IJACSSEJournal- International Journal of Advanced Computer Systems and Software Engineering

E-ISSN: 2716-5256 online

FACE MASK AND CONTACTLESS TEMPERATURE DETECTOR

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ARTICLE HISTORY
Received: 10 June 2021
Accepted: 20 July 2021
Published Online: 31 July 2021

KEYWORDS
COVID-19
face mask and temperature detector
contactless temperature detector

ABSTRACT

The World Health Organization has declared that COVID-19 is a pandemic (2020). The pathogenesis of COVID-19 is still unclear at this time, but because COVID-19 is similar to other coronaviruses and respiratory diseases it indicates that the disease can spread through large respiratory droplets and direct or indirect contact with infected secretions. Wearing a face mask is mandatory in Malaysia when a person is in a public place to curb the spread of this disease. However, researchers are aware that there will be problems in complying with the guidelines of wearing face masks among users of library of Seberang Perai Polytechnic (PSP). Therefore, to overcome this problem, the researchers have developed a project that involves setting Face Mask and Temperature (FMT) Detector. The research methodology includes the use of components integration between webcams, contactless temperature sensor MLX90614, Raspberry Pi 3B, character LCD display, piezo buzzer and Python programming language to provide a detector based on Agile models. Originally designed to detect and display temperature readings of those entering the library, to remind those who may have forgotten to wear face masks while entering the library to wear face masks by displaying an indicator mark on the LCD screen and sounding the alarm. It will also warn those whose temperature exceeds 37.5℃ with a buzzer sound as a warning. This is meant for low-cost self-check devices, which means it can be placed in strategic locations and users need to self-scan scan their faces facing the detector as is the case in most places nowadays. But the difference is, if there is no face mask, the detector will not show the temperature unless the alarm sounds and 'facemask = X' will be displayed on the screen. In the future, this device can be widely used commercially everywhere at a more economical cost.

1.0 INTRODUCTION

According to Merriam-Webster (2020), a pandemic is an outbreak of a disease that occurs over a wide geographic area and and typically affects a significant proportion of the population. A global coordinated effort is needed to stop the further spread of the virus. According to the data obtained from Worldometers (2020), a website that reports daily status of the COVID-19 situation worldwide, the disease has infected nearly 23 million people and caused the death of nearly 790,000 people from December 2019 to August 2020. COVID-19 has also impacted the global economy and increased worldwide unemployment. So, to save lives and to prevent the global economy from getting worse, we need to prevent COVID-19 from spreading by taking precautionary measures. When those who are infected cough or sneeze, the droplets coming out from their cough or sneezing becomes the contagion of the disease and infects others who may inhale the droplets or touch surfaces that the droplets had settled on.

People are being asked to practice social and physical distancing of keeping at least 1 meter away from each other and to avoid crowded places to avoid getting infected. To fight the rising number of cases in Malaysia, the government has mandated the wearing of face masks in all public places and taking temperature reading before entering any public area. Preventing people who have common symptoms of COVID-19 such as fever, cough, shortness of breath from entering public places could reduce the infection from spreading. According to Dr. Jamilah Abdullah (2012), normal body temperature is between 36.5ºC-37.5ºC. Above this is fever. Indicating a viral or bacterial infection. In this situation the less physical contact with others, the better for our safety (Abdullah et al, 2017).

Therefore, the researchers put forward the idea to build an innovative product that can measure body temperature by using a contactless detector integrated with a detector that can detect the wearing of a face mask (FMT detector). The main reason for choosing to develop this innovative product was to take simple steps in controlling the COVID-19 pandemic that could easily spread in public places. Through the use of innovative products can ensure that students and staff of PSP are generally in a safe state while on campus and in the library in particular where there will be a lot of interaction and congestion between students in confined spaces. If students do not wear face masks and experience symptoms of fever with abnormal body temperature, they can spread the disease easily to others. Therefore, with the availability of a detector, this device can be used to detect abnormal body temperature readings of 37.5℃ and above, as well as detect whether a person is wearing a face mask or not before visitors enter the library. This is a simple measure that can control the spread of COVID-19 among students, staff and polytechnic visitors who are experiencing symptoms. If a person forgets to wear a face mask, he can continue to wear it and if a person finds out that he has a fever through a reading from the detector, then he can continue to see a doctor for immediate treatment.

