COMP4801 Final Year Project

Body Temperature Measuring System with Smart Patrol Robot

Final Report

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Abstract

In this project a thermal camera is installed on an indoor patrol robot provided by the Hong Kong International Airport (HKIA) and the Hong Kong Airport Authority (HKAA). The thermal camera will first capture the image from human, then translate thermal energy intro visible thermogram and a program will further send the heat diagram data to the computer via email system. This robot will be used to check the body temperature of inbound passengers and will notify staff at HKIA of any passengers who are found to have a high temperature so that they can be isolated. Due to the fact that Coronavirus Disease 2019 (COVID-19) is raging at every corner of the world currently, public health becomes a crucial issue and governments in all countries try to adopt different preventive measures to fight for this disease. The sense of defending sickness also arouse from this virus. One of an effective method to prevent a widespread of a disease in a country or city is to avoid people who are sick from crossing national boarders so that local people can be protected. With the help of this mobile body temperature checking robot, the risk of widespread of viruses and disease can be reduced. All the testing are implemented in the Innovation Wing in the University of Hong Kong (HKU).

(219 words)

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Acknowledgements

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I would like to thank Hong Kong International Airport and Hong Kong Airport Authority for offering this opportunity and providing us the robots in this project.

At last, I would like to praise my commendable groupmates, Lee Ka Fun and Tse Man Kit, with our cooperation, the degree of progress on the project goes smooth.

List of Figures/ Tables

Abbreviations

AGV	Automatic guided vehicles
API	Application program interface
COVID-19	Coronavirus Disease 2019
FLIR	Forward looking infrared camera
HKAA	The Airport Authority Hong Kong
HKIA	The Hong Kong International Airport
HKU	The University of Hong Kong
IP	Internet Protocol
LAN	Local Area Network
MQTT	Message Queuing Telemetry Transport
RTSP	Real Time Streaming Protocol
SDK	Software Development Kit

CHAPTER ONE: INTRODUCTION

1.1 Background and motivation

The Hong Kong International Airport (HKIA) has maintained its position as one of the best airports in the world for more than twenty years. With its well-known busiest cargo airport award for consecutively ten years, the Special Architectural Award and with more than 80 other World's best airport awards[1], HKIA becomes one of the top airports throughout the world. As an important international airport, HKIA handled around 71.5 million travellers as well as connections to around 220 destinations worldwide by 120 airlines with 419,795 air traffic movements in year 2019[2].

HKIA is committed to building a superior image by providing passengers a unique experience along with improving the operational efficiency through the use of technology in innovative and effective ways[3]. To achieve this goal, the Airport Authority Hong Kong (HKAA) decides to reformulate the future travel experience by collaborating with other technology companies and business partners as well as initiating a Smart Airport Project in 2018[4].

In the Smart Airport Project, there are two main parts of the all-in-one indoor patrol robot which are top module and automatic guided vehicles (AGV). They are able to monitor the facilities and environment in the terminals by collecting and analysing the various data in a consolidate platform for enhancing facilities management operation efficiency and reducing labour force. The data will be collected through the measurement of WiFi signal, iBeacon signal, lighting luminance, temperature and humility and collection of environment video.

1.2 Current situation

The statistics from Section 1.1 indicates that there are numerous of visitors in HKIA every day and they might have interactions with each other within a close distance without awareness. In addition, there are over 220 shops and 60 restaurants with over 78,000 staff members working in HKIA in 2019. HKIA is at risk of the widespread of diseases from various countries. Owning the high reputation on excellent facilities, adopting innovation measures is an essential strategies for HKIA on the diseases and viruses precaution.

At this moment, most of the indoor patrol robots using in HKIA are only for cleaning[5][6], customer service[7] and robot kiosk[8]. In order to fully utilise the robot to deal with the current public health issue, the idea of installing a thermal camera on an indoor patrol robot is will be discussed in Section 1.3.

Currently, the body temperature checking system adopted is only the stationary thermal cameras for arrival passengers in the arrival hall. The passengers are requested to go to a specific area to let the fixed camera detect their body temperature. Yet, the visitors in the airport lobby are excluded and the coverage of the stationary thermal cameras of the detected area is not high.

1.3 Objective

In the project, the thermal camera is implement on the indoor patrol robot. A diagram with temperature shown in thermography can be acquired and the image of the detected person can be selected. This scope of the project includes two parts, with the design and the data collection from the thermal camera. A better design is needed for higher coverage and improve the data collection.

Before the installation of thermal camara, the sensor function which is stored in the robot is used to draw a planar graph and the route for the robot, as known as map drawing in Section 4.2.2. The planar graph map can show all the obstacles in that area. Therefore, the robot will not bump on the obstacles. The route will then be drawn on the planar graph so that the robot will follow the path and measure the temperature of people nearby. Face recognition and duplicate removal are also applied to same similar face and removed the similar cases discovered at the same time

In order to guarantee that the robot can be successfully applied in HKIA, we will first test the robot in the Innovation Wing in HKU. We will use the sensor function to draw the planar diagram of Innovation Wing and then draw the route for the robot. The robot will travel along the path in the Innovation Wing to check the temperature of the students there. If there is a student with abnormally high temperature, the robot will alert the staff.

1.4 Project contribution

An indoor patrol robot with thermal temperature function is expected to be used by HKIA for body temperature checking alongside the current stationary thermal camera. The movable camera can check the body temperature in different angle to ensure higher accuracy. With the aid of the robot, HKIA can act as the first line of diseases defender.

1.5 Outline of the report

The report consists of five chapters. The first chapter provides a major overview of the background and motivation of this project, significant role of HKIA in in relation to worldwide current situation, together with the usefulness on the installation of the thermal camera. Additionally, it states the objective and contribution of the project by indicating the importance of this work.

Chapter two illustrated the project background. The reason of working on this project will also be discussed.

Chapter three evaluates the methodology implemented in this project, including the equipment set up of indoor patrol robots, top module and AGV, as well as thermal camera and normal camera. Besides, this chapter further explains the function of the camera through the algorithm of infrared thermography, image segmentation with threshold method and object selection with template matching. Moreover, the methodology used on face recognition is also highlighted.

Chapter four shows the experiments and results of this project. Starting form thermal camera installation to implementation, map drawing and location marking with navigation software, mask detection, alert system in both sound and email method, script for handling alert email, development of web portal, implementation of face recognition and duplication removal are all highlighted in this chapter.

Chapter fives concludes this project with stating both the challenges during and after the project and the future works of this project.

CHAPTER TWO: PROJECT BACKGROUND

2.1 Patrol Robot

Two robots, named Mark 2 and Mark 3 are sent from the Hong Kong International Airport for this project (Figure 2.1). The robots are from Teksbotics (Hong Kong) Ltd. They are moved to Tam Wing Fan Innovation Wing and the working environment is also based there in room Workshop 1 (Figure 2.2). It is the location for development and testing of this project.

