Menoufia J. of Electronic Engineering Research (MJEER), Vol. 31, No. 1, Jan. 2022

An Improved Technique for Crowd Counting Based on Thermal Bands

Asmaa S. Hassan
Lecturer Assistant at Higher Institute of Engineering ,Science and Culture City- 6th Oct.
Asmaaeng@csi.edu.eg

Ayman EL-SAYED
Dean of the faculty of ElectronicEngineering, Computer Science and Engineering Dep., Menoufia University
ayman.elsayed@el-eng.menofia.edu.eg

Mohamed M. Dessouky
Faculty of Electronic Engineering, Computer Science and Engineering Dep., Menoufia University
mohamed.moawad@el-eng.menofia.edu.eg

Abstract— **The estimation and the controlling processes in the crowd counting filed are the most important on over applications related to surveillance systems and control follow related peoples to give them a complete safety especially in the large groups that contain a huge collection of individuals. There were found various events in human histories that gather a huge number of crowds in the same place. For example, in religion occasions as in HAJJ season which occurs every year, these events cause accidents that lead to death. So, to avoid and prevent all types of accidents related to these huge crowds; this paper presents an improved technique to estimate the density of peoples in the same place to help the decision makers to monitor and control the pedestrians overcrowded in the large collection of individuals. The proposed technique depends on the thermal bands for human, according to the big variance of temperature human body between the skin and the skin covered with clothes. Also, it presents the whole range of the temperature for each frame in the video. The essential characteristic of crowd counting technique is that it does not require a previously stored and trained data, but it uses a live video stream as input. Also, it does not require any intervention from individuals. The research's approach depends on capturing the thermal features of an individual. The result of this technique is introduced and proved to be highly accurate, and the experimental results demonstrate the effectiveness of the approach.**

Keywords—Crowd estimating, Crowd Control, visible image bands, thermal image band, pedestrians' detection

I. INTRODUCTION

This paper handles the effect of using Infrared bands in the estimation of the density of people in the crowd. Today this field of research has witnessed in various developments. Estimating crowd size and distinguishing individuals is a major problem in visual and invisible surveillance systems. The accurate and direct appreciation of pedestrians in a wide range of individuals such as public events, shopping malls, and religious events can support managers and organizers of these events with valuable information [1]. These events cause accidents that lead to death especially in the huge and large crowds. From this point of view, the main objective of this paper is to present a practical intelligent solution to avoid and prevent all types of accidents related to these huge crowds. The proposed solution automatically depends on measuring the density of the individuals in the crowd based on body thermal features through radiation emitted from objects due to their temperature. The emission of thermal radiation in the infrared spectral region is caused by the formation of atoms forming the body at temperatures above absolute zero and returning to the non-excited state, which causes electromagnetic radiation to be emitted in the infrared region. Where the atoms are in the state of continuous excitation to the high levels of the excited level and then return to the level of ground energy state [2-4]. Figure 1 shows the structure of electromagnetic rays and its section.

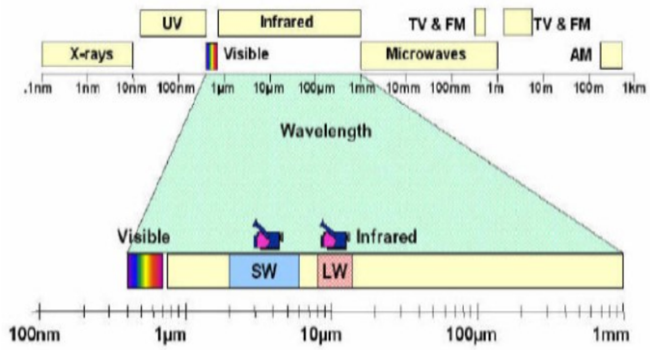


Fig. 1. The structure of electromagnetic rays

The rest of the paper is organized as follows. Related work is discussed in section 1. The proposed approach for crowd counting is introduced in details in section 2. The adopted database is presented in section 3. The experimental results are discussed in section 4. Section 5 includes the main conclusion.

II. RELATED WORK

This section presents the literature reviews for crowd counting fields in the visible and thermal spectrum bands. The existing solutions can be broadly categorized into three groups in crowd counting visible bands first.

Detection based approach this method based on specific the location and parts of human body through analyzing and extract the texture features presented in the image such as calculating the density of the colors and detection features of the human body such as head detection [5-7], second regression-based approach this method works as a function of linear or nonlinear correspondences between image features and the number of people in the training data [8].

