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FACE DETECTIC ... :D ON COLOR

IMAGE PROCESSING

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ABSTRACT

This thesis examines and implements the methods for face detection of thermal images based on color image processing. The overall work describes on how thermal images can enhance the performance of thermal scanner used in the International Airport. In order to examine all aspects of the face detection with a suspicion of fever, the task has been divided into two consecutive steps: Firstly, Color detection for identifying hot temperature regions on skins and secondly, face detection with no identification. Using a thermal image model for the color region, the possible regions in which faces can be narrow down and could be found rationally. Furthermore, trying to do identification on a region that does not include a face is inefficient. Therefore, using a faster and less complex algorithm to do the general face detection is a faster way to identify faces. In this project, color threshold and mapping method are used in order to detect faces. . In particular to come up with methods that will help increase the chances of correct matches, I propose to apply method focusing on color detection that will detect the higher temperature on human's face using image processing. It focuses on thermal image based method which implemented with MATLAB software. Consequently, in order to successfully be able to identify individuals correctly, advance image processing techniques will be used to enhance the detection rate and efficiency by developing graphical user interface (GUI) in MATLAB to achieve better recognition rate. Finally, all the different steps are merged into an integrated system for full face detection. The system is evaluated based on accuracy and performance.

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LIST OF ABBREVIATION

GUI	-	Graphic User Interface
ROI	-	Region of Interest
SARS	-	Severe Acute Respiratory Syndrome
IR	-	Infra Red
COM	-	Computer
ATC	-	Automatic Temperature Compensator
RGB	-	Red, Green and Blue primaries

CHAPTER I

INTRODUCTION

1.1 Background

Face detection is a necessary first step in face recognition system with the purpose of localizing and extracting the face region. Apart from increasing the efficiency of face recognition systems, face detection technique also opens up door of opportunity for application areas such as content-based image retrieval, video encoding, video conferencing, crowd surveillance and intelligent human computer interfaces [14].

Face detection techniques can be classified to two schools of philosophy which the first is image based techniques and the second one is feature based techniques. Image based techniques address face detection as a general recognition problem whereby pattern recognition is applied to the whole image which has undergone certain transformation. The face knowledge is therefore implicit to the users and mapping and training schemes are utilized to achieve what is known as recognition. Feature based technique on the other hand has an explicit knowledge on the face detection problem whereby features representing face as defined by the designer are first extracted from images. Face detection are thus achieved by verifying to a certain degree of confidence that features extracted from images represent face.

Color analysis on images has long been used as a technique which can give additional dimension to image compared to grey scale image. Classification is easier to handle in color space compared to gray scale. It is a known fact that color tend to cluster in close proximity in normalized color space or chromaticity space. This has also brought about the possibility of modeling skin color in terms of thermal image. Skin based on thermal image color has been used for detecting the skin region with its unique tool of temperature range will help in defining people with fever. Using this color differentiator, region of interest is identified based on certain threshold value..

The growth of international travel and economic migration require a consistent, prompt, effective and global disease prevention policy. Elevated human body temperature, or fever, is often a reliable indicator of many serious infections. Since the recent outbreak of serious flu strains such as H1N1, and the spread of severe acute respiratory syndrome (SARS), public health authorities have been looking for a fast, easy, contactless (non-invasive), and reliable method to detect elevated human body temperature. When used properly, infrared screening is such a method: a vital tool in the detection of elevated body temperatures in high-risk groups such as travelers. It is being used by health authorities around the world to screen passengers entering a country via mass transportation, and has proven itself as an effective monitoring method.

FLIR cameras automatically detect elevated skin temperatures that may indicate a fever and underlying infection. Each camera's unique Automatic Temperature Compensator (ATC) adjusts for ambient conditions to minimize false readings. The color image, temperature scale, and alarm mechanism make it easy to decide when a person needs further examination.

The built-in functions of FLIR cameras include color images and temperature scales, and sound alarms that can be set to go off when a certain temperature threshold is exceeded. These functions make it easy for an operator to instantly decide whether the subject needs to be referred for medical examination. Since the cameras produces images in real time the total evaluation process takes less than a second. This makes infrared technology very useful for rapidly screening large groups of people. Below are the steps taken then which take place as individual screening but here is the basic idea of how thermal images can help increase the efficiency and quality of the system in the airport.

Step 1: Individuals are remotely monitored as they pass a screening check points set up at an airport, border, or in the entrance lobby to a corporation or school.

Step 2: FLIR camera operator looks at a color monitor that shows audible and/or visible color alarms when an individual shows an "out of norm" body temperature.

