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CAD System Based on Face Mask Recognition for Respiratory Infections Diseases Hospital

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Abstract**: The infection of respiratory diseases can be eliminating and controlling by wearing face mask in contaminated areas. However, to control people about wearing face mask it has been challenging unless the automatic recognitions are applied. Therefore, in this paper, a Face Mask Recognition System by Computer Aided Design (CAD) is introduced. The proposed design system is based on face, mouth and nose detections in captured image. The CAD system considers to be implemented for specialized respiratory diseases hospital with different departments, each department controlled by separated door. The main goal of this paper is to design system based on software programs that helps reduce the spread of respiratory diseases and controlling wearing face mask inside respiratory infection diseases hospital based on mask detection and mask color detection. The proposed system designed for hospital with three respiratory diseases departments and three mask color applied each mask color for each department. The mask recognition system has been used cascaded object detector that is Local Binary Pattern Histogram LBPH algorithm, then color detection as artificial intelligence-based method, Red, Green, and Blue (RGB) color of the face mask images. Finally, by using of Convolutional Neural Network (CNN), the classification accuracy of color recognition achieved 100%, and also the whole system functionality tested successfully obtained all results by testing accuracy 95%. The hardware designing circuit simulation in Proteus software were obtained to control the systems of hospital department doors based on the results obtained from MATLAB software.

Keywords: CAD, RGB, CNN, Respiratory Infection Diseases.

1. INTRODUCTION

There are many diseases that affect the respiratory system, and they are usually spreadable because the germs and viruses that cause disease can be transmitted through the air and

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droplets during sneezing or coughing to infect other people. The respiratory system is one of the body's most vulnerable to infectious diseases, as there are many diseases such as tuberculosis, Respiratory Syncytial Virus (RSV) and Coronavirus Disease (COVID-19). Tuberculosis, it is a respiratory disease, caused by a bacterial infection mycobacterium tuberculosis, which attacks the lungs, is transmitted through the air by coughing or sneezing if there is no protection.[1] RSV, it is a virus that attacks the respiratory system and is the most common cause of bronchi and pneumonia infection, and it can cause serious complications if it affects babies or elderly. COVID-19 is an infectious respiratory disease and anyone can get sick with this virus. However, some people will become seriously ill, especially those with underlying health conditions such as diabetes, cardiovascular disease or chronic respiratory disease and [2]. There are many ways to reduce the risks of contracting these diseases, including vaccination, handwashing and wearing gloves and covering the nose and mouth by face mask [3]. The face mask has been technologically recognized by researchers is their techniques and methods, that presented in the recent years to overcome the spread of COVID-19 through the world [4~7].

Engineers for years, have been trying to overcome the spread of the virus technologically, many researches had been made and many technologies have been implemented in this field based on Digital Image Processing DIP and Artificial Intelligent AI systems; The paper referenced as [8] proposed face mask detection by using YOLOV5 objection detection algorithm, and the results of the experiment have a success rate of about 97.9% high accuracy. The paper referenced as [9] proposed face mask detection by using depth-wise separable convolutional neural network, and the results of the experiment have a success rate of about 93.14% high accuracy. The paper referenced as [10] proposed face mask detection by using face recognition classifier model which uses image processing and extensive deep learning techniques, the output of the classifier is a bounding box as “Red” for the subject who is not wearing a mask and “Green” for presence of mask, also, it contains a label in “text” format which holds the prediction of the detection as "Mask" or "No- Mask". The paper referenced as [11] proposed A real time face mask detection by using Keras, OpenCV, and convolutional neural network, and the results of the experiment have a success rate of about 98% high accuracy.

In developing countries, as a contribution to reduce the spread of respiratory disease and controlling the use of face masks inside respiratory hospitals, this paper has been proposed Computer Aid Design (CAD) system. This CAD is advance system inside the respiratory infection diseases hospital to prevent the spread of virus among people inside the hospital. The targeted hospital includes three sections or departments for respiratory infectious diseases such as, Tuberculosis department, RSV department and COVID-19 department. Each of these department has their own controlled door by this proposed CAD system. The proposed system based on face mask recognition and color of the face mask using the techniques DIP and AI. This proposed paper has to fulfill number of objectives; as to detect face, mouth and nose features in obtained image as face mask recognition. Also, to implement controlling entrance doors of each department based on face mask color detection mechanisms.