Third Tracked based approach is based on the mobile crowd to identify individuals in the crowd such as motion filtering, direction clustering, and dynamic learning [9, 12]. Nowadays, human biometrics moved from visible bands to thermal bands especially pedestrians' detection. Literature research have proved that thermal bands can outperform many of the visible bands' problems. This fact attracted researchers to use thermal bands in the field of crowd counting and control [13]. The existing solutions can be broadly categorized into two groups first background-based approach this approach based on extract foreground from background [14]. Second Heat signature-based approach this approach to monitoring and estimate the number of pedestrians in the crowd depending on infrared cameras concepts [15].

III. PROPOSED WORK

Nowadays, pedestrians counting are the most widely spreading techniques in the research area to help the decision makers to monitor and control the pedestrians overcrowded in the large collection of individuals. This paper presents contribution to the field of crowd density calculation which is based on using heat signature for human density calculations with adding an enhancement on previous researches. The enhancement is dividing the temperature range for human shield into two ranges (covered and uncovered) based on the important fact of the big variance between the two temperatures captured by the thermal camera. The human normal case uncovered skin temperature such as arms and face more than the temperature of covered skin with clothes. The experiments conducted to check the system's efficiency to show the higher accuracy rates resulted by the proposed approach. Figure 2 presents the flowchart that summarizes the steps of the proposed approach.

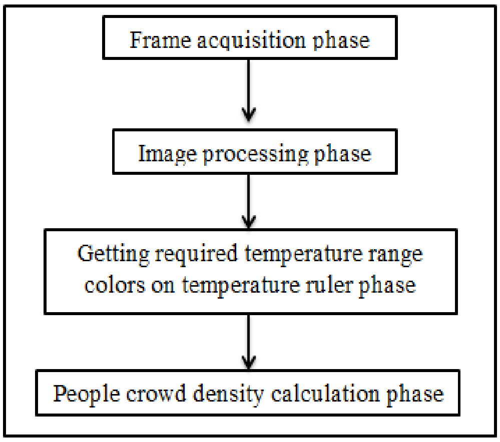


Fig. 2. The flowchart for proposed approach.

The following steps present the proposed approach through these basic implementation

A. Frame acquisition phase

features' analysis indicates that each video frame consists of 240*320*3 RGB pixels. Each frame contains two different boxes to indicate the temperatures range in this frame. These boxes represent the maximum and minimum degrees of temperature as shown in Figure 3. These boxes were specified and cropped to get the temperature range of this frame using function imcrop at fixed point, for box represents maximum degree at 269 in X-axis and 46 in Y-axis , box represents minimum degree at 296 in X-axis and 179 in Y-axis and 21 and 16 for width and length respectively.

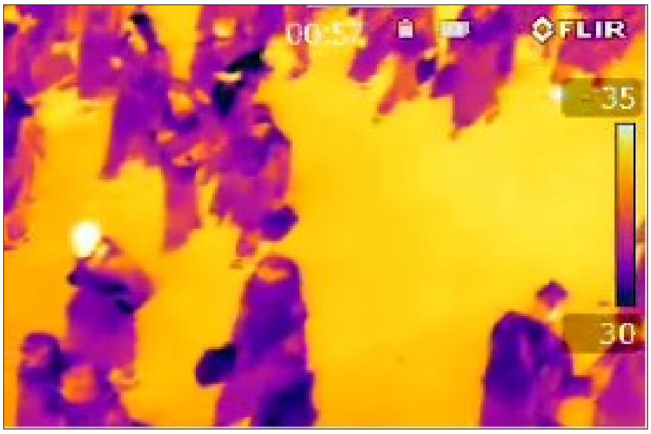


Fig.3. The heat temperature representation of one frame scene extracted from thermal video

B. Image processing phase

Image processing is an essential part in the approach, and it can be divided into several steps; the first step converts the RGB image of the frame to gray scale image, the second step converts the image from gray to binary to become more pure and clear, while the last step apply some morphological operations to the binary image resulting from the previous step to make enhancements on the image such as fill gaps by removing isolated pixels.Prepare Your Paper Before Styling

C. Numbers recognizing phase

As indicates from the previous phases, the converted binary image is divided into two different images; each one consists of one digit that the value of this number rates between zero and nine which represents the minimum and maximum temperature degrees. This phase compares between these digits' images and the pre-stored digits images in dataset by the components of its shape and size for of the ten digits (0-09) to estimate the correct degree as show in Figure 4.

