# FOREGROUND AND BACKGROUND DETECTION OF THERMAL IMAGE FOR H1N1 SCREENING

**NUR SYAZREEN BINTI ARDNAN**

**This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Hons.) (Electronics)**

**Faculty of Electrical & Electronics Engineering**

**Universiti Malaysia Pahang**

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# ABSTRACT

The thermal imaging cameras used in airports are specifically designed to detect anyone with a higher than normal body temperature in a subtle and non invasive way. The cameras are able to gather information on an individual's body temperature in a matter of seconds allowing airport officials to vastly narrow down possible carriers of the diseases and help avoid a flu pandemic. The cameras produce infrared images of peoples and detects if the temperature falls within a certain acceptable range. The dissertation objective is to design software to automatically detect the people in the image. Using image pre-processing technique which background-subtraction to remove the background of the image and by using image processing technique such as thresholding and morphology, to detect the foreground of the image which are the peoples, filling, lining and some more techniques, FGdetection.m is the execution file in MATLAB that takes the input image and output the image with detected peoples.

## ABSTRAK

Kamera pengimejan terma yang digunakan di lapangan terbang yang direka khas untuk mengesan sesiapa yang mempunyai suhu badan yang tinggi daripada suhu normal menggunakan cara yang halus dan bukan invasive. Kamera tersebut mampu mengumpul maklumat mengenai suhu badan seseorang individu dari jarak yang jauh untuk mengelakkan merebaknya wabak tersebut. Kamera menghasilkan imej infra merah dan mengesan sekiranya suhu jatuh dalam julat tertentu. Objektif projek adalah untuk mereka bentuk perisian secara automatic untuk mengesan orang dalam imej. Dengan menggunakan teknik imej pra-pemprosesan penolakan latar belakang untuk menghilangkan latar belakang imej dan dengan menggunakan teknik pemprosesan imej seperti pengambangan dan morfologi untuk mengesan latar hadapan imej. Fail FGdetection.m adalah fail pelaksanaan didalam Matlab yang mengambil imej asal dan menghasilkan imej dengan orang yang telah dikesan sebagai keputusan akhir.

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| | |
|---|---|
| H1N1 | 'Influenza' A (H1N1) Virus Is A Subtype Of Influenza A Virus |
| T | Threshold |
| $P_F$ | Background Sample Contaminate |
| ROI | Regions-Of-Interest |
| CSM | Contour Saliency Map |
| FP | False Positives |
| SDG | Spatial Distribution of Gaussians |
| SCD | Shape Context Descriptor |
| JPEG | Joint Photographic Experts Group (Image Format) |
| AVI | Audio Video Interleave (Video Format) |
| BGS | Background Subtraction |
| BMW | Morphological Binary Image |
| BWsdil | Dilated Image |
| FG | Foreground |
| BG | Background |
| R | Reflection |
| H | Human |

# CHAPTER 1

# INTRODUCTION

This chapter explains the overview of project background, the problem of the project, the objectives of the project and project scope.

## 1.1 Project Background

Enter the age of faster computer, computer vision systems have been developed and widely used in many applications. One of the most usual applications is in automated video monitoring system, for example the systems that aiming at object tracking, event detection and scene interpretation. The detection and tracking of moving objects is actually a lower level vision task to achieve higher level event understanding. It is a critical task because we need to provide a classification of the pixels into foreground and background. This is what the project is about.

Regarding the matter of H1N1 influenza virus that has been spread throughout the world, technology has come up with the video monitoring screening that use to detect people with the flue. The screening will be held at airport where people coming into the country will be scan using thermal imaging cameras to check whether they are free from the virus or not. The purposed of using thermal images because thermal image can be captured by sensing the radiation emitted/reflected from objects under different environmental conditions, both day and night. As long as the thermal property of a foreground object is slightly different from their surroundings, this object will appear at a contrast from the environment. Thus, thermal images can provide useful information which is not available in visual images, in particular for surveillance and monitoring propose.