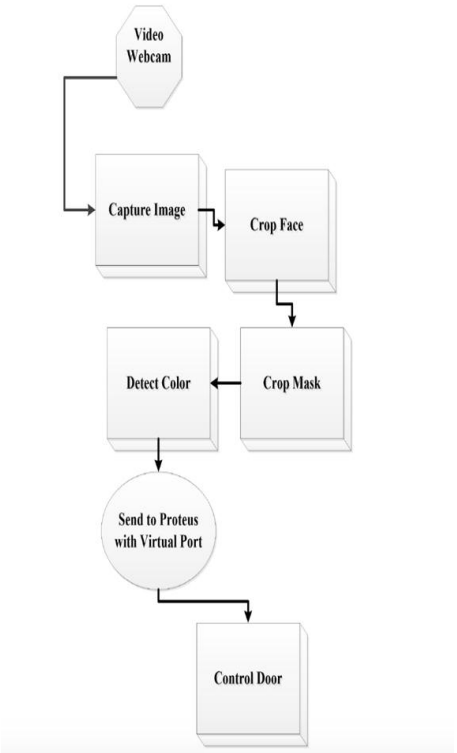
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The paper contains main five section; as background and introduction introduced in section one, section two includes the proposed system configuration design, section three includes the technique's used in the proposed system, the results and discussion were introduced in section four, finally section five include the conclusions.

The Proposed System Design Configurations

The design of the proposed system configures, can permit the people with wearing mask only to enter the respiratory infection diseases hospital. The permission mechanism is by controlling the main entrance door and sub division doors for each department inside the hospital by the detection of wearing mask and the mask colour. The images are loaded by video webcams as shown in Fig.1. The descriptive framework of the proposed system shown in Fig.2.



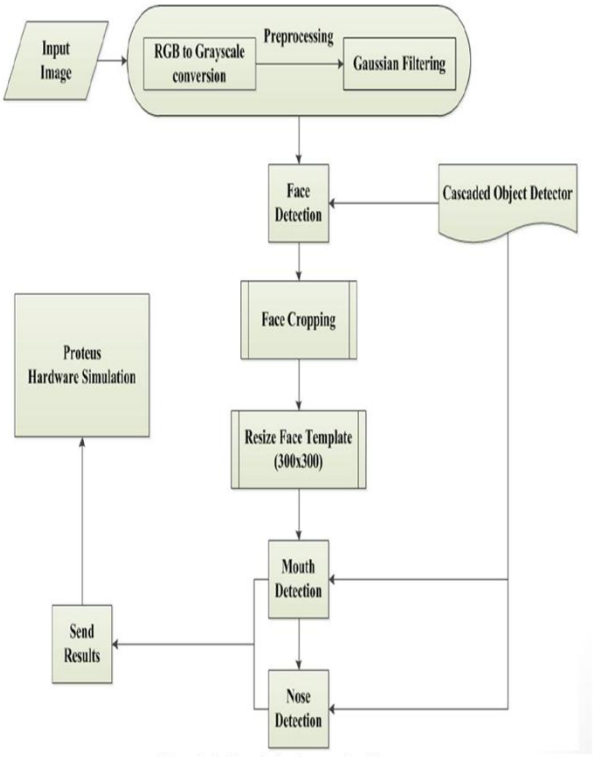


Fig.1 The CAD System Block Diagram Fig.2 The CAD System Framework

The used dataset in the training stage of mask color recognition system created locally as shown in Fig.3. The dataset consists of 450 images; 150 for each color (Red, Green, and Blue) as estimation for different department inside the hospital.

The main proposed system training and testing operations are performed on the dataset by the steps that described in the flowchart that shown in Fig.4. The method first starts with input image captured from the camera. Then the used method focused on the face feature of nose and mouth to detect the wearing mask, then the color classification method focused to

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determine the color of the mask which is red, green or blue. the output signals are to activate the departmental doors circuit to control which door will be open or remain closed.
The additional circuit simulated with Proteus simulation software to control main three door based on red mask for door 1 and green mask for door 2 and blue mask for door 3, estimated for different separated departmental inside the respiratory infection disease.



