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A Contactless Visitor Access Monitoring System

Yi-Sin Bong* and Gin-Chong Lee

***Abstract*— This project presents a contactless visitor access monitoring in small premises which implemented deep learning model in face recognition, develop the graphical user interface (GUI) for new visitor registration and visitor identification. Five stages of monitoring process are designed in the contactless visitor access monitoring (CVAM) GUI, the first step is to give instructions to the admin user regarding the monitoring process, the second step is to perform face recognition, the third step is to scan the body temperature, the fourth step is to perform mask detection on the visitor, and the final stage is to record visitor access time. Another visitor registration (VisReg) GUI is designed to register new visitors into the system. In VisReg, admin user is required to pre-process face images with MTCNN technique and generate new classifier with a ResNet pre-trained model. The contactless visitor access monitoring process is demonstrated. The face recognition gives an accuracy of 82%, while the mask detection gives an accuracy of 95% when tested with the validation dataset. It can be concluded that the visitor monitoring process can be carried out in a contactless way to eliminate the close contact between the security officers, receptionist, and visitors.**

Keywords— Deep Learning, Face Recognition, Mask Detection, Contactless, Visitor Monitoring.

I. INTRODUCTION

Contactless visitor access monitoring is proposed as one of the approaches to minimize human to human contact by performing the visitor monitoring task in a contactless way with an artificial intelligence face recognition technology. The system will allow the security guards or receptionist at a premise to perform a prompting jobs such as asking visitors to check their body temperature, counting the number of visitors, verifying visitors' identity, and perform mask detection remotely. Most of the visitor access monitoring processes required a close contact between the security officer or receptionists and the visitors. Security component needs to be considered in a human-computer interacting system. To enhance the security, most systems implemented biometric technologies. Among all the biometric technologies, face recognition is the most suitable technology in a contactless visitor access monitoring system. Face recognition technology managed to avoid user contact while performing authentication process and it is not expensive to implement into the system. There are two approaches to develop a face recognition technology, these two approaches are known as deep learning and machine learning. According to research, in terms of classification results, the deep learning approach surpassed the recognition rate of machine learning process. Moreover, there are several deep learning models can be used in face recognition technology.

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These models are known as AlexNet, VGGNet, GoogLeNet, and ResNet. Based on the reseach studies, ResNet is known as the deep learning model with the highest accuracy when compared to other models. The contactless visitor access monitoring system will be designed with the transfer learning method. Studies have shown that transfer learning in deep learning is considered as one of the methods where pre-trained models are used to solve the similar problems with the minimum time and cost. Multi-task Cascaded Convolutional Neural Network (MTCNN) will also be used to pre-process the input data to update the classifier for the face recognition or mask detection in this project. This system aims to help the security guards or receptionists to perform the monitoring process in a premise contectlessly. Security guards will be able to record body temperature, verify the identity of a visitor and calculate the number of visitors together with their log in time remotely, with the aids from face recognition, mask detection, speech assistance, and infrared temperature sensor that are built in the system.

II. LITERATURE REVIEW

A contactless visitor access monitoring has been suggested as a monitoring system that is appropriate for today's society. This review will compare current developed visitor access monitoring systems. Moreover, explain the benefits, together with the drawbacks of different kinds of biometric technologies. The reasons for choosing face recognition as a tool for this project will be presented and addressed. In addition, various deep learning models that used Convolutional Neural Network (CNN) will be analysed and examined for their strengths and weaknesses. Moreover, different developed systems will be investigated and compared. In order to perform face detection, Multi-task Cascaded Convolutional Neural Network (MTCNN) will be reviewed.

Visitor Access Monitoring Systems: Visitor access monitoring system is used in premises to enhance the security by tracking and verifying the identity of visitors. An authorization process will be carried out before letting the visitors enter the premises.

TABLE 1. Comparison between the developed systems.

	Easy Visitor Management System 2.0 [1]	***MicroVMS System*** *[2]*
Technology Type	Ratio frequency identification (RFID)	Ratio frequency identification (RFID)
System Type	System-based	System-based
Functions	Visitor monitoring	Visitor monitoring
Software platform	Windows	Windows
Pandemic preventive measures	Yes	No
Disadvantages	During the monitoring process, visitors will have a high chance of close contact with the security guards or the receptionists.	

Based on the Table 1, it is shown that both systems have implemented the RFID technology. To implement this technology, security guards or receptionists are required to have a close contact between the visitors as they are required to take visitors' MyKad to carry out the monitoring process. Therefore, this method will not be used in the project. In next section, similar developed AI system has been reviewed. From the review, a better approach to enhance the security for this project has been decided.

