Face Mask Wear Detection by using Facial Recognition System for Entrance Authorization

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***Abstract*—A Face Mask Wear Detection Device for Entrance Authorization is designed to ensure that everyone wears a face mask at all times in a confined space. It is one of the easiest methods to lower the rate of coronavirus infection and hence save lives. Asthma, high blood pressure, heart failure, and many other chronic conditions can be fatal to those who are infected by the novel Coronavirus (nCoV-21). Consequently, the goal of this research is for face mask wear detection devices that help to reduce the rate of Novel Coronavirus infection on-premises or in public places by ensuring that customers comply with Standard Handling Procedures (SOP) set by the Ministry of Malaysian Health (MOH). Customers' faces are recognized by this device whether or not they are covered by a face mask upon entry into a facility. Additionally, the use of this device can contribute to ensuring compliance with the maximum number of customers allowed on the premises. A facial recognition system is the goal of this study that uses technology designed as an individual disciplinary aid and follows the safety procedure at this critical time. This research was developed using the engineering design process development model which has four phases namely; identifying the problem, making possible solutions, prototype development and testing and evaluating the solution. Results indicate that the developed product can function effectively. Experts have discovered that using this product helps people stick to their face mask routines. The design of this product has improved, which means that the overall quality of the product is elevated to be capable of performing as intended in terms of intelligent technologies.**

Keywords*—Face recognition; face detection; face mask; coronavirus; intelligent system

I. Introduction

COVID-19 is the group of viruses that infect humans through inhalation and contact to the point of death which is transmitted by the SARS-CoV-2 virus, which is a new type of virus from Novel Coronavirus (2021-nCoV). This can lead to lung injury (ALI) and respiratory distress syndrome (ARDS) which affects lung failure and results in death [1]. The current COVID-19 pandemic caused by the novel SARS-CoV-2 Coronavirus (2021-nCoV), first detected in late 2019 in Wuhan province, China, has spread rapidly worldwide and has infected more than 10 million individuals on 29 Jun 2020 [2].

Standard Operating Procedures (SOP) are work instructions and detailed guidelines for work that are documented in writing by the responsible party. SOPs detail the repetitive work processes that will be carried out or followed in the organization. They keep a record of how activities are carried out to support and facilitate quality data as well as consistent compliance with technical and quality device requirements [3]. The development and application of SOPs are an essential part of a successful quality device since it provides information to individuals performing tasks effectively, and facilitates consistency in the quality and integrity of the product or result.

Face masks are made of fabric that works to prevent germs from entering the human body through respiration. Face masks are respiratory protection used as a way to protect individuals from inhaling harmful substances or contaminants in the air. Respiratory protection or face masks are not intended to replace the preferred method of eliminating disease but are used to adequately protect the wearer [4]. However, hygiene is a widely accepted method of preventing the spread of disease infection. Washing hands with soap have been recommended as a primary and cost-effective preventative measure to prevent bacterial infections that cause influenza-related respiratory illnesses [5].

The National Health Council (NSC) issued Standard Operating Procedures (SOP) to ensure the reduction of Novel Coronavirus (2021-nCoV) infections among Malaysians are still not fully complied with. The National Security Council (NSC) in Malaysia still has a few citizens who don't abide by the NSC's SOPs. It is necessary to conduct surveillance at all building entrances to address this issue. However, a large number of people will be affected by this change. The current staff is unable to monitor and care for all of the areas that the public uses.

Consequently, this study is intended for customers who enter a business. The purposes of this study, which focus on three key areas, are as follows:

- Design a face mask wear detection device.
- Develop a face mask wear detection device.
- Test the functionality of this device designed to detect faces and to determine whether the customer is wearing a face mask properly or not.

Artificial Intelligence (AI) must be utilized to simplify efforts to halt the spread of the COVID-19 virus and find solutions to all of the challenging detection issues outlined above.

II. Related Work

Facial recognition is a technology that is becoming increasingly prevalent today. Images taken with this technology can be compared to a database of reference images. In addition, pattern recognition is an important aspect of the field. Automatic Teller Machines (ATMs), e-banking systems like Maybank2u and CIMB Click, and computer logins for security gates and computer networks are just a few instances of security systems that rely solely on pass numbers. Unauthorized individuals who come into possession of this route number will be able to use it in place of the original owner. However, one's face is inalienable as one's own. In this way, the current security system can be enhanced by utilizing facial recognition technology. As stated by Lee, H.S et al., if the facial image recognition path number is compromised, it will constitute the best security feature [6].