The thermal cameras are able to gather information on an individual's body temperature in a matter of seconds allowing airport officials to greatly narrow down possible carriers of the diseases and help avoid a flu pandemic. The cameras produce infrared images of people's faces and detects if the temperature falls within a certain acceptable range. The cameras are easy to use by non specialist and airport security can train to use the thermal imaging camera within a few hours.

In any such systems that involve automated monitoring, the primary and basic step that needs to do is to make apart the foreground and background pixels from the image. "*Segmenting foreground objects from a video sequence is a fundamental and critical step in video surveillance, traffic monitoring, video conferencing and many other applications"* [2]. This first step is very important to the system because it will ease the next process to be done. As the data for this project is taken from the H1N1 screening at Kuala Lumpur International Airport (KLIA), that make the foreground for the image is the people that passing through the thermal camera at the screening area. While for the background is the rest in the image except for the people.

## 1.2 Problem Statement

In any automated monitoring system, it is important to separate the foreground and the background of the image in order to get the specific output. It is a primary step in any event detection. But there is some constraint that will affect the system. Some of them are the illuminations changes like the clouds moving in the sky; probably behind the window if the camera is indoor. Besides, motions change like swaying of the door and secondary illumination effects that cause by the shadow of the foreground objects (people) are also part of the problem. In addition, how the thermal image reacts in uncontrolled environment like lighting changing is also effect the efficiency of the system.

Besides, the main difficulty with trying to separate an image from its background is that there are pixels which cover an area of the picture which is partly foreground and partly background. This is because the heat from the people will affect the surrounding of the people and the ‘Halo’ is exists. In this project, we will detect the Halo; person surrounding that affected by the heat from person.

In some cases, the implemented method does not work well if the background has similar color as the foreground (the foreground cannot be identified by the color model) and there is little motion in the foreground (a pixel could be considered to be foreground even if there is little/no motion presented, according to the trained motion model).

## 1.3 Objectives

The objectives of this project is to :

i. To develop a program that can separate between foreground and background of the thermal image in MATLAB.

ii. To remove the complexity of the thermal image hence the suspected person with the influenza virus will be easily detected.

## 1.4 Scope of the Project

This project is about to detect and separate the foreground and the background of the thermal image that taken from the H1N1 screening at KLIA. For this project, the foreground is only the people that are passing through the thermal camera that use for the screening. Hence, it will only detect the contour for the people; not to detect any feature on that person, while the background of the image is totally remove. With that, the image is now more simple and easy to process. After getting the pixels image separation, the foreground and the background is then will be separate regarding their temperature value. The data used are thermal images that have a static background since the project will be executed in video sequence.

## 1.5 Thesis Outline

The Foreground and Background Detection of Thermal Image for H1N1 Screening final thesis is a combination of 5 chapters that contains and elaborates specific topics such as the introduction, literature review, methodology, result and discussion, and conclusion and future work. The detailed discussion about the thesis outline on each chapter is as below:

Chapter 1: Introduction of the project. The explanation for the project will be given in a general term. The objectives of the project will be elaborated. It is followed by the explanation in the scope of project.

Chapter 2: Literature review for this project will be elaborated in this chapter. Explanation will be focused on object detection and tracking technique related past researched and based on theory and conceptual ideas. It is focusing on image processing research which is associate to this project.

Chapter 3: Methodology of the project. This chapter discusses the full methodology of the overall project.

Chapter 4: Results and Discussion. This chapter explains the results regarding the performance of the system. Discussion also included affirming the results.

Chapter 5: Conclusion and Future Work. Conclusion of the project and some future recommendation for further development of this project are being discussed in this chapter.

# CHAPTER 2

# LITERATURE REVIEW

This chapter reviews similar works done by others and how the works related to the project. Some of the methods used could help this project.