Face Recognition using Deep Learning Models: AlexNet, VGGNet, GoogLeNet, and ResNet are the deep learning models that will be introduced in this section. A different level of output is given by these models. This section will give the descriptions of AlexNet, VGGNet, GoogLeNet, and ResNet in brief before comparing the performance of these deep learning models. The common practice to apply all these deep learning model in applications is using a method called transfer learning.

TABLE 2. Comparison between AlexNet, VGGNet, GogLeNet, and ResNet. [3]

Models	Strengths	Gaps
AlexNet	• The CNN has introduced regularization. • Interacting with complex architectures is possible.	• Neurons in the first and second layers are inactive. • In the learned feature-maps, broad filter size induced aliasing artifacts
VGGNet	• Simple and homogeneous topology for an effective receptive field.	• The high computational complexity is due to fully connected layers.
GoogLeNet	• With the bottleneck layer, global average last-layer pooling, and sparse connections, the number of parameters is reduced.	• Because of the representational bottleneck, useful data can be lost.

ResNet	• For deeper networks, error rates are reduced. • The vanishing gradient problem's effect has been minimized.	• The model architecture is intricate. • During feed forwarding, feature-map content is degraded.

Table 2 showed the strengths and weaknesses of the discussed models. It is, however, insufficient to say that deep learning architectures can work well in face recognition. Based on a research paper [4], it has evaluated the efficiency of various models that have been discussed in this section. The experiment has tested the performance of the face recognition that was developed with different models. Figure 1 and Figure 2 have showed the error rate and the accuracy of these models.

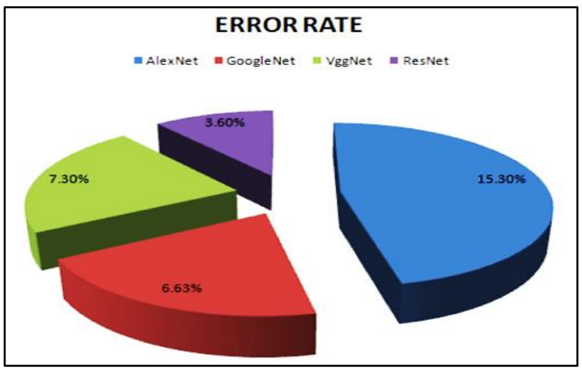

FIGURE 1. Comparing the error rate of various deep learning models. [4].

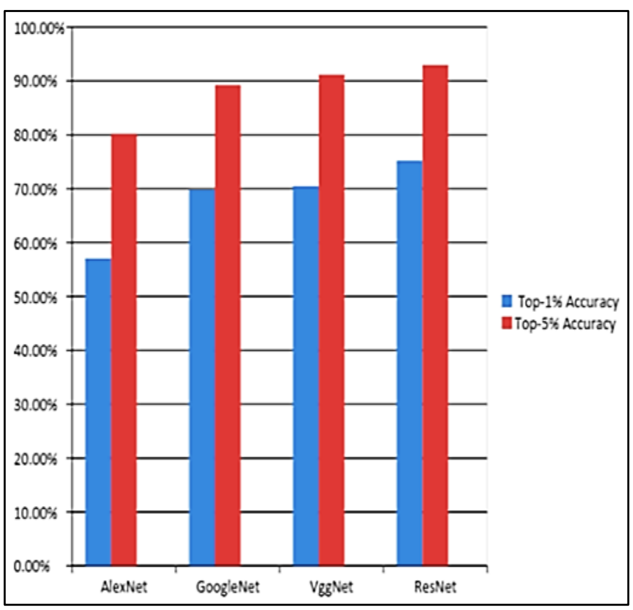

FIGURE 2. Comparing the accuracies of various deep learning models. [4].

In contrast to AlexNet, GoogLeNet, and VGGNet, ResNet have the lowest error rate as shown in Figure 1. AlexNet has the largest error rate, followed by VGGNet, and finally GoogLeNet's error rate. In terms of accuracy, ResNet also has the highest accuracy when compared with other deep learning models, as shown in Figure 2. According to the results of this study, ResNet is the best model to be used because it has the lowest error rate and the highest accuracy [4]. The implementation of ResNet will be used to build the face recognition in this project. As a deep learning architecture, it will be used for feature extraction, together with the classification of face images. In this project, ResNet will be implemented with the transfer learning method.

Transfer Learning: Transfer learning is a process used to transfer information gained from a problem. The information gained is then used to solve another similar problem. This technique will help to increase accuracy or decrease training time.