Fig.3. The Red, Green, Blue Mask Datasets

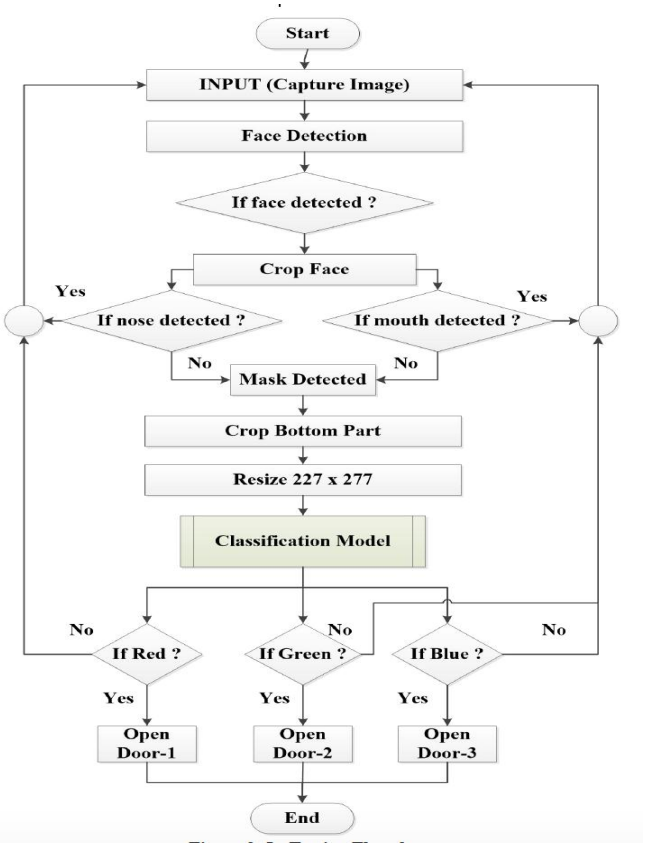


Fig.4 The Main System Flowchart

The Proposed System Methods and Techniques

The object identification is a technology that related to computer vision, and it used here in this proposed paper as a main technique for face mask and color detection. The main method of the proposed system is to create a face mask detector by putting the concept into practice using a MATLAB 2021a, Proteus and machine learning technologies. The digital image processing steps and the face detection and nose and mouth features detection based on the steps shown on the flowchart mentioned in Fig 4 as; capture image step, dataset creation step for the recognition process, training dataset step for CNN algorithm asked to recognize some unknown face mask and face mask detection and recognitions step.

In this proposed system, the main techniques used in face mask recognitions is Local Binary Pattern Histogram LBPH algorithm. The human face features are detected based on cascade classifications using the function “vision. Cascade Object Detector ('Frontal Face LBP')”. Then for mouth features are detected based on cascade classifications using the function

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"vision. Cascade Object Detector ('Mouth', 'Merge Threshold')" and "mouth detector (face Croped Img)". Then for nose features are detected based on cascade classifications using the function "vision. Cascade Object Detector ('Nose', 'Merge Threshold')" and "nose detector (face Croped Img)". Finally, after face mask recognitions, then mask color has been recognized based on color classification techniques for three color red, green and blue using the functions as; "case 1: sprint ("DB/ red/ %d _ %d.jpg" , Number , counter); case 2: sprint ("DB/ green/ %d _ %d.jpg " , Number , counter); case 3: sprint ("DB / blue/ %d _ %d.jpg " , Number , counter)"

The simulations mode for hardware designing circuit diagram is based on proteus simulations software. As shown in Fig.5, the electronic circuit model needs to simulate hospital department doors by control mechanisms used the output result of face mask and color recognitions. Virtual terminal is used as bridge virtual ports to connect MATLAB with Proteus through virtual serial ports. Fig.6, below shows the interface of virtual serial port application used in this paper. Finally, the proposed system is tested by GUI design and the video captured image as will show in the results section.

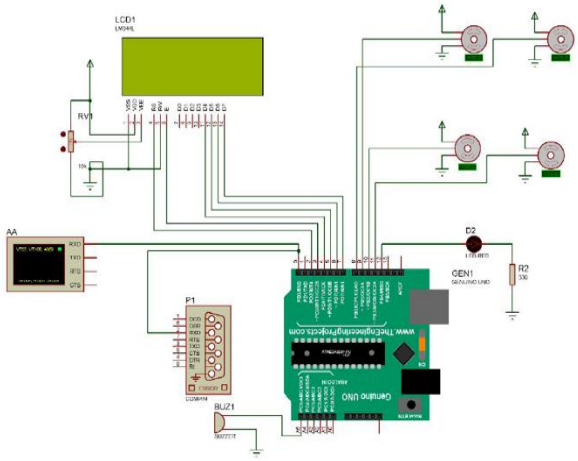


Fig.5 The hardware Simulation Model.