Step 3: Persons with an elevated body temperature are sent to a separate line for further screening by a healthcare professional or designate.

It is therefore believed that using a built-in color temperature scale enables an immediate decision on whether or not the subject requires further examination using face detection method. All areas within the camera's field of view that are hotter than a predefined temperature can be easily and immediately recognized on the image display. The color of interest within the image will be able conserve computing the image data

1.2 Objectives and Scope of Research

The objectives of this project are:

1. To inspect flu by detection of temperature and color on face using thermal imaging
2. Ability to recognize faces of freely moving people with high accuracy
3. Implementation of face detection system using image processing method

Attention has focused on the use of thermal imaging in detecting individuals with fever as one of a symptom of H1N1. To make thermal imaging easier for humans to interpret, thermal cameras often use false color in their displays, different color indicate different kind of temperatures ranging. . It makes sense that a thermal image is the best method for detection where in this project, to detect face with high temperature on specific spot on face such as forehead as necessary. The main goal and the key objective of this project is to inspect flu by detection of temperature and color on forehead in thermal imaging and the ability to recognize faces of freely moving people automatically of a person whose carries along the flu. Based on the past thermal imagery research, color detection is used in facial component detection where different kind of colors are used to differentiate whether it is mouth, eyes, nose, ears, forehead, chin and cheek. The classification of these will be considered as the main target in order to detect the mass forehead of a passengers arrived at the airport.

The color code differentiates the target component and in this case, the higher temperature on forehead will be the target component. This project presents the implementation of face detection system using image processing method. It describes on how thermal images can enhance the performance of thermal scanner used in the international airport. The reasons come from the need of automatic recognitions as the simplest way to identify the individual figure of face with the viruses. By doing so, the first and foremost part of the project is forehead detection where it must be capture in order to detect a person having a fever or not. Then and only the automation of face can be proceed using different kind of method referred to the previous researched in thermal imaging.

1.3 Project Scopes

The scope of this project is to detect flu as a first symptom of swine flu (H1N1) virus. Furthermore, the data used in this project was taken back at Kuala Lumpur International Airport. That is why the data collection for image processing is valid only for KLIA purposes only. It includes the temperature value at that time and the temperature set for the thermal image camera in snapping the data's.

1.4 Problem Statements

For the problem statements, currently, in the airport setting, mass vision thermal scanning of arriving travellers are used and person with symptoms are manually identified. This project presents the implementation of face detection system using image processing method. It describes on how thermal images can enhance the performance of thermal scanner used in the international airport effectively. Previously, there are two kind of devices been used to prevent the spread of the flu. Health officers at the airport are manually using artery scan health scanner and Braun thermo scan. Currently, in the airport setting, mass vision thermal scanning of arriving travelers has been used to screen for several different infectious disease to detect the virus of H1N1. It enables mass screening of passengers. The temperatures of every single person are checked on the go with no need to inspect every passenger. The main issue here is the need of automatic recognitions as the simplest way to identify the individual figure of face with the viruses rather than do it manually go and pick the person up by the health officers themselves. The drawback of do it manually is the cost of time. More time will be wasted to find and go pick up the person and the worst part is the arriving travelers need to spend lots of time stuck in the airport to do the screening test. Imagine if they have been several hours on the flight and when they have reached their destination, they need to wait for several hours again. Also, by do it manually, the probability for the health officers of picking the wrong target person is high because it involves manpower and false decision will occur sometimes. If there is a system which detects the forehead having high temperature on it and it automatically can detect the face of a person, the issue of the travelers need to wait for the screening test and the need of greater number of health officer to do the job to find a person having a symptom will be eliminated and it is not an issue anymore. The advantages of having this system is it can be use in the airport twenty four hours a day in seven days straight with the accurate result will be achieved. This shows why an automatic recognition is needed for the great flow of efficiency operation in the airport.

1.5 Thesis Outline

The rest of the thesis consists of two main parts, namely color and face detection. Both parts have been described in chapter three and four. This thesis is organized in five chapters. Chapter one consist of introduction, which covers background of research problem, research objectives and thesis outline. Chapter two consists of literature review which discuss on the prior works done in face detection using different approaches, while the third chapter consist of the methodology. The fourth chapter consists of the result obtained within this study. Finally, the fifth chapter summarizes the research finding and suggests potential work for future studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Face detection is a computer based technology that determines the locations and sizes of human faces in arbitrary (digital) images. Face detection is the necessary first step in face recognition system [14]. It carries the objectives of localizing face region and to extract it out of an image. Successful face detection will enable face recognition to be carried out smoothly and more efficiently and at the same time reduce false recognition. Human can do this almost effortlessly but for a computer, sophisticated algorithm with efficient computation is the only solution to solve this kind of problem. Face detection is applied to other areas which are equally important such as content based image retrieval, video conferencing, crowd surveillance and intelligent Human Computer Interaction (HCI).

