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FACE MASK DETECTION AND WARNING SYSTEM FOR PREVENTING RESPIRATORY INFECTION USING THE INTERNET OF THINGS

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Abstract: The respiratory-related diseases can spread and cause infection from patients to other people easily. The mask can help preventing or reduce the risk of spreading respiratory diseases from person to person. This research presents the development of the warning system to the people for wearing the masks by using the ESP32-CAM and IoT devices. The Haar-like feature and cascade classify training techniques are used to detect the human faces and the masks in this system. A total of 2,160 sampling images was trained for modeling the mask detection on human faces. The result shows that the accuracy of the developed system is 91.60% for mask detection. The system evaluation in black box testing has the mean value 4.51 with a standard deviation 0.51 and a mean value 4.62 with a standard deviation 0.49 by experts and users, respectively. Moreover, the acceptance of the system has a high consensus. It could be said that the developed system can detect and classify the person who is wearing the face mask for protecting the respiratory infection at the highest level.

Keywords: Arduino, coronavirus, ESP32-CAM, face mask, healthcare, internet of things, respiratory infections, warning system

I. INTRODUCTION

Today, the world is in crisis with the risk of spreading new respiratory diseases. The novel coronavirus 2019 (COVID-19) [1] is a new strain of the virus that was discovered in late 2019, which has never been found or appeared in humans before. It is currently being attacked worldwide is prevalent in Southeast Asian countries. The face mask is a protective mask that covering the nose and mouth. The mask can help preventing or reduce the risk of spreading respiratory diseases from person to person. Nevertheless, today there is a large number of people who do not pay attention or ignore or forget to wear a mask to prevent the spread of disease from themselves to other people or prevent infections that may spread from other patients.

There are several types of masks for use in the real world, such as surgical mask, N95 respirator, P100 respirator, or gas mask [2]. The face masks have different colors and the abilities to protect the disease or particular dust. For example, a surgical mask does not protect the coronavirus and should be worn no later than 3 to 8 hours [3]. However, wearing a face mask may help increase the weariness of the wearer and help prevent the spread of respiratory diseases. Therefore, reminding people to wear a face mask is a stimulant for those who have not yet worn a face mask to have awareness and turn to wear a face mask. To detect or classify or wear masks, it requires machine learning to help recognize facial features or masks, including wearing a mask. Examples of learning and face detection can use the Viola-Jones technique [4][5] based the Haar-like feature techniques [4][5][6][7][8] to detect.

Besides, the introduction of internet technology will significantly facilitate everyday life, especially the internet of things (IoT), in which everything is an electronic device that can communicate and control the system and information over the internet. For example, the low-cost auto robot for collecting the floating garbage was developed by using IoT devices, or the smart aquarium monitoring was developed for helping the entrepreneur with automate water changing system. Moreover, IoT helps the elderly improve their daily lives by using intelligent walking sticks developed from IoT devices.

This research objective is to develop a system to alert people who have not worn a mask to turn their attention. The researchers are developing a system for voice alarms and thanks to people already wearing masks by using IoT devices as a threat warning device to prevent the spread of the respiratory infection.

II. MATERIALS AND METHODS

There are six steps for the development of a warning system to wearing a face mask to prevent respiratory infections as follows.

A. Data collection

The key to the notification of wearing a mask is the mask detection on the human face. This work needs the images, which include a mask or without mask on the human faces for training and testing data. The researchers collect the 2,160 images in total from the Google search engine by using the Python version 3.6 for grabbing all photos. There are 1,014 images for the masks only, 836 images for people who are wearing the mask, and 310 images for people who do not wear the mask. The sample images are shown in Figure 1 and Figure 2.

Figure 1: The sample images of the masks from the Google search engine [9][10][11][12][13][14][15][16][17]

Figure 2: The sample images of people who are wearing the mask from the Google search engine [18][19][20][21][22][23][24][25][26]

B. Data preprocessing

After the images were gathering from the Google search engine by the Python programming processing in this work, all images should be customized in three processes as follows.