Transfer learning allows the new models to be quickly prototyped using the pre-trained models which are produced from another similar task. It requires high cost and long time to train millions of images, this is the reason that transfer learning is introduced to convolutional neural network (CNN) [5]. The primary reason that pre-trained model is used in deep learning is that in order to train a huge model with large datasets, more computational power is required. Moreover, the time taken to train a network might take up to a number of weeks, but with the help of pre-trained model, the learning process can be expedited by training the new network with the pre-trained weights. Therefore, in this project, transfer learning is implemented [6]. To update the classifier for the face recognition, data pre-processing is important content to be considered. In the next section, MTCNN will be discussed.

MTCNN for Face Detection: MTCNN is a technique used for face detection and face alignment.

This approach is designed to perform the task of detecting and aligning the face at the same time. MTCNN has the improve results compared to the conventional approach, it can accurately locate the face. The time taken to detect the face is shorter. Moreover, it can detect the face in real time [7]. In this project, the MTCNN method is used to pre-process the face images of the visitors. The pre-processed images are then used as the input to update the classifier that will be used to perform the face recognition in contactless visitor access monitoring. Based on the study [8], under natural conditions such as the change of the distance and head deflection, MTCNN has a higher accuracy in face detection. Therefore, MTCNN is implemented to pre-process the input data such as face images that will be used to update the classifier.

III. METHODOLOGY

System Design: Figure 3 showed the design of the system. The webcam will perform a live record to the face of the visitor, the recorded frames on the face of the visitor will be used as an input to the contactless visitor access monitoring (CVAM) GUI. This CVAM will determine whether this visitor is registered to the system. The unregistered visitor can be registered with another GUI known as visitor registration (VisReg). The body temperature value will also get passed into the CVAM through the Arduino Nano during the monitoring process. The CVAM will then determine whether the taken body temperature is normal.

In this project, two GUIs are designed and developed: 1) Contactless Visitor Access Monitoring (CVAM) and 2) Visitor Registration (VisReg). The CVAM performs the contactless visitor access monitoring process while the VisReg registers new visitors into the system. The contactless visitor access monitoring GUI will perform face recognition, body temperature scanning, and mask detection on the visitors. The processes are designed to carry out the monitoring process in a sequential method. Other than that, this program will record the login time for every visitor. However, whenever a monitoring process is completed, a text file will pop out to prompt the admin user to manually input the visitor's name. For the visitor registration GUI, it is designed to allow the admin user to choose the pre-trained model and input the new dataset such as face images to generate the new updated classifier. Moreover, it also allowed admin users to carry out the pre-process function that will crop the face of the person in each face images and output those cropped images into another folder with the person's name.

Contactless Visitor Access Monitoring Process (CVAM): Based on Figure 4, there are five GUIs represented by "Main Page", "Face Recognition", "Temperature Screening", "Mask Detection", and "Final Stage". These five stages represented the monitoring procedures in a contactless visitor access monitoring process. During the monitoring process, with the aid of this system, the admin user will monitor if a visitor fulfills all conditions that are set in this program. The decision to proceed from one stage to another stage will be decide by the admin user. Moreover, a voice assistant is designed to help the admin user to guide the visitor to carry out all the required procedures.

Figure 5 showed the design for the Stage 1 Menu. When the "Start" button is clicked, the Stage 2 menu will be opened, and the Stage 1 menu will be closed. This program implementation to jump from one stage to another will be same for all the remaining stages. In the face recognition stage as shown in Figure 6, the system will help the admin user to determine whether a visitor is registered. Whenever a visitor is not recognized by the system, the voice assistant will speak the message such as "You are not recognized, please contact us to make registration" to the visitor.

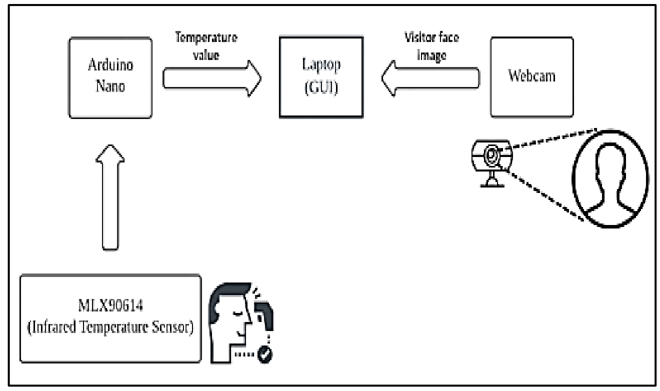

FIGURE 3. System design.