2.0 METHODOLOGY

According to Sacolick (2020) SDLC or the Software Development Life Cycle is a process that produces software with the highest quality and lowest cost in the shortest time possible. It provides a well-structured flow of phases that helps organizations to quickly produce high-quality software which is well tested and ready for use. Agile model was chosen to implement in SDLC process which anticipates change and allows for much more flexibility than traditional methods. Clients can make small objective changes without huge amendments to the budget or schedule. This method saves the client money and time because the client tests and approves the product at each step of development. If there are any problems faced, then changes can be made during production cycles to fix the issue. There are several phases in the agile model which we will be using which are planning, analysis, design, implementation, testing, and maintenance. In this section, each phase will be discussed in detail.

2.1 Planning phase

In the planning phase, the need for FMT detectors was identified and discussed with stakeholders who is a PSP's librarian on the problem of no screening device being able to control the inward movement of students who do not wear masks and may have symptoms such as fever to the library. Objective setting is also set to ensure the achievement of goals when the product has been completed. The FMT detector will help us achieve the following objectives:

i. To detect and display the temperature reading of those entering the library.
ii. To track and remind students, staff and visitors entering the library area to wear face masks by displaying an indicator mark on the screen.
iii. To alert students, staff and visitor whose temperature are 37.5℃ and above or no face mask is detected by displaying an indicator mark on the screen together with buzzer sound as a warning.

In addition, the planning phase also involves setting the scope of the project where the innovation product developed is a self -examination detector tool for the use of students, staff and visitors of the PSP library. The project will use a webcam, MLX 90614 contactless temperature sensor, Raspberry Pi 3B board, character LCD display, piezo buzzer and powered by USB Power Brick. If the user is accessing the Raspberry Pi remotely, a device compatible with VNC Viewer and VNC is required (PC, laptop, Smartphone). The MLX 90614 contactless temperature sensor is used to read the body temperature of the scanned visitor's face. The temperature reading will be shown on the screen display along with a tick sign (/) for permission to enter the library while a cross sign (X) for not allowing visitor to enter if the temperature reading is above normal level with a warning sound turned on from the buzzer. At the same time, the webcam will scan the face to detect the wearing of a face mask on the visitor's face. The same information will be displayed on the screen display with a tick sign (/) for entry permission, and a cross sign (X) for not allowing visitor to enter if no face mask is detected or imperfect face mask wear also along with the warning sound turned on from the buzzer.

2.2 Analysis phase

In the analysis phase, the research was carried out based on project requirements. The need software, hardware requirements, and the programming language to be used is determined. Observations were made around the study area which is PSP's library to identify the cause of the problem. The results of interviews conducted with librarians were also analyzed to determine the requirements and project specifications demanded by stakeholders. Consequently, researchers have identified the features needed in the development of this innovative project by creating a facial recognition system that can be used to identify whether a person is wearing a face mask or not, and a contactless thermal sensor to identify symptoms such as fever without close contact with anyone. These two features need to be combined to be an easy-to-carry face mask detection and body temperature detection tool, which is small enough to be strategically placed and used in small areas, then it will be a life saver especially in places frequented by people from a variety of backgrounds. It needs to come with easy operation by simply recharging the power bank on a daily basis and can be used by stakeholders without additional power resources to manage it.

According to Pyrosales (2020), thermal sensors and infrared sensors are the most common types of non -contact temperature sensors, and are used in the following situations: when the target object is moving (such as on a conveyor belt or in a moving machine), if the distance is very long if there is a hazardous (such as high voltage) or at very high temperatures where the contact sensor is unable to function properly. Whereas according to V. Nguyen, Nicole J. Cohen et al (2010), infrared thermal detection system (ITDS) offers a potentially useful alternative to contact thermometry and this technology is used for fever screening in hospitals, airports, and other mass transit points during severe acute respiratory syndrome and the 2009 influenza A (H1N1) pandemic. Thus, contactless thermal detectors are safer to use to detect a person's temperature when the condition is horrible and dangerous. Based on the statement by Symanovich (2020), face recognition is a way of recognizing human faces through technology. Face recognition systems use biometrics to map facial features from images or videos. It compares information with a known database of faces to find matches. To recognize a face, the camera must be able to identify features found on a human face such as a pair of eyes, nose, and mouth and lock the face using an algorithm. But it should be remembered that face recognition is not face recognition, it is just face search software, according to Heinzman (2019). To prevent breaches of personal biometric data, FMT detectors will not identify faces, but will only detect the wearing of a face mask on a visitor's face. This is in line with Pascu's (2020) statement where biometric companies around the world are working to release advanced solutions to identify people wearing masks, to introduce contactless technology to ensure environmental safety and to develop fever detectors to aid containment efforts global. This facial recognition technology is available through examples of open source or closed source software such as OpenCV (Open Computer Vision), YOLO (You Only See Once), and others. The results of the analysis from the study of the existing system are also obtained and compared with the project proposal system to be developed. The following is a table that compares the proposed project with the existing project:

Table 1. Comparison proposed project with existing projects.

Parameter	**FMT Detector**	**ACFT-3516DS327C (HUPUU, 2020)**	**MS1110FT (TeleEye, 2020)**
Source Code of the system	Open Source (mostly build from python)	Close Source	Close Source
Power intake	5V/2.5A	DC 12V/3A	12W
Multi Language	English only (for current time being)	Support	Support
Temperature Range	70 ~ 125°C	30 ~ 45°C	0 ~ 50°C
Internet Interface	- RJ45 100Mbps Ethernet - Got wireless option	- RJ45 100Mbps Ethernet - No wireless	- RJ45 100Mbps - Built-in WIFI module
Facial Recognition	Just detect either wearing face mask or not	- Can save up to 100,000 facial recognition records - Support 22400 face comparison library	Face Database up to 20,000
System OS	Raspberry Pi OS	Not mentioned	Not mentioned
Camera	5 Mega Pixel	2 Mega Pixel	2 MP Dual Lens
Advantage	- Fully Open Source - Consume less power - Portable as long got power bank with micro-USB - Connect to Raspberry Pi - Real time warning with buzzer to alert the user - Can put it anywhere	- Just Plug and Play - Multi Language support - Save up to 100,000 facial recognition record - Higher temperature accuracy - Automatic register and record information - Real time warning	- Just Plug and Play - Face Database up to 20,000 - Support tampered alarm - Over Heat Warning and alarm I/O
Disadvantage	- Doesn't automatic register and record information	- Expensive - Cannot put this project 3m near source of heat	Expensive

2.3 *Design phase*

The requirements specifications from the first phase and the second phase that have been studied are translated in this phase by providing the system design. This phase begins with the requirements document submitted by the requirements phase and maps the requirements into the design. System design assists in determining the overall hardware and system requirements to help the project team and stakeholders get a clear picture of the product that has been set before the implementation phase begins. The design made determines the components, interface and features of the device. This phase involves the design of a flow chart that describes the entire work process involved in the use of the device, refer to Figure 1. In addition, the physical design of the detector, refer to Figure 2 is also made to show how it will look. The administrator interface design of the system is also made along with floor plan sketches to explain the position in which the tool will be installed.