Figure 2.1: Patrol robot Mark 2 (left) and Mark 3 (right)

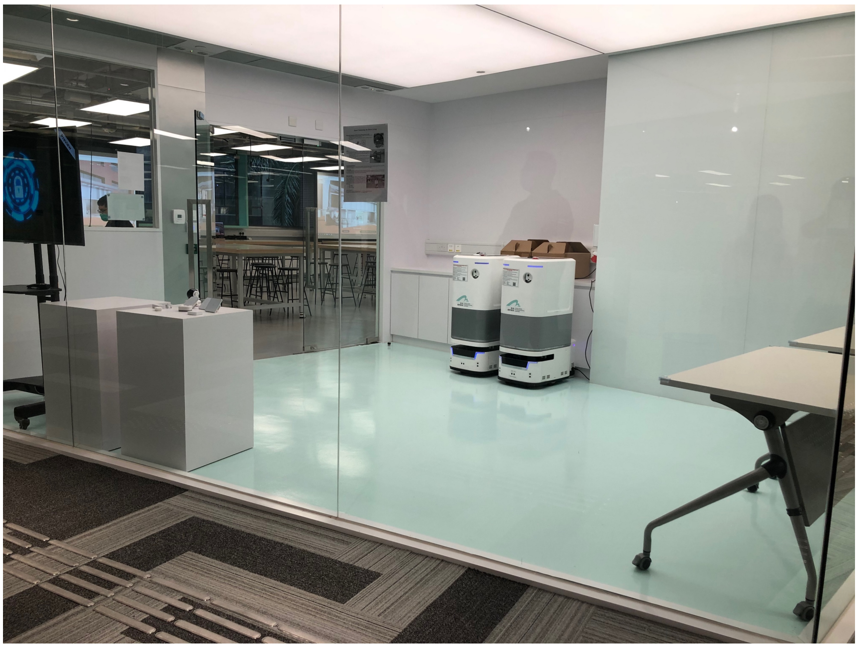


Figure 2.2: Workshop 1 in Tam Wing Fan Innovation Wing in the HKU

2.2 Importance of temperature control and wide installation of thermal cameras

Public health is permanently a metropolitan issue. In view of the year 2020, the infectious epidemic, Coronavirus Disease 2019 (COVID-19), originated in Wuhan, China, is currently raging through the globe, as well as leading to more than one million of global deaths[9]. This pandemic calls forth the public to pay attention to the preventive measures on all other the diseases and viruses, namely hand-foot-mouth disease and Ebola.

Recently, preventing COVID-19 is the major concern from across the globe. However, most of the communicable diseases share similar symptoms in which the major common symptom is fever. Once the visitors with high temperature are identified, they will likely be sent to hospital for further quarantine measures immediately. This can greatly prevent future human interactions with that sick travellers. In the current situation, temperature control is an fundamental way to discover the patients.

2.3 Camera selection

Heretofore, my group purchased the forward looking infrared camera (FLIR) module C5 from B&T Engineering Limited on the 26th November 2020. It is a thermographic body temperature measurement camera turret. Before considering module C5, our group has also made a research on module C2, however, C5 is better module which has a high standard so we switched to this. Our group would like to have a camera that can provide application program interface (API) to obtain raw data, such as heat map from the computer program. Infrared image can be transferred from the computer to an USB. After the research, our group found that FLIR C5 can connect to window machine and developed a Software Development Kit (SDK).

2.4 Workshop

The first workshop was held on 6th October, 2020 from a thermal camera vendor representing the company Xensor. The vendor introduced one of their thermal camera product to my project group and taught us how to use it. However, the thermal camera was still not ready to be used and our group had to select another thermal camera.

The second workshop was held on 29th October, 2020 and our group had met the indoor patrol robot. A staff in charge of the robot from Teksbotic (Hong Kong) Ltd showed us the function of the robot. We had learnt how to control the robot and how to implement the programmes into the robot. Beside, we has tried to use the sensor function which is stored in the robot to draw a planar diagram in a room and the route for the robot. The robot was able to identify us as the obstacles and showed the us in the planar diagram.

2.5 Testing

Testing will first be carried out in the open area in Tam Wing Fan Innovation Wing in the HKU campus (Figure 2.2) and later on be performed in terminal of HKIA. Two areas in terminal of HKIA are selected which are the airside of terminal 1 and the landside of terminal 2. The testing will be implemented to check the feasibility. The patrol robot will be used in the innovation wing to check the body temperature of the students.

Figure 2.3: Open area in Tam Wing Fan Innovation Wing in the HKU

2.6 Summary

This chapter has explained the background of the project. Introducing the robot, camara selection process, workshops held and testing environment. The next chapter will present the methodology of this project.

CHAPTER THREE: METHODOLOGY

3.1 Overview

Chapter three will explain the technologies, equipment set up, algorithm, model design and the method used behind the technology, together with infrared thermography, the image segmentation by using threshold method and object selection by using template matching. Moreover, the theory of face recognition will also be discussed. This chapter clarifies the data and image explanation how the cameras operate.

3.2 Equipment set up

3.2.1 Indoor patrol robot

(a) (b) (c)

Figure 3.1: Indoor patrol robot. (a) AGV, (b) top module and (c) the entire robot with the combination of AGV below and top module on top.

The Indoor patrol robot is made up of two major parts, including AGV (Figure 3.1(a)) and top module (Figure 3.1 (b)). Top module is placed on top of AGV. AGV is a mature technology that navigates around the area in an accurate manner and it is capable to avoid the physical barriers while top module performs functions including data collection, staring, pausing or cancelling patrol mission and specific navigation points travelling. The overall dimensions of the robot are 610mm in length × 460mm in width × 1050mm in height (Figure 3.1(c)).

3.2.2 Thermal imaging camera

Thermal imaging camera, as known as thermal camera, is a device that can transform thermal energy (i.e. heat) into visible light for the purpose of thermal analysis[10]. This camera will assist our project on the body temperature checking of traveller.

Thermogram, the imaged produced by thermal imaging camera, and thermography, an algorithm applied in this specific transformation. Figure 3.1 shows the thermal camera.

Figure 3.2: Thermographic body temperature measurement camera turret

3.3 Algorithm and model design

3.3.1 System Architecture

The idea of this project is to develop an end-to-end solution such that the robot is able to patrol, identify visitors with unnaturally high body temperature and alert the staff when a suspected fever case is discovered. With reference to Figure 3.3 below, the diagram illustrates the workflow of the smart patrol robot starting from patrolling in the airport gates area to the later process including transferring relevant information to the web portal of the airport staff.

