Evaluation of an Intelligent Video Surveillance Model Based on Human Behaviour Detection and Analysis

Ashraf Abbas M. AL-Modwahi , Halimah Badioze Zaman, and Azlina Ahmad

The institute of Visual Informatics (IVI), Universiti Kebangsaan Malaysia (UKM), 43600 Bangi, Selangor, Malaysia.

Abstract

Smart video surveillance has become popular, as it is a high-tech solution for public safety, facilities surveillance, and traffic monitoring. Recently, we proposed and developed an Intelligent Video Surveillance Model Based on Human Behaviour Detection and Analysis (IVSM) by applying a novel algorithm and 3 Dimensional (3D) detection techniques. Hence, in this paper, we are presenting an evaluation based on usability testing, which conducted on the developed model. The results show that our model of intelligent video surveillance fulfills the lack of data in the process of detecting and analyzing human behaviour.

Keywords:

Video Surveillance, Human Behaviour detection and analysis, intelligent video surveillance model, 3D recognition, Face Recognition, Surveillance model lunationion.

1. Introduction

Research on the prediction of crime occurrence on video surveillance has been quite intensive in the past decade. Intelligent video surveillance technology can make real time monitoring for surveillance scenes, which uses computer vision and video analytic methods to create an intelligent analysis without human intervention. We adopted 3 Dimensional (3D) detection in an Intelligent Video Surveillance Model based on Human Behaviour Detection and Analysis (IVSM) to get the needed data and then developed a novel activity recognition algorithm to empower the process of human behaviour analysis.

The study involved two aspects as follows: (i) Development of an Intelligent Video Surveillance system for the topic: Intelligent Video Surveillance Model based on Human Behaviour Detection and Analysis (IVSM) which involved investigating the System Requirement Specification (SRS) and System Design Specification (SDS) of IVSM: identifying a suitable development methodology for IVSM based on the Repetitive Participatory Development Life Cycle of an Intelligent Video Surveillance Model based on Human Behaviour Detection and Analysis (RP-IVSM), (ii) Practical acceptability evaluation based on usability testing of IVSM which involved four constructs: Preciseness, Efficiency, Ease of Use, and Flexibility. The usability testing was conducted based on a case study at a Seven Eleven store for the indoor video surveillance application and at a condominium gate for the outdoor video surveillance application. In this paper, we are presenting the aspect of the practical acceptability evaluation that based on usability testing of IVSM.

The system testing and evaluation involved the practical acceptability evaluation for the IVSM based on the usability testing, adopting four constructs: preciseness, efficiency, ease of use, and flexibility. The usability constructs were chosen to investigate the following:

i. Overall IVSM system compliance to the usability constructs (preciseness, efficiency, ease of use, flexibility) among security specialists and security guards.
ii. Each component of IVSM system compliance to the usability constructs (preciseness, efficiency, ease of use, and flexibility).
iii. Each component of the IVSM system complies with each item of the five usability constructs (preciseness, efficiency, ease of use, and flexibility).
iv. Time taken by the system to analyze the behaviour of the detected object.

The usability testing was conducted based on a case study at surveillance environments (indoor and outdoor). The researcher conducted training on how to use the system and collect data through the administration of questionnaire and the observation instruments.

2. Related Work

Surveillance technology began in the 1970s with Closed Circuit Television (CCTV) system that were analog based, which were built from cameras,

multiplexers, monitors, and time-lapse Video Camera Recorders (VCR). These analog systems were based on the original TV standard from the mid 1900s that are becoming obsolete in the new century due to the High Definition (HD) television. Recently, HD cameras were being offered in the market, those cameras working in IP network installations, their popularity for extremely clear images and powerful range have increased demand for IP video management software. Researchers keep doing their best with the speed of innovation for better response to the increasing challenges of the security world.