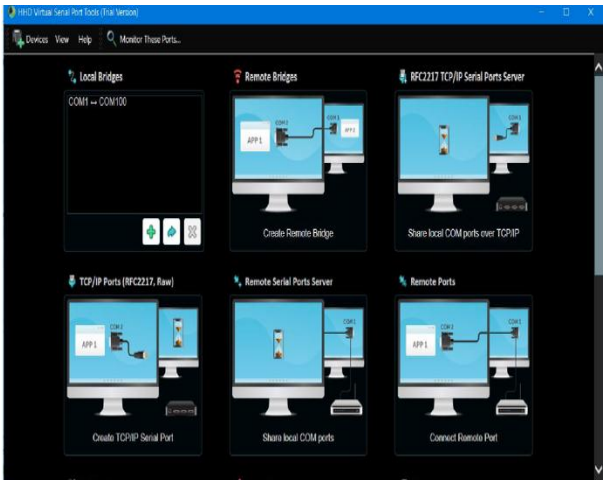


Fig.6 The Virtual Serial Port Software

2. THE PROPOSED SYSTEM RESULTS & DISCUSSION

The results below show the testing of face detection from image input using cascaded object detection, and also Mask Detection is performed by search for facial objects such like nose and mouth as mentioned before, for controlling the doors inside in hospital. As shown in Fig.7 and Fig.8 below shows the simulation initialization in Proteus application, the figures shows the starting of the system simulation and connection to MATLAB through virtual serial port.

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Fig.7 the Input Image System Test GUI

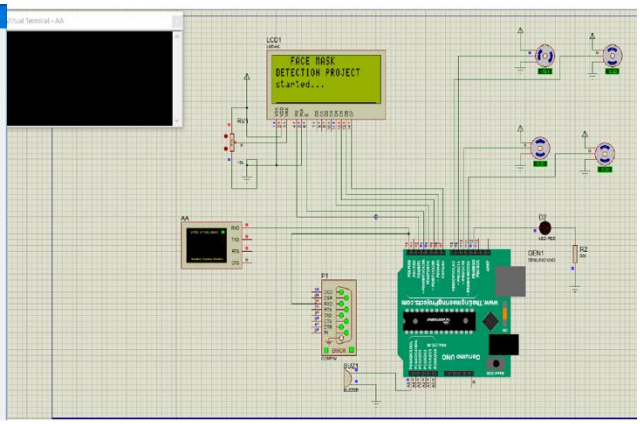


Fig.8 the Simulation Test Started

Fig.9 shows the output from system GUI test image with Proteus for No Mask Scenario, where the door will remain closed. Fig.10 shows the output from system GUI test image with Proteus for Mask OK Scenario, where the door will switch ON