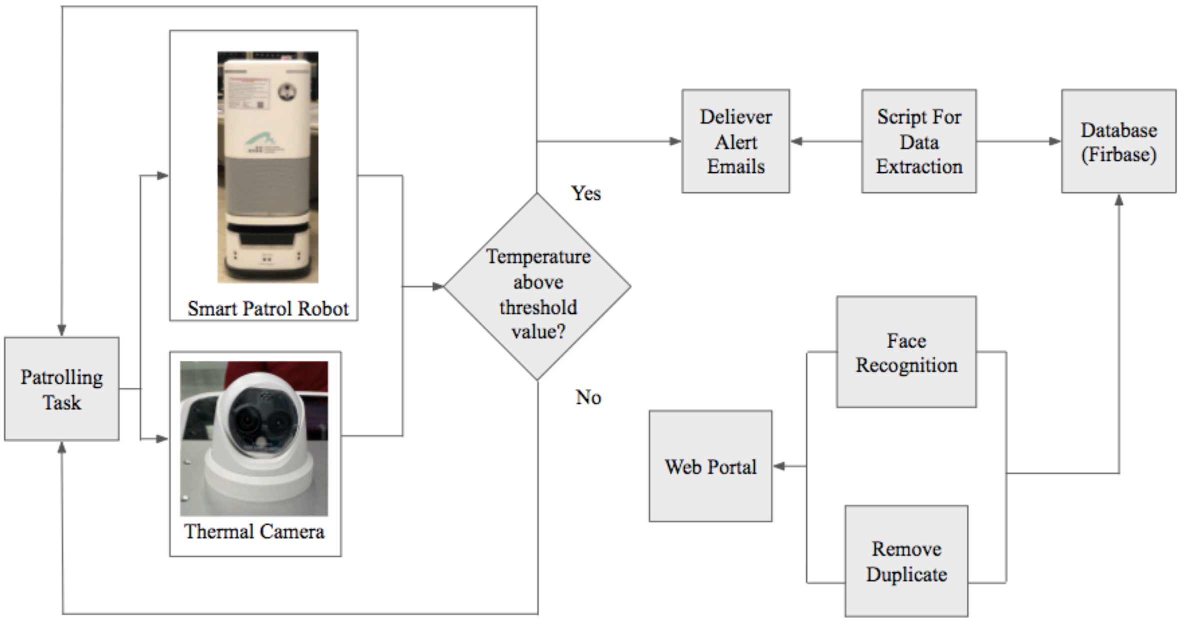


Figure 3.3: System architecture of the project

The solution of this project is made up of data collection and alert handling. Referring to Figure 3.3, this first step is that the patrol robot will receive the patrolling task and start its operation with its digital camera and thermographic camera. When a person with body temperature above the threshold value, which is set manually, is sensed by the camera, both the thermal image and normal image will be captures and an email alert is made. The data in the email will be analysed and uploaded the storage system of Firebase. At the end, the airport staff can use the web portal to view and manage the suspected fever cases in the airport gate area. The email alert, Script for data extraction will be further discussed in Section 4.2.6, Section 4.2.7 respectively.

3.3.2 Infrared thermography

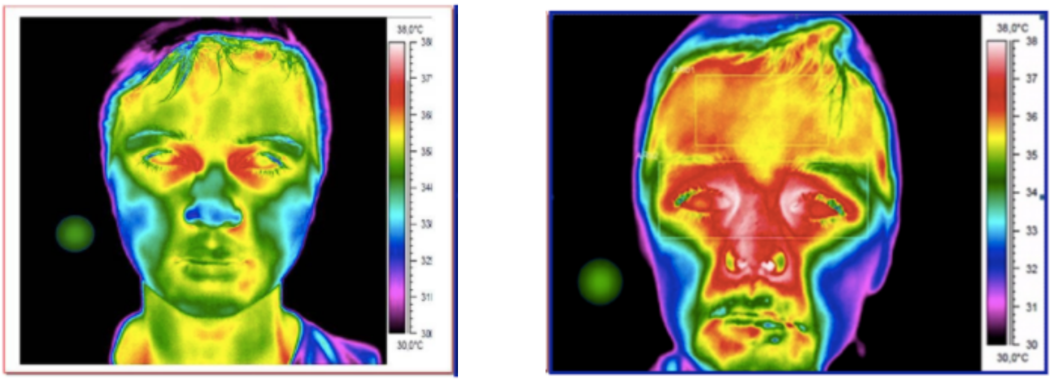
Infrared thermography reflects temperature of human body in thermogram based on Planck's Law. Planck's Law, as known as black body radiation law, provides that every object with a temperature above absolute zero (i.e. 0 K and -273.15 ºC) emits energy in the form of electromagnetic radiation[11]. A blackbody theoretically means that an object absorbs all the radiation falling on it at all frequency, however, reflecting and transmitting none. This a hypothetical object that is a perfect absorber and emitter of radiation over all wavelengths[12]. The electromagnetic radiation from Planck's Law can be calculated as follow (equation 2.1).

$$E_\lambda = \frac{8\pi hc}{\lambda^5} \times \frac{1}{e^{\left(\frac{hc}{kT\lambda}\right)} - 1} \qquad (3.1) \quad [13]$$

Equation 3.1 is the Planck's Law equation, where E_λ is the energy radiated per unit volume by a cavity of a blackbody in the wavelength interval λ to λ + Δ λ and Δ λ denotes the increment of wavelength, h is Planck's constant ($6.626 \times 10^{-34} js^{-1}$), c

speed of light ($2.998 \times 10^{8}\ ms^{-1}$), k is the Botzmann constant ($1.381 \times 10^{-23}\ m^{2}kgs^{-2}K^{-1}$) and T is the absolute temperature.

With Planck's Law, the surface temperature of human body can be monitored [14] after the temperature of living thing is successfully captured in an infrared thermography in from of thermogram (Figure 3.4 (a) and Figure 3.4 (b)). With the correlation between skin temperature and thermal physiology, infrared thermography has been widely applied to identify diseases such as diabetes neuropathy, breast cancer and also peripheral vascular disorders[15]. As a result, infrared thermography can be used in the project to detect a human whose body is with abnormally high or low temperature and then identified him as fever case.



(a) (b)

Figure 3.4: Infrared thermography of a child. (a) A face with normal temperature, (b) a fever face with eyes and eye corners in high temperature[16].

3.3.3 Image segmentation by using threshold method

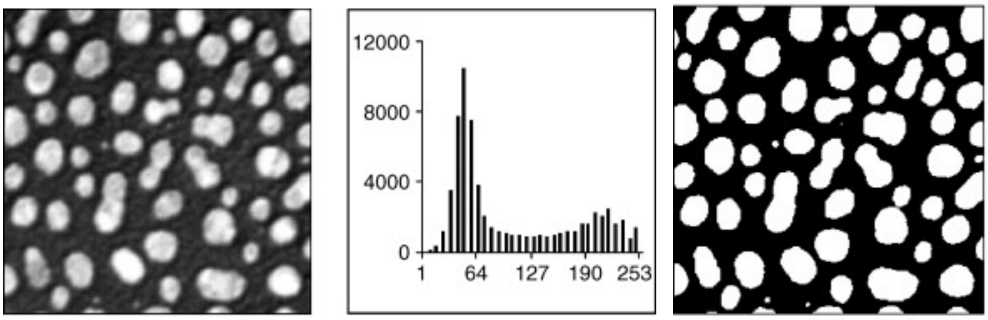
Image segmentation is an indispensable process in computer vision, video and image application. Given that digital image is made up of a matrix of pixels in computer systems, image segmentation makes use of this pixels characteristics of the image to partition an image into separate regions, in which the separated regions correctly match with different real world object.

Global grey level thresholding is one of the efficient image segmentation method used in the world. Pixel values indicate the levels of grey. Pixel values are represented between 0 to 225 in decimal number. These 256 different values come from 1 bytes in binary form which is the same as 8 bits. Then, the values will be in a histogram, which is a bar graph with a frequency distribution of pixel values in digital image (Figure 2.5(b)). Due to the fact that the grey level of pixels of the an object are totally distinct from that of the background based on a grey level histogram, the image can be partitioned into an image with foreground and background by selecting a threshold T that separates the pixels into two dominant groups[17].
The result of image segmentation thresholding is a binary image, where pixels with value 1 match to object while pixels with value 0 match to the background. Below is the equation of separating the pixels into black and white with the threshold.

$$p(x,y) = \begin{cases} 1 \text{ if } (x,y) > T \\ 0 \text{ if } (x,y) \leq T \end{cases} \qquad (3.2) \quad [18]$$

Equation 3.2 indicates that whether a specific pixel p belongs to 0 or 1 depends on its pixel value by comparing with the threshold T.