Video surveillance system is a video streams from cameras are sent to a control center and operators monitor the videos. Yet human operator monitoring of the views every moment of every day is almost impossible [1]. Therefore, intelligent surveillance systems are required, systems that are capable of automated scene analysis. Various researchers [2], [3], [4], [5], [6], [7] have attempted to develop a robust smart video surveillance systems in the past few years. There were a number of studies to enable smart video surveillance with a multi-camera network; most of the studies treat central processing approaches in which a scene analysis is processed inside a central server domain once all available information has been collected in the server [8], [9], [10], [11]. Such approaches require tremendous efforts in building the system and, moreover, limit the scalability. The systems implemented were only focusing on recording and offline analysis rather than real-time analyzing the detected object's behaviour to predict the incidence of any threats. It was clear that there is a need to design and develop an intelligent video surveillance system to detect and analyze the human behaviour. Therefore, a study was conducted to investigate a new model in video surveillance to detect threats.

To accomplish scalable smart video surveillance, an inference framework in visual sensor networks is necessary, one in which autonomous scene analysis is performed via distributed and collaborative processing among camera nodes without necessity for a high performance server. [2], [3], [4], [12] presented smart video surveillance frameworks for their integrated systems. Their video surveillance frameworks have great implications on our research, where the framework of our proposed model has its basics from their proposed frameworks. The design and implementation of our intelligent video surveillance system were based on an intelligent framework.

Detection is essential in the smart video surveillance systems. An efficient occupancy reasoning algorithm that is essential in smart video surveillance based on [2] framework was proposed. They estimated the existence probabilities for every camera and combine them using the work-tree architecture in a distributed and collaborative manner. RANSAC algorithm used by [3] for eliminating the features that belong to the moving objects. Thus, a better motion model estimate can be generated. Using the motion model parameters of the stationary persistent features, the second frame is registered on the first frame by warping. Two dimensional affine transformations are described as follows:

$$\begin{pmatrix} X_i \\ Y_i \end{pmatrix} = \begin{pmatrix} a_1 & a_2 \\ a_3 & a_4 \end{pmatrix} \begin{pmatrix} x_i \\ y_i \end{pmatrix} + \begin{pmatrix} a_5 \\ a_6 \end{pmatrix} \quad (1)$$

Where (xi, yi) are locations of feature points in the previous frame, and (Xi, Yi) are locations of feature points in current frame. Theoretically, to determine six affine parameters, three pairs of matched feature points are enough. How to select these three pairs of feature points will affect the precision of affine parameter estimation. To reduce this estimation error, these parameters can be solved in the least-squares method based on all matched feature points. A novel algorithm proposed by [13] for moving object detection and tracking. Their proposed algorithm includes two schemes: one for spatio-temporal spatial segmentation and the other for temporal segmentation. A combination of these schemes is used to identify moving objects and to track them. A compound Markov random field (MRF) model is used as the prior image attribute model, which takes care of the spatial distribution of colour, temporal colour coherence and edge map in the temporal frames to obtain a spatio-temporal spatial segmentation. In this scheme, segmentation is considered as a pixel labeling problem and is solved using the maximum a posteriori probability (MAP) estimation technique. A novel and accurate approach proposed by [14] to motion detection for the automatic video surveillance system. Their method achieves complete detection of moving objects by involving three significant proposed modules: a background modeling (BM) module, an alarm trigger (AT) module, and an object extraction (OE) module. For their proposed BM module, a unique two-phase background matching procedure is performed using rapid matching followed by accurate matching in order to produce optimum background pixels for the background model. Next, their proposed AT module

eliminates the unnecessary examination of the entire background region, allowing the subsequent OE module to only process blocks containing moving objects. Finally, the OE module forms the binary object detection mask in order to achieve highly complete detection of moving objects.

Some in depth studies presented by [12], [15] on the challenges and issues in many real time video surveillance applications, highlighting the need for an improved video tracking algorithm for effective design of video surveillance systems. In addition, their studies focused on providing a new proposal in three fold ways, thereby producing a refined approach as compared to previous techniques for real time video surveillance.

3. Evaluation and Testing Of IVSM

The practical acceptability evaluation based on the usability testing of the IVSM system was guided by the following research question "What is the data analysis models used to analyze the four (4) constructs incorporated into the usability testing of IVSM?"