According to Yaaseen, M. S. et.al, facial recognition is the most difficult aspect of picture analysis since it involves the human body [7]. Facial recognition is a problem of pattern recognition, and its primary goal is to identify reasoning from facial expressions that are not fixed. Since the 1980s, facial recognition has been a widely discussed topic aimed at solving several practical problems. Face recognition uses biometric methods, which is a distinguishable and quantifiable characteristic that is used to label and describe specific individuals to identify personalities primarily by their faces.

It is shown in Fig. 1, how the basic structure of face recognition works in its simplest form. The facial features are captured and stored in a database during the first stage. It is performed in the extraction stage to find or remove specific facial features. The database will be evaluated by comparing it to previously captured facial features for reference. A comparison is made between the features that were captured and the features that were registered in the database based on the extraction and process reference [8]. According to previous studies, several conclude that there are numerous facial recognition techniques, including:

A. Holistic Matching Method

Sereen et al. [9] used this method to make a match when the captured facial features are crooked or the facial expressions don't match the database system. This method has unique characteristics, such as pattern points. The difference between the distances between the two eyes will aid in distinguishing the various facial angles of each individual. This method makes use of 2D technology to aid the expertise.

B. Feature-Based Method

Shen Li et al. [10] discussed this type of feature-based recognition which is an improvement on previous methods of recognition technology. Features detected on 2D images use geometric classification and facial structure in terms of points, lines or areas. The data obtained from those features are converted to mathematical data.

Fig. 1. Basic Structure of Face Recognition.

C. Hybrid Method

HiviIsmat Dino et al. [11] designed a system using the holistic matching method and the feature-based method, this hybrid method employs 3D technology. The hybrid model is the result of the advancement of the previous two methods, with the exception that it uses more accurate and sophisticated recognition. This type of hybrid recognizes more features on the face known as facial node points and identifies the face more deeply.

D. Skin Texture Analysis Method

Shepley developed a Skin Texture System Analysis using facial recognition technique by converting unique lines, patterns, and spots visible on an individual's skin translated into mathematical space. Therefore, skin texture analysis is more sophisticated compared to the Hybrid type [12].

E. Thermal Cameras Method

Arthur et al. [13] proposed thermal face verification to recognize faces using thermal cameras, which is a more advanced face recognition method. As shown in Fig. 2, this technique measures the rate at which heat is emitted from individuals or other sources of heat. The object's heat output determines the image that is produced.

Fig. 2. Camera Thermal.

A number of previous studies employing various face recognition-related technologies have been identified in the Table I. Nonetheless, the study has provided suggestions for improving this system. Among previous research are shown in the following tables [14]-[16].

Table II depicts the commercially available products that are relevant to this study. An overview and theoretical description of the face mask wear detection device for determining whether a person can enter a building has been presented in this review. The researcher can use this literature review to identify the hardware, equipment, and software required to continue the study.

TABLE I. REFERENCES LIST PREVIOUS RESEARCH

No	Innovation System		
	Author	***Product Name***	***Description***
1	Hung-Che June 30, 2020	Facemask ATM and Reminder	• The ATM and Reminder Facemask was developed to discipline each individual to wear a face mask when leaving the house and premises. • The method used is Motion Sensor and Piezo Buzzer, it works to detect the user's movement when crossing the device while the Piezo Buzzer will buzz very loudly. • The ultrasonic sensor works to calculate the number of face masks in the device. • Furthermore, the LCD serves to display the number of face masks. Finally, it uses the Arduino Uno in this research.
2	Julian-grodzicky Dec 1, 2018	Face Tracking and Recognition using Matlab	• Face Tracking and Recognition using Matlab and Arduino is a study of various image preparation procedures to better extract half of the face and upgrade RGB images to GRAY. • Customization of channel combinations for Find Neighbor extraction via a pre-adjusted interface. • With this technique, the use of these coordinated channels can be analyzed and thus guarantee facial recognition
3	Khanday & Bashir, 2018	Face Recognition Techniques: Critical Review	• This article discusses the study of the types of face recognition and the challenges of how to improve the efficiency and rate of recognition for face identification in large databases. • Then, it is compared with the accuracy or rate of recognition. This study stated • The advantage of using the biometric artificial intelligence (AI) method is easier when compared to the biometric method which requires special help from people for authentication. • This biometric artificial intelligence (AI) has challenges in recognizing faces in moving face conditions, twin poses variations and good lighting conditions for face recognition to be made.