1) Face detection: Before training data for face masks classification, all images should be resized to the same image dimension. In this process, face detection and object detection [27] were used to find the center of the position where there is a mask or a human face. The Haar-like feature was applied to detect the face of people by using the library OpenCV version 3.3.0. The people's face was detected in Figure 3.

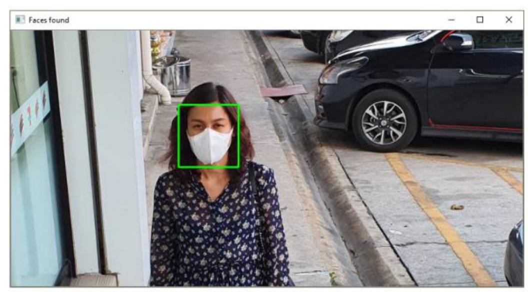


Figure 3: Face detection to find the center of the people's faces on the image

2) Image cropping: When the face was detected, the center of the face was calculated and cropping an image as a square picture. The minimized distance from the center of the face to all sides (top, bottom, left, right) of images is the default distance for cropping. The square image cropped is shown in Figure 4.

Figure 4: The cropped of a square image

3) Image resizing: By default, the image dimensions are 225x255 pixels. So, all cropped square images were scaled to 225x225 pixels before being used in the next step of training.

C. Face masks classification

In this step, all images were trained by using the Haar-like feature-based cascade classifiers technique for detecting the object such as face or mask. The 1,850 images were set to the positive samples to find the objects of interest. For negative samples, there are 310 images, which are the people who do not wear the mask. After the cascade classifier training finished, the model output was generated as an XML file formatted. This XML file was used in the IoT development step.

D. Internet of things

This system was developed in the IoT platform by using the Arduino IDE version 1.8.10 on Windows 10 Professional Edition x64. It consists of four devices in IoT; there are ESP32-CAM board, LM386 audio amplifier module, speaker 8 ohms 1.5 watts, and batteries pack. The IoT devices were connected in Figure 5.

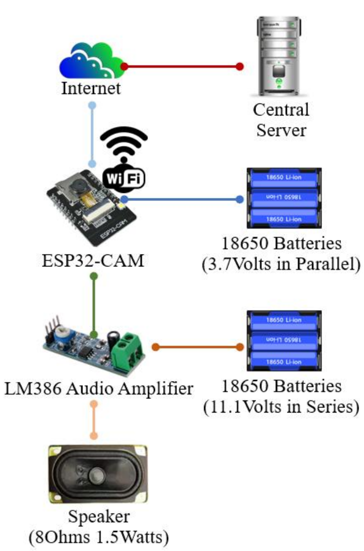


Figure 5: The IoT devices for the warning system to face mask detection

1) ESP32-CAM board: This is the development board which has the ESP32-S microcontroller chip, microSD card slot, and OV2640 camera module. It is a small size board with a footprint of 27x40.5x4.5 millimeters. The ESP32-S chip is developed by Shenzhen Ai-Thinker Technology. For the OV2640 camera module, it can operate with the maximum resolution of 1600x1200 pixels at fifteen frames per second. It comes with a sensor image array up to two megapixels. Moreover, it consists of the smallest 802.11b/g/n Wi-Fi with Bluetooth version 4.2 communications, and a built-in LED that works as a flashlight.

2) LM386 audio amplifier module: This module used to gain the audio signal for a loudspeaker. The onboard resistance can adjustable for the volume enlargement. In general, it can operate with a voltage range between five and twelve volts.

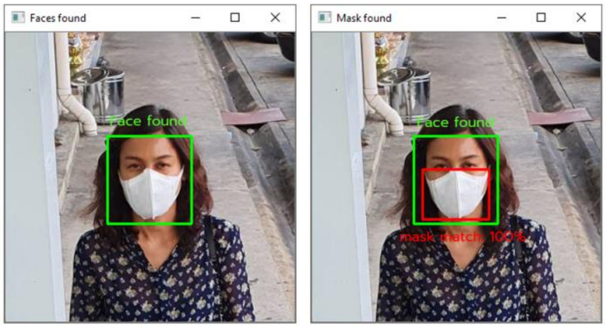
3) Speaker 8 ohms 1.5 watts: This loudspeaker is used to deliver the message to people who are walking around or pass through the field of view from the OV2640 camera module.