3.1 Demographic Profile of Respondent

The demographic profile of the respondents comprised of security guards' profile and security specialists' profile. The demographic profile of the respondents for the security guards is as illustrated in Table 1. Based on the Table, 96% of (5 guards) feel convenient to use a computer and don't feel forced, 25% only than security guards face difficulties in using computer applications, 87% indicates that security guards likes to use technology to assist them while doing their jobs, 65% of the selected guards have used video surveillance systems before, and none of them used system that can analyze a human behaviour.

Table 1: Security Guards' Profile

NO	Statement	A (%)	B (%)	C (%)	D (%)	E (%)
1.	Do you feel like, you are forced to use the computer?	0	20	0	0	0
2.	Do you have difficulties using Computer applications?	25	60	10	10	20
3.	Do you like to use Information Technology to help you doing better in your work?	100	50	95	90	100
4.	Have you used computer video surveillance systems?	80	0	100	60	85
5.	Have you used any computer software for analyzing human behaviour?	0	0	0	0	0

The demographic profile of the respondents for the security specialists is as illustrated in Table 2. Based on the Table the average years of experience for the chosen security specialists is 8 years, 97% that intelligent video surveillance system is important to the security specialists, 89% information technology helps video surveillance according to the selected security specialists, 98% is the average of the security specialists in the area of video surveillance, none of them have dealt and seen any computer software that able to analyze human behaviour, and none of them feel like they are forced to use computer to do their job.

Table 2: Security Specialists' Profile

NO	Statement	A (%) Years	B (%) Years	C (%) Years	D (%) Years	E (%) Years
1.	How many years have you been working in the field of security?	4	12	4	6	13
2.	Do you think that intelligent video surveillance system is important?	100	100	90	95	100
3.	Would you like to use Information Technology to help you doing better in your work?	90	90	95	90	80
4.	Have you used computer video surveillance systems before?	100	100	100	90	100

5.	Have you seen or used any computer software for analyzing human behaviour?	0	0	0	0	0
6.	Do you feel like, you are forced to use computer for video surveillance?	0	0	0	0	0

3.2 Findings of Usability Testing

The Intelligent Video Surveillance Model based on Human Behaviour Detection and Analysis (IVSM) system was built and evaluated through the usability testing based on a case study at an indoor and outdoor environment. The system has the ability to monitor the indoor and outdoor environment in any lighting condition even if the light is off, due to the IR filter. This usability testing was conducted based on four (4) usability constructs: preciseness, efficiency, ease of use, and flexibility. The results of the findings are discussed based on constructs, components, and Items.

- **Findings of Usability Testing of the IVSM System**

The usability testing mean average findings for the preciseness, efficiency, ease of use, and flexibility as illustrated in Table 3. Based on the Table, Findings show that the security guards and the security specialists mean average scores obtained for preciseness, efficiency, ease of use, and flexibility constructs were from 3.58 to 4.32, which are interpreted as high. Hence, IVSM is highly accepted as suitable in fulfilling the needs of the four usability constructs in a study by the respondents (security guards and specialists). The usability testing of the overall IVSM system was based on the Data Analysis Model (DAM) as can be observed in Figure 1.

Table 3: Usability mean Average Result for The IVSM: System

Construct	Security Guards		Security Specialists	
	Mean	Int.	Mean	Int.
Preciseness	4.16	H	3.58	M
Efficiency	4.07	H	3.80	H
Ease Of Use	4.32	H	3.89	H
Flexibility	4.11	H	4.31	H

