International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Impact Factor (2018): 5.426

Crowd Management Challenges: Tackling Approach for Real Time Crowd Monitoring

Ali Mohammed Al-Shaery[1], Mohamed Osama Khozium[2]

[1]Assist. Prof., Civil Engineering Dept., Dean of Consulting Research and Studies Institute (ICRS)
Umm Al- Qura University, Makkah Al-Mukarramah, Saudi Arabia
amshaery[at]uqu.edu.sa

[2]Professor, Department of Engineering & Applied Science - Computers, MCC
Umm Al-Qura University, Makkah Al-Mukarramah, Saudi Arabia
osama[at]khozium.com

Abstract: ***Due to the growing population, crowd management became an important issue and a challenge for the security agencies across the world, where effective crowd management can prevent serious accidents, and in some cases, mortalities. Thus, a great number of researchers haven't saved any effort in their trials to find a proper solution for crowd management. However, monitoring a large area of crowd is a task full of obstacles and challenges. Crowd management per se is not a simple procedure; it includes some challenging and consecutive steps which are proper crowd analysis, identification, and monitoring and anomalous activity detection. This paper attempts to sum up most of the available and presented works that are concerned about crowd management and monitoring with presenting a tackling approach that will be more accurate for real-time crowd monitoring.***

Keywords: Crowd Monitoring, Thermography, Spatiotemporal Domain, Support vector machine (SVM), Wearable devices

1. Introduction

Crowd is a situation which describes a large group of people who have similar interests such as large concerts or sports events, or they are just only casual crowds [1]. The crowd could be quantified by the number of individuals per unit area at a given moment.

If this crowd wasn't properly managed, disasters like stampedes and congestions might occur.

Whereas crowd management is defined as the systematic planning and supervision of the orderly movement and assembly of people, it involves the assessment of people who handle capabilities of a space which is prior to use [2].

Most of the crowd disasters that have occurred before could have been prevented by the application of simple crowd management strategies, where the main aim of the crowd management is to avoid the critical crowd densities and the rapid movements of groups[2].

And by the increase of crowd density, a transition to a chaotic state occurs, and thus, outbreaks of panic since the individuals have lost control causing a "crowd turbulence" phenomenon, and this phenomenon can trigger disasters [3].

This paper is divided into five sections: the introduction is the first section, the second section is the challenges that face crowd management and the third section is about the crowd management methods.

A discussion took place in the fourth section, and then we conclude the paper in the last section including future work.

2. The Crowd Management Challenges

Researchers have proposed several methods and techniques to understand crowd behaviors for developing a safe and secure environment in order to avoid crowd congestion, public riots and terror attacks. In crowded scenes, standard computer vision techniques are not applicable in first hand manner due to severe occlusion and complex background scenarios. Many computer vision algorithms exist for tracking, detecting and in analyzing behavior of crowded scene. Although they provide a good result in a low to medium density of population, but it is still a challenge to deal with a dense crowd [4][5].

Also, in the analysis and the understanding of the video scenes, the main focus is on the detection of the object, its tracking and its behavior recognition, and therefore, the conventional methods fail sometimes in the crowded scenes of high density because they are extremely cluttered and have high occlusions [6][7].

Another problem was presented where they identified some issues concerning the unexpected behaviors of crowd, and thus causing difficulty in controlling this crowd [8].

These points are summed up to clarify that:

The behavior of people in a crowd is unexpected and unpredictable even if they are all involved in the same act or are gathered for the same reason, and this makes the crowd management more complicated.

For pedestrians, the movement is so easy and flexible in comparison to vehicles and driving since they are governed by driving regulations, however, pedestrians can easily change their movements and directions whenever they want and wherever they want.

Human behaviors are different, and they even change according to the situation, for instance, people's behavior in low crowd will not be the same as in medium or large crowd.

The datasets that represent the crowd scenarios are deficient.

3. Crowd Management Modules

Crowd management can be divided into two parts, 90% of it relies on the preparations and the identification of potential hazards that can be known by the "what-if" scenarios, while the remaining 10% depend on monitoring the crowd for preventing the unpredicted situations and noticing the abnormal behaviors at an early stage to overcome the consecutive problems [9].Many researches have been proposed to find a proper solution for crowd management. The following paragraphs will present the study of some crowd control and management systems.

3.1 Satellite Images

A new approach for the automatic detection of crowded areas using satellite images of very high resolution has been proposed [10].