2.2 Previous Work on Face Detection

[1] **H.Ghayoumi Zadeh** (2011) presented that thermal imaging is a method of improving visibility of objects in a dark environment by detecting the objects infrared radiation by using the thermal images, problems can be solved easily because of its good. All of the substances have its own electromagnetic radiation higher than absolute zero as a function of their temperature to be realized as natural or thermal radiation. A thermal imager essentially a heat sensor that is capable of detecting tiny differences in temperature. The device collects the infrared radiation from objects in the scene and creates an electronic image based on information about the temperature differences. Plank's law describes that the wavelength of the peak of electromagnetic radiation from any object is inversely proportional to its absolute temperature. Because objects are rarely precisely the same temperature as other objects around them, a thermal camera can detect them and they will appear as distinct in a thermal image. By using different kind of colors will help users identify objects at different temperatures.

In the article optimized visual and thermal image fusion for efficient face recognition [2] **M.Hanif, Usman Ali (2006)**, presented that the Gabor filter technique was used as a method which extract facial features where efficient wavelet domain data fusion of thermal and visual images were used to achieve better face recognition/detection. Data fusion technique can be divided into two broad ways where the comparison between these two techniques is use. The first method is spatial domain data and on the other hand is wavelet domain data fusion as the aim of the project. The importance techniques for both methods are combining the thermal image and visual image for accuracy and for the need of information. Gabor filter is one of the methods in filtering the image for better result in automated face detection. The idea came as we can't locate feature points manually in detecting points automatically we have to calculate the Gabor filter response at every point to see the behavior of the image around that point. Gabor filter firstly apply feature point selection carried by feature vector generation followed with similarity calculation and lastly calculating the overall difference, the comparison can be make due to the calculation. Accuracy result of Gabor filter shown that despite four of those techniques in wavelet domain data fusion, optimized image fusion shows the greater percentage (95.84%) with the formula applied by Fused image=0.3*thermal + 0.7*visual compared to spatial domain data fusion with 91% with $F(x,y)\ F\ T(x,y)\ (F\ 1)V(x,y)$ is apply.

Most human facial recognition experiments with thermal images conducted in the visible and near infrared spectrums presented by **R.Gault et al.** [3] In this paper, the hypothesis is that information contained in the upper part of the face is more valuable toward recognition than information contained in the lower part of the face. based on the features present in the upper and lower halves of the image as a whole and in smaller sections for automatic face recognition, recognition rate of it will be identify. It has been shown that just one feature especially eyebrows can be sufficient to identify a famous face in the visible spectrum. If the top half of one face is combined with the bottom half of another face, the two distinct faces are difficult to recognize. However if taken alone the individual features are sometimes sufficient for facial recognition. According to **Klare and Jain** [4], there are three levels of facial features for recognition. Level one features are the global features that can be captured from the face, such as skin, color, gender or general appearances. Level two features include localized face information that require cortex processing, such as the structure of the face, spatial relation of facial components or precise shape of the face. level three features are the finer details use to describe the irregularities in the facial skin which include micro features such as facial marks, skin discoloration and moles, these can be used to distinguish between twins and similar people.

[5] **L.Trujillo et al** (2005) said that facial expression recognition is centered around extracting emotional content from visual images. Based on current literature little work has been made on solving the facial expression recognition problem for thermal images. Using thermal image for facial analysis has two significant drawbacks. First, image loose important texture information especially over the eyes and mouth area depending mostly on the person body temperature. Second, glasses that been wearing cause dark cold patches on an image because they don't conduct heat. In this paper, building a robust facial expression recognition system based on a combined local and global eigenfeature representation approach of thermal facial images. By considering that facial texture is localized around facial features, eye and mouth position can been approximately localized using a simple but novel technique of interest point extraction and clustering. More robust representation can be form by combining both local and global information of facial images. First and foremost facial features are localized through interest point clustering. In face localization as one of the goal in this project, each faces of person are not centered within the image frame. This makes facial feature localization a more difficult task. A simple yet robust method for face localization using thermal images based on the property that higher image intensities correspond to regions with high thermal content. Locating the face by approximating its center near to nose area around the face. In order to locate the center, thresholding operation over the entire image frame is apply.