L=Low M= Moderate H= High

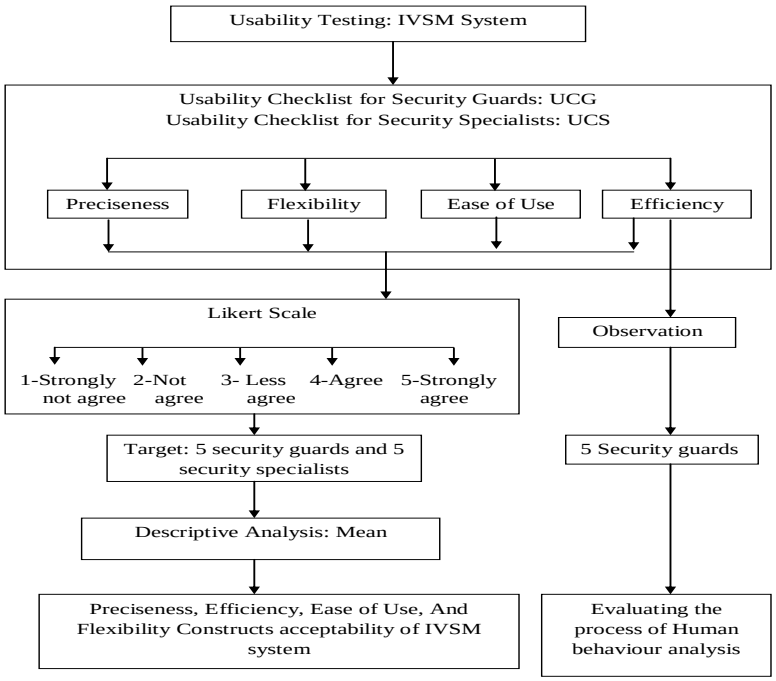

Fig. 1 Data Analysis Model (DAM).

- **Findings of Usability Testing of IVSM: Detection Component**

The usability testing mean average findings for constructs preciseness, efficiency, ease of use, and flexibility for the Detection component of IVSM are as illustrated in Table 4. Based on the Table, findings show that security guards and specialists mean average scores obtained for the preciseness and flexibility constructs were from 2.58 to 4.11 respectively, which were interpreted as high. Thus, the Detection component of IVSM is highly accepted as suitable in fulfilling the needs of preciseness, efficiency, ease of use, and flexibility usability constructs in the study of the respondents. The findings of the usability testing also found that the security guards and specialist mean average scores obtained for the preciseness construct were 3.52 and 2.58 respectively, which were interpreted as moderate. Hence, the Detection component of IVSM was moderately accepted as suitable in fulfilling the needs of the preciseness usability construct in the study by the respondents (Security Guards and Specialists). Based on Table 4 too, findings show that the respondents mean average scores obtained for the efficiency construct were 3.67 and 3.08 respectively, which were interpreted as high and moderate. Thus, the Detection component of IVSM was highly and moderately accepted as suitable in fulfilling the needs of the effectiveness usability construct in the study by the respondent (Security Guards and Specialists).

Table 4: Usability mean Average Result for The IVSM: Detection Component

Construct	Security Guards		Security Specialists	
	Mean	Int.	Mean	Int.
Preciseness	3.52	M	2.58	M
Efficiency	3.67	H	3.08	M
Ease Of Use	4.07	H	3.83	H
Flexibility	3.95	H	4.11	H

L=Low M= Moderate H= High

The findings of the study also found that the security guards and specialists mean average scores obtained for the ease of use construct were 4.07 and 3.83 respectively, which were interpreted as high. Therefore, the Detection component of the IVSM system was highly accepted as suitable in fulfilling the needs of the ease of use usability construct in the study by the respondents. Findings of the study also found that the respondents mean average scores obtained for the flexibility construct were 3.95 and 4.11 respectively, which were interpreted as high. Therefore, the Detection component of the IVSM system was highly accepted as suitable in fulfilling the needs of the flexibility usability construct in the study by the respondents.

- **Findings of Usability Testing of IVSM: Classification Component**

The usability testing mean average findings for constructs preciseness, efficiency, ease of use, and flexibility for the Classification component of IVSM are as illustrated in Table 5. Based on the Table, findings show that security guards and specialists mean average scores obtained for the preciseness and flexibility constructs were from 3.22 to 4.33 respectively, which were interpreted as high. Thus, the Classification component of IVSM is highly accepted as suitable in fulfilling the needs of preciseness, efficiency, ease of use, and flexibility usability constructs in the study of the respondents. The findings of the usability testing also found that the security guards and specialist mean average scores obtained for the preciseness construct were 3.98 and 3.22 respectively, which were interpreted as high and moderate. Hence, the Classification component of IVSM was moderately accepted as suitable in fulfilling the needs of the preciseness usability construct in the study by the respondents (Security Guards and Specialists). Based on Table 5 too, findings show that the respondents mean average scores obtained for the efficiency construct were 3.60 and 3.54 respectively, which were interpreted as high and moderate.