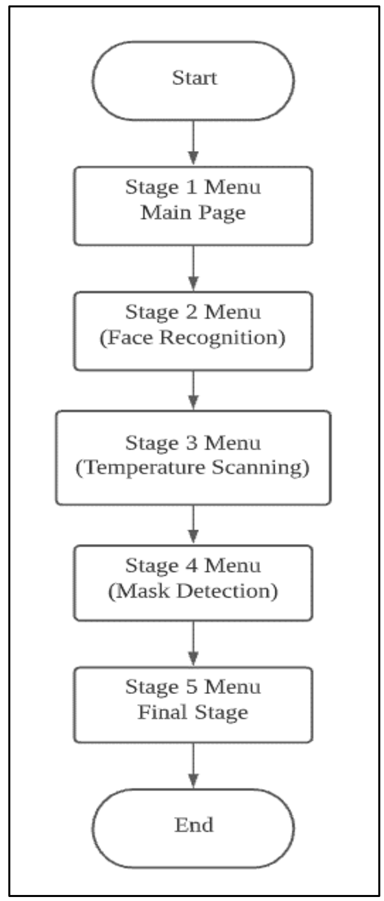

FIGURE 4. Flow chart representing the contactless visitor access monitoring process.

When the visitor is recognized by the system, it will send message such as "You are identified, we will proceed to temperature screening". When the face is not detected, it will give message such as "Face is not detected, please look at the camera" to prompt the admin user to look at the camera. When the visitor is recognized, the "Next Step" button can be clicked to jump to the Stage 3 menu. Moreover, when the "Next Step" button is clicked, the current window will be closed, and the Stage 3 menu which is designed to perform body temperature scanning will be invoked.

During the process, the webcam which is designed to take the black and white video will get turned on. This allowed the admin user to monitor that the visitor is measuring the body temperature. During the transition from one process to another process, the voice assistant will inform the visitor that the temperature scanning process is being carried out. Figure 7 showed the Stage 3 Menu, the temperature sensor will update its latest value every 13 seconds. Therefore, whenever the admin user clicked the button on the GUI, but the latest temperature is not updated yet, the voice assistant will send the message “Taking your temperature, hold on” to the visitor. When the latest value is updated, if the temperature is more than 37°*C*, the voice assistant will speak the message such as “High body temperature detected. Sorry, you cannot enter the premise” to the visitor. If the temperature is in an acceptable range, it will send a message “Temperature taken, we will proceed to mask detection”. Figure 8 showed the Stage 4 Menu, in this stage, a program is designed to aid the admin user to determine if a visitor is wearing a mask. In the mask detection stage, when mask is detected, the speech assistant sends the message “You are allowed to proceed. Thank you for wearing a mask” will be sent to the visitor. If the mask is not detected, the message such as “You are not allowed to proceed. Please wear a mask” will be sent to the visitor. The “Start Detection” will execute the mask detection program, while the “Next Step” button will perform an operation to jump to the next stage. When the visitor passes the mask detection stage, the next stage that follows is the final stage of the contactless visitor access monitoring process. Figure 9 showed the Stage 5 Menu. In Stage 5 menu, the visitor’s logon time will be recorded by the system. However, the admin user is required to input the visitor’s name manually in the space provided. When the “Record” button is clicked, a file with the current date will be created. The date and time will be written into the file automatically when the text file is opened. The only thing that the admin user needs to do is to type in the name of the current visitor that has passed all the monitoring stages.

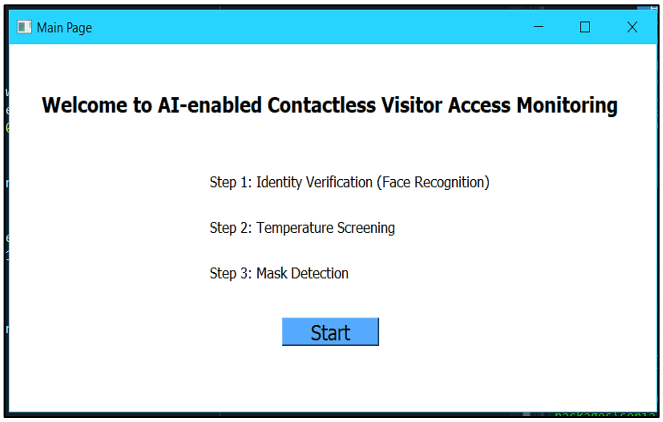

FIGURE 5. Design for main page.

FIGURE 6. Design for face recognition page..