## 2.1 Foreground and Background Detection

Foreground background detection plays a very important role in a video content analysis system. It is a foundation for various post-processing modules such as object tracking, recognition, and counting. Many approaches are proposed on this topic based on the background module and procedure used to maintain the model. In the past, the computational power of the processor limited the complexity of foreground background detection implementation. This lead to a dilemma, some complicated implementations were too slow to catch up with real-time requirements; the other basic implementations required a very controlled environment.

Recently, faster computers allow researchers to design a complicated foreground background detection algorithm and meet real-time requirements. Real-world foreground background detection should be robust and adaptive to different light conditions in a noisy environment. There are two types of foreground background detection methods: non-adaptive and adaptive. Non-adaptive methods depend on certain numbers of video frames and do not maintain a background model in the algorithm. Adaptive methods usually maintain a background model and the parameters of the background model evolve over time like used in [2].

### 2.1.2 Background Subtraction

From Yi-Wang [6] study, she used this traditional method as the first implementation to separate the foreground form the background. This method is used to compare frame-background with a pre-defined threshold, Th. If the difference of a pixel is larger than Th, then it is classified as foreground, or else, it is claimed as its background. The assumption behind this algorithm is that the foreground is constantly moving while the background remains static.

As implied in the results, this implementation of the algorithm does not work very well and is sensitive to the threshold. One of the reasons is that in such a short sequence, the flies(foreground) do not move very much, so the averaging procedure is unable to get a clean background. Besides, the threshold is not very well tuned. However, better performance could be achieved by better estimation of the background and smoothing the frames before subtraction (takes longer time).

The background subtraction method is also used in J.Mike's [2] study. This method is used as a hypothesis test. It involves two distinct processes that work in a closed loop which background modeling and foreground detection. As for the background modeling, they created a model of the background in the field of view of the camera and it is periodically updated; for example to account the illumination changes. While for the foreground detection, decision is used to make sure the model is suitable with the background. The resulting change label field is fed back into background modeling so that no foreground intensities contaminate the background model. In this paper [2], they also adapted the selection of a detection threshold to varying video statistic by means two statistical models.

While, James and Vinay [4] mentions that standard background-subtraction techniques alone are rendered ineffective due to the thermal halos and polarity changes. Hence, they propose a new robust background-subtraction algorithm that can be used to detect people in thermal imagery regardless of the image polarity and thermal halo. The approach is designed to handle problems related to halo artifacts and uncalibrated polarity switches that are typically associated with common ferroelectric (chopper) sensors. These problems render classic background-subtraction and hot-spot detection methods ineffective by themselves. Their approach first uses a standard background-subtraction technique to identify local regions-of-interest. The foreground and background gradient information within each region are then combined as to highlight only the person boundary. This boundary is then thinned and thresholded to form contour fragments.

Ying-REN [5] paper proposes a Spatial Distribution of Gaussians (SDG) model which is based on the theory of optimal decision. It extends the application of the background subtraction to the moving sensor and is robust even with less accurate motion compensation, noise, or environmental changes. The detection based on SDG model can keep the shape of the detected object perfectly, and show good results even when the detection is applied to small moving objects in a highly textured background. The algorithm is a pixel-wise case; no iterative computations are required. As such, it is suitable for parallel implementations for real-time consideration.

### 2.1.3 Background Modeling

Background modeling, also referred to as background maintenance, is at the heart of any background removal algorithm [7]. This method has been used by Cong Zhao [8] by proposed a learning-based method for background subtraction. To build a correct background model when training samples are not foreground-free, they propose a novel robust dictionary learning algorithm.

Louis and Donald [1] used a quantization technique to generate a compressed form of background model. The background model maintenance is achieved by updating red, green and blue values of the matched codeword via a weighted average. By substituting a smaller learning rate will bring a faster codeword adaption, thus leading to a lower rate of false detection when quick illumination changes occur.

