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Date : 22nd June 2016

DEVELOPMENT OF VISION-BASED ANOMALY DETECTION SYSTEM IN A DYNAMIC ENVIRONMENT USING BACKGROUND SUBTRACTION

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A report submitted in partial fulfilment of the requirements for the degree of Mechatronics Engineering

Faculty of Electrical Engineering

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JUNE 2016

STUDENT'S DECLERATION

I declare that this report entitle "Development of vision-based anomaly detection system in a dynamic environments using background subtraction" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature:

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ABSTRACT

Recently, surveillance systems have received a great interest from various users throughout the world. Some of these systems have started using background subtraction which is able to observe the activities in progress. So far, some of background subtraction based systems have been able to detect moving objects, however, the small view and the high rate of data still a technical challenge. The previous works done on this field by researchers still face some challenges which degrade the performance parameters; the precision, computing times, adaptability with multimodal backgrounds. Moreover, there are some challenges with applications and environment including the change in illumination, dynamic backgrounds or the blur caused by bad weather conditions and so on. The objective of this project is to evaluate and analyses the performance of Gaussian Mixture Model algorithms (GMM) for subtracting the foreground objects from the background in out-door scenes in different situations including all the challenges encountered in dynamic backgrounds, with bad weather conditions and the change in illumination. Then, the feasibility of GMM for surveillance systems is tested using some Datasets (image sequences and videos) which contain all the conditions and using a webcam. It will contribute to the development of vision based anomaly detection systems for monitoring and providing content-based images and videos recording of object's motion in a dynamic environment. The proposed method in this project is to use GMM which is suitable for multimodal backgrounds. The procedure to detect and then track the anomaly objects is done using C++ and OpenCV libraries as it contains various programming functions used for image processing. It does process sequences of images, videos and real-time videos streaming from a camera. The result shows that, GMM algorithms are able to detect and track anomaly objects in a dynamic environment. The feasibility of GMM for surveillance systems is proved. The precision of algorithms in most of the conditions tested was more than 90% and in the worst condition during snowy weather it wasn't less than 50%.

ABSTRAK

Kebelakangan ini, sistem-sistem pengawasan mendapat minat yang besar daripada pelbagai pengguna seluruh dunia. beberapa sistem-sistem ini telah mula menggunakan penolakan latar belakang yang adalah mampu untuk memantau gerakan dalam masa nyata. Setakat ini, beberapa system-sistem penolakan latar belakang berdasarkan telah dapat mengesan objek yang bergerak, Walau bagaimanapun, paparan kecil dan tinggi kadar data masih cabaran teknikal. kajian yang telah dijalankan sebelum ini oleh penyelidik- penyelidik di bidang ini masih menghadapi beberapa cabaran yang merendahkan prestasi parameter; ketepatan, Pengkomputeran masa, kadar keupayaan menyesuaikan diri dengan latar-belakang multimodal. Selain itu, Terdapat beberapa cabaran dengan aplikasi-aplikasi dan persekitaran termasuk perubahan dalam pencahayaan, latar-belakang yang dinamik atau blur disebabkan oleh keadaan cuaca yang buruk dan sebagainya. Objektif projek ini adalah untuk menilai dan menganalisis prestasi Gaussian algoritma Campuran Model untuk segmen objek latar depan dari latar belakang dalam adegan di luar dalam situasi yang berlainan termasuk semua cabaran yang dihadapi dalam latar belakang dinamik, dengan keadaan cuaca yang buruk dan perubahan dalam pencahayaan. Kemudian, kebolehlaksanaan GMM untuk system-sistem pengawasan adalah diuji menggunakan beberapa Dataset (urutan imej dan video) yang mengandungi semua syarat-syarat dan menggunakan web-cam juga. Ia akan menyumbang kepada pembangunan sistem pengesanan anomali penglihatan berasaskan untuk pemantauan dan menyediakan berasaskan kandungan imej dan video daripada gerakan objek dalam persekitaran yang dinamik. Kaedah yang dicadangkan dalam projek ini adalah dengan menggunakan Campuran Model Gaussian (GMM) yang sesuai untuk latar belakang multimodal. Prosedur untuk segmen, mengesan dan mengesan objek anomali dilakukan dengan menggunakan C ++ dan OpenCV libraries kerana mengandungi pelbagai fungsi digunakan untuk pemprosesan imej. ia urutan imej proses, video dan video masa sebenar streaming dari kamera. Hasilnya menunjukkan bahawa, GMM algoritma dapat mengesan dan menjejaki anomali objek dalam persekitaran yang dinamik.

kebolehlaksanaan daripada GMM untuk sistem pengawasan adalah dibuktikan. Ketepatan algoritma dalam kebanyakan keadaan diuji adalah lebih daripada 90% dan dalam keadaan yang paling teruk semasa cuaca bersalji ia adalah tidak kurang daripada 50%.