For example, Figure 3.5 shows the result of image segmentation by using global grey level threshold method. The original image (Figure 3.5(a)) contains light grey dots on a dark grey background. From Figure 3.5(b), the y-axis of a histogram shows the pixel count and x-axis shows pixel value. When the threshold $t = 127$, the pixels with value larger than 127 will become 1 while those with value smaller or equal 127 becomes 0 and the image segment comes out clearer in black and white only, resulting in Figure 3.5(c).



(a) (b) (c)

Figure 3.5: Example of global grey level thresholding. (a) Original image, (b) histogram of image (a), (c) Result of grey level thresholding[18]

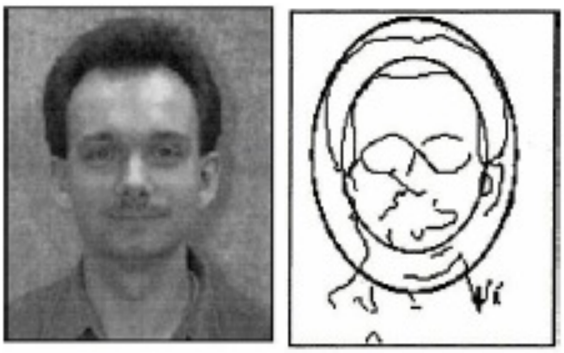
In the project, the image of human face and the background can be segmented by using global grey level thresholding method because of its advantages of simplifying image representation, edges or regions, more meaningful and easy image can be captured for analysis for the next step, object selection by using template matching, as stated in Section 3.3.4.

3.3.4 Object selection by using template matching

After the process of image segmentation stated in 3.3.3, the next step is object selection process on human facial area. This project mainly focuses on the body temperature of human body which is checked from the facial part. Given that ranged from 36.0 ^{o}C to 37.2 ^{o}C is regarded as normal temperature while body temperature with 37.2 ^{o}C to 39.8

^{o}C is regarded as fever, our aim is to check whether there exists facial area with temperature exceeding 37.2 ^{o}C.

Object selection filters out the facial area of the image captured by the camera. Templated matching is a basic technique used for image processing such as edge detection, feature extraction and object extraction[19]. It is also a way that can specifically select a region with the specific shape chosen[20]. When the elliptical and circular templates are chosen, the contour of human face can be easily identified because the shape of human face is similar to an ellipse or a circle. As shown in Figure 3.6, a normal upright face of a man (Figure 3.6 (a)) can be selected by applying elliptical ring on the contour of his face (Figure 3.6 (b)) and the ring fully covers his face.



(a) (b)

Figure 3.6: Example of template matching (a) Normal upright face of a man (b) Applying elliptical ring on the contour of human face[21]

With this method, a face can be identified for body temperature checking in the project.

3.3.5 Face recognition

Face recognition is implemented in this project to identify faces. Face Recognition is a technique for detecting the faces of people whose photographs have been saved in a data collection. Face recognition has still been a major focus of study, despite the fact that other methods of identification can be more reliable. This is due to its non-intrusive nature and the fact that it is people's preferred form of personal identification. Biometrics are used to map facial features from the photographs or videos. The facial recognition system will compare the information from a known faces database to find a matched face. Face recognition is able to verify the personal identity[22].

Face recognition systems apply algorithm to select distinctive and specific details from a face of a person. The algorithm is classified as template based and geometry base algorithm. The template based algorithm is constructed from several analyses and statistical tools, such as, Linear Discriminant Analysis (LDA), Principle Component Analysis (PCA), Support Vector Machines (SVM), Trace Transforms and Kernel methods. For the geometric based algorithm, as known as a feature based algorithm, analyses the geometric relationship and local facial features.

There are several detailed steps to work out the facial recognition.

Beginning with the face detection, the thermal camera acts a normal camera to recognise and track the picture of a face, no matter the photo contains only one person or a crowd.

Then it comes to face analysis, that picture of the face is taken and examined. Since it is easier to align a 2D image with public photos or the photos in a database, the facial recognition technology does not use 3D images, instead, it uses 2D images. The unique features mentioned in the previous paragraph include the shape of chin, the distance between the two eyes, the distance between jaw and forehead, the contour of mouth hand lips, chins and ears, as well as the deepness of eye sockets.

After analysing the face, the image will then be converted to data. The face from a capture converts analogue information into a collection of digital data. The analysis of faces are basically reduced to the mathematical formula. Similar to finger print, faceprint of a person is unique and the numerical code generated from the process is called faceprint.

The final process is to find a match face. The faceprint generated will then be passed for comparison from a database of all the other known faces.

3.4 Summary

This chapter has explained the theory and principle used in the project. The installation of the camera and the function of thermal camera used in body temperature detection. The next chapter will present the achievements, experiments and results of this project.

CHAPTER FOUR:

EXPERIMENTS AND RESULTS

4.1 Overview

This chapter will include the experiments and results of this project. It includes the installation of thermal camera, map drawing and location marking with navigation software, mask detection, alert system in both sound and email method, script for handling alert email, development of web portal, implementation of face recognition and duplication removal.

4.2 Achievements

4.2.1 Installation of thermal camera

The installation of thermal camera is successfully done in the first half of the project. In order to install the thermal camera, a new IP address is assigned to the thermal camera such that the camera is on the subnet with the router of the robot. Via the LAN connection, the thermal camera connects to the router of the robot and the thermal camera is further integrated to the robot computer through the Ethernet connection. The thermal camera (Figure 4.1(b)) replaced the original camera (Figure 4.1(a)) on top of the robot. The existing DC 12V power supply is connected to power the thermal camera.

(a) (b)

Figure 4.1: Patrol robots with camara. (a) original camera (b) Newly installed thermal camera

The thermal camera is fully powered by the internal battery in the patrol robot. Since the camera is connected to the robot computer through ethernet connect, the live view of the camera can be accessed by the robot computer as shown in Figure 4.2. The robot computer can access to the normal vision and the thermal vision of the thermal camera in real-time.