The main disadvantage of this system is that the images are not of high enough resolution to see each person individually with sharp details, however, the capability of noticing a change in the components of the colors at the place of existence of a person somehow helped in overcoming this disadvantage.

As a result, they developed an algorithm which was tested on panchromatic Worldview-2 satellite image dataset.

They also compared their algorithm with another algorithm obtained result from an airborne image which was taken from the same area, and the final conclusion indicated the possibility of using this algorithm in real-life events, however, it's not of a 100 % accuracy.

3.2 The Minimum Mean Square Error (MMSE)

Tracking people in crowded area using a simple method depending on scenes from a video sequence was the idea proposed, where identification of people in subsequent frames depends on computing the MMSE between the frames of the video sequence [11].

3.3 Slices in the Spatiotemporal Domain

This technique was proposed to determine the crowd from a moving platform using these slices to detect intersections and inward movements between several moving objects [12].

Calculations are done by the system to figure out the probability of the distribution functions regarding the right and the left inward motions, and as a result, concluding a decision about crowd detection.

Success was proved by this system since it had the ability to automatically detect crowded scenes of people moving in directions opposite to each other whether it was at a short or a long distance.

3.4 A Two Step Mode Computer Based System

This system - which is for monitoring the crowd and avoiding disasters- is mainly based on the combination between two modules, the fuzzy logic and the Graphical Information System (GIS) [13] .

The system is achieved in two steps:

a) Pre-disaster planning.
b) Real-time crowd analysis.

The first step is responsible for determining the sensitive locations, space management, and by the help of GIS it determines the evacuation paths, and finally manages the related arrangements.

The second step analyzes the crowd at real-time for the detection of any emergency.

The fuzzy system mainly is responsible for determining the crowd and planning an action, while the GIS is for determining the shortest path.

3.5 Analyzing Still Images using Information Fusion

A useful tool has been presented which is used in estimating the crowd behavior that is derived from distributed sensors [14].
The aim of the tool is to automatically alert the operators and to be aware about the occurrence of an abnormal behavior, not the identification of an exact position of a person in the scene.

3.6 Support Vector Machine (SVM)

The support vector machine algorithm with Higher-Order Singular Value Decomposition (HOSVD) was proposed by the authors for the crowd density measurement, where different density levels of crowd were determined by SVM [15].

However, this is a very time consuming way, and also since the SVM is a classification technique, it will need an accurate training dataset, and this is not easily found in crowd management applications.

3.7 Gaussian Mixture Model (GMM)

Deep learning was used to notice the abnormal events which can happen in a crowd [16].They used GMM to study from videos in an unsupervised form the normal events patterns.

The main disadvantage of GMM I that it's computational time can be very long.

3.8 Wearable Devices

Special devices can be worn for crowd management such as smart bracelets that have internet connection.

These bracelets can immediately send data to the server, or when demanded. The problem is when the communication falls down, but in this case the data is locally stored and will be resent to the server whenever the connection is back.

To overcome this problem, it was suggested to use the adhoc hotspot Wi-Fi in smart phones to avoid this breakdown especially during emergencies [17].

However, the consuming resources are the most important things to be considered.

3.9 Infrared Thermography

Thermographic images have been proposed for determining the crowd density in a specific area [18][19][20]. This method depends on a physical phenomenon which states that anybody emits electromagnetic radiation as long as the temperature of this body is above absolute zero, these radiations emit energy which is called "wavelength", and it can be calculated using the following equation,

$$E = h \times \frac{C}{\lambda}$$

Where $h = 626068 \times 10^{-34}$ m^2.kg/sec which represents the Planck's constant.

C = 299,792,458 m/s is the speed of light in vacuum, while the wave length is represented by λ .

Thermography is a measurement technique which allows the determination of one's environment whether there is visible illumination or not, it also allows seeing variations in temperature, and as a result, warm objects such as humans or warm-blooded animals can be seen clearly against cooler backgrounds such as the environment day or night. For example, Figure 1 shows an example of thermal image of some people moving in Haram area.

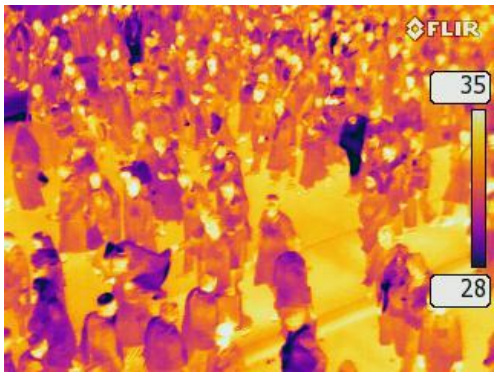

Figure 1: shows thermal image of hajjes in haram area

For crowd management using thermography, a software module is used, and this software requires two types of inputs, the first is the video that was captured by the FLIR camera, and the second is the range of normal human temperature, noting that, the human temperature when captured by the FLIR camera will be different, and this depends on the time of capturing the image whether it's day or night, the temperature of the ground and the density of the crowd.