4) Batteries pack: This battery pack is combined from several of 18650 cells. It used to supply the power for the ESP32-CAM board and the LM386 audio amplifier module.

All coding which developed in C++ language were uploaded to the ESP32-CAM board and the cascade model in an XML file was uploaded to the microSD card for the face mask classification or face mask detection. Besides, two sentences for reminders of wearing masks and thank you were recorded on this microSD card. Also, this system was communicated to the central server. This developed server is the logging server for keeping the people who walk past the system or the field of view of the camera. This logging used to cross-check the system efficiency and accuracy for classifying the people who wear the mask or not.

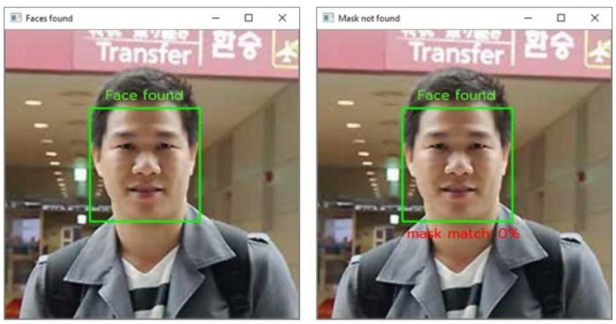
For the work process of the wearing mask notification system, the process will be as follows: 1) when someone walks through the field of view of the camera, the system will capture the still image, 2) take the still image to analyze the image to find the position of that person's face, 3) when the face was detected, the system will distinguish whether the face is wearing a mask or not, and 4) sound notification as each case. If someone walks into the field of view of the camera and does not wear a mask at the moment, the system will notify an alert sound with the message that ‘Please wear a mask.’ On the other hand, the message ‘Thank you for your cooperation’ was delivered to people who are wearing the mask.

The people’s face detection and face mask detection can be simulated in a green box and a red box, respectively, shown in Figure 6 and Figure 7.



(a) Face detected in green box (b) Face mask detected in red box

Figure 6: The face and face mask detection simulation



(a) Face detected in green box (b) Face mask does not detected

Figure 7: The face mask does not found simulation

E. System implementation and testing

The developed system was installed in front of the entrance to places such as shops or corridors that related to the shopping center or community. The system was set up at five different places for testing and gathering the result of mask detection and warning to the people. In this research, the system detects the one hundred people for each place. So, there are five hundred persons in total.

F. System evaluation

According to the previous step, the five hundred people were detected and classified the mask were wearing. All people who walk past the system were logging into the central server. The system was evaluated the efficiency by using the precision, the recall, the F-measure, and the accuracy in (1), (2), (3), and (4) [28], respectively.

$$Precision = \frac{TP}{TP + FP} \quad (1)$$

$$Recall = \frac{TP}{TP + FN} \quad (2)$$

$$F - measure = \frac{2 \times Precision \times Recall}{Precision + Recall} \quad (3)$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (4)$$

Where

TP: When a masked person walks past the system, the system can detect that the mask is worn.

FP: When a person does not wear a mask walks past the system, the system can detect that the mask is worn.

TN: When a person does not wear a mask walks past the system, the system can detect that the mask is not worn.

FN: When a masked person walks past the system, the system can detect that the mask is not worn.

Moreover, the system was evaluated by nine experts who expertise in information technology and human health care and thirty-five users was evaluated by using black box testing. The black box testing is that it ignores the internal processing of the system [29]. The terms of evaluation are function testing, compatibility testing, usability testing, performance testing, and stress testing. All criteria of the evaluation were scored as the Likert scale [29][30][31]. These scores were analyzed to mean and standard deviation (SD) value.