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LIST OF SYMBOLS

N	-	Number of Gaussians.
W_i	-	The weight of Gaussian.
μ	-	The mean.
Σ	-	The covariance matrix.
TP	-	True positive.
TN	-	True negative.
FP	-	False positive.
FN	-	False negative.
Si(j)	-	The jth pixel of image i.
m	-	Size.
S	-	Sequence.
n	-	Length.
Lux	-	Unit of illuminance (one lumen per square meter)
PSNR	-	Peak signal to noise ratio

LIST OF TERMINOLOGY

BGSLibrary	-	An open source library that contains a list of background subtraction algorithms.
BCM	-	A dataset that provide sequences of images and videos which are used by all researchers to test their algorithms.
Ground truth image	-	A binary mask of the original image.
Frames	-	A single capture of a video, simply, it is an image.
Learning sequence	-	The full sequence of a video being framed.
Evaluation sequence	-	Several frames selected from the full sequence.
Real videos	-	Short videos contains various weather conditions.
F-measure	-	The harmonic mean between the precision and recall values.
PSNR	-	Peak signal to noise ratio.
Fps	-	Frame per a second
KBpf	-	Kilo byte per a frame

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CHAPTER 1

INTRODUCTION

Recently, surveillance systems have received a great interest from various users throughout the world. These systems started using traditional framing cameras then using video cameras which are able to observe the activities in progress. Some of these systems so far have been able to track the ongoing activity, however the small view and the high rate of data still technical challenges. Vision based anomaly detection system is a system that monitors and provides content-based images and videos recording of objects' motion in a dynamic environment. This report is organized to present the steps that have been undergone in order to complete the project. Benchmarking with the previous projects done by other researchers [1]–[5] were reviewed. This was ended with a hypothesis which is shown in the methodology section and the results are discussed and presented in the results section.

This report is written to present the documentation of a final year project for Bachelor degree of mechatronics engineering course. This report shows the steps that have been conducted to accomplish the project objectives since the beginning. The report is organized in five chapters, chapter 1 shows the introduction including the motivation, problem statement, objectives and the scope of the project. Chapter 2 presents the background and literature review on the previous works in this field ended with a clarification on the best method. Followed by the methodology, results and conclusion in chapter 3, 4 and 5 respectively.

1.1 Project Motivation

Since the existence of people on this planet they try to invent any possible techniques to secure their lives and make it better and comfortable or to solve any problem that disturbs their normal lives. Nowadays, vast variety of applications implement vision based surveillance systems in different ways, however, there still a need for more convenient system which can be used for anomaly objects detection in dynamic environments. The demands to this vision based monitoring system may varies from an application to another, however, it still brings a general common advantage. These applications include security, industrial automation, traffic management, military usages, entertainment parks and medical diagnosis. Therefore, in my opinion this project is one of the best projects among all the other areas of experts in engineering. Besides that, it will form the first step towards a comprehensive understanding of the vision-based systems also will establish a solid foundation for further studies in this field in the future.

The impact of surveillance systems in term of public safety, according to [6] the analysis found that these systems were more effective in parking lots where their use resulted in 51% decrease in crimes,7% decrease in city centers and in public housing communities, and a 23% drop in public transit systems. The same trend is observed in the other fields of applications, however, these levels of achievements are not yet satisfying. Therefore, this project is motivated by that fact and it is a consideration and reflection from the projects and researches that have been done on vision based systems.

The development of vision based applications is growing then this lead to a need for sophisticated techniques that can be used for segmentation, object detection, object tracking, object classification and so on. According to SDM [52] which is the number one security channel media, the responds of surveillance systems' users and dealers when asked to predict the potential market of surveillance system in the future, then their responses were as shown in Figure 1.1. Since then, some methods have been proposed for the development of vision based systems.

There are many surveillance systems that are currently used with affordable prices, however there still a need for a complete system with higher sensitivity and precision. In this project background subtraction method is used which is able to localize, classify, detect and track

moving objects. The object is tracked and based on that a suitable reaction is to be made according to the application being implemented. This system is able to detect moving objects in certain scenes using background subtraction technique at witch many filters and functions can be used based on the field of usage. Moreover, the reaction of this system also will vary in multiple forms based on the user setting, therefore this will bring a valuable assistance for human to monitor wider areas with less efforts.