Also human temperature will be affected by the crowd density, where their temperature rises in a high crowd and vice versa, and as a result, calibration step should be done every 30 minutes. Figure 2 shows some thermal images during the calibration step.

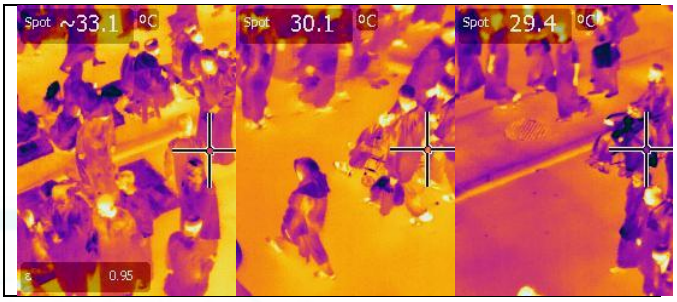

Figure 2: Examples of Thermal images

An analysis algorithm was made which is capable of determining the minimum and the maximum temperatures at any frame of the entered video where a normal temperature range of humans is given. The module will calculate the percentage of the present temperature range, and accordingly, crowd density can be determined.

This module mainly aims to calculate the crowd density in real-time.

However, a big problem faces the thermography which is the background removal, where background removal in images with mild occlusion is a hard task especially that in problems classification the main target and focus is required to be on the object itself and not its shadow.

3.10 Visual sensing method

Monitoring the crowd actions such as the crowd density and the pattern of mobility can be done efficiently by the CCTV, however, some problems should be considered while using the visual sensors. These problems are:

- The cameras can only capture whatever it is directly pointing at, and thus, any obstacle that gets in the way cannot be avoided [21].
- It is somehow a difficult task to fuse the information gathered from different cameras to produce a perception of the area on a wide scale.
- The quality of the images taken by the camera will greatly depend on the lighting, an thus it will be a problem when being used at night
- CCTV cameras can be used for tracking the crowds, however, the use of the temporary camera networks is expensive a consumes a lot of time, which can let us conclude that the CCTV cameras aren't the best option to be used in events that don't regularly happen at the same location.

3.11 Mobile / Non-Visual Sensing Method

Another way for crowd monitoring that can be used which can be by the smartphones where the GPS sensors can cover a lot of geographical area [22]. Also, using the smartphones for data collection will help in understanding and managing the crowd since the movements will be collected in different patterns and will provide the exact location of the user.

On the other hand, some limitations are found due to the energy consumption and the privacy issues. It can't guarantee the complete coverage of the event, and also there is no availability of real-time feedback which is very essential for crowd management.

4. Discussion

Indeed many researches have been proposed to find the most appropriate solution for such an important topic, and the target is to find the most convenient module with least expenses and the most time saving and accuracy.

Tackling approach is proposed, where collaboration between different modules is necessary to cover every aspect, since the combination between two or more different methods can help in avoiding the disadvantages found and take benefit of the advantages to create a stronger and a more accurate system.

The proposed collaboration is between the satellite images, thermography and the wearable devices.

Satellite images have the advantage of being fast and have the ability of covering a wide area, however, it is not of high enough resolution to recognize each person individually with sharp details, while thermography allows seeing variations in temperature, and as a result, warm objects such as humans or warm-blooded animals can be seen clearly against cooler backgrounds such as the environment day or night, but the main disadvantage of thermography is the shadow present in the image, however, this can be dealt with by using shadow removal technique for providing accurate estimation of the crowd. Another disadvantage, the infrared camera used for thermography can only capture a very limited area, and in addition, calibration step must be done every 30 minutes due to the difference in temperature.

Wearable devices -such as bracelets- is also a proposed module for crowd monitoring, where smart bracelets that have internet connection can immediately send data to the server, or when demanded. The problem is when the communication falls down, but in this case the data is locally stored and will be resent to the server whenever the connection is back.