Table 5: Usability mean Average Result for The IVSM: Classification Component

Construct	Security Guards		Security Specialists	
	Mean	Int.	Mean	Int.
Preciseness	3.98	H	3.22	M
Efficiency	3.60	M	3.54	M

Ease Of Use	4.33	H	3.83	H
Flexibility	4.13	H	4.33	H

L=Low M= Moderate H= High

Thus, the Classification component of IVSM was moderately accepted as suitable in fulfilling the needs of the effectiveness usability construct in the study by the respondent (Security Guards and Specialists). The findings of the study also found that the security guards and specialists mean average scores obtained for the ease of use construct were 4.33 and 3.83 respectively, which were interpreted as high. Therefore, the Classification component of the IVSM system was highly accepted as suitable in fulfilling the needs of the ease of use usability construct in the study by the respondents.

Findings also show that the respondents mean average scores obtained for the flexibility construct were 4.13 and 4.33 respectively, which were interpreted as high. Therefore, the Classification component of the IVSM system was highly accepted as suitable in fulfilling the needs of the flexibility usability construct in the study by the respondent

- **Findings of Usability Testing of IVSM: Classification Component**

The usability testing mean average findings for constructs preciseness, efficiency, ease of use, and flexibility for the Tracking component of IVSM are as illustrated in Table 6. Based on the Table, findings show that security guards and specialists mean average scores obtained for the preciseness and flexibility constructs were from 3.79 to 4.38 respectively, which were interpreted as high. Thus, the Tracking component of IVSM is highly accepted as suitable in fulfilling the needs of preciseness, efficiency, ease of use, and flexibility usability constructs in the study of the respondents. The findings of the usability testing also found that the security guards and specialist mean average scores obtained for the preciseness construct were 4.31 and 3.79 respectively, which were interpreted as high. Hence, the Tracking component of IVSM was highly accepted as suitable in fulfilling the needs of the preciseness usability construct in the study by the respondents (Security Guards and Specialists). Based on Table 6 too, findings show that the respondents mean average scores obtained for the efficiency construct were 4.24 and 4.09 respectively, which were interpreted as high. Thus, the Tracking component of IVSM was highly accepted as suitable in fulfilling the needs of the effectiveness usability construct in the study by the respondent (Security Guards and Specialists).

Table 6: Usability mean Average Result for The IVSM: Tracking Component

Construct	Security Guards		Security Specialists	
	Mean	Int.	Mean	Int.
Preciseness	4.31	H	3.79	H
Efficiency	4.24	H	4.09	H
Ease Of Use	4.48	H	3.88	H
Flexibility	4.11	H	4.38	H

L=Low M= Moderate H= High

The respondent mean average scores obtained for the ease of use construct were 4.48 and 3.88 respectively, which were interpreted as high. Therefore, the Tracking component of the IVSM system was highly accepted as suitable in fulfilling the needs of the ease of use usability construct in the study by the respondents. Findings of the study also found that the respondents mean average scores obtained for the flexibility construct were 4.11 and 4.38 respectively, which were interpreted as high. Therefore, the Tracking component of the IVSM system was highly accepted as suitable in fulfilling the needs of the flexibility usability construct in the study by the respondents.

- **Findings of Usability Testing of IVSM: Face Recognition Component**

Findings for constructs preciseness, efficiency, ease of use, and flexibility of the Face Recognition component of IVSM are as illustrated in Table 7. Based on the Table, findings show that security guards and specialists mean average scores obtained for the preciseness and flexibility constructs were from 4.39 to 4.30 respectively, which were interpreted as high. Therefore, the Facial Recognition component of IVSM is highly accepted as suitable in fulfilling the needs of preciseness, efficiency, ease of use, and flexibility usability constructs in the study of the respondents.