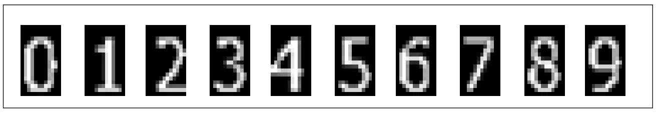


Fig.4. The pre-stored ten-digit images

The previous steps are applied on both upper and lower boxes that represent maximum and minimum temperature values as presented in Figure 5.

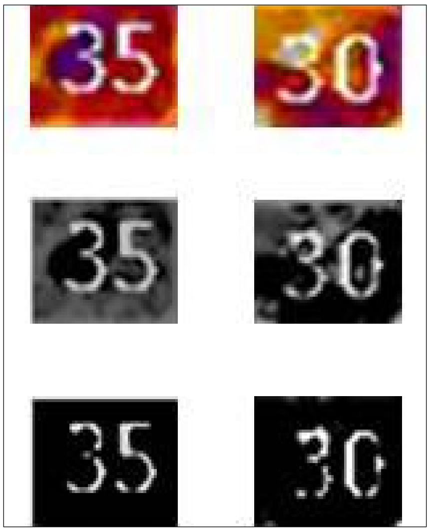


Fig. 5. Sample of cropped boxes represent upper and lower temperature degree, converted from RGB to gray and then to binary level.

D. Temperature range colors acquiring phase

After cropping those boxes and applying the previous steps, the temperature range of the video frame has been automatically recognized. For each frame, the higher temperature ([redacted] (T)) and the lower temperature ([redacted] (T)) values are identified. The higher and lower degrees for the required temperature range ([redacted] (R)) and ([redacted] (R)) are provided. The following equations are used to calculate the difference of the temperature degrees in the frame, and the difference of the required temperature range to be used in calculating the density of individuals.

[redacted] (1)

[redacted] (2)

Where:

[redacted] Denotes difference of temperature degrees, and

[redacted] Denotes difference of temperature range required

The temperature ruler that is placed in the video frames is located at the right part of the image frame exactly located starts in 307 in X-axis and 70 in Y-axis. The width and height of the temperature ruler are 8 and 101 pixels respectively (fixed values in FLIR camera). Figure 6 shows a sample of the used temperature ruler.

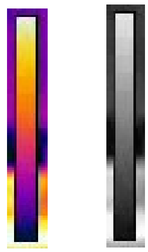


Fig.6. The heat temperature ruler representation of one frame scene.

In equation (3), a ratio value RT is calculated between range variation and total variation of temperature degree.

$$RT = \Delta RD / \Delta TD \qquad (3)$$

The height of the required range temperature is calculated by multiplying previous ratio value with the whole temperature ruler height (which is 101 as a standard degree). This height is used to find out the size of the required range from size of the whole ruler. Equation (4) shows how to calculate the value of the range height.

[redacted] (4)

Where: [redacted] denotes range height value

In the equations from 5 to 7 the start position of the ruler is determined to know the part of the temperature colors which represent the required temperature range this can be explained in following steps:

- **First**, the number of rows for each temperature degree is calculated by dividing the ruler height (101) on the difference of the temperature degree in the frame.

[redacted] (5)

- **Then** the upper part from the ruler which is above the required range is calculated from the difference between higher temperature value in the frame (*MAX* ([redacted]) and the higher temperature value in the range ([redacted]).

$$rows\ down\ from\ ruler\ begin = (MAX(T) - MAX(R) * (rows\ for\ each\ degree) \qquad (6)$$

- **Finally**, the start position of the required temperature range from the ruler is calculated by adding the rows value calculated in the previous step on the row value of the top of the ruler (Y-axis value which is 70).

[redacted] *(7)*

From the above equations, the needed portion of the ruler representing the required temperature range colors are cropped from the whole temperature ruler according to the calculated start point and the range height as presented in Figure 7.

Fig.7. Sample for cropping range height from ruler height

E. Crowd density estimation

The crowd density calculation is based on getting the number of pixels with color values in the whole frame which is like the color values in the temperature ruler portion determined in section 2.4. This number of pixels value is divided by the total number of pixels in the image frame which is 320 for columns and 240 for rows. The density percentage value DP is estimated by multiplying the total value by 100 as indicates is the following equation (8).