In facial feature localization, a combined method that uses both local and global information could be more appropriate approach. Facial features are more difficult to find in thermal images due to the loss of specific feature properties. Using Harris operator to extract the interest point in an image, good information localization within the image can be formed. Next, clustering of the set of detected interest point. Set of K clusters are define and k-means clustering algorithm has been used. There are several region of low thermal content that can deceive the cluster approach. Some of those regions are nose, cold patches on the cheek and texture of non facial features such as cloth. The result shows that when setting K=9, two cluster centroids top left and top right are positioned over both aye region. It is possible by using this kind of method to detect the forehead of each person for forehead flu detection.

[6] **B.Martinez,X.Binefa,M.Pantic (2010)** studied the problem of detecting facial components in thermal imagery specifically for detection of eyes, nostrils, and mouth. The detection of eyes and nostrils are performed using Haar features and the GentleBoost algorithm which are shown to provide excellent detection rates. In the previous paper working on detection using thermal images in [5], where the feature point extaractor based on Harris features is applied. Then clustering using k-means is performed, under the assumption that the clusters will be coincident with the facial components. The problems are divided into the detection of eyes and nostrils and the detection of the mouth. This is because of the different nature of the problems and that the mouth detection is more challenging. The analysis is performed by means using GentleBoost classifier. Boosting works by sequentially applying a classification algorithm to reweighted version of the training data, for many classification algorithm, the simple strategy results in dramatic improvement in performance [7]. For testing and comparison to show the effective of GentleBoost algorithm, other classifier has been used. They are support vector machine(SVM), Gaussian mixture models(GMM), and Subclass discriminant analysis (SDA). At the end, the result shows that all these provide lower performance compared to GentleBoost.

For the detection of eyes and nostrils, all possible image patches with intensity are considered. Each patch is decomposed into a feature vector by means of Haar wavelets.two classifier are applied to each patches. The first one called detector and the second one is identifier. Firstly, the image patch representation by means of Haar wavelet decomposition is presented. As Haar features is suitable for application to thermal images as thermal imagery has a low signal to noise ratio and Haar features are robust to noise. In detector classifier, 16 x 16 patch size is used and a filter bank containing wavelets of sizes 8 x8, 4 x4, 2 x 2. The identifier use a patch sizes of 32 x 32, filter bank containing wavelets of sizes 16 x16, 8 x8, 4 x 4, and 2 x 2. Later, the procedure followed in order to obtain the training set used for training each of the classifier. This procedure is the same for both detector and identifier. Also, it contains first test conducted in order to select the best classifier of this task. A correct eyes and nostrils detection rate after the experiment show the excellent rate which is 0.8.

[8] **G. Bebis et al** (2006) stated that thermal infrared (IR) imagery offers a promising alternative to visible imagery for face recognition due to its relative insentive to variations in face appearance caused by illumination changes. Despite its advantages, however thermal IR has several limitations. First, it is sensitive to temperature changes in the surrounding environment. Currents of cold or warm air could influence the performance of systems using IR imagery. Second, it is sensitive to variations in the heat patterns of the face. factors that could contribute to these variations include facial expression and psychology conditions like lack of sleep, fear, stress and excitement. Finally, IR is opaque to glass. The focus of this study is on the sensitivity of thermal IR imagery to facial occlusions caused by eyeglass. Specifically, experimental result illustrates that recognition performance in the IR spectrum degrades seriously when eyeglass are present in the in the probe image but not in the gallery image and vice versa. To address this serious limitation of IR, fusing IR is propose with visible imagery. Since IR and visible imagery capture intrinsically different characteristics of the observed faces, intuitively a better face description could be found by utilizing the complimentary information present in two spectra. Two different fusion schemes have been investigated in the study. The first one is pixel- based and operates in the wavelet domain, while the second one is feature-based and operates in the eigenspace domain. In both cases, implementation of a simple and general framework based on genetic algorithms (GA) has been used to find an optimum fusion strategy. Based on the following steps starting from encoding, fitness evaluation, initial population, selection, crossover and mutation. The approach has been evaluated through extensive experiments using the Equinox face database and the eigenface recognition methodology. After the experiments, the result illustrates significant performance improvements in recognition which suggesting that IR and visible fusion is a viable approach that deserves further consideration.