In Jian Zhou study [11], there are three different backgrounds modeling processes in the system, two of which are performed individually in each camera view. Due to the significant temperature difference between the environment and human body, the detection of human in thermal image is relatively easy. Therefore, a static Gaussian model is used to model each pixel in the background. By collecting a fixed amount of background frames, the mean and variance ($\mu$, $\sigma$2) are calculated to model each background pixel. By applying this model to an incoming image, a probability map can be generated for foreground detection.

### 2.1.4 Foreground Modeling

In J.Mike's [2] foreground modeling, they proposed foreground model based on small spatial neighbourhood, like in the same frame. $P_F$ is assumed uniform, thus preventing any decision bias by moving objects. They set the object specific as the first model while the second model is slow object motion as otherwise, background sample contaminate $P_{F.}$ They also have demonstrated that ergodicity in time also holds spatially which are local-in-time and local-in-space and both are the models that produce equivalent background characteristic.

### 2.1.5 Foreground Detection

Foreground detection compares the input video frame with the background model, and identifies candidate foreground pixels from the output frame. To obtain this classification, the map is usually binarized by thresholding. The correct value of the threshold depends on the scene, on the camera noise, and on the illumination conditions. The study [7] discussed how to generate the different map given the background model and the current frame, and then they discussed the thresholding technique to obtain foreground background classification.

By using both the background modeling step and foreground detection step, we can find the algorithm successfully detects foreground pixels and builds a correct dictionary as long as the outliers are not dominant. It seems that foreground pixels can be segmented even if it covers almost the whole frame [8].

## 2.2 Thermal Imagery

Thermal image can be captured by sensing the radiation emitted from objects under different environment conditions, both day and night. As long as the thermal property of a foreground object is slightly different from their surroundings, this object will appear at a contrast from the environment. Thus, thermal image can provide useful information which is not available in visual image, in particular of surveillance and monitoring proposes.

### 2.2.1 Thermal Image in Uncontrolled Environment

Louis and Donald [1] mention that foreground and background segmentation will be challenging when the automated video monitoring take place in uncontrolled environments. Specific environmental condition will not bear an equivalent impact on thermal and visible imaging because the properties of radiation propagation in the atmosphere vary greatly with wavelength range. For the luminosity and temperature changes, since the sunlight warms up the exposed surface, long-term illumination changes also affect thermal images. Moreover, dark surfaces with low reflective properties, as asphalt, will be more strongly affected by sun’s rays than brighter objects. It is why a scene observed at 4PM and 4AM appears so differently.

In the first case, asphalt and other inanimate objects have been heated all day long and appear warmer than people. As for atmospheric conditions, the first factor that has significant impact on contrast of thermal images is the wind, which accelerates warm objects cool down. Hence, the background will tend to have a more uniform temperature and less contrast during strong wind days.

### 2.2.2 Halo Detection

Even though thermal imaging have many advantages, these beyond-visible-spectrum imaging modalities have their own challenges such as saturation or halo effect that appears around very hot and very cold objects [9]. But because of this specialty, most of previous strategies for detection in thermal imagery use “hot-spot” algorithms, relying on the assumption that the person (object) is much hotter than the surrounding environments [10].

A standard Gaussian background subtraction approach is use to find the regions-of-interest (ROI) that contain the people and the surrounding halo. The approach is use to identify the pixels in the foreground image that are statistically different from the background model using the equation (1) in [10].

James and Vinay [4] study is then continue by examine each region-of-interest individually to separate the person (or people) from the surrounding halo. From the earlier observations regarding thermal halos, the gradient strengths within the ROI can be used to identify much of the person boundary. For each ROI, we form a contour saliency map (CSM), where the value of each pixel in the CSM represents the confidence/belief of that pixel belonging to the boundary of the person.