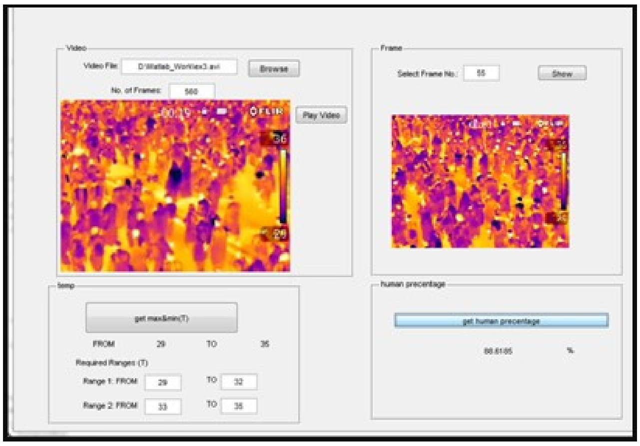
$$Dp = \left(\frac{pixels\ MATCHING\ WITH\ RULER\ COLOLS}{row * columns}\right) * 100 \qquad (8)$$

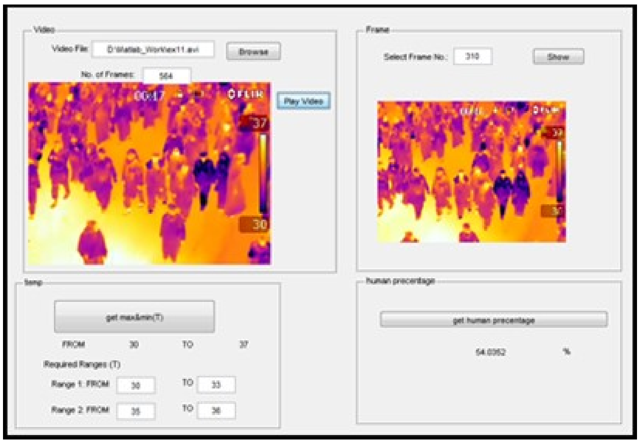
IV. VIDEO DATASET

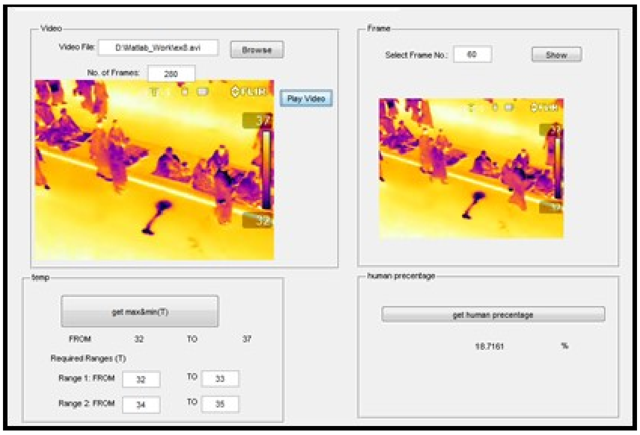
The videos dataset is taken by several Forward-Looking Infrared (FLIR) cameras placed on the roads at a height of about 10 meters above all the roads connecting between Arafat to Muzdalifah. Generally, the FLIR camera is usually depending on utilize far infrared region. These cameras were used by the University of Umm Al Qura / Saudi Arabia to capture videos of the various scenes of the pedestrian status in this specific area [15]. All the videos are with dimensions of 320 pixels width and 240 pixels height. The data set contains 11 different video sequences it is composed about 5000 video frames. All the captured videos of type AVI format with a rate of 18 fps, duration of the video from 11 seconds to 59 seconds.

V. EXPERIMENT RESULT

The proposed approach has been obtained from various infrared videos produced by using thermal cameras. The following are samples of the GUIs (graphical user interface) of the system. The result depends on using two different ranges of temperature. These two ranges indicate the temperature of the individual's skin and the temperature of skin covered with the clothe using Range 1 for skin covered temperature range (skin covered with clothes) and Range 2 for skin temperature range like (arms, face, etc), No of frames represents whole frames numbers in this video, select frame No represents the specific frame, get max and min (t) represents the temperature of frame and get human percentage represents the density of humans in this frame. The eye estimation for some sample can estimate the number of people because they are few enough to be counted by eye as shown in Figures (8 -c) and (8- d). It shows that there are 18% and 11% density people in the frame. According to the reference [15] the area covered in this frame is 48 m^2 from about 8 m width and 6 m length. And which tells that about 2 persons in average can be stands in 1 m^2, we can say that the 18 % of density means about 18 persons in the frame and 11 % means about 11 persons.