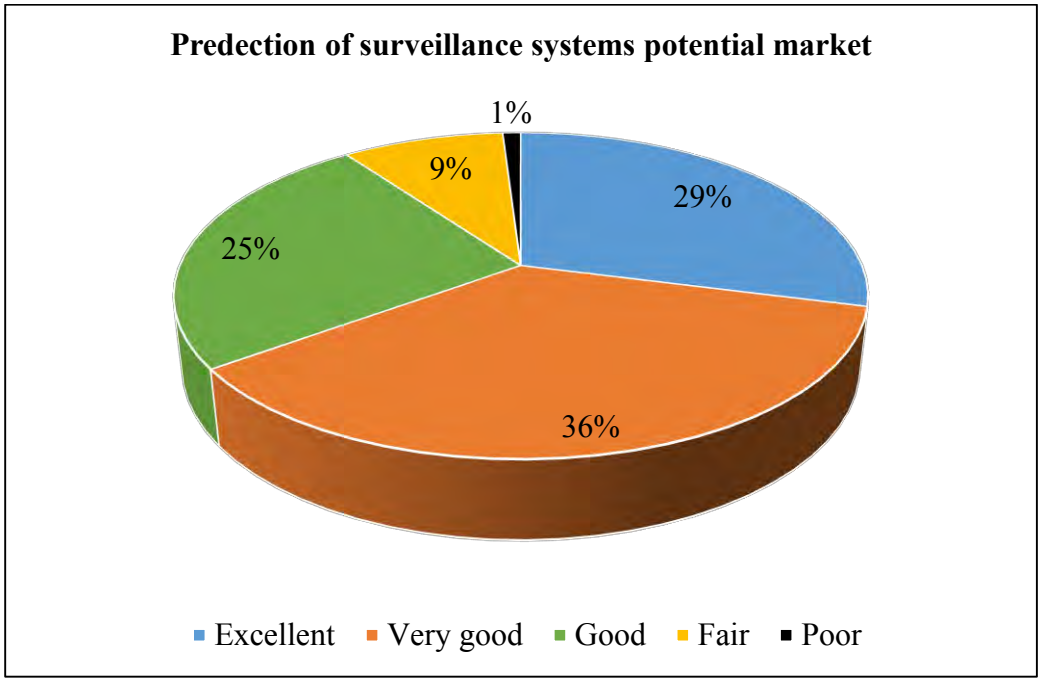

Figure 4.1: Percentage of respondents to SDM's 2006 forecast [52].

As mentioned earlier, the development of this system would bring direct advantage to the aerial surveillance applications and security applications. In addition, the success achieved in this project will have a positive impact on the overall vision based system that may use background subtraction for object recognition and classification.

1.2 Problem statement

The security is necessary matter for our lives in all aspects because without achieving the safety and security; the development cannot be achieved. Therefore, researchers and institutes gave an attention to this issue and have started to develop new techniques that can reduce dangers and can monitor wider areas. There are many surveillance systems that are currently built with affordable prices, however there still a need for a complete system with higher sensitivity and precision and faster processing times with less complexity and less memory occupancy as well as to be able to detect, recognize and then track moving objects at real time.

In such scenarios there are some challenges and specifications that form constraints against the development in certain applications. The surveillance system should be able to cope with different types of challenges including the variation in illumination, the blur caused by bad weather conditions, presence of shadow and the multimodal scenes. This project is a reflection to what have been done in this field which consider all the aspects and components required to resolve the problem with affordable costs.

To what extent the background subtraction using Gaussian Mixture Model can achieve the desired performance in a dynamic environment?

It is hypothesized that GMM algorithms are able to segment the foreground objects from background scenes and able to detect abnormal objects in dynamic environments which qualify it to be implemented for aerial surveillance systems and other similar systems.

1.3 Objectives

1) To evaluate and analyze the performance of Gaussian Mixture Model algorithms for subtracting the foreground objects from the background in out-door scenes in different situations and then tracking it: with variation in illumination, blur and noisy scenes .
2) Test the feasibility of Gaussian Mixture Model algorithms for surveillance applications.

1.4 Scope

The focus of this project is on detecting and tracking anomaly objects moving in a dynamic scene. The method used is background subtraction which mainly subtract the foreground body from the background scene. This is done using C++ language which is usually linked with Open Computer Vision library (OpenCV) as it contains various programming functions that are used for image processing. In this project Gaussian Mixture Model (GMM) also known as Mixture of Gaussian algorithm (MOG) is used. GMM was chosen here to be used after conducting a comprehensive comparison between the algorithms that suit the parameters of this application. The final three algorithms were run on visual studio software which were fed by image sequences, videos and videos streaming from a camera. These images and videos have all the challenging conditions which simulate the real surveillance systems.