TABLE II. CURRENT PRODUCT IN THE MARKET

No	In-Market		
	Product Image	***Product Name***	***Description of product***
1		Barth People Counter PC-10	-The maximum limit of people can be set easily via Touch Display -High-quality aluminium stele with stainless steel base -Fast and easy setup in less than 5 minutes shortcomings: • Need large and heavy space • Affordable cost (~RM 7,497.95)
2	 	Face recognition system	-Supports face mask detection -Record staff entry and exit times -Record both staff and visitor records -Supports door/door access control protocol shortcomings: • Cannot limit the number of customers • Cost is quite expensive (~ RM3,500.00)
3		Automatic infrared heat scanner	-Shorter filtering period shortcomings: • Cannot limit the number of customers. • No automatic doors. • Price in the range of RM8,000.00

III. METHODOLOGY

The methodology section describes all the necessary information that is required to obtain the results of the study. Six work steps need to be done by the researcher to develop a Face Mask Wear detection Device. There are four phases underway to develop a face mask wear detection device for entry into the premises. Phase 1: Determining the Problem and Background of the research, Phase 2: Making Solutions Possible, Phase 3: Prototype Development and Phase 4: Test and evaluate the solution.

A. Research Design

Problem analysis is the initial phase of the study conducted to identify problems that arise and set the direction of product development as well as identify the function of the product to be developed. At this stage, the objectives and goals of the study are determined based on the problem factors that exist. This determination is made to ensure that the development process is carried out following the objectives and purposes of the study and is used as a guide throughout the development period.

Furthermore, suggest solutions to problems encountered. Problem-solving in the study conducted is a step taken to propose appropriate solutions and methods to be applied throughout the development process done by developing or proposing some solutions that are capable of overcoming the problems encountered.

Data collection has been done for customers that follow SOPs when entering premises. Based on the data, most of the customers failed to wear mask properly when entering a premise. This also violates the limit of customers on a premise. Thus, the customer's failure to comply with SOPs during the endemic is the problem statement for this research.

The selection of this problem-solving method consists of several factors that influence the development process of the Face Mask Wear Detection Device by using the Facial Recognition System for Entrance Authorization which consists of the design method, material to be used, required functionality and complexity of the development method. Lastly, create a form of control model capable of solving the problems encountered by developing a prototype.

B. Development Procedure

Engineering Design Process (EDP) is a process for solving problem statements that occur and can be used in almost any situation [17]. The use of this model helps to study and understand the problem and its possible solutions at each step or phase of the research process. EDP is a process that includes steps that can be repeated, although not always in the same sequence but still guided by the objectives of the study. Furthermore, several steps cover several aspects such as planning, designing, testing, and refining the design. This process is often initiated based on clear research objectives and goals and is a journey process aimed at solving problems (National Academy of Engineering, 2020). Based on Fig. 3, six work steps need to be done by the researcher to develop a Face Mask Wear Detection System for Premises Entry Permission. There are four phases carried out to develop the system [18].

The stages of product development that have been completed in the creation of the face mask wear detection system. By adhering to this methodology, the success of product development is made more systematic [19]-[21].

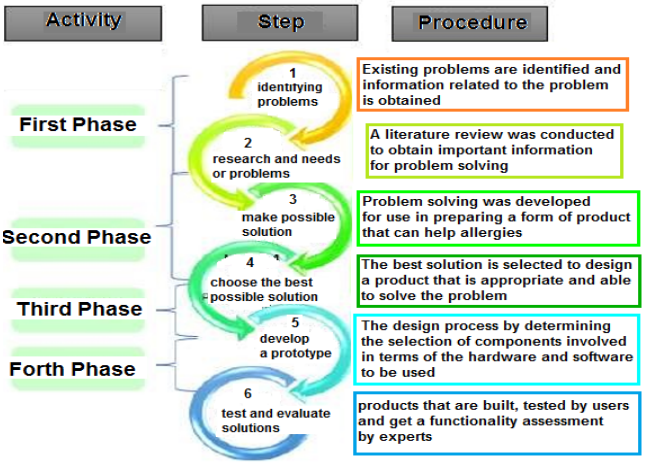

Fig. 3. Phases in Product Development.