The overall system framework development of the warning system to face mask detection can be illustrated in Figure 8.

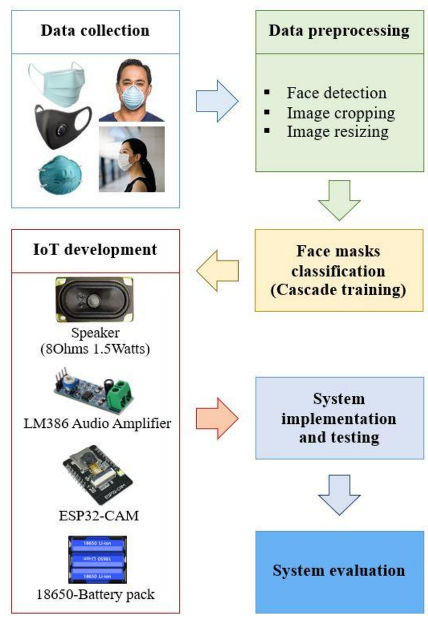


Figure 8: The face mask detection and warning system framework

III. RESULTS

The warning system development to wear a face mask for respiratory infection protection using IoT was evaluated in two sections: the system efficiency and the system evaluation in black box testing.

A. The result of system efficiency

According to (1), (2), (3), and (4), the system was evaluated by cross-checking with the logging on a central server, which is developed for keeping all people who walk past the system. The result of the mask detection is shown in Figure 9.

		Actual	
		Positive	*Negative*
Predicted (Mask detection)	*Positive*	*TP* 291	*FP* 15
	Negative	*FN* 26	*TN* 188

Precision = *291/(291+15) = 0.9510 =* ***95.10%***

Recall = *291/(291+27) = 0.9151 =* ***91.51%***

F-measure = *2x(0.9510x0.9151)/(0.9510+0.9151)*
= *0.9327 =* ***93.27%***

Accuracy = *(291+167)/(291+167+15+27) = 0.9160 =* ***91.60%***

Figure 9: The result of system efficiency

Figure 9 shows that the efficiency of system evaluation has the precision value at 95.10%, the recall at 91.51%, the F-measure at 93.27%, and the accuracy at 91.60%.

B. The result of system evaluation in black box testing

The result of system evaluation in black box testing was assessed by nine experts in the field of information technology/human health care and thirty-five users. The result has shown that the indicator of 'Usability testing' is the highest from experts and users. For the average mean in total, the result of the evaluation by thirty-five users at 4.62 with 0.49 of standard deviation, and average mean at 4.51 with 0.51 of standard deviation by nine experts, respectively.

According to the result evaluation for acceptance of the system that could be detected by experts and users while being used has high consensus. All of the values, the interquartile ranges (IQR) have no more than 1, and the quartile deviation (QD) no more than 0.5 [32] shows in Table 1.

Table 1: The result of system evaluation in black box testing

AssessmentIndicators	Mean	SD	Quartiles			IQR	QD	Evaluation
			Q1	Median	Q3			
Experts								
1. Functional testing	4.44	0.53	4	4	5	1	0.5	The high
2. Compatibility testing	4.44	0.53	4	4	5	1	0.5	The high
3. Usability testing	4.67	0.50	4	5	5	1	0.5	The highest
4. Performance testing	4.44	0.53	4	4	5	1	0.5	The high
5. Security testing	4.44	0.53	4	4	5	1	0.5	The high
Total	**4.51**	**0.51**	**4**	**5**	**5**	**1**	**0.5**	The highest
Users								
1. Functional testing	4.63	0.49	4	5	5	1	0.5	The highest
2. Compatibility testing	4.57	0.50	4	5	5	1	0.5	The highest
3. Usability testing	4.69	0.47	4	5	5	1	0.5	The highest
4. Performance testing	4.66	0.48	4	5	5	1	0.5	The highest
5. Security testing	4.54	0.51	4	5	5	1	0.5	The highest
Total	**4.62**	**0.49**	**4**	**5**	**5**	1	0.5	The highest