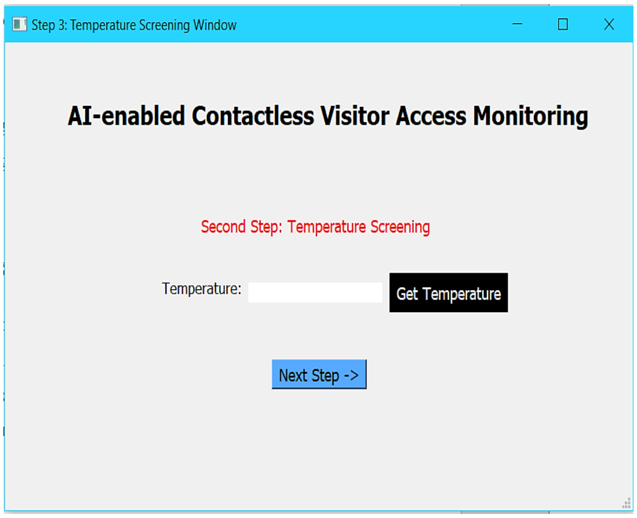

FIGURE 7. Design for temperature scanning page.

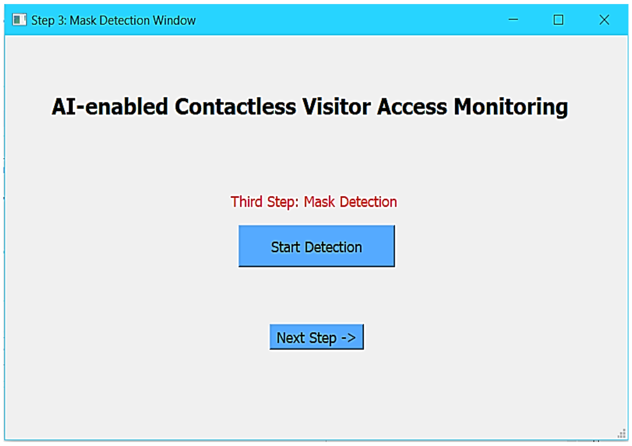

FIGURE 8. Design for mask detection page.

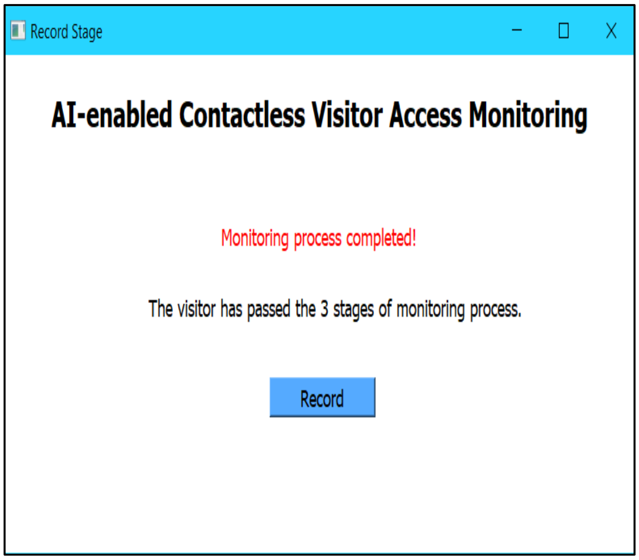

FIGURE 9. Design for final stage page.

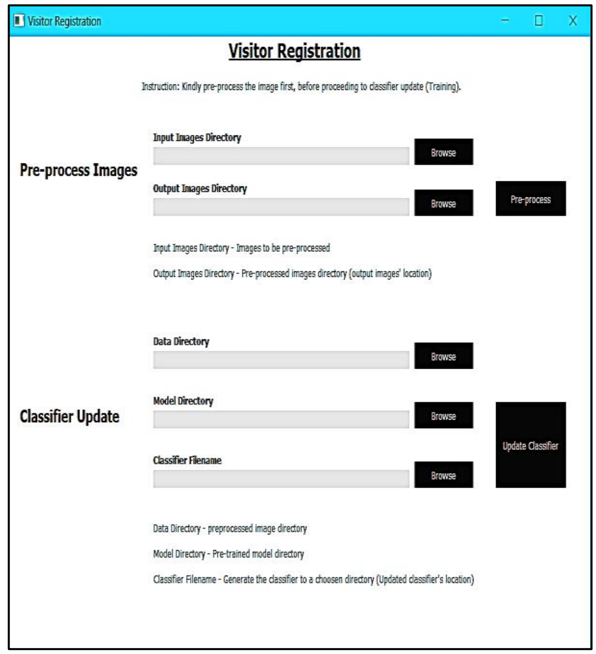

FIGURE 10. Design for VisReg.