Identify applicable funding agency here. If none, delete this text box.

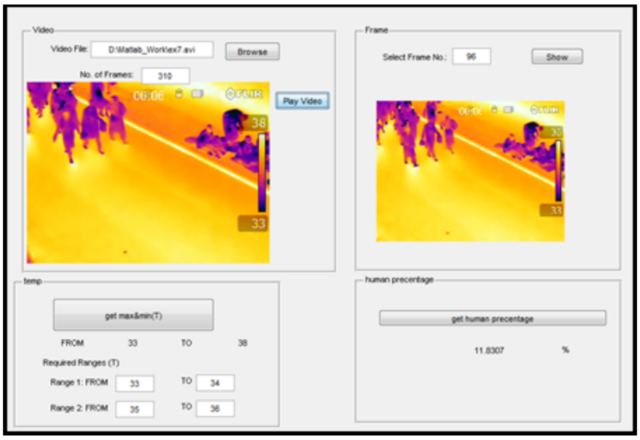


Fig . 8. Samples results for (a) overcrowded, (b) medium-crowded and (c) and (d non-crowded using two (covered and uncovered) ranges.

Figure 8 (a, b, c and d) Samples results for overcrowded, medium-crowded and non-crowded using two (covered and uncovered) ranges.

TABLE I. REPRESENTS THE RESULTS FOR SAMPLES OF THE PROPOSED APPROACH

Proposed Approach	**Fig(a)**	**Fig(b)**	**Fig(c)**	**Fig(d)**
Cases	Crowded	Medium Crowed	Non crowed	Non crowed
Density of people	88.6%	54%	18.7%	11.8%

Table 2 presents a comparison between the two previous algorithms presented in [4] and [15] and the proposed approach in case of crowded. The algorithms use the same dataset from the same thermal videos captured from hajj season. This comparison on the same case (crowded) and same sample video frame.

TABLE II. PEDESTRIAN DETECTION ALGORITHMS AND PROPOSED APPROACH IN CROWDED.

Algorithm / Case	**CMINS Algorithm [15]**	**HSBS Algorithm [4]**	**Proposed Approach**
Crowded	48.72%	58.87%	88.6%
Accuracy	68.7 %	78.87 %	92 %

As shown in Figure 8, the percentage of people in this video frame is exceeding the 3/4 of the overall frame. CMINS gives the size of only about 48.7 % while in HSBC got about 58.8 % but in the proposed approach the result about 88.6% for crowd density (human percentage).

As presented in the accuracy summary table 1, a clear enhancement appears in density peoples' calculations in the proposed approach about (92%).

Figure 9 shows Comparison between the proposed and previous work

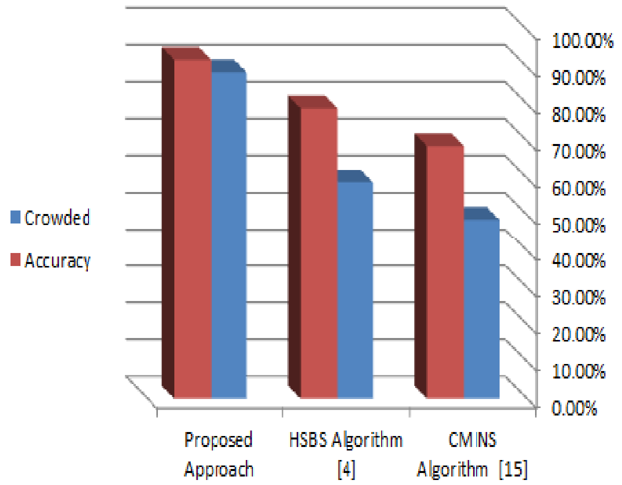


Fig.9. Comparison between the proposed and previous work

VI. CONCLUSION

This work proposed an approach for crowd counting estimation by heat signature. The approach depends on measuring the density of the crowd with taking in consideration the fact of difference differentiating between individual's skin temperature in both covered skins and uncovered skin. This work is tested using video frames which extracted using thermal video frames instead of the visible image because thermal bands can outperform many of the visible bands' problems such as shadow problem, and presents the whole range temperature degree for each frame in the video.