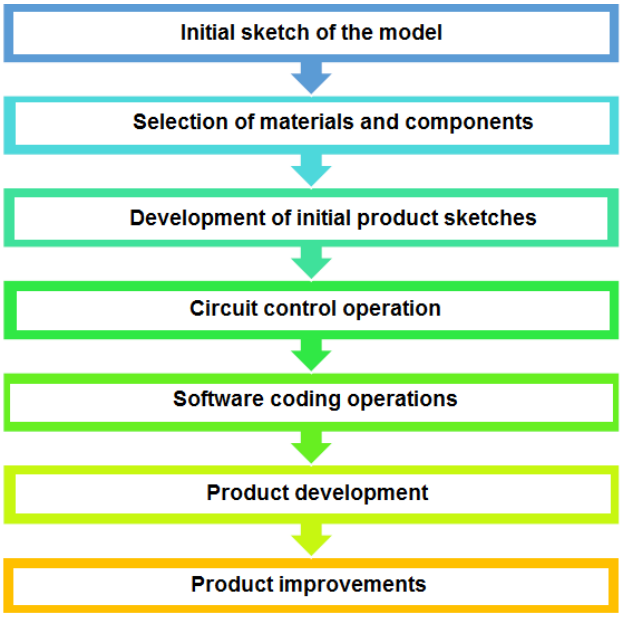

Fig. 4. Product Development Process.

Fig. 4 illustrates the stages of the product development process of the SOP Compliance Testing Device and the Application of Face Mask.

C. Model Development

The model development is influenced by suitability and user-friendliness. It is always used according to the objectives of the study. The design produced must be durable, easy to move, lightweight, affordable and easy to work with users. Therefore, the researcher proposed a model for the use of face mask detection device for entry into the premises based on the suitability and needs of users. Fig. 5 shows a model sketch of a face mask wear detection device for entrance authorization.

D. FaceMack Detection Method

The system will start by tracking the physical distance with the device using an IR sensor. Then proceed with the recognition of the physical face by using the ESP32-CAM module. The client image is detected and matched with the image that is in the user database but if, the distance setting is not reached by the IR sensor, the ESP32-CAM Module is inactive and the LCD will display “Take a step back to re-scan”.

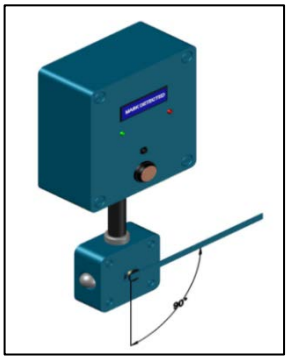

Fig. 5. Model Sketch of A Face Mask Wear Detection Device for Entrance Authorization.

On activation of ESP32 - CAM, it will detect the physical face whether the customer is wearing a face mask or not. The calculation of the percentage of customer face recognition implemented by the ESP32-CAM will be sent to the Arduino Uno for further decision.

If, the percentage is equal to or greater than 99%, the LCD will display "Mask: (percentage)" and "ENTER ALLOWED" and the Servo will rotate 90 degrees clockwise and it will rotate 90 degrees counterclockwise after a few seconds delay. While the percentage is less than 99%, the LCD will display "Mask: (percentage)" and "PLEASE WEAR MASK" as well as the Servo will not rotate. The process is illustrated in Fig. 6.