By combining these three modules together, each module will have a way in fixing the drawback found in the other module. In addition, this combination will increase the benefits taken from the advantages of each module, as an example, the satellite will provide the benefit of fast response and wide coverage, while the accuracy problem found due to the satellites can be fixed by the help of thermography. All of the gathered data will be collected in a system and will be filtered to produce an accurate result gathered from the available sources. Figure 3 shows data movement from the three sources to data filtering system, crowd management system then decision support system which sends decisions to the stakeholders for dealing with the crowd situation.

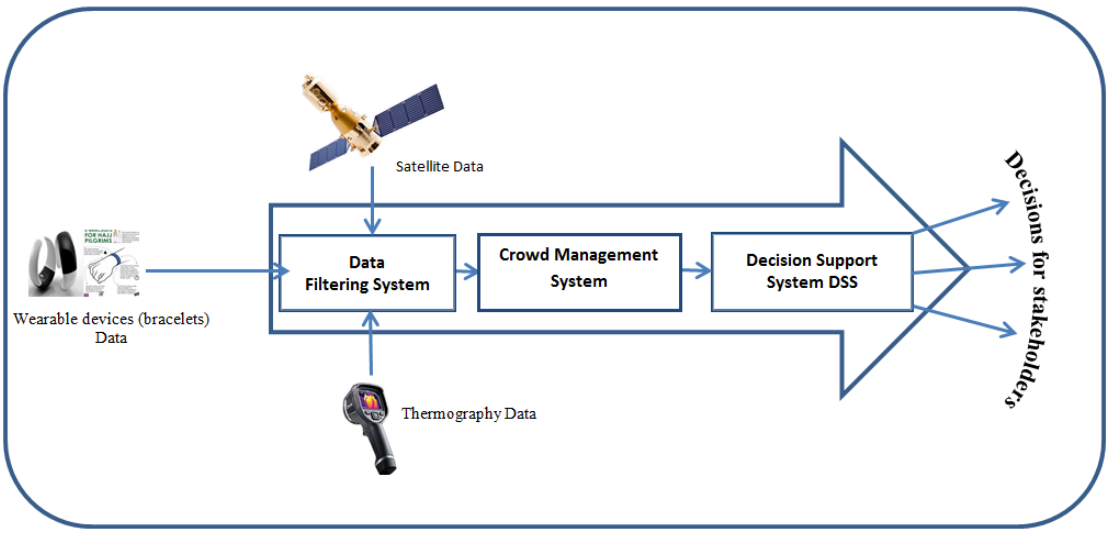

Figure 3: Data movement flow architecture

The main target is to choose more than one module for providing a higher accuracy; however, other modules can be combined depending on the present situation and their available facilities. And it must be put in consideration that crowd management doesn't only depend on determining the density of the crowd, but also there are some general affecting factors, such as:

- Special parameters, where data from video must be used to identify the personal space, the formation of groups or even the headways.

- Location parameters, to know the effect of maximum load of crowd, the speed threshold and weight capacity.
- Macroscopic parameters, where there is a very important relation between speed, flow and density.
- Weather and environmental factors, they can affect the density of the crowd such as the effect of hunger, thirst, noise, smell, dehydration or even road blockage.

These factors must be taken in consideration to increase the accuracy of the results, and to provide a better method for crowd management since they will have a great effect in the choice of the most appropriate modules to be collaborated together for providing an effective tackling approach.

5. Conclusion and Future Work

5.1. Conclusion

In this paper, a tackling approach has been proposed for crowd management. Many modules have been proposed for crowd management, some are visual sensing methods such as satellite images, video sequences or infrared thermography, and others are non-visual sensing methods such as smart bracelets or hotspot Wi-Fi in smartphones. However, the tackling approach depends on the combination between more than one of these modules, to take advantage of their benefits, and overcome their drawbacks.

The aim of this tackling technique it to provide a system which gives results with the highest accuracy for proper crowd management .While the main aim in this paper is the real-time calculation of crowd density, since the decisions that will be taken will depend on this calculation, so it has to be highly accurate.

5.2. Future work

Crowd management does not only depend on monitoring of the crowd, it also depends on data analysis and decision support, so a survey will be done in those aspects since they play a big role in crowd management.