IV. CONCLUSION

This research presents development of warning system to wear a face mask for respiratory infection protection using IoT. The ESP32-CAM with the ESP32-S microcontroller chip is used as the main board. It collects images by detecting the people who are in focus and in view of the OV2640 camera module. This system is focusing on the essentials of face detection and mask detection on people's faces. All 2,160 sampling images of people's faces with or without the mask and the images of several kinds of masks were trained in cascade classified technique in Python by using the Open CV library. The model was trained and applied to the IoT development in Arduino IDE for detecting and classifying the people who are wearing the mask or not. This system was implemented, tested, and evaluated. For the efficiency of system evaluation, the precision, recall, and F-measure are 95.10%, 91.51%, and 93.27%, respectively, where the accuracy is 91.60%.

Moreover, the system was evaluated by nine experts in black box testing. The result of the system evaluation in black box testing shows the total average mean 4.51 with a standard deviation 0.51 by experts and the total average mean 4.62 with a standard deviation 0.49 by users. According to the result evaluation for acceptance of the system that could be detected by experts and users while being used has high consensus. All of the values the in interquartile range (IQR) no more than 1 and the quartile deviation (QD) no more than 0.5. It could be said that the developed system can detect and classify the person who is wearing the face mask for protecting the respiratory infection at the highest level.

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V. REFERENCES

[1]. World Health Organization. Accessed on: 17-Apr-2020. [Online]. Available : https://www.who.int/health-topics/coronavirus/

[2]. Miller, A. M., Brueck, H., and Gal, S. All the different types of face masks, and who should wear them during the coronavirus outbreak. Last Accessed on: 20-Mar-2020. [Online]. Available: https://www.businessinsider.com/types-of-masks-used-for-coronavirus-outbreak-n95-surgical-2020-3/

[3]. Hicham, D. Which masks actually protect against coronavirus? Last Accessed on: 4-April-2020. [Online]. Available: http://emag.medicalexpo.com/which-masks-actually-protect-against-coronavirus/.

[4]. Viola, P. and Jones, M. J. Rapid object detection using a boosted cascade of simple features. In Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition. 2001. 1–1.

[5]. Viola, P. and Jones, M. J. Robust real-time face detection. International Journal of Computer Vision. 2004. 57(2): 137–154.

[6]. Wang, Y. Q. An analysis of the Viola-Jones face detection algorithm. Image Processing On Line. 2014, 4: 128–148.

[7]. Gajjar, A., Yang, X., Wu, L., Koc, H., Unwala, I., Zhang, Y., and Feng, Y. An FPGA synthesis of face detection algorithm using Haar classifier. In Proceedings of the 2018 2nd International Conference on Algorithms, Computing and Systems; 2018. 133–137.

[8]. Wilson, P. I. and Fernandez, J. Facial feature detection using Haar classifiers. Journal of Computing Sciences in Colleges. 2006. 21(4): 127–133.

[9]. Best Xiaomi Smartmi anti-pollution air sport face mask. Accessed on: 10-May-2020. [Online]. Available: https://www.getprice.com.au/xiaomi-smartmi-anti-pollution-air-sport-face-mask.htm

[10]. Medical mask PNG transparent image. Accessed on: 10-May-2020. [Online]. Available: http://www.pngmart.com/image/172423/

[11]. Pitta Mask: Mask light gray color. Accessed on: 10-May-2020. [Online]. Available: https://www.robinson.co.th/en/pitta-mask-mask-light-gray-color-total-3-pcs-pack-rbs34856185/

[12]. Half mask medium - PAF-1010 - CleanSpace. Accessed on: 10-May-2020. [Online]. Available: https://prosafety.com/en/cleanspace-accessories/1872-cleanspace-half-mask-medium--paf-1010.html

[13]. Download pale blue face mask transparent PNG. Accessed on: 10-May-2020. [Online]. Available: https://www.stickpng.com/img/science/face-masks/pale-blue-face-mask/