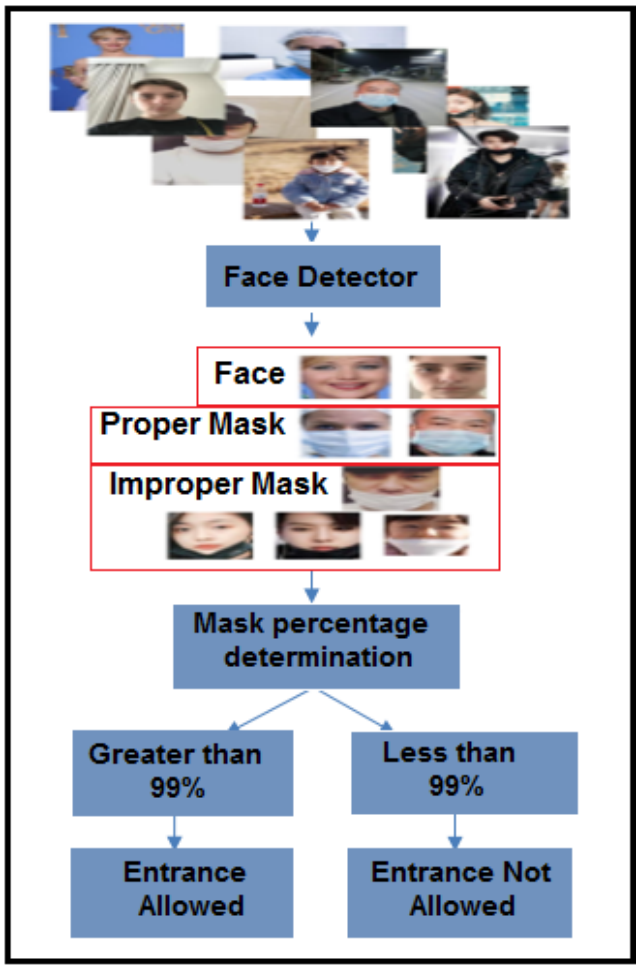

Fig. 6. A Fowchart for Methods Aiming to Identify Wearing Mask Conditions.

IV. Result and Discussion

The face mask wear detection device for entry into the premises has several key components required to complete the entire system and be able to operate properly and effectively. This main component has been conducted a functionality test so that researchers can identify whether it can operate well and under the requirements of the operation.

A. Facial Recognition Functionality Analysis (ESP32-CAM)

In the development of this product, facial recognition technology is utilized to compare database images with captured images. The researcher has devised a testing method that involves measuring the distance between the prototype and the human face to determine the functionality and effectiveness of facial recognition. Setting the test distance scale from 0 cm to 100 cm and measuring the recognition time required to detect the face yielded data from three different angle view which is left, front and right angle view. The data collected was recorded for the front angle view, left angle view and right angle view of the facial recognition effectiveness test in Table III, Table IV, and Table V, respectively.

Based on the collected analytical data, the researcher can identify the distance that must be determined for the system to initiate facial recognition. This is to ensure that face recognition is performed by a single person at a distance from the customer in front of the device. The researcher used an IR sensor to support the system by setting the distance between the customer's face recognition and the distance set by the customer. Fig. 7 shows the IR sensor's detection distance for initiating facial affirmation in the following way.

TABLE III. Left Angle View of Facial Recognition Effectiveness Test

No	Left Angle View		
	Distance (cm)	Detected	Time to detect(s)
1	0	No	-
2	10	No	-
3	20	No	-
4	30	No	-
5	40	Yes	4.0
6	50	Yes	4.5
7	60	Yes	4.3
8	70	Yes	4.0
9	80	No	-
10	90	No	-
11	100	No	-

TABLE IV. Front View of Facial Recognition Effectiveness Test

No	Front View		
	Distance (cm)	Detected	Time to detect(s)
1	0	No	-
2	10	No	-
3	20	Yes	4.2
4	30	Yes	4.0
5	40	Yes	4.1
6	50	Yes	3.6
7	60	Yes	3.6
8	70	Yes	5.4
9	80	No	-
10	90	No	-
11	100	No	-

TABLE V. RIGHT ANGLE VIEW OF FACIAL RECOGNITION EFFECTIVENESS TEST

No	Right Angle View		
	Distance (cm)	Detected	Time to detect(s)
1	0	No	-
2	10	No	-
3	20	No	-
4	30	No	-
5	40	Yes	4.3
6	50	Yes	4.5
7	60	Yes	4.2
8	70	Yes	4.1
9	80	No	-
10	90	No	-
11	100	No	-