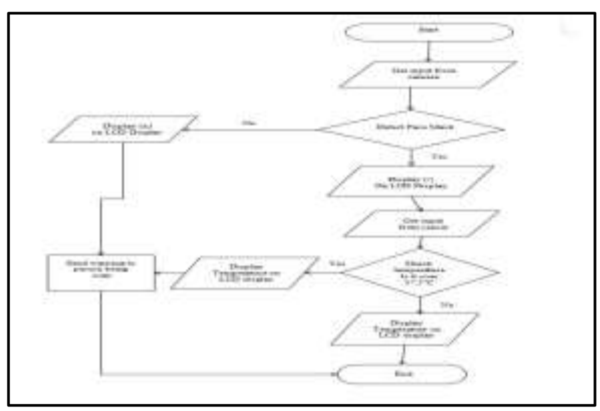

Figure 1. Flow chart

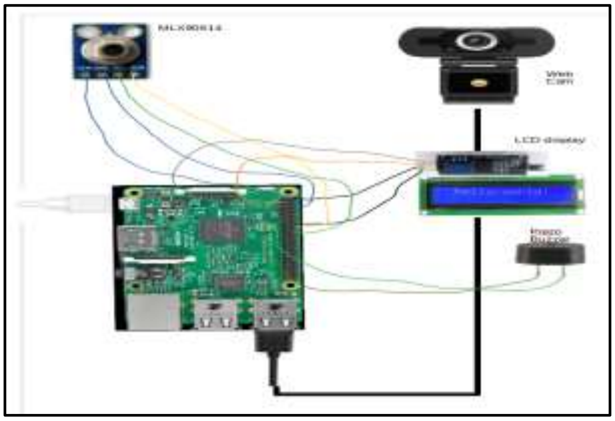

Figure 2. Detector Schematic Design

2.4 Implementation phase

In the implementation phase, programming code involving the Python programming language is generated to achieve the set objectives. This is the longest phase of the software development life cycle. Once the code is developed, the code is then used to ensure it works well and can meet the needs of stakeholders. Programming involves the development and application of detectors by providing hardware components and complementing their functions by integration with programming code. Software configuration for FMT detectors uses Phyton which is a high-level programming language found in almost all operating systems. Python has a lib for the MLX90614 thermal sensor. The reason Python was chosen over C# or C++ is because larger references are available than other programming languages that can be used for this project. Also, OpenCV is compatible with Python, therefore, we can find many examples of the use of OpenCV using Python. In addition to Phyton, VNC is used to remotely access the Raspberry Pi. A VNC client (or viewer) is a program that represents screen data originating from a server, receives updates from it, and may handle it by notifying the server about local input being collected. Because the Raspbian OS comes with a VNC server, users can communicate via a Raspberry Pi IP address.

The component used for a face mask scanner is a webcam that scans and reports the presence or absence of face mask wear or not on the person’s face. The MLX 90614 contactless temperature sensor is used to read the visitor's temperature at the same time as the face scan is made. The LCD display is connected to a webcam and a contactless thermal sensor via a Raspberry Pi to display information on the compliance status and temperature of the face mask by displaying ‘facemask = /’, while if the visitor is not compliant it will display ‘facemask = X’ and warn users, refer to Figure 4.

After detecting the face mask, the detector will then measure the visitor’s body temperature. If the body temperature exceeds the normal reading level of 37.5℃ and above, it will show the temperature on the LCD display and warn the user, refer to Figure 5. Whereas if the temperature is normal, lower than 37.5℃, it will show the temperature on the LCD display and visitors are allowed to enter the library. In addition, the buzzer installation is also connected to a webcam and a contactless thermal sensor via the Raspberry Pi to complete the detector function. The loudspeaker is programmed to sound the alarm whenever there is a non-compliant visitor. without a face mask and the body temperature reading exceeds the normal reading. If the face mask is not detected after the detector has finished scanning, the FMT detector will emit a buzz sound from the buzzer together with the sign on the LCD display. Then after the detection of the face mask, it began to measure the temperature. If the user's temperature is higher than 37.5℃, the temperature will display and also emit noise from the buzzer. To meet the desired features, validation is performed repeatedly on hardware components that are integrated with Python program code to alert visitors. Figures 5 shows a part of a Python program coded to display body temperature output and face mask wear detection on an LCD display.

Figure 3. The LCD display shows a visitor did not wear facemask

Figure 4. The LCD display shows a visitor's temperature higher than 37.5℃ and do not wear or wearing an imperfect face mask.

```
if detectfaceM == True:
    mylcd.lcd_display_string("facemask = /",1)
    x = start2()
    #x = start4()
    y = x

    if float(y) <= 37.5:
        print("Temperature ="+y)
        mylcd.lcd_display_string("Temp = "+str(y), 2)
        time.sleep(5.0)
    else:
        print("Temperature ="+y)
        mylcd.lcd_display_string("Temp = "+str(y), 2)
        start3()
        time.sleep(5.0)
elif detectfaceM == False:
    mylcd.lcd_display_string("facemask = X", 1)
    start1()
    time.sleep(5.0)
else:
    mylcd.lcd_display_string("Detect No One" ,1)
    mylcd.lcd_clear()
```

Figure 5. A part of a Python code to detect face mask body temperature

2.5 Testing phase

In the next phase, which is the testing phase, the system is repeatedly tested on it to see the problems that need to be fixed. Several types of testing are conducted to determine whether each component can function properly which involves unit testing, integration testing and user acceptance testing. Each test sets a specific procedure and all results are recorded to facilitate improvement and maintenance in the next phase.

