International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET

Face Mask Detection and Body Temperature Assessment Using IoT with Deep Learning

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Article Info
Volume 9, Issue 2
Page Number : 368-375

Publication Issue :
March-April-2022

Article History
Accepted : 15 April 2022
Published: 30 April 2022

ABSTRACT

Masks play a crucial role in protecting the health of individuals against respiratory diseases, as is one of the few precautions available for COVID-19 in the absence of immunization. However, some people refuse to wear face masks with so many excuses. Moreover, developing the face mask detector is very crucial in this case. The pre-trained model in the learning approach requires the embedded vision processing system to achieve the accuracy in the detection process. The effective algorithm is required to perform the face wearing level identification in fast manner. The significant objective of the system is to build the automated solution for the detection of the uncovered faces and to create the contactless system to measure the body thermal conditions. The system identifies the level of face mask wearing using the Restricted Boltzmann Machine in Deep learning algorithm. And also identifies the body temperature using the MLX90614 IR Based Contactless sensor. The voice notification is generated using the HMM Model in the audio synthesis circuit.

Keywords: Deep Learning, Mask Detection, IR Sensor, Neural Network, RBM

I. INTRODUCTION

The corona virus COVID-19 pandemic is causing a global health crisis so the effective protection methods are wearing a face mask in public areas according to the World Health Organization (WHO). Wearing a mask is among the non-pharmaceutical intervention measures that can be used to cut the primary source of SARS-CoV2 droplets expelled by an infected individual. Face mask detection refers to detect whether a person is wearing a mask or not. Although numerous research have committed efforts in designing efficient algorithms for face detection and recognition but there exists an essential difference between 'detection of the face under mask' and 'detection of mask over face'.

In order to detect a face mask, the object detection algorithm can be implemented. The state of art of object detection algorithm which has a robust performance is the You Only Look Once (YOLO). The YOLO algorithm to detect the face in real-time application with accuracy and fast detection time.

The learning techniques have been widely applied in various applications domains such as computational learning, pattern recognition, data analysis, Information retrieval, Computer vision and Image Analysis. The rapid developments of optimized learning techniques provides the significant impacts on signal processing systems. The neural network model is inspired by the Bio-inspired computing and biophysical neurons. The neural network operations are performed in two stage operation, namely, training stage and testing stage. The neurons are the basic entity of the neural network which performs the mathematical operations well defined function by taking the input and produces the output in current segment or in the current layer.

The basic neural network has three layers, namely, input layer, hidden layer and output layer. The layer has the weight and bias to operate the neurons to produce the output. A neuron has the weight factor for each available input feature. The weight values of the neuron is tuned in the training stage and used to perform the classification in the testing stage. Non-linear behavior in a neural network is accomplished by use of an activation function to which the output is passed and modified. To construct a standard neural network, it is essential to utilize neurons to produce real-valued activations and, by adjusting the weights, the NNs behave as expected. The choice of describing solution is calculated by applying an objective approximation called the objective function. This procedure is assessed between the problem and the generated solution as the input and it computes the component holding the relation of the solution to the problem.

II. RELATED WORK

2.1 A Deep Learning Based Light – Weight Face Mask Detector With Residual Context Attention And Gaussian Heatmap To Fight Against Covid-19

This paper proposes a deep learning based single-shot light-weight face mask detector to meet the low computational requirements for embedded systems, as well as achieve high performance. This paper proposes two novel methods to enhance the model's feature to process the extraction. First, to extract rich context information and focus on crucial face mask related regions, this paper proposes a novel residual context attention module. Second, to learn more discriminating features for faces with and without masks, this paper introduces a novel auxiliary task using synthesized Gaussian heat map. Ablation studies show these methods are considerably boost the feature extraction ability and increase the final detection performance. Comparison with other models shows the proposed model achieves state-of-the-art results on two public data sets, it is AIZOO and Moxa3K face mask datasets. In particular, it compared with another light-weight , the mean average precision of our model is 1.7% higher on AIZOO dataset, and 10.47% higher on Moxa3K dataset. Therefore, the proposed model has high potential to contribute to public health care and fight against the corona virus disease 2019 pandemic.