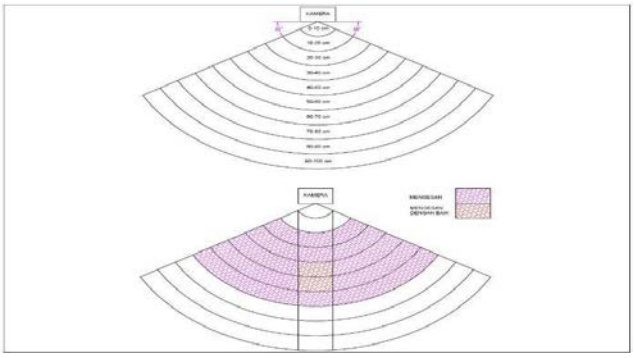

Fig. 7. Operating Face Recognition Area.

Another aspect of facial recognition that requires investigation is the rate of recognition. This is since researchers must examine the percentage of faces detected in clients who wear face masks in a variety of ways. As a result, the researchers created various face mask wear variations and tested the detected face rate to reduce the device's error rate in determining which customers were correctly wearing face masks.

Fig. 8 presents the fact that the consumer is not concealing their face resulting in 80% of displays on the LCD.

Fig. 8. The Device Displays “Please Wear the Mask”.

Fig. 9. The Device Displays “Enter Allowed”.

Since the customer is concealing their identity with a face mask, the LCD has a display rate of 100% as shown in Fig. 9.

Fig. 10. Side View of Customer's Face.

Since the customer is not wearing a face mask, 60% of the displays on the LCD are visible even inside view as shown in Fig. 10. Data analysis is to determine the percentage value of wearing the mask for the proper way of wearing the mask. The images recorded by ESP32-CAM were compared to face shapes in the database and made face detection results. The percentage value of wearing the mask for the prototype to allow the customer to enter the premises is above 98%. The gate was controlled by a servo motor the rotation is 90˚.

Arduino Uno programming is carried out using an Arduino IDE where the Arduino Uno circuit is connected to a face mask wear detector device for premise entry permission and connected to the laptop port using a Universal Serial Port (USB) cable. In this product two components need coding namely ESP32-CAM and also Arduino Uno it is written in C ++ language through the Arduino IDE platform. ESP 32 CAM needs to use CH340G USB to TTL Serial Converter to send code from PC into ESP32-CAM while Arduino Uno only uses USB Printer Cable B Type for Arduino Printing to transfer code from PC to Arduino Uno.

V. CONCLUSION AND FUTURE WORK

The purpose of the face mask wear detection by using a facial recognition system for premise entry permission is to assist customers in determining whether they are wearing a face mask or not. The overall functionality of this system, which is designed to detect this face, has been thoroughly tested so that it can perform as expected. The percentage of

customer face recognition achieved using the codes (coding) set in the ESP32-CAM will be sent to the Arduino Uno for further consideration. If a percentage equal to or greater than 99% is calculated, the bar will be raised to allow entry into the premises. While calculations with a percentage less than 99% are not permitted.

The development of a product necessitates careful and systematic planning to be successfully implemented.

The researcher can learn about the benefits and drawbacks of the product development process based on this discussion. As a result, the study contributes to create a face mask wear detection device and follow SOPs to self-discipline to properly wear face masks. The study produces a face mask wear detection device to improve the efficiency and ease of use of Covid-19 transmission. The system's functionality is being tested to detect faces and determine whether or not the customer is wearing a face mask. Ensure that the number of customers does not exceed the limits set by the premises' owner by reducing the labour cost. Another contributions that can be highlighted in this manuscript is the use of real data obtained by testing the level of effectiveness face-to-face and the provision of accurate results. Furthermore, the two levels emphasised which are proper and improper, are to form a system that will be used to assist researchers in taking into account the mask's position factor.

Since there is currently a limit to how far a sensor can detect, the results may be skewed if we don't make the above-mentioned improvements. However, without the above-mentioned body temperature monitoring system, the objective and interpretation of the results will not be affected because the scope of analysis will be different. It is only beneficial to enhance the functionality of the system.

In the future, some improvements and refinements to this existing system have been proposed by researchers as opportunities for others to participate. The following suggestions can be implemented such as combining this facial recognition technology with a body temperature monitoring system for online health monitoring and;it is advised to include a product efficiency analysis by calculating the average error rate of face detection at a distance.

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