2.6 Maintenance phase

The maintenance phase occurs as soon as the system is operational. This includes the implementation of changes that the software may experience over a period of time, or the implementation of new requirements after the software has been rated. This phase also includes addressing errors that may exist in the software or hardware even after the testing phase also monitors system performance, fixes bugs and requested changes are made. In this phase, the project planning that has been made will be fully implemented by deploying it to the living environment. It is then monitored and checked for possible improvements that can be made for it.

3.0 RESULTS AND DISCUSSION

The result of the development this innovation project involving the detection of face masks and body temperature is to achieve the overall objectives that have been set. The first objective to detect and display the temperature readings of those entering the library is achieved where the LCD display will show the body temperature readings on the screen obtained from the face scanner for visitor information. Then, the second objective of tracking and reminding students, staff and visitors entering the library area to wear face masks by displaying indicator signs on the screen was also achieved. The 'facemask = /' sign will be displayed when the wearing of a perfect face mask is detected. If there are those who do not wear a face mask or wear a face mask incorrectly, the LCD display will show a sign 'facemask = X' as a reminder so that those who forgot can wear a face mask or can wear it properly before entering the library. Furthermore, temperature readings can also be accessed via a connection to a PC monitor or laptop with an HDMI cable with remote access using a VNC viewer. In this way, the project owner, the PSP's library, can see the output on their PC, laptop or mobile phone through a webcam and sensor for temperature readings and the wearing of face masks. Next, the third objective to warn students, staff and visitors whose temperature is 37.5℃ and above or not wearing a face mask by displaying an indicator sign on the screen along with a buzzer sound as a reminder was also achieved. Warnings are given with an 'X' sign display meaning do not allow entry with the sound of the buzzer installed.

The following tables show the results of each test that has been performed including unit testing (Table 2), integration testing (Table 3) between the installed components and finally user acceptance testing (Table 4). All these tests are implemented to ensure that each component functions as specified and in achieving the objectives that have been set.

Table 2. Unit testing results.

No	Test Case Name	Test Procedure	Precondition	Expected Result	Result (Pass/ Fail)
1.	Webcam	Need to place face near to the Webcam	Wear mask	Detect face with mask or not	Pass
2.	MLX90614 temperature sensor	Face needs to be in front of sensor	Wear mask	Detect temperature is normal or high	Pass
3.	LCD Display	Display the result of wear mask or not	None	Output be (/) sign if wear mask and (X) if does not wear mask	Pass
4.	SD Card	Save the memory	None	Data will be stored to SD Card	Pass
5.	Power Brick	Switch on the power to work	None	It will be work once powered on	Pass
6.	Buzzer	Alert with sound if didn't wear mask	None	It will work once it detects face without mask or high temperature	Pass
7.	VNC remote access	Allow to remotely access detector	VNC installed on device used for remote access	Allow to remotely access the FMT detector	Pass

Table 3. Integration testing result.

No	Test Case Name	Test Procedure	Precondition	Expected Result	Result (Pass/ Fail)
1.	Detection of Face Mask	Detect user got wear facemask	Face needs to be in front of webcam and don't get too close to webcam	Display 'face mask = /' on LCD display and the frame show border box is green on remote access	Pass
2.	Detection of Face Mask	Detect user didn't wear facemask	Face needs to be in front of webcam and don't get too close to webcam	Display 'face mask = X' on LCD display and show border box	Pass

				is red on remote access and buzzer goes off	
3.	Detection of temperature	Detect user temperature is normal	Face needs to be in front of sensor	Show temperature of user on LCD and remote access	Pass
4.	Detection of temperature	Detect abnormal temperature	Face needs to be in front of sensor	Show temperature on LCD and remote access	Pass

Table 4. User acceptance testing result.

No.	Test Case Name	Acceptance Requirement	Result (Pass/ Fail)	Tester	Comments
1.	Detection of Face Mask (did not wear face mask)	Show (X) on LCD screen	Pass	- Visitors - Librarian - Developer	Good
2.	Detection of Face Mask (wear face mask)	Show (/) on LCD screen	Pass	- Visitors - Librarian - Developer	Good
3.	Detection of temperature (abnormal)	Show temperature and have buzzing sound	Pass	- Visitors - Librarian - Developer	Need to test repeatedly to get different temperature readings
4.	Detection of temperature (normal)	Show temperature	Pass	- Visitors - Librarian - Developer	Good