Table 7: Usability mean Average Result for The IVSM: Face Recognition Component

Construct	Security Guards		Security Specialists	
	Mean	Int.	Mean	Int.
Preciseness	4.53	H	4.39	H
Efficiency	4.27	H	4.13	H
Ease Of Use	4.14	H	4.07	H
Flexibility	4.15	H	4.30	H

L=Low M= Moderate H= High

The findings of the usability testing also found that the security guards and specialist mean average scores obtained for the preciseness construct were 4.53 and 4.39 respectively, which were interpreted as high. Hence, the Face Recognition component of IVSM was highly accepted as suitable in fulfilling the needs of the preciseness usability construct in the study by the respondents (Security Guards and Specialists). Based on Table 7 too, findings show that the respondents mean average scores obtained for the efficiency construct were 4.27 and 4.13 respectively, which were interpreted as high. Thus, the Face Recognition component of IVSM was highly accepted as suitable in fulfilling the needs of the effectiveness usability construct in the study by the respondent (Security Guards and Specialists). The findings of the study also found that the respondent mean average scores obtained for the ease of use construct were 4.14 and 4.07 respectively, which were interpreted as high. Therefore, the Face Recognition component of the IVSM system was highly accepted as suitable in fulfilling the needs of the ease of use usability construct in the study by the respondents. The findings also show that the respondents mean average scores obtained for the flexibility construct were 4.15 and 4.30 respectively, which were interpreted as high. Therefore, the Face recognition component of the IVSM system was highly accepted as suitable in fulfilling the needs of the flexibility usability construct in the study by the respondents.

- **Findings of Usability Testing of IVSM: Human Behaviour Analysis Component**

The usability testing mean average findings for constructs preciseness, efficiency, ease of use, and flexibility for the Human Behaviour Analysis component of IVSM are as illustrated in Table 8. Based on the Table, findings show that security guards and specialists mean average scores obtained for the preciseness and flexibility constructs were from 3.83 to 4.48 respectively, which were interpreted as high. Therefore, the Human Behaviour Analysis component of IVSM is highly accepted as suitable in fulfilling the needs of preciseness, efficiency, ease of use, and flexibility usability constructs in the study of the respondents. The findings of the usability testing also found that the security guards and specialist mean average scores obtained for the preciseness construct were 4.48 and 4.39 respectively, which were interpreted as high. Hence, the Human Behaviour Analysis component of IVSM was highly accepted as suitable in fulfilling the needs of the preciseness usability construct in the study by the respondents (Security Guards and Specialists). Based on Table 8 too, findings show that the respondents mean average scores obtained for the efficiency construct were 4.55 and 4.13 respectively, which were interpreted as high. Therefore, the Human Behaviour Analysis component of IVSM was highly accepted as suitable in fulfilling the needs of the effectiveness usability construct in the study by the respondent (Security Guards and Specialists).

Table 8: Usability mean Average Result for The IVSM: Human B. A Component

Construct	Security Guards		Security Specialists	
	Mean	Int.	Mean	Int.
Preciseness	4.48	H	3.92	H
Efficiency	4.55	H	4.13	H
Ease Of Use	4.58	H	3.83	H
Flexibility	4.24	H	3.92	H

L=Low M= Moderate H= High

The findings of the study also found that the respondent mean average scores obtained for the ease of use construct were 4.58 and 3.83 respectively, which were interpreted as high. Therefore, the Human Behavior Analysis component of the IVSM system was highly accepted as suitable in fulfilling the needs of the ease of use usability construct in the study by the respondents. The findings of the study

also found that the respondents mean average scores obtained for the flexibility construct were 4.24 and 3.92 respectively, which were interpreted as high. Therefore, the Human Behavior Analysis component of the IVSM system was highly accepted as suitable in fulfilling the needs of the flexibility usability construct in the study by the respondents.