The experimental result indicates that the accuracy rate evaluated in this paper is more robust than the accuracy rate which was mentioned in previous studies especially in real time estimation and individual counting in the crowded areas. Also this paper proves the experimental results accuracy of methodical used in places of overcrowded and not crowded. One of the advantages of this system is not require the followings

- Any information about the crowd, whether it is crowded or not crowded.
- Dealing with shadow problems.
- Any information about the crowd, whether it is crowded or not crowded.
- Dealing with shadow problems.
- The segment foreground from background.
- The segment between individual people.
- Tracking anything (neither objects nor corners).

REFERENCES

[1] B. Zhan, D. Monekosso, P. Remagnino, S. Velastin, and L.-Q. Xu, "Crowd analysis: A survey," Machine Vis. Applicat., vol. 19, no. 2, pp. 345-357, 2008.

[2] M.Teena, and A.Manickavasagan, "Imaging with Electromagnetic Spectrum, " Springer, Berlin, Heidelberg, 16 May, 2014, pp. 147-173.

[3] R. Steadman, "Norms of apparent temperature in Australia," Aust. Met. Mag. 43, 1994. pp. 1-16

[4] N. K. Negied, E. Hemayed, and M. Fayek, "HSBS: A Human's Heat Signature & Background Subtraction Hybrid Approach For Crowd Counting and Analysis," International Journal of Pattern Recognition and Artificial Intelligence, vol. 30, no. 8, May,2016.

[5] L. Guohui, J. Hongwen, and M. Zhang, "A moving object detection approach using Integrated Background template for smart video sensor," in Proceedings of the 21st IEEE Instrumentation and Measurement Technology Conference, Vol. I, Italy, 18-20 May 2004, pp. 462- 466

[6] K, Zheng Ma and A. B. Chan, Beyond counting: comparisons of density maps for crowd analysis tasks-counting,detection, and tracking." IEEE Transactions on Circuits and Systems for Video Technology.2018.

[7] D. Merad, Kh. Aziz, and N. Thome, "Fast People Counting Using Head Detection From Skeleton Graph," Seventh IEEE International Conference on Advanced Video and Signal Based Surveillance, (Boston, MA), 2010, pp. 233–240..

[8] M. Jiang, and Y. Zhao, "An Improved Method of Crowd Counting Based on Regression",in: 3rd International Conference on Multimedia Technology (ICMT),ed.by Aly A.Farag, ISBN: 97890-78677-89-5, Published by Atlantis Press, Guangzhou, China 2013, pp. 143-150.

[9] B. Chan, Z. J. Liang, and N. Vasconcelos, "Privacy Preserving Crowd Monitoring: Counting People without People Models or Tracking", in: CVPR 2008 : IEEE conference on Computer Vision and Patteren Recognition, Anchorage, Alaska, Jun 24, 2008 - Jun 26, 2008.

[10] R. Rajeev and S. S. Sridhar, "Tracking People Motion Based on Lloyd's Clustering Algorithm", International Journal of Computer Science and Information Technologies (IJCSIT), vol.5, no.2, 2014.

[11] M. H. zadeh, G. Pan, and M. Yao, "Counting moving people in crowds using motion statistics of feature-points", Springer publications, Multimed. Tools Appl. 72, February 9th, 2014. pp. 453–487.

[12] X F, X. Shi and D. Yeung. "Spatiotemporal Modeling for Crowd Counting in Videos" In: IEEE International Conference on Computer Vision (ICCV), Oct 22, 2017 - Oct 29, 2017, Venice, Italy

[13] Nermin K. Negied, Elsayed E. Hemayed, and Magda D. Fayek, "Pedestrians' Detection in Thermal Bands – Critical Survey", J. Electr. Syst. Inform. Technol. (2015), http://dx.doi.org/10.1016/j.jesit.2015.06.002.

[14] G. Abuarafah and M. O. Khozium, "Integration of Background Removal and Thermography Techniques for Crowd Density Scrutinizing", International Journal of Computing Academic Research (IJCAR), ISSN 2305-9184, vol 2, no. 1, February 2013. pp.14-25.

[15] G. Abuarafah, M. O. Khozium, and E. AbdRabou, "Real-time Crowd Monitoring using Infrared Thermal Video Sequences", Journal of American Science, vol. 3, August, 2012.