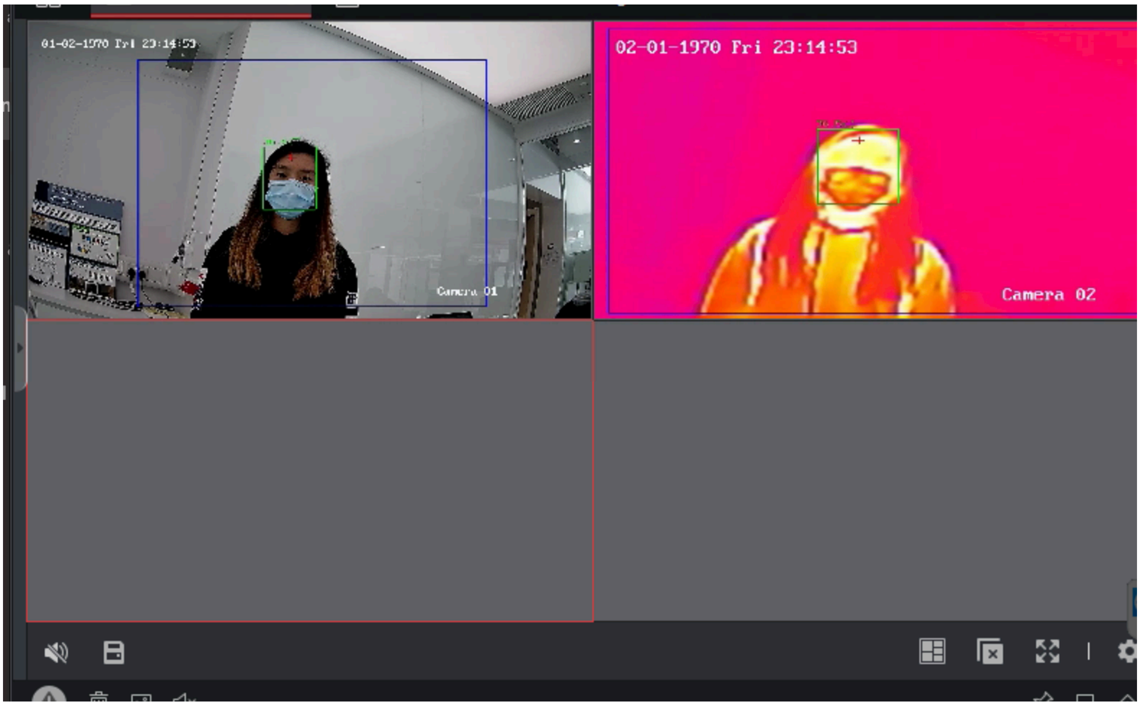


Figure 4.2: Live view of the thermal camera

4.2.2 Map drawing

In this project, the robot the will patrol along the assigned path. The path is drawn with the navigation software Unodopo Naci Studio from the vendor of the robot, Teksbotic (Hong Kong) Ltd.

Due to the fact the testing area of this project is in HKU Innovation Wing, the map drawn below in the open area inside the Innovation Wing. I have created multiple target points as the navigation targets for the robot.

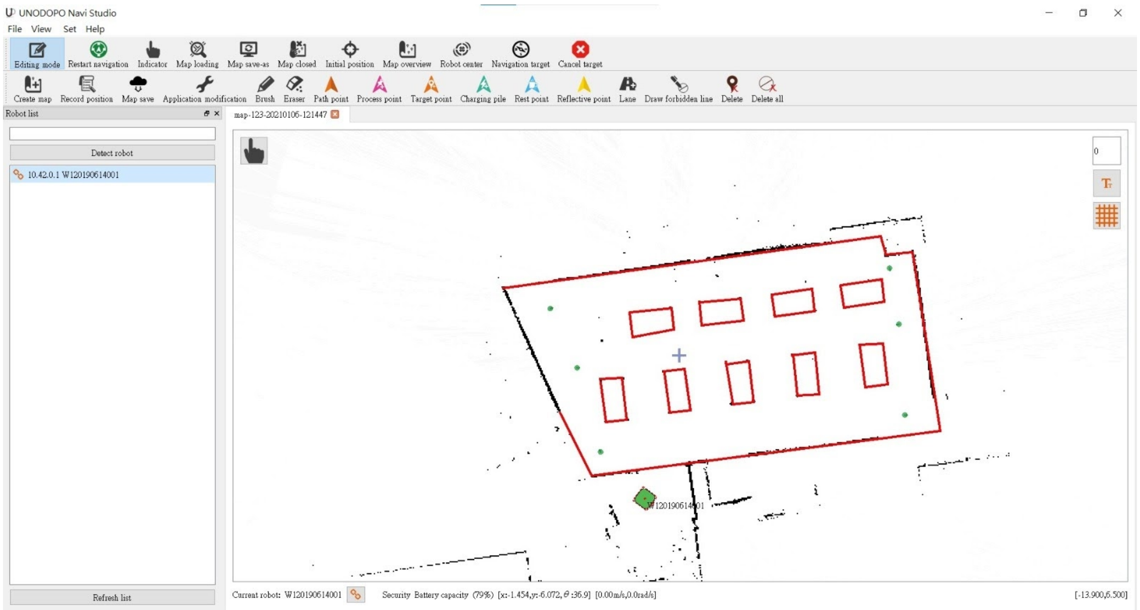


Figure 4.3: The map of the open area in Innovation Wing

Figure 4.3 shows the map of the open area in Innovation Wing drawn by the Unodopo Navi Studio. The patrol robot is the green square shown on the map. The blacks dots are the obstacles that scanned by the robot and the read lines are drawn manually to represent the obstacles.

With the software above, an automatic task chain can be established (Figure 4.4). This chain gives instruction to the patrol robot and orders the robot to travel to different navigation points in sequence.

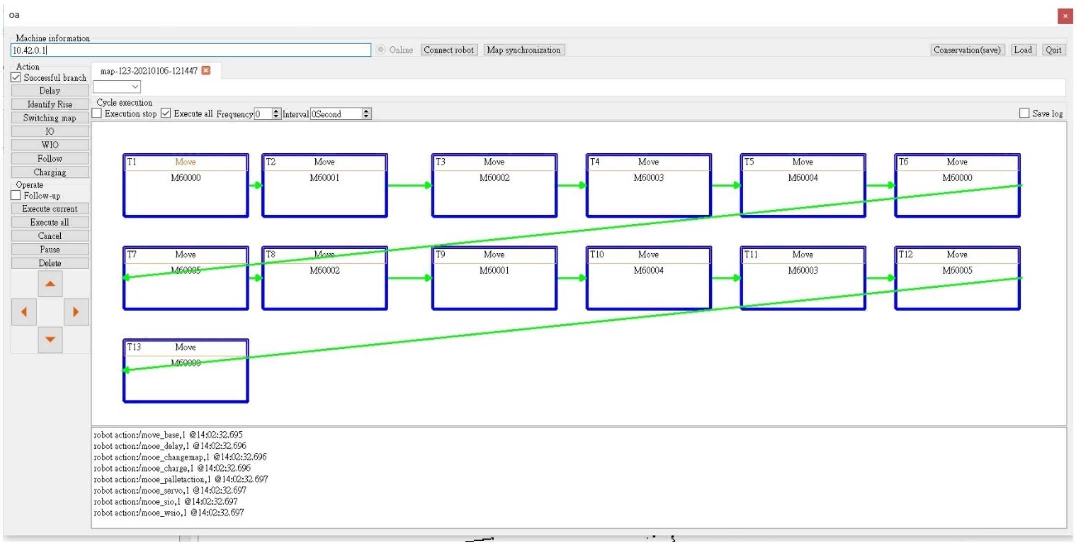


Figure 4.4: Robot patrol task chain

In Figure 4.4, the rectangle boxes are the node representing a single movement to a specific target navigation point. The green arrows indicate the travelling sequence of the patrol robot.

This travelling path shown in Figure 4.4 is optimized. During the patrol, the thermal camera above the robot will be allowed to look at all the corners from the open area from all angles. This path setting not only reduces the chances of blind spots of finding suspected fever case but also enhances the measurement reliability

4.2.3 Location marking

Location marking was one of the challenges I faced during the project. The challenge is about determining the location marking for the results generated from the thermal camera. Previously, the robot was only capable of travelling along the assigned path, absence from the ability of knowing its current location when the thermal diagram photos were captured. My achievement on this part is that the robot can now identify the current location accurately with the zone marking.

Figure 4.5: Zones in Innovation Wing open area

According to Figure 4.5, the open area in Innovation Wing is separated into 5 zones vertically, marked in purple line. Starting from the left, the leftmost table is zone 1, then the every two tables from a zone vertically until the two tables on the right in the open area.

This location marking achievement can allow the airport staff to identify and access the suspected fever person in an easier manner.

4.2.4 Mask detection

Mask detection is done in this project. The camera can identify whether the person is wearing mask or not. Moreover, this camera can also detect sunglasses.