4. Conclusion

Recently, we proposed and developed an Intelligent Video Surveillance Model Based on Human Behaviour Detection and Analysis (IVSM) by applying a novel algorithm and 3 Dimensional (3D) detection techniques. In this paper, we discussed findings on the practical acceptability evaluation base on usability testing for IVSM based on four constructs: preciseness, efficiency, ease of use, and flexibility. The respondents were comprised of security guards and security specialists. The testing was conducted based on a case study at a Seven Eleven store for the indoor video surveillance application and at a condominium gate for the outdoor video surveillance application. All the constructs were analyzed using a Likert scale questionnaire in terms of IVSM as a whole system and the individual components of IVSM. All the constructs were measured based on the Data Analysis Model (DAM). Generally, the findings revealed that IVSM is practically accepted as suitable in meetings the needs of the usability constructs of this study by security guards and specialists.

Acknowledgments

This work was supported by Ministry of Higher Education (MoHE) research grant LRGS/TD/2011/UKM/ICT/04/03.

References

[1] Javed, O. & Shah, M. (2002). "Tracking and Object Classification for Automated Surveillance," *Proceedings of the 7th European Conference on Computer Vision*, Part-IV, pp. 343-357.

[2] Cho, Y., Lim, S., & Yang, H. (2010). Collaborative occupancy reasoning in visual sensor network for scalable smart video surveillance. *IEEE Transactions on Consumer Electronics*, *56*(3), 1997–2003.

[3] Sekmen, A., Yao, F., & Malkani, M. (2008). Smart video surveillance for airborne platforms. *Robotica*, *27*(05), 749.

[4] Zhang, S., Chan, S. C., Qiu, R. D., Ng, K. T., Hung, Y. S., & Lu, W. (2012). ON THE DESIGN AND IMPLEMENTATION OF A HIGH DEFINITION MULTIVIEW INTELLIGENT VIDEO SURVEILLANCE SYSTEM Department of Electrical and Electronic Engineering , The University of Hong Kong School of Electronic and information Engineering , Tianjin University, 353–357.

[5] Stauffer, C. & Grimson, W. (1999). "Adaptive Background Mixture Models for Real-Time Tracking," *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, Vol. 2, pp. 246-252.

[6] Zhu, X., Deng, H., Chen, Z., & Yang, H. (2012). Design of Large-Scale Video Surveillance System Based on P2P Streaming. *2011 3rd International Workshop on Intelligent Systems and Applications*, 1–4.

[7] Liu, H., Tang, C., Wu, S., & Wang, H. (2011). Real-time video surveillance for large scenes. *2011 International Conference on Wireless Communications and Signal Processing (WCSP)*, 1–4.

[8] Lin, C.-F., Yuan, S.-M., Leu, M.-C., & Tsai, C.-T. (2012). A Framework for Scalable Cloud Video Recorder System in Surveillance Environment. 655–660. doi:10.1109/UIC-ATC.2012.72.

[9] Popoola, O. P. (2012). Video-Based Abnormal Human Behavior Recognition—A Review. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, *42*(6), 865–878.

[10] Castanon, G., Saligrama, V., Caron, A. L., & Jodoin, P.-M. (2012). Real-Time Activity Search of Surveillance Video. 2012 IEEE Ninth International Conference on Advanced Video and Signal-Based Surveillance, 246–251.

[11] Thornton, J., & Baran-Gale, J. (2011). Person attribute search for large-area video surveillance. *... Security (HST), 2011* , 55–61.

[12] Wu, D., Ci, S., Luo, H., Ye, Y., & Wang, H. (2011). Video surveillance over wireless sensor and actuator networks using active cameras. *Automatic Control, IEEE*, *56*(10), 2467–2472

[13] Subudhi, B. N., Nanda, P. K., & Ghosh, A. (2011). A Change Information Based Fast Algorithm for Video Object Detection and Tracking. *IEEE Transactions on Circuits and Systems for Video Technology*, *21*(7), 993–1004.

[14] Huang (2011). An Advanced Motion Detection Algorithm with Video Quality Analysis for Video, 21(1), 1–14.

[15] Kalaiselvan, C., & SivananthaRaja, a. (2012). Investigation on tracking system for real time video surveillance applications. *Proceedings of the CUBE International Information Technology Conference on - CUBE '12*, 108.