One of the FMT detector feature is that it can detect whether someone is wearing a face mask or not. This is made possible by OpenCV and TensorFlow. It scans by using a webcam connected to the Raspberry Pi via USB. The FMT scans the face to see if it can detect a nose, a mouth, the ears and the eyes. If it detects the nose and mouth, then it displays that the person is not wearing a mask. If the does not detect that the person's mouth and nose, then it displays that the person is wearing a mask. The results will be displayed on an LCD display, 'facemask = /' will be displayed if the person is wearing mask, and 'facemask = X' if they are not wearing a mask. An alert will be sounded by a buzzer in the detector also if someone is not wearing a mask. On the administrator side, the result of someone not wearing a mask will be displayed on the interface. The other feature of the FMT detector is that it can scan someone's temperature. This is done by the use of a MXL90614 non-contact IR temperature sensor which is connected to the Raspberry Pi via GPIO headers. The FMT detector is programmed in a way that only after it detects that the person is wearing a facemask, that the temperature will be scanned. This is to make sure that the person is wearing a mask. Once it detects the mask, it scans for the temperature which then both facemask and temperature detection results are displayed on the LCD screen. The temperature reading will be displayed as so Temp = (X). If the temperature is 37.5℃ and above, then an alert sound will go on. The temperature reading will also be shown in the administrator's interface, the librarian.

Finally, through the use of FMT detector, it can reduce the rate of infection from spreading faster in which control of movement of students, staff and visitors can be made by the librarian with the view from tracking cameras without placing guards at the library entrance to check the body temperature and monitor the use of face masks.

However, there are identified limitations to the developed project where the first limitation is the high latency between the webcam and the Raspberry Pi. The high latency between the webcam and the Raspberry Pi is due to the USB interface. Next is temperature result glitch out. What is meant here is a sensor because it is separated I2C bus for LCD screen and the temperature, instead of using 1 default I2C bus with multiple of slave device. So, sometimes it will glitch out with 1K℃. Lastly, the limitation of this project is that when the user is too close to the webcam, it will cause the program to malfunction. The reason it happens is that the webcam captures too many pixels and the Raspberry Pi CPU can't handle the load that caused it to crash.

4.0 CONCLUSION

The FMT detector developed for this project uses a low-cost equipment equipped with a webcam, thermal sensor and Raspberry Pi 3B which is expected to be easily used in helping to deal with the current COVID-19 situation especially in monitoring body temperature and the use of face masks. This detector was developed as one of the initiatives taken to assist PSP management in general and librarians in particular in providing a detector that can control the spread of the virus among students and staff. At an increasing rate of infection in an extraordinary number where it can cause, then it is very important that everyone follows the rules of mandatory mask wearing in all public places, especially in enclosed areas such as libraries. Students, staff and visitors who come in contact with outsiders can infect themselves and spread the virus to their friends and colleagues at the polytechnic. This small step can curb the spread of the virus where the use of which is installed at the entrance can ensure that everyone is wearing a face mask and they know their current body temperature. At the same time, this is also an opportunity for the developer to further increase of knowledge in using the available hardware and software to develop and program IoT (Internet of Things) equipment from scratch, and it provides a very lucrative opportunity for future preparation (Hamdi et al, 2021), (Alghamdi et al, 2021). Proposed future improvements for project quality improvement are where the use of more powerful devices such as high-spec laptops or PC and Raspberry Pi 4 to reduce coding time. Also, it is recommended to use the camera interface that is the Camera Serial Interface (CSI) for less latency to get camera input. Besides that. improving one's knowledge of the GUI interface will also be very helpful in this project. Finally, use an Ethernet jack for stable LAN remote access into the project. For future projects, the FMT detector can be applied together with an app for use in public vehicles or can also be in houses and cars so that everyone can be reminded to wear a face mask and alert with their body temperature before going out in public.

Acknowledgement

Here we would like to acknowledge assistance, loyalty, sacrifice of time and financial support from the members of the project team who have equally contributed in making this project a success. Apart from that, not to be forgotten is the Department of Information and Communication Technology, Seberang Perai Polytechnic in providing moral support in making this project a success. Therefore, appreciation is also given to the library management, especially the librarians who assisted the project team in identifying the project requirements and the permissions granted for the projects that had been completed in their place. Lastly, to the whole family who are the back bone and always provide support from the beginning until the project is completed. Thank you all.

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