References

[1] Schauer, L., Werner, M. and Marcus, P. (2014) 'Estimating Crowd Densities and Pedestrian Flows Using Wi-Fi and Bluetooth', Proceedings of the 11th International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services, pp. 171–177. doi: 10.4108/icst.mobiquitous.2014.257870.
[2] Fruin, J. (1993).The causes and prevention of crowd disasters. Engineering for crowd safety. Elsevier, New York, 1-10.
[3] Helbing, D., Johansson, A., Al-Abideen, H. Z., (2007). The Dynamics Of Crowd Disasters: An Emprical Study. Physical Review E75: 046109.
[4] Zhan, Beibei, et al. "Crowd analysis: a survey." Machine Vision and Applications 19.5–6(2008): 345–357.
[5] Li, Teng, et al. "Crowded scene analysis: A survey." Circuits and Systems for Video Technology, IEEE Transactions on 25.3 (2015): 367–386.
[6] Hu, Weiming, et al. "A survey on visual surveillance of object motion and behaviors."Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on34.3 (2004): 334–352.
[7] Badal, Tapas, et al. "An Adaptive Codebook Model for Change Detection with Dynamic Background." 2015 11th International Conference on Signal-Image Technology and Internet Based Systems (SITIS). IEEE, 2015.
[8] Haghani, M. and Sarvi, M. (2018) 'Crowd behaviour and motion: Empirical methods', Transportation Research Part B: Methodological. Elsevier Ltd, 107, pp. 253–294. doi: 10.1016/j.trb.2017.06.017.
[9] Martella, C., Li, J., Conrado, C. and Vermeeren, A. (2017) 'On current crowd management practices and the need for increased situation awareness, prediction, and intervention', Safety Science, 91, pp. 381–393. doi: 10.1016/j.ssci.2016.09.006.
[10] Sirmacek, B., &Reinartz,P. (2011). Automatic crowd analysis from very high resolution satellite images. Proceedings of Photogrammetry and Image Analysis Confrence. Munich, Germany.
[11] Mahalingam, G., Kambhamettu, C., &Aguirre, B. (2009). Crowd Analysis from Video. 2009 NSF Engineering Research and Innovation Conference. Hawaii.
[12] Pini, R., Ofer, M., Shai, A., & Amnon, S. (2004). Crowd detection in video sequences. IEEE Intelligent Vehicles Symposium, 2004: 66-71.
[13] Deshpande, N. P., and Gupta, R., (2010). Crowd management ussing fuzzy logic and G.I.S. WIT Transactions on Information and Communication Technologies, 43:325-334.
[14] Andersson, Maria, & Rydell, Joakim. (2009). Estimation of crowd behavior using sensor networks and sensor fusion. Fusion, 2009. FUSION'09., 396-403.
[15] Zhou, B., Zhang, F. and Peng, L. (2012) 'Higher-order SVD analysis for crowd density estimation', Computer Vision and Image Understanding. Elsevier Inc., 116(9), pp. 1014–1021. doi: 10.1016/j.cviu.2012.05.005.
[16] Feng, Y., Yuan, Y. and Lu, X. (2017) 'Learning deep event models for crowd anomaly detection', Neurocomputing, 219, pp. 548–556. doi: 10.1016/j.neucom.2016.09.063.
[17] Franke, T., Negele, S., Kampis, G. and Lukowicz, P. (2016) 'Leveraging human mobility in smartphone based Ad-Hoc information distribution in crowd management scenarios', Proceedings of the 2015 2nd International Conference on Information and Communication Technologies for Disaster Management, ICT-DM 2015, pp. 27–34. doi: 10.1109/ICT-DM.2015.7402053.
[18] Abuarafah A. G., Khozium M. O., and Abd Rabou E., (2012). "Real-time Crowd Monitoring using Infrared Thermal Video Sequences". Journal of American Science, 8(3), pp.133-140.
[19] Khozium M. O., Abuarafah A. G., and Abd Rabou E., (2012). "A Proposed Computer-Based System Architecture for Crowd Management of Pilgrims using Thermography". Life Science Journal 9(2), pp.377-383.
[20] Khozium, (2012). "A Hybrid Intelligent Information System for the Administration of Massive Mass of Hajjis". Life Science Journal 9(2), pp.377-383.
[21] Yaseen, S., Al-Habaibeh, A., Su, D. and Otham, F. (2013) 'Real-time crowd density mapping using a novel sensory fusion model of infrared and visual systems', Safety Science, 57, pp. 313–325. doi: 10.1016/j.ssci.2013.03.007.
[22] Roggen, D., Wirz, M., Tröster, G. and Helbing, D. (2011) 'Recognition of Crowd Behavior from Mobile Sensors with Pattern Analysis and Graph Clustering Methods', 0(0), pp. 1–24. doi: 10.3934/nhm.2011.6.521