Visitor Registration (VisReg): There is one GUI designed for visitor registration. VisReg is designed to allow the admin user to pre-process the new visitor images and update the classifier.

The design of the VisReg is shown in Figure 10. When the "Pre-process" button is clicked, the program will pre-process the input images based on the given directory and generate the pre-processed images based on the output images directory. There are two features designed in VisReg, the first feature is to perform image pre-processing while the second feature is to perform classifier update. For image pre-processing, the admin user is required to choose the file which contained all the original face images and choose the output directory to generate another folder to store all the pre-processed images.

For the classifier update feature, the program will require the admin user to choose the pre-processed images directory as the input data, choose the pre-trained model directory, and choose a directory to store the generated classifier. Multi-task Cascaded Convolutional Neural Networks (MTCNN) is used to perform the image pre-processing. To update the classifier, admin user is required to input the face images in different folders and the folders must be labelled with the names of the visitors. The total images required for a visitor is designed to be more than 40 images. Based on study [9], the Support Vector Machine (SVM) was introduced as a reliable tool for several data mining tasks, including classification. In the classifier program, the function will retrieve the input data, which is the pre-processed images and the pre-trained model that have been chosen by the admin user. The admin user is also required to select the output directory to save the generated classifier.

Experiment 1 (Testing the Accuracy of Face Recognition): An experiment has been conducted. The experiment has tested the accuracy of the face recognition in this project by using a validation set to test the updated classifier. The first dataset is labelled as "AAUnknown", to identify unregistered visitors, it consisted of 85 images, the reason this dataset has more images than other datasets is to allow the system to have higher probability to categorize a visitor as an unregistered visitor if that visitor is not registered. The second dataset is labelled as a visitor named as "Leslie Cheung", it consisted of 40 images. The third dataset is labelled as a visitor named as "Lisa", it consists of 40 images. The fourth dataset is named as "Shahrukh Khan", which consists of 40 images. The fifth dataset is labelled as "YiSin Bong", also consists of 40 images. images and update the classifier.

Experiment 2 (Testing the Performance of Mask Detection): The experiment has tested the accuracy of the mask detection in this project. There are 2 classes of datasets in this experiment. These datasets are pre-processed and have been used to generate a classifier. The first dataset consists of the 47 images of a person that wore a mask while the second dataset consists of the 47 images of a person that did not wore a mask. The datasets are labelled as "With Mask" and "Without Mask". These datasets will be pre-processed, and a new classifier will be generated. This experiment will test the accuracy of the mask detection with a validation dataset.

IV. RESULT AND DISCUSSION

Demonstration of VisReg and CVAM: The contactless visitor access monitoring system is demonstrated. The demonstration includes the VisReg's features such as image pre-processing and classifier updating. Moreover, body temperature measurement, face recognition, and mask detection will be demonstrated with CVAM. The whole contactless visitor access monitoring process has been demonstrated with the use of VisReg and CVAM. In the first step, the visitor images have been pre-processed. In the second step, the pre-processed images are used as the input to train the classifier to register the visitor into the system. For example, a visitor named "YiSin Bong" has been registered into the system. In the third step, the CVAM is executed, in the Stage 1 Menu, the important instructions such as the steps required for this monitoring process are shown to the admin user. In Step 4, the face recognition feature is demonstrated. To show if the system can classify between the registered visitor and the unregistered visitor, a non-registered person has been used to test the face recognition system. Based on Figure 11, it has showed that when a non-registered person is detected, that person has been identified as an unregistered visitor. Therefore, with this demonstration, it can be identified that the system can classify between a registered visitor and a non-registered visitor. In Step 5, with the instruction given from the voice assistant, the registered visitor has been prompted to put their forehead close to the contactless infrared temperature sensor. As discussed before, when a registered visitor has a body temperature higher than 37°C, the registered visitor will not be allowed to enter the premise. However, during the demonstration, the visitor has a normal temperature. Therefore, the registered visitor has passed the temperature scanning test. In Step 6, the mask detection has been carried out to scan if the registered visitor has worn a mask. Based on Figure 12, it has been shown that the system is able to classify if a visitor has worn a mask or not. As the visitor has worn a mask during the monitoring process, it is then continued to the final stage to record visitor's access time.

In Step 7, which is the final step in this demonstration, the visitor access time has been recorded by the admin user as shown in Figure 13. Based on the demonstration, it has showed that the monitoring process can be carry out in a contactless way to eliminate close contact between security guards, receptionists, and visitors.