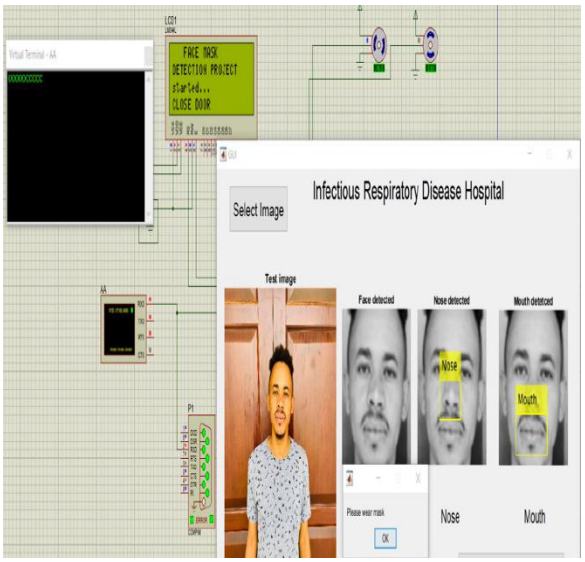


Fig.9 Simulation test without wearing Mask

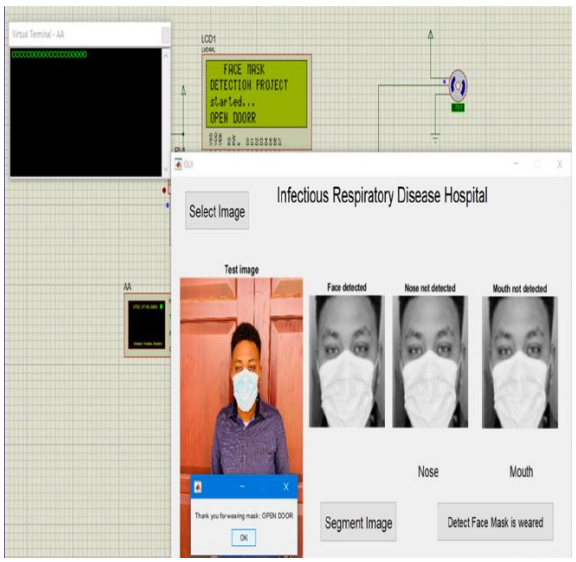


Fig.10 Simulation test with wearing Mask

Fig.11 shows the training progress and result for validation with 25% of data for testing. Table as Fig.12 below shows the training progress while executing the training execution here the accuracy results us shown with other training performance metrics are automatically generated by the training toolbox.

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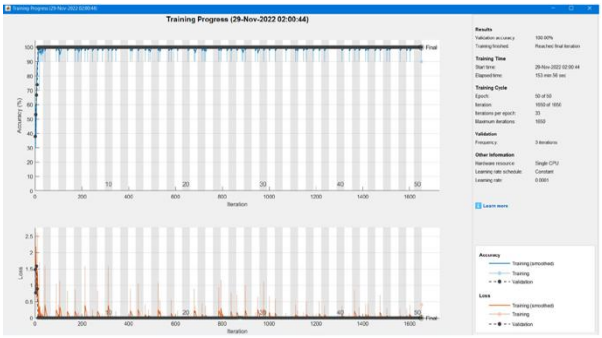


Figure.11 Training Results.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Validation Accuracy	Mini-batch Loss	Validation Loss	Base Learning Rate
1	1	00:00:08	30.00%	37.84%	1.7714	1.4774	1.0000e-04
1	3	00:00:18	40.00%	53.15%	1.3256	0.7720	1.0000e-04
1	6	00:00:24	70.00%	66.67%	1.5529	1.5800	1.0000e-04
1	9	00:00:30	80.00%	73.87%	1.8102	0.8870	1.0000e-04
1	12	00:00:35	90.00%	100.00%	0.3527	0.0026	1.0000e-04
1	15	00:00:41	100.00%	99.10%	0.0014	0.0164	1.0000e-04
1	18	00:00:47	80.00%	100.00%	1.6905	0.0001	1.0000e-04
1	21	00:00:53	100.00%	100.00%	0.0030	0.0033	1.0000e-04
1	24	00:00:59	90.00%	100.00%	0.2017	0.0220	1.0000e-04
1	27	00:01:05	90.00%	100.00%	0.2064	0.0015	1.0000e-04
1	30	00:01:11	100.00%	100.00%	0.0035	4.5582e-05	1.0000e-04
1	33	00:01:18	90.00%	100.00%	0.2718	2.1905e-05	1.0000e-04
2	36	00:01:24	100.00%	100.00%	4.1605e-06	3.3357e-05	1.0000e-04
2	39	00:01:31	100.00%	100.00%	0.0055	4.8601e-05	1.0000e-04
2	42	00:01:37	90.00%	100.00%	1.5962	5.8574e-05	1.0000e-04
2	45	00:01:43	100.00%	100.00%	2.6299e-05	9.2240e-05	1.0000e-04
2	48	00:01:49	100.00%	100.00%	0.0002	0.0002	1.0000e-04

Fig.12 Training Progress Results

The final Results of the projects as shown on Figures 13~16 for RGB Color for controlling the hospital departments doors. The testing of captured image without MASK where no action will be taken in Fig.13. The result of the captured image from camera for RED mask detection shown in Fig.14. the result of the captured image from camera for BLUE mask detection shown in Fig 15. Finally, the result of the captured image from camera for GREEN mask detection shown in Fig.16.

