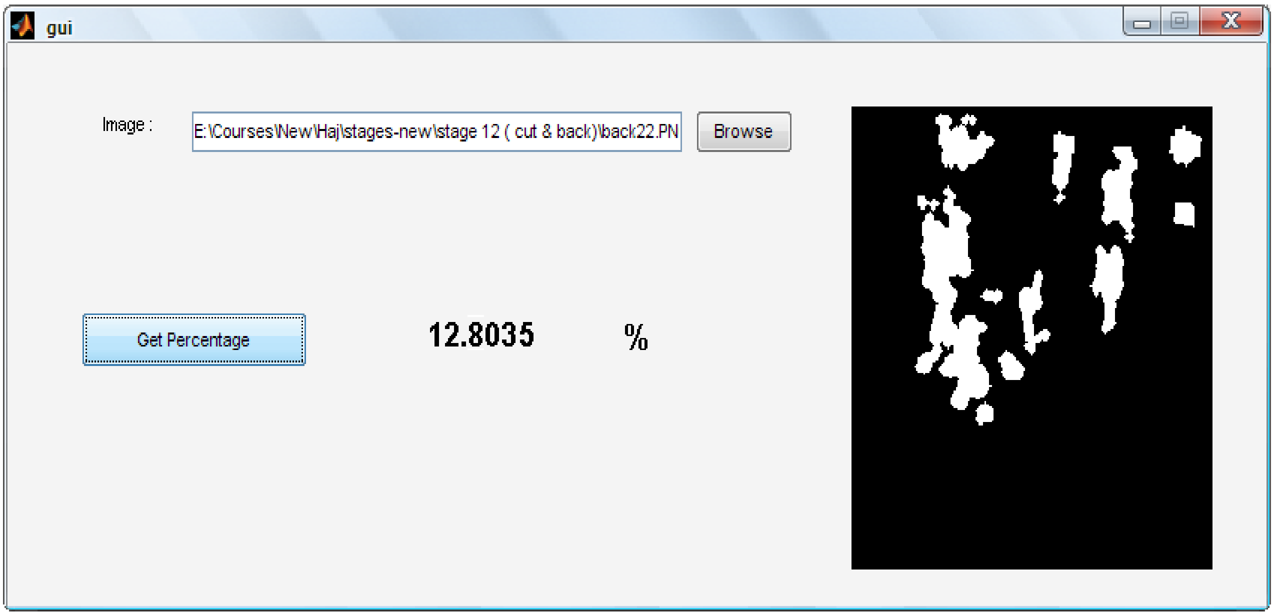


Fig.11: CMINS program screenshot to calculate density of the crowd from thermal image after background removal

Seg1 is the segmented image which is binary and summation of it is the summation of white pixels in it, so the percentage is calculated as follows:

$$Per = 1/N * \sum seg1$$

Background image from Normal video

We will try the same background removal method for the normal image as done with the thermal image. This is done to know the difference in the accuracy of the density of the crowd in both thermal and regular video's cases.

First, we extracted the background image as an average of all the frames of the captured video (from a normal camera fig.5).

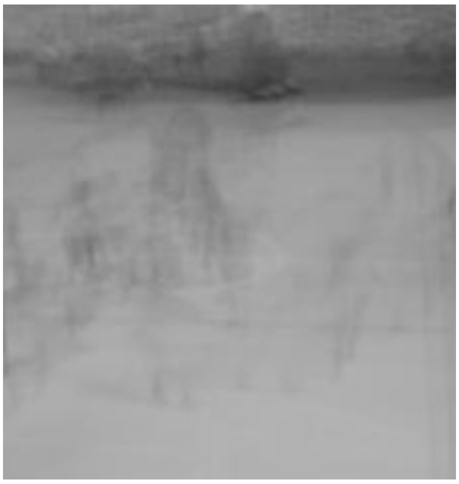


Fig.12: Background image from the Normal Video

Normal image after background removal

After extracting the background from the normal video screenshot, we will get the following binary image for the moving objects as shown in white color along with their shadows and light effects.(Fig.13)

Fig.13: Normal image after the background removal

CMINS program screenshot to calculate density from normal image after background removal.

Now the CMINS program is used again to calculate the density from the usual image after removing the background.
We get a density of about 16.9 % which is not accurate if compared to the thermal image due to the existence of shadows in the screenshot of the normal image. (Fig.14)

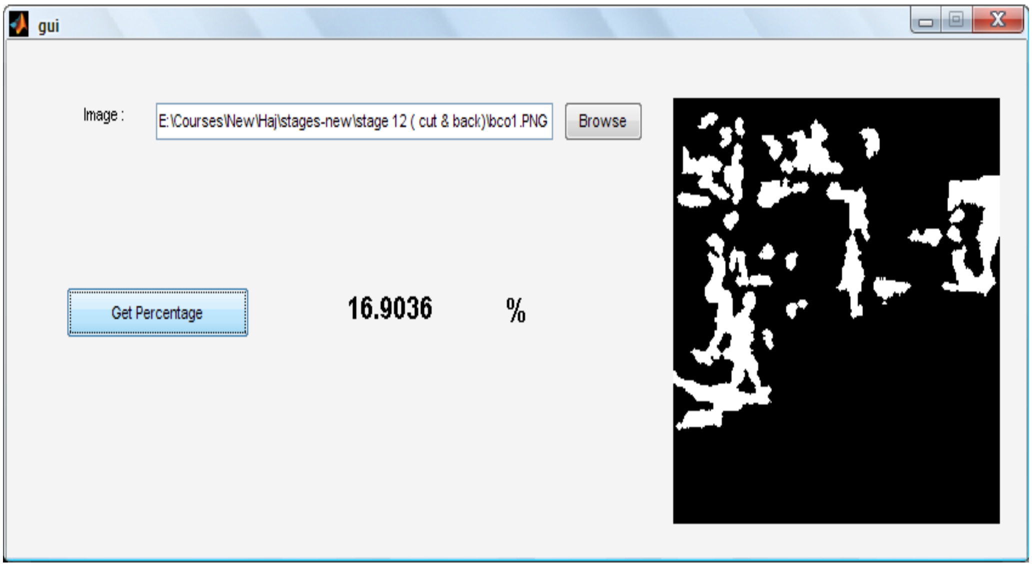


Fig.14: CMINS program screenshot to calculate density of crowd from normal image after background removal

Conclusions and future work

In summary, we have proposed an innovative technique of integrating the background removal image processing technique and the thermography technique.
There are mainly two points of interest in this paper. Firstly, the previous used techniques which illustrated with their disadvantages have proven the need of the new technique described in this paper. Secondly, the experimental setup has been exemplified, giving the results as discussed below...
(Note: 13% is the accurate crowd density of the sample image used in the experiment)

- Crowd density is **not accurate** using the thermal image without background removal. It was 14.9% by using the CMINS program. This is because of matching some colors the people with some of the colors of the background.
- Crowd density **is accurate** using the thermal image with the background removal. It was 12.8% by using the CMINS program. This is because of the extraction of background from the thermal image.
- Crowd density is **not accurate** using the normal image with the background removal. It was 16.9% by using the CMINS program. This is because of the shadow of the people.

In the future, we may include the background removal technique in the CMINS program.

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