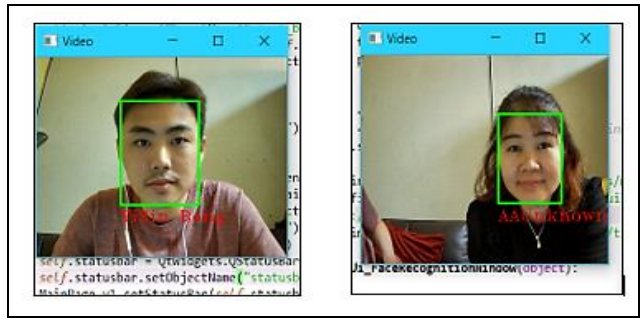

FIGURE 11. Face recognition on registered user and non-registered user.

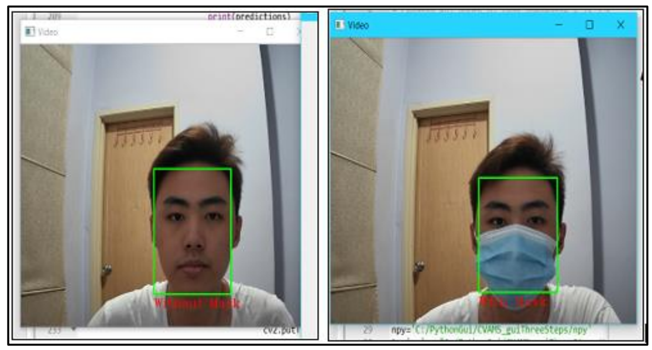

FIGURE 12. Face recognition on registered user (With mask and without mask).

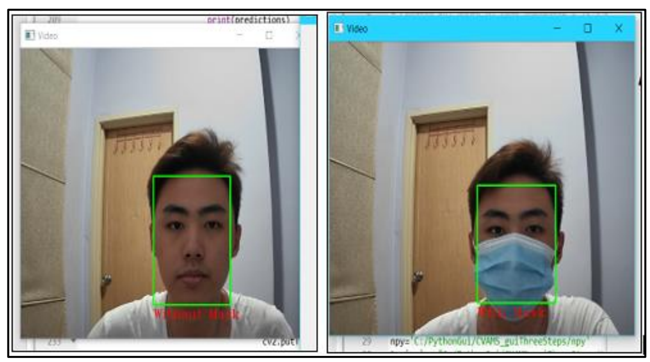

FIGURE 13. Text file to record visitor access time.

Experiment 1 (Testing the Accuracy of Face Recognition): Table 2 showed the confusion matrix generated from the performance of the classifier for the face recognition. The true negative (TN) represented the number of incorrect predictions that is true while the true positive (TP) represented the number of correct predictions that are true. The false negative (FP) means that when a wrong class is incorrectly classified as a true class while the false positive (FP) happens when a true class is incorrectly classified as a wrong class. In this experiment, the true positive (TP) is represented by the condition when the face recognition has accurately identified that a registered visitor as an authorized person to enter the premise. The true negative (TN) is represented by a situation when the face recognition has accurately identified that an unregistered visitor is not an authorized person. The false negative (FN) is represented by the condition when the face recognition has incorrectly identified a registered visitor as an unauthorized person. As for the false positive (FP), it is represented by a situation when the face recognition has incorrectly identified an unauthorized person as a registered visitor. Equation (1) showed a formula that can be used to calculate the accuracy with the recorded data. By using the Equation (1), the accuracy calculated for the face recognition is 82%. To increase the accuracy, more images may be added into every classes to increase the performance of the classifier.

$$Accuracy = \frac{TN + TP}{TN + TP + FN + FP} \tag{1}$$

Experiment 2 (Testing the Performance of Mask Detection): The validation datasets have been used to test the accuracy of the mask detection in this project. A confusion matrix as shown in Table 3 has been generated to show the result from this experiment. The true positive (TP) value is represented by the situation when the mask detection has accurately predicted that a person is wearing a mask. The true negative (TN) is represented by the condition when mask detection has correctly predicted that the person is not wearing a mask. The false positive (FP) is represented by the situation when the mask detection has incorrectly predicted that a person has worn a mask. As for the false negative (FN), this happened when the mask detection has incorrectly predicted that a person did not wear a mask. From Equation (1), the accuracy of the mask detection is 95%. The accuracy is reduced by an image which the face has been covered partially with the hands of the person in the image. This has caused mask detection to predict the person has worn a mask. Therefore, there are limitations in the mask detection that has been implemented in this project.

TABLE 3. Confusion matrix (performance of classifier for face recognition).