### 2.2.3 Improved Human Detection in Thermal Images

The James and Mark [3] study is using a two-stage template approach to detect person in thermal imagery that combines a special background subtraction method with AdaBoosted template classification technique. The first stage is begin with fast screening procedure to hypothesize only the location of the people in the image. To enhance the detection rate, a thermal-based background subtraction technique is employed in the screening process. Any window location that passes this first stage is examined in the next stage by AdaBoosted ensemble classifier using a set of filter.

The method is cast into a multi-resolution framework to detect people of different sizes and distances to the cameras. As the person pixels in thermal imagery can vary considerably, a simple appearance template of the pixel gray levels will not suffice. They instead use more invariant edge/gradient information and adopt preprocessing approach to suppress the background gradient information while highlighting only the foreground object (person) edges. In the end, the two-stage method was able to detect every person with no false positives (FP).

While in Weihong study [12], their method is based on the Shape Context Descriptor (SCD) with the Adaboost cascade classifier framework. Experiment show that shape context features with boosting classification provide a significant improvement in human detection in thermal images.

The various method used in previous research will be probably help this project in future. Even though the background subtraction is a common and traditional method to segment the background, it is still use time to time by upgrading it. The previous ‘hot-spot’ strategies in [10] relying on the assumption that object/human will emit much stronger thermal signal than environment, is not always correct in many practical situation. For example, the temperature of object/human surrounding may be higher in summer daytime.

# CHAPTER 3

# METHODOLOGY

This section is about project flow and methodology uses. Figure 3.1 shows the general flowchart of the steps taken towards the detection of the people in the image. The project begins with image acquisition followed by pre-processing step. Then it continues with processing step and finally the output is gain.

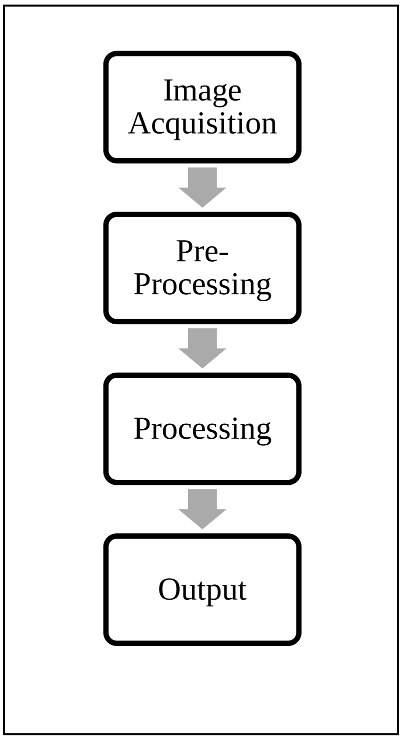


Figure 3.1: The methodology of general flow chart.

## 3.1 Image Acquisition

As the first step, data were acquired at KLIA screening area by using Thermal Camera FLIR.The data is taken from three different angles. There are two types of data available; the images that are in JPEG image compression standard and temperature data that are in MAT file. Both data are frames that are extracted from videos that are in AVI format. Though there are more than one data available, but throughout this project, only images data are processed. The images are in true color which in temperature mapped. As we can see in figure 3.3, the color for high temperature area is green. Only images data are processed because the ultimate goal for the study is to detect the foreground of the images which are the peoples. Hence the temperature details are not crucial. This case study uses an offline database method where all images are grouped into one.

For the images, there are two types of image that need to be classified. The first one is background image and the second is foreground image. The background image is taken at the screening area while no one is passing through. As for the foreground image, it is taken when the area is packed with people after a flight is arrived. From three different angles, there are 543 background images and 1810 foreground images. Figure 3.2 a) , b) and c) are samples of background images while figure 3.3 a) , b) and c) are samples of foreground images from different angles.

(a) Angle 1

(b) Angle 2

(c) Angle 3

Figure 3.2: Samples of background images from three angles.

(a) Image with foreground at angle 1

(b) Image with foreground at angle 2

(c) Image with foreground at angle 3

Figure 3.3: Samples of foreground images from three angles.