The study doesn't investigate practically the hardware structure of the final system as the purpose is to simulate the system using software only which is sufficient to prove the feasibility of GMM for anomaly detection systems. In terms of the algorithm's limitations, although GMM has many advantages it has drowbacks such as the fact that is not easy to accurately model backgrounds with high frequency alteration using few Gaussian components. Furthermore, for computational reasons it is suggested that using constant number of Gaussian components for every pixel is not necessary as many pixels need only one Gaussian distribution because they are unimodal. Moreover, for high accuracy processing GMM is slower compared to one Gaussian scheme [7].

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Vision based anomaly detection system is a vision system that monitor and provide content-based images and videos recording from objects motion in a dynamic environment. Anomaly detection is a significant issue that has a profound effect on success of various applications; therefore it has been discussed for years in multiple fields. Anomaly detection is widely known issue and has been covered in many fields including discrete sequence data [8], and temporal data [9]. However, anomaly detection in dynamic environment is barely touched in [8], [10].

There are many methods used in computer vision system for detecting moving objects. Background Subtraction method is a famous method that has been used since 1990s for video surveillance systems. This technique is designed to separate the foreground objects from the background of the scene. It is processed in two steps:(1)Background initialization at which the background model is built, (2) Foreground detection, in this step the foreground is compared with the background model and during this step the image is analyzed and then the background is updated(background maintenance) [11]. In this stage of process, background subtraction is done to figure out the new bodies. Figure 2.1 illustrates the overall process of the system.

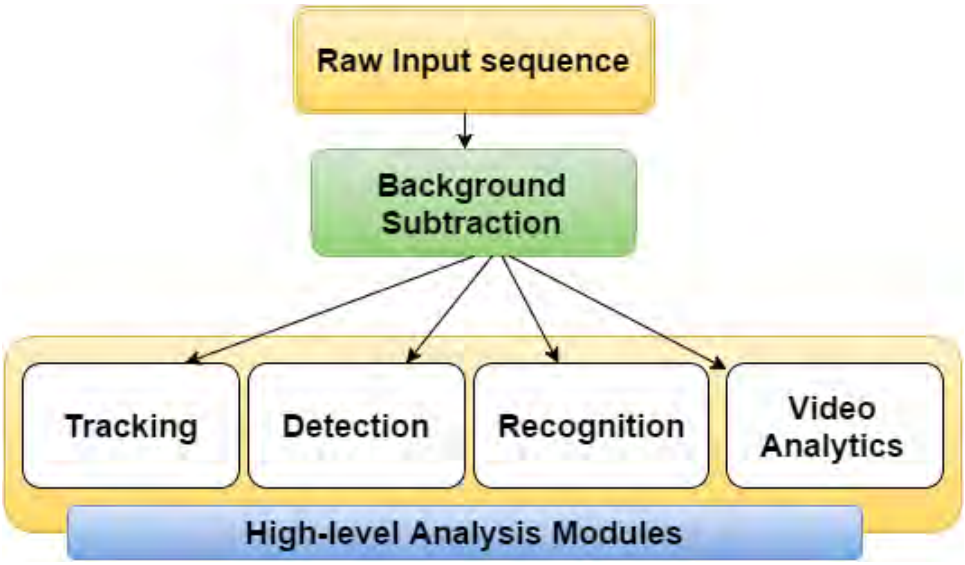

Figure 2.1: The work-flow of video surveillance system, indicate the position of BS in the process

As shown in Figure 2.1 the process starts by the operation on the raw video received from the camera or storage device then separating the background part from the foreground part, the foreground part is the unexpected moving body. This is followed by high-level modules at which the video contents will pass through several techniques. For example, in the tracking module the concentration will be on the anomaly objects which means that the algorithm will send back instructions to the camera which may be driven by a motor to let it follow the motion of that object. In the detection module, in the same manner the task it focused on the foreground objects; locations and motion. Next is recognizing the shape of the anomaly object and eventually the video analytics are conducted thus the system react and response based on the instructions set by the user.

2.1.1 Fundamentals of image processing

Image processing has been applied in many applications since 1920s. Generally, digital image processing (DIP) concentrates on enhancing the pictorial data for human perception and processing the image data for various purposes such as transmission, storage and representation