2.2 A Review On Face Mask Detection Using Convolutional Neural Network

This paper used three deep learning methods for face mask detection, including Max pooling, Average pooling, and MobileNetV2 architecture, and these methods showed of detection precision. A dataset containing of 1845 images from various sources and

120 co-author pictures taken with a webcam and also mobile phone camera is used to train on deep learning architecture. The Max pooling achieved training accuracy of 96.49% and validation accuracy is 98.67%. and the Average pooling achieved training accuracy of 95.19% and validation accuracy is 96.23%. MobileNetV2 architecture has highest accuracy of 99.72% for the training and 99.82% for validation.

2.3 An Automated System To Limit Covid-19 Using Facial Mask Detection In Smart City Network

This paper proposes a system that restrict the growth of COVID-19 by finding out people who are not wearing any facial mask in a smart city network where all the public places are monitoring with CCTV cameras. If person without a mask is detected, the corresponding authority is informed through the city network. A deep learning architecture is trained on dataset that consists of images of people with and without masks it collected from various sources. The trained architecture achieved accuracy of 98.7% on distinguishing people with and without a facial mask for previously unseen test data. It is hoped that our study would be useful tool to reduce the spread of this communicable disease for many countries in the world.

2.4 Covid-19 Face Mask Detection With Deep Learning And Computer Vision

The corona virus COVID-19 pandemic is causing a global health crisis so the effective protection methods wearing a face mask in public areas according to the World Health Organization. The COVID-19 pandemic forced governments across the world to impose lockdowns to prevent virus. Reports indicate that wearing facemasks at work reduces the risk of transmission. This paper uses the dataset to build a COVID-19 face mask detector with computer vision using Python, OpenCV, and Tensor Flow and Keras. In the proposed system live video stream is used and finally in output it gives alert sound(buzzer) when someone not wearing mask. The main goal is to identify whether the person on image/video stream is wearing a face mask or not with the help of computer vision and deep learning.

III. METHODOLOGY AND SYSTEM DESIGN

In the existing system software based face mask detection system in video is developed based on the object recognition. The two stage detectors are used to identify the objects in the video streams. And the affine transformation is developed to crop the facial areas from uncontrolled real-time images having differences in face size, orientation and background. This step helps in localizing the person who is violating the facemask norms in public areas/offices.

The system has following limitations,

- Less Accuracy of face mask detection.
- The detection time very high and complex structure of operation.
- Algorithm requires the higher processing capacity in terms of memory.

The embedded system based face mask detection system is developed to identify the level of face mask wearing using the Restricted Boltzmann Machine deep learning algorithm. It also identifies face mask in highly accurate manner by using the unsupervised learning approach with the generalized human face pattern. The accumulated pattern provides the fast and effective system of face mask detection using the Viola Jones algorithm. Additionally, the contactless IR temperature sensor is used to check the temperature level of the human body and report it while the person having the threshold level temperature. RBM based learning methodology is utilized to perform the face mask wearing level in effective manner. In this methodology bipartite structure neural network is designed to improve the accuracy.

The neural network model provides the effective solution in both supervised and unsupervised classification process. It handles the various input stream and performs the analysis efficiently by reducing the classification error. And also provides the output in the output layer for the corresponding input stream.

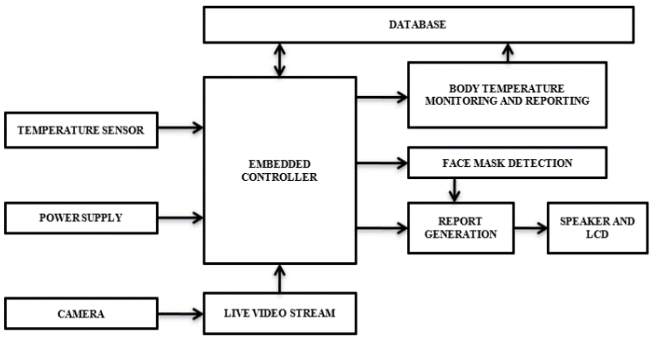

Figure 1. Block Diagram for face mask detection

The system implementations has following modules,

- Configuring IoT environment and Establishing remote interface using SSH
- Camera Function activation and Live Video Feed Capturing
- Applying RBM Deep learning and facemask Detection
- Activating the Sensors and Fetching Sensed Values in Interface
- Validating the Temperature and Report Maintenance

The analysis includes the mathematical function and computations with are based functional operations of the neuron which deterministically validates the output and minimizes the error. Here the problem is the generalized solution for obtaining the optimal model by applying the linear and nonlinear optimization process. The existing and available learning methodologies are developed to provide the solution with the high accuracy. But the system should be to satisfy the principle of optimality with the least convergence.