4.2.5 Verbal alert

I had managed to establish a verbal alert in the thermal camera. When a person with body temperature above the measurement threshold is sensed by the thermal camera, the camera will automatically make a verbal alert by playing "Temperature is abnormal, please check!"

4.2.6 Email alert

When a person with abnormally high temperature approach the camera senses him, an email alerts (Figure 4.6) will be made automatically. Those emails are sent from the alert system to a designed email account. In this project the email is patrolrobotfyp@gmail.com. The email also includes the details of that event, which refers to the identified case. The details in text information and 3 attachments The text information includes the threshold of the alarm, temperature of the person, triggering time, etc. The three attachments from the emails are three captured images, consisting of the detected face surrounded by a box with body temperature shown on top of the face, a normal photo with captured face and a same photo but in thermal diagram.

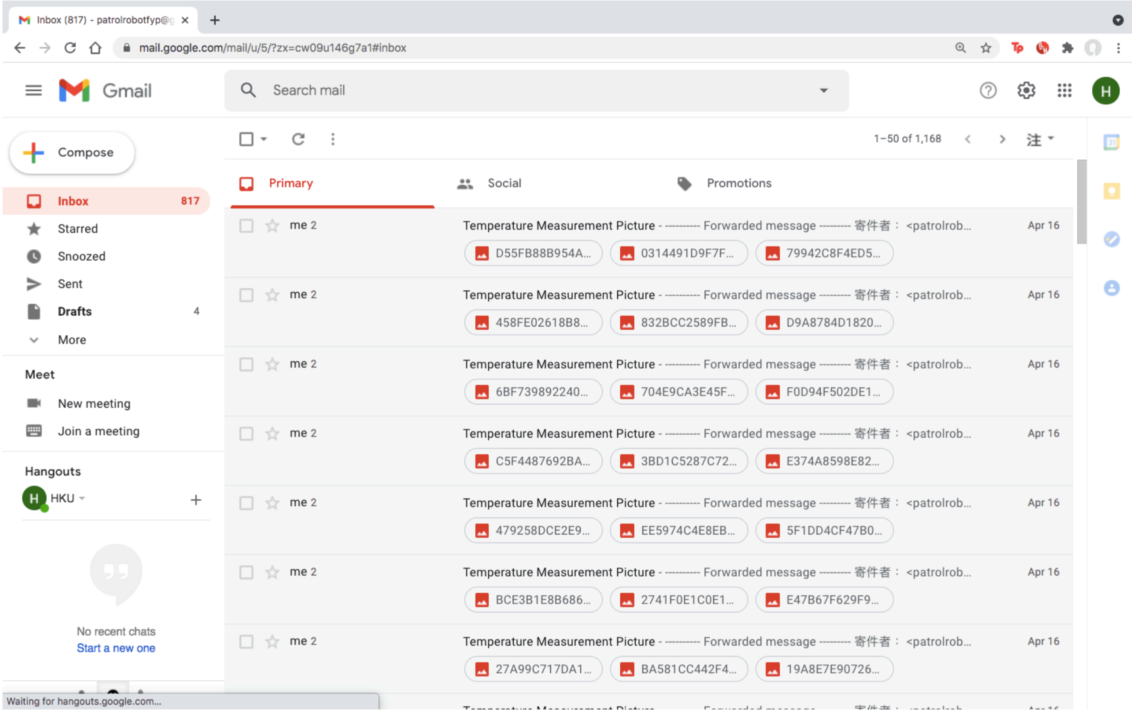


Figure 4.6: Automated email sample sent

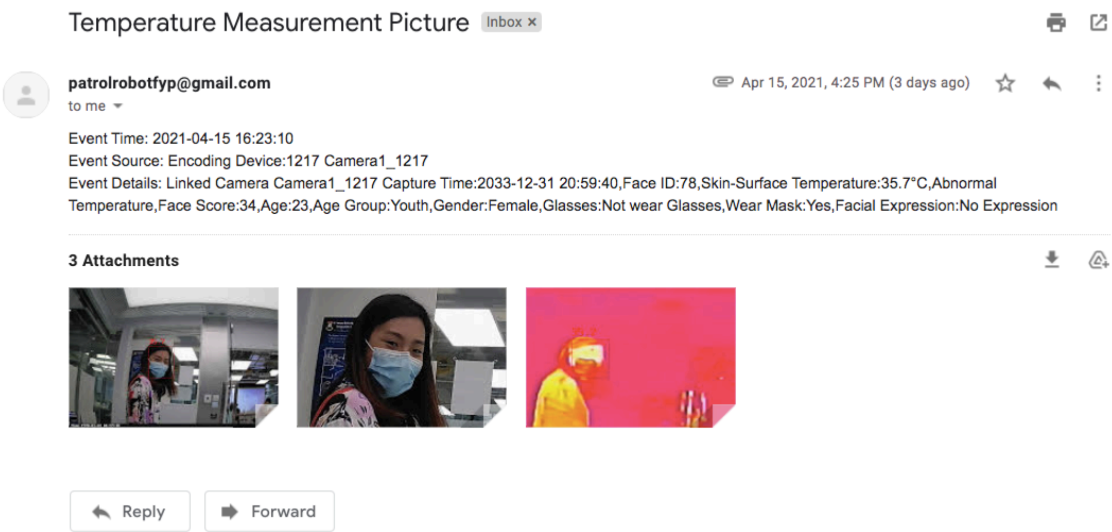


Figure 4.7: Details of the email

4.2.7 Script for handling alert email

For the purpose of analysing the alert emails that are received from the thermal camera, a script in programming language, JavaScript, is written to extract the images with captured faces and some critical information from the email. The information includes the temperature variation of that person, the specific date and time that the images are captures. The extracted information is then be upload to the storage system of firebase.

4.2.8 Development of web portal

The web portal is designed and developed for the airport staff to monitor the case details in the gate area in HKIA. The development of web portal consists of designing and deploying. I have participated in both the backend and frontend work for the web portal. In the web portal, Firebase acts as the backend database storage system and React with JavaScript library is used for the frontend display development and the web portal is successfully made.

In the first half of the project period, the user interface of the web portal was designed with the digital design and prototyping tool, Figma. Figure 4.8 shows the initial design of the landing page and Figure 4.9 the detailed views from the suspected cases.