[9] **Mariusz Marzec et al** (2007) presented an algorithm enabling a fully automatic detection of characteristic areas on thermograms containing patient's faces in a front projection. A resolution of problems occurring at the segmentation of face images, such as a change of position, orientation and scale, has been proposed. In addition, attempts to eliminate the effect of the background and of disturbances caused by the haircut and the hairline were made. The algorithm may be used to detect selected points and areas of a face or as a preliminary component in the face recognition, as a development of optical analysis methods or in the quantitative analysis of face on thermograms. The studies described in this paper are aimed at preparing an algorithm for automatic analysis of face thermograms. In the process of temperature value determination, the algorithm analyses the set temperature range.The range is analysed with an iteration step of ΔT=0.25 °C. The detection of forehead is based on the information obtained in previous steps of the algorithm. The input parameters received by the forehead detection block comprise the determined eyebrows line and the preliminary determined upper outline of the forehead area defined acc. to the TSzablon magnitude data *ISK.* a potential area of the forehead, which is then analysed from the haircut disturbances elimination point of view. Examples of the forehead area detection and analysis in the light and in the infrared radiation are presented in papers [10]. In the method proposed, to detect the forehead area and the hairline, a preliminary verification of the area was applied on the basis of [5 x 5] sample standard deviation for each pixel of the potential forehead area. Because of a high diversity in the set of thermograms studied this solution was not universal. Therefore attempts were made to analyse the histogram, the preliminary determined forehead area and to determine the condition of pixels selection based on the results obtained in this way. The method for temperature threshold detection in this group of images described at the beginning allowed a proper selection of the threshold at the normalisation of examined images. The head and its outline detection was more precise than in the studies so far and allowed eliminating at this stage the problems with a thick hairline (of too low temperature).

[11] **Mrinal Kanti Bhowmik et al** (2011) attempted that the main aim is to tackle all these problems to give an accurate automatic face recognition. These problems can be solved using thermal images and also using fused images of visual and thermal images. The image produced by employing fusion method provides the combined information of both the visual and thermal images and thus provides more detailed and reliable information which helps in constructing more efficient face recognition system. Objective of this chapter is to introduce the role of different IR spectrums, their applications, some interesting critical observations, available thermal databases, review works, some experimental results on thermal faces as well as on fused faces of visual and thermal face images in face recognition field; and finally sorting their limitations out. Fused image comprises of more than one image. So, the resulted fused image is more informative than any of the individual image. In face recognition, sometimes visual images are found to be more helpful than thermal images. So, we can apply the concept of fusion in face recognition to get better result of person recognition. So, fusion of both thermal and visual images will generate a new fused image that will store the information of both thermal and visual faces. Pixel level fusion is the combination of the raw data from multiple source images into a single image. It combines information into a single image from a set of image sources using pixel, feature or decision level techniques.

The features extracted from visual intensity images also lack the specificity required for uniquely determining the identity of the imaged object. The process of image fusion may be where pixel data of 70% of visual image and 30% of thermal image of same class or same image is brought together into a common operating image or now commonly referred to as a Common Relevant Operating Picture (CROP). This implies that an additional degree of filtering and intelligence is to be applied to the pixel streams to present pertinent information to the user. So image pixel fusion has the capacity to enable seamless working in a heterogeneous work environment.

[12] **Karl B. J. Axnick and Kim C. Ng** (2006) introduced an algorithm for face recognition that is fast, robust and accurate. It is designed primarily for access control applications involving small databases such as access to a building, a laboratory or equipment. The algorithm is robust enough to handle inputs from varying sources (2D, 3D and infrared) to detect and recognise faces quickly even when those faces are varied from the database images with pose, illumination and expression changes. It uses common image processing techniques and heuristics to rapidly find salient feature points on a face. Normalised geometric distances and angles are extracted from these salient point locations to generate a unique signature for the face in the image Face detection is a bottleneck for any face recognition system where the target is not held in a controlled state. To overcame this bottleneck by using a combination of many weak filters to quickly capture possible faces in the image. A more modern version of this method was used in this research to verify a novel face detection that uses background subtraction, blob analysis and eye recognition. Since this method is faster and more robust than Lienhart's method which use Haar face detector and has comparable accuracy it was used in the actual system implementation and speed tests. Lienhart's method was also used, but for checking the paper's algorithm accuracy as the database composed of still images and random backgrounds, making the background subtraction approach inadmissible in some tests.. Expression variations are combated by giving salient points diminished weights when they lie in large expression variation areas, most notably the mouth and other locations learned by differentiating the 3D and 2D scans of many test faces with greatly varying expressions, but with absolutely no other variants. Noise variation is handled in the following manner: visible points that would have been found but are not found due to corrupted scan data, do not alter the recognition score either positively or negatively. Points that are not lost due to noise but simply contain noise have their effects diminished by using many salient points for recognition. The performance of the final system has been tested and it achieves recognition speeds of less than 1 second per face at accuracies from 73.5% to 100% depending on the input image type.