[14]. Hepa full face masks report chinese man uses sanitary pad as face mask in. Accessed on: 10-May-2020. [Online]. Available: http://agendametal.com.br/Buy-Hepa-Full-Face-Masks.html

[15]. Face mask with valve - betterbuys sponduct reusable & washable for kids - blue. Accessed on: 10-May-2020. [Online]. Available: https://www.takealot.com/face-mask-with-valve-betterbuys-sponduct-reusable-washable-for-k/PLID69530356/

[16]. Fine guard comfort face mask with livinguard technology. Accessed on: 10-May-2020. [Online]. Available: https://www.thefineshop.com/products/fine-guard-n95/

[17]. KN95 FFP2 NR respirator face mask. Accessed on: 10-May-2020. [Online]. Available:

https://www.serasupplies.com/product/kn95-ffp2-respirator-face-mask-uk/
[18]. Doctor mask PNG image - surgical face mask UK, transparent PNG. Accessed on: 10-May-2020. [Online]. Available: https://www.uokpl.rs/rsmax/hoRRxix/
[19]. Standard cone mask with headband, blue. Accessed on: 10-May-2020. [Online]. Available: https://products.halyardhealth.com/infection-prevention/facial-respiratory-protection/masks-respirators/standard-cone-mask-with-headband-blue.html
[20]. Fernandez, C. 12 luxury face masks over $100 people are wearing just for fashion. Accessed on: 24-Aug-2020. [Online]. Available: https://www.insider.com/where-to-buy-designer-luxury-face-masks-2020-7/
[21]. 3M face mask N95 (KN95) respirator 9501V+ PM2.5. Accessed on: 17-Jul-2020. [Online]. Available: https://www.obszone.com/22995/3m-face-mask-n95-kn95-respirator-9501v-pm2.5.html
[22]. Miller, K. Pregnant women don't seem to have elevated risk of severe coronavirus, experts say. Accessed on: 12-May-2020. [Online]. Available: https://www.whattoexpect.com/news/pregnancy/pregnancy-coronavirus-risk/
[23]. Respirator mask waterproof mask NK95 mask face. Accessed on: 10-May-2020. [Online]. Available: https://kn95facemask.en.made-in-china.com/product/YdGJSnKTuthx/China-Respirator-Mask-Waterproof-Mask-Nk95-Mask-Face.html
[24]. MAXVIVI luminous personality mask dust masks men and women couple tide black heart cotton masks MK833271. Accessed on: 10-May-2020. [Online]. Available: https://www.openchinacart.com/supermall/8980259/
[25]. Power unit - PAF-0034 - CleanSpace. Accessed on: 10-May-2020. [Online]. Available: https://prosafety.com/en/cleanspace-engineblocks/1738-cleanspace-power-unit--paf-0034.html
[26]. Gas respirator anti-fog mask PM2.5 respirator mask filter dust mask. Accessed on: 10-May-2020. [Online]. Available: https://www.joom.com/en/products/5c85fbbc8b2c3701011fdb4e/
[27]. Sritrakulchai,K., Samuthsorn, P., Suethong, W., and Boonsatit, N. Investigation for face and object identification from a digital image. Engineering and Applied Science Research.2013. 40(3):385–395.
[28]. Nuanmeesri, S. (in press). Mobile application for the purpose of marketing, product distribution and location-based logistics for elderly farmers. Applied Computing and Informatics. 2020.
[29]. Likert, R. A technique for the measurement of attitudes. Archives of Psychology. 1932.1–55.
[30]. Nuanmeesri, S. The augmented reality for teaching Thai students about the human heart. International Journal of Emerging Technologies in Learning. 2018. 13(6): 203–213.
[31]. Nuanmeesri, S. and Poomhiran, L. Perspective electrical circuit simulation with virtual reality. International Journal of Online Engineering. 2019. 15(5): 28–37.
[32]. Nuanmeesri, S. Extended study of undergraduate students'usage of mobile application for individual differentiation learning support of lecture-based general education subjects. International Journal of Interactive Mobile Technologies. 2019. 13(9): 99–112.