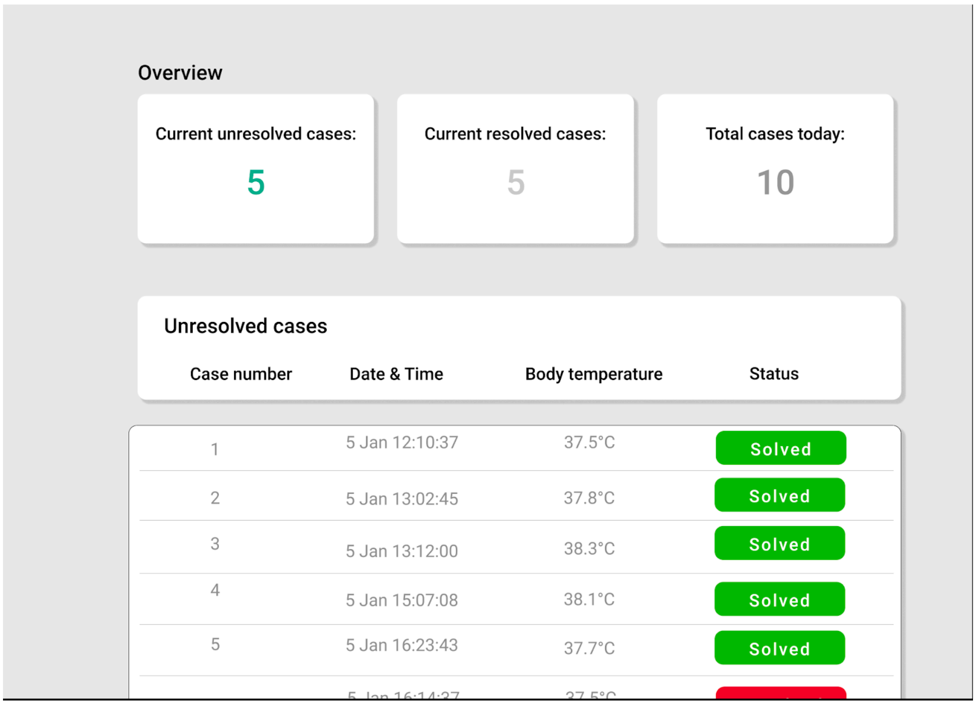


Figure 4.8: Design of the user interface of the landing page of web portal

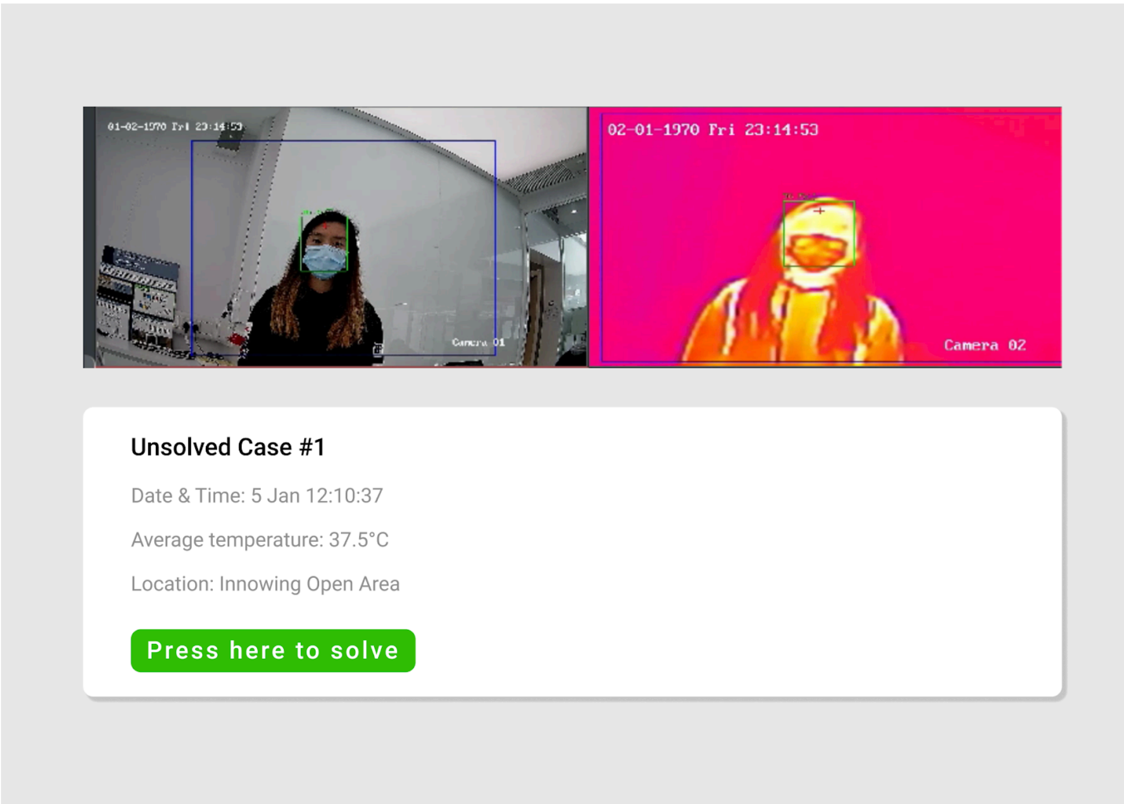


Figure 4.9: Design of the user interface the detailed views from the suspected cases

In the design, the landing page is made up of two main parts, the overview of the cases with abnormally high temperature of that day and the list of all the suspected cases (Figure 4.8). When a case is selected, the case details will be shown (Figure 4.9).

After the instalment of the thermal camera and the implementation of face recognition together with the duplication removal, a successful web portal is made (Figure 4.10).

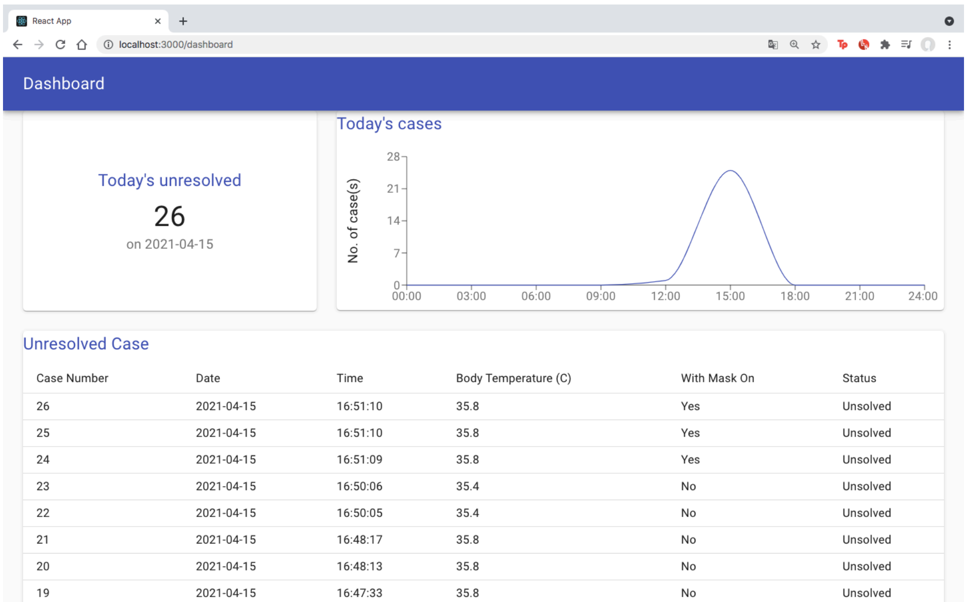


Figure 4.10: Landing page of the successful web portal

As shown in Figure 4.10, the web portal shows the number of unsolved cases, a graph with number of cases against the time and the list of all the unsolved cases. Web portal user can click into each case to view the details (Figure 4.11).