Actual Value \ Predicted Value	Negative	Positive
Negative	TN = 8	FP = 2
Positive	FN = 7	TP = 33

TABLE 4. Confusion matrix (performance of classifier for mask detection).

Actual Value \ Predicted Value	Negative	Positive
Negative	TN = 9	FP = 1
Positive	FN = 0	TP = 10

V. Conclusion

A contactless visitor access monitoring process is proposed and designed. Based on the findings, a demonstration has been carried out and it has been found that the visitor monitoring process can be carried out in a contactless way. With the implementation of voice assistant, even though the admin user is far away from the visitor, clear instructions can still be given to the visitor during the monitoring process. Moreover, based on the findings from Experiment 1, the face recognition achieved an accuracy of 82%. On the other hand, based on the result from Experiment 2, the measured accuracy for the mask detection is 95%. When a visitor's face is covered with hands, the mask detection will give incorrect prediction. Therefore, from both experiments, it can be concluded that decisions from human is still needed during the monitoring process.

VI. Limitations

With a low-quality webcam, the mask detection will have a lower accuracy, and sometimes, the face of the visitors cannot be detected. The second limitation of this project is that the designed contactless visitor access monitoring process can only be applied to small premises which prior appointment is needed before visiting the premise, the registration of visitor is not designed to be carried out in the premise as the aim of this project is to prevent close contact between visitors, security guards and receptionists. Unregistered visitor is required to send their face images to the admin user through any messaging mobile applications and wait for the admin user to register. This registration process might be tedious to certain visitors.

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AUTHOR CONTRIBUTIONS

Yi-Sin Bong: Conceptualization, Data Curation, Methodology, Validation, Writing – Original Draft Preparation;

Gin-Chong Lee: Project Administration, Supervision, Writing – Review & Editing.

CONFLICT OF INTERESTS

No conflict of interests were disclosed.

REFERENCES

[1] J.N. Albrecht and E. Raymond, "National destination pledges: Visitor management through emotional engagement, commitment and interpretation," *Tourism Management Perspectives*, vol. 40, pp. 100894, 2021. DOI: https://doi.org/10.1016/j.tmp.2021.100894

[2] J.C. Skibins, "The infinite visit: a unifying temporal/spatial framework for visitor management.," *Managing visitor experiences in nature-based tourism*, pp. 21-33, 2021. DOI: https://doi.org/10.1079/9781789245714.0021

[3] A. Khan, A. Sohail, U. Zahoora and A. S. Qureshi, “A survey of the recent architectures of deep convolutional neural networks,” *Artificial Intelligence Review*, pp. 1–62, 2020. DOI: https://doi.org/10.1007/s10462-020-09825-6

[4] I. Kansal, R. Popli and C. Singla, "Comparative Analysis of various Machine and Deep Learning Models for Face Mask Detection using Digital Images," *2021 9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)*, pp. 1-5, 2021. DOI: https://doi.org/10.1109/icrito51393.2021.9596407

[5] R. Ribani and M. Marengoni, “A survey of transfer learning for convolutional neural networks,” *in Proc. 2019 32nd SIBGRAPI Conference on Graphics*, Patterns and Images Tutorials (SIBGRAPI-T), 2019. DOI: https://doi.org/10.1109/SIBGRAPI-T.2019.00010

[6] A. Misal and S. Sayyad, "Corrosion Image Classification using Deep Learning and Transfer Learning Approaches," *2024 4th Asian Conference on Innovation in Technology (ASIANCON)*, pp. 1-6, 2024. DOI: https://doi.org/10.1109/ASIANCON62057.2024.10837953

[7] H. Ku and W. Dong, “Face recognition based on MTCNN and convolutional neural network,” *Frontiers in Signal Processing*, vol. 4, pp. 37–42, 2020. DOI: https://doi.org/10.22606/fsp.2020.41006

[8] X. Chen, X. Luo, X. Liu and J. Fang, “Eyes localization algorithm based on prior MTCNN face detection,” *in Proc. 2019 IEEE 8th Joint International Information Technology and Artificial Intelligence Conference (ITAIC),* 2019, pp. 1707–1710. DOI: https://doi.org/10.1109/ITAIC.2019.8785430

[9] A.R. Shekhar, A.K. Saeed, B.A. Johnson and B.M. Rodriguez, "Derivation, optimization, and comparative analysis of support vector machines application to multi-class image data," *Multimodal Image Exploitation and Learning 2024*, pp. 9, 2024. DOI: https://doi.org/10.1117/12.3014060

ETHICS STATEMENTS

Our publication ethics follow The Committee of Publication Ethics (COPE) guideline. https://publicationethics.org/