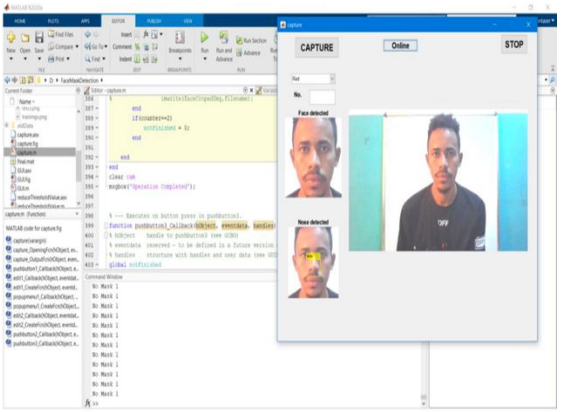


Fig.13 Video Test without Mask.

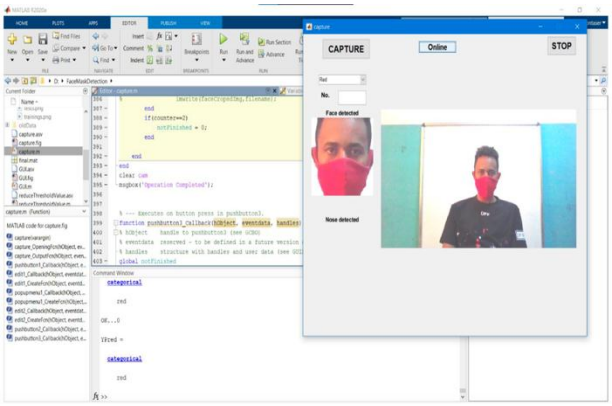


Fig.14 Video Test with Red Mask

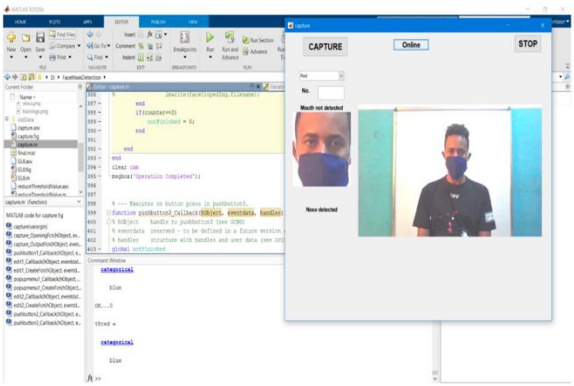


Fig.13 Video Test with Blue Mask.

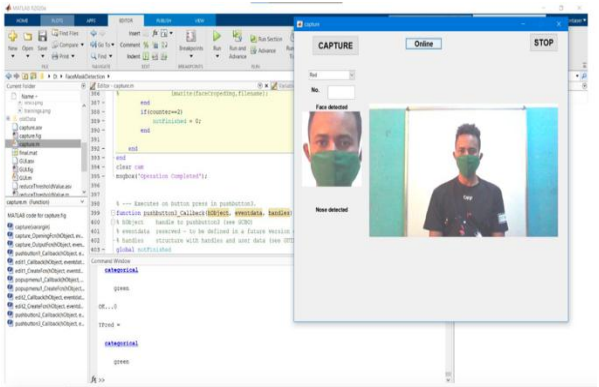


Fig.14 Video Test with Red Mask

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3. CONCLUSIONS

The basic infections control for specialized respiratory diseases hospital is to wear face mask. Since, wearing face masks are one of the effective tools to overcome the spread of respiratory diseases among people inside the hospital. The proposed system in this paper has been designed as CAD system to play an important role in protecting people inside the hospital by sophisticated technologies. This proposed system integrated with embedded technology to finalize the implementation of hospital departmental doors controlled by Face/Mask/Color recognitions. This system can be used for three different departments inside the hospital estimated as tuberculosis department, Respiratory Syncytial Virus department and Coronavirus Disease department. The control design of this proposed system based on the image captured from the camera in front of each department door for people need to enter the hospital. By following the methods steps, the captured image face has been recognized then mask has been recognized based on the introduced methods LBPH, then mask color has been recognized based on color classification techniques RGB for three color red, green and blue. Each of these colors for masks estimated for different department door inside the hospital. The system validation accuracy 100% and testing accuracy was 95%. For future development will be to consider using more accurate face/mask detection mechanism rather than cascaded detector or use more sophisticated model of cascaded object recognizing system.

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