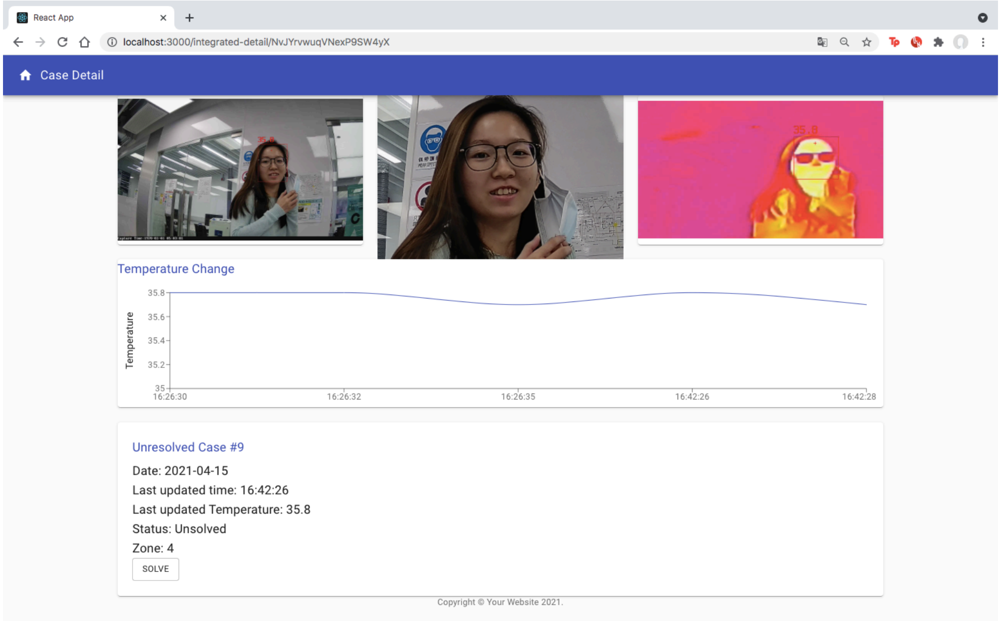


Figure 4.11: Case detail page in web portal

Three photos are shown in this page and the photos are collected from the emails mentioned in Section 4.2.7. From left to right, the photos are the detected face surrounded by a box with body temperature shown on top of the face, a normal photo with captured face and a same photo but in thermal diagram.

With the help of face recognition, the web portal will show the temperature change against time of the same person as well. However, the face recognition only works when the person is not wearing mask. This problem will be discussed in Section

There is also a “SOLVE” button in the case detail page. If the suspected fever person is found and the case is solved, the airport staff can press the button the solve the case and the number of unsolved case will reduce by 1.

4.2.9 Implementation of face recognition

In this face recognition part, I have implemented Azure Face API such that our project is able to identify the same face identification, which means detecting the same face from the same person.

Azure Face API is a face service from Microsoft Face API and it detects, recognises and analyses human face from the images by using the artificial intelligence and cloud based face algorithm.

I have done a test by downloading a dataset which contains 87 photos from 5 celebrities for comparison. From the result of the dataset testing, an accuracy with more than 0.8 is obtained.

Indeed, there are other related libraries which can also be used for face recognition. For example, OpenFace, the initial toolkit eligible for face detection and the pre-trained deep neural network, and the Python face recognition library, face_recognition. However, these two tools are only suitable for uncovered face. When a face with accessories, such as mask and sunglasses, no result can be made because of the failure of detecting and location human face.

Therefore, comparing with OpenFace and the Python face_recognition , Azure Face API is used for the face recognition part in our project because it can achieve the accuracy with more than 80% while the other two fail to achieve this result with high accuracy.

4.2.10 Remove Duplication

Doubling counting was one of the challenges I encountered in the project. Given that the robot patrolled along the same path repeatedly, the same faces were captured multiple times at the same moment. It greatly harm the notification function. In my design, once a person with unusually high body temperature appears in the sensible area of the camera, a normal photo, photo with face detected and photo with thermal diagram will be captured and saved. This is a new case known and added to database.

Currently, the duplicated or similar cases can be removed. When two similar cases are captured are the same time in identical environment with similar results, the second case will be removed in order to prevent duplication. The technique behind is by checking the similar of the photos and the time of the photos captured. This achievement can eliminate the problem of double counting.

CHAPTER FIVE:

CONCLUSIONS AND FUTURE WORKS

COVID-19 continues to rage around the world, temperature checking becomes an indispensable element in our daily life. The target of our project is to implement a thermal camera on the indoor patrol robot which is provided by HKIA to improve current body temperature checking method with higher up-to-date accuracy and alleviate labour force. Assuming that this project will eventually succeed, the patrol robot will be adopted by HKAA and used in HKIA to safeguard the public health.

5.1 Challenges during the project

5.1.1 Technical problem

A technical problem was discovered from patrol robot Mark 2. Robot Mark 2 could not be controlled with the joystick and it could not move with the instructions simultaneity even it was controlled by the navigation software. Robot Mark 2 would stop suddenly with any reason and back to normal after a while. Therefore, on the 30th December 2020, an engineer came for fixation and Mark 2 was sent back for further checking and repairing.

5.1.2 Barrier sensor problem

There is a challenge to guarantee that the robot can patrol steadily through the assigned path without triggering the barrier sensor system even though the robot is able to pass through the aisle.

The barrier sensor of the robot is set and fixed with a width of 1.2 meters. Even though the robot is narrow enough to pass through the aisle from the assigned path, the barrier alert is still triggered and the robot stops its motion with red lights until the obstacle disappear (Figure). In the Innovation Wing, the aisle in zone 1, between the first table and the wall is wide enough for the robot to pass but it is less than 1.2 meters. Hence, the robot cannot travel through that point. Although some arrangement can be made, for example, move away the table to leave a wider road, it is not the result that I prefer because the problem of barrier sensor should be solved instead of removing the obstacles. Therefore, the problem of robot misunderstanding is a challenge in this project.

Figure 5.1: Barrier alert is triggered with red lights

5.1.3 Face recognition with mask

Face recognition with mask is an extra task implemented in this project. Unfortunately, this task cannot be done because the library does not support this function.

As stated in Section 4.2.9, I have tried OpenFace, Python face_recognition library and Azure Face API to test for the face recognition with mask. However, none of them can perform face detection in dataset when masks are put on, as a result, it is able to compare the similar of two faces with masks.

For the test result of OpenFace, only 1066 faces can be detected out of 2466 photos of faces with mask with known identity. This statistic shows that the result cannot even pass 50%. Python face_recognition and Azure Face API cannot apply face recognition with mask, but only mask detection, which is detecting a person with mask on or not.

5.2 Challenges remained after the project

In terms of technical constraints, the face identification with mask putting cannot be located. Even I have tried several libraries from OpenFace, Python and Azure, none of them can capture the face with mask. This problem hinders the idea of detecting face in the current situation of COVID-19.

5.2.1 Future plans

At this stage, I am facing the challenge of face detection with masks aforementioned in Section 5.1.3. The face with accessories cannot be detected or located by the libraries in all means.

In the following, I would suggest two extra applications that can be applied in this project. Firstly, a life streaming of detection can be done such that once there is suspected case found, the staff from the HKIA can immediately identify the face of that specific visitors. Message Queuing Telemetry Transport (MQTT) and Real Time Streaming Protocol (RTSP) can be applied in this field. Secondly, a mobile application can additionally be developed from a web application. A display similar to the web portal shows in Figure 4.8 and Figure 4.9 will first be deployed as web application. Then, a mobile application with similar display is made for the staff. With this mobile app, the staff can get the information of the cases in a more convenient way instantly.

CHAPTER SIX: CONCLUSION

COVID-19 continues to rage around the world, temperature checking becomes an indispensable element in our daily life. The target of our project is to implement a thermal camera on the indoor patrol robot which is provided by HKIA to improve current body temperature checking method with higher up-to-date accuracy and alleviate labour force. Assuming that this project will eventually succeed, the patrol robot will be adopted by HKAA and used in HKIA to safeguard the public health.

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