IV. IMPLEMENTATIONS AND DISCUSSIONS

Configuring IoT environment and Establishing remote interface using SSH

Raspbian OS has been loaded in the SD card using the win32disk image. After mounting the SD card in the Raspberry-PI, SSH and the VNC are enabled using the raspi-config interface. Connection is initialized using wired interface via Ethernet cable and the Class 4 IP address is assigned to raspberry in static manner. Remote interface is validated using the putty and VNC software via SSH connectivity. After logging in the UI, wifi interface is activated to access via mobile interface.

Camera Function activation and Live Video Feed Capturing

Connect the camera with the Raspberry in the camera module interface. Activate the Camera module. Create the pattern based on the camera output. Process the video sequence and convert into image frame. Perform the Pattern recognition for the captured live feed.

Applying RBM Deep learning and facemask Detection.

The Viola–Jones object detection framework is used to perform the detection of faces in the image frame. It extracts the HAAR feature and localize the faces and it is done by making each pixel equal to the entire sum of all pixels above and to the left of the concerned pixel. The face detection process was performed using Haar Cascade algorithm. The initial stage of this test was to determine the performance of the face detection process within frontal conditions or face to face with the camera. The system indicator could detect the face captured by the camera by the appearance of a green box enclosing the detected face. The next process is to determine the system capability to detect faces that were not directly facing the camera, or in a condition where the face made a certain angle to the camera.

The testing was done several times by making various face angle to the camera until the system could not detect the face anymore. According to the test results obtained, the face tilt maximum angle that could still be detected by the camera was about 30o. Thus, if the face angle of the camera has exceeded 30o, the face can no longer be able to be detected by the system. The face recognition process was performed using Viola Jones algorithm because of its smaller computation load, thus it is relatively fast and can be used for the real-time recognition process. The Viola Jones concept is to not look the whole image as a high dimensional vector, but to only review the local features of the important objects. The extracted object features only have low dimensions, for example, in face recognition case, it will only review the face, eye, and mouth features.

The basic idea of PCA and Viola Jones is to make a summary of the local image structure by comparing each pixel with the neighbor pixel by taking a pixel as the center and developing (threshold) of the neighbor pixel's value. If the intensity value of the center pixel is greater or equal to its neighbor, it will be marked with a value of 1 and if it will not be marked with a value of 0. This process can generate the binary values for each pixel, such as 11001111. Below is the testing result to get the eye and mouth features of a person's face marked with a blue circle for the eye position and a green circle for the mouth position.

The face identification process was performed by extracting the face features which is, in this case, was the position of the eyes and the mouth. The structure position, the eyes, and mouth position between one person and another is unique, thus it could serve as a feature for identification and classification or recognition process. To be able to perform the recognition or classification process, it is necessary to create a database of faces that contain some different face positions you want to recognize. For each person, a minimum of 15 different face poses would be stored in the database.

The face database will be collected in a specific folder that later would be called by the application to be used to be compared with the face captured by the camera. The results of the comparison would determine whether the face is common with the face stored in the database, or in the other words whether the face can be recognized or not. For each face in the database, it would be labeled as a number indicating the identity of a person. Afterward, the face file location in the folder and the label would be arranged in a matrix stored in CSV format. The face recognition application would read the face file and its label through the matrix.

The first column consisted of face image file location path stored in database folder, while the second column contained the identifiers of each face. For one person, it needs to store different various face positions files with the same label or identity. The red box enclosing the face indicates that the faces are detectable and the text above the box indicates the identification result, which in this case the identity is determined dynamically. The system could detect and recognize a face though with a complex background image. In this case, HAAR Cascade face detection algorithm could detect the position of the face precisely, further to cut the face area according to the size of the box surrounding the face. The size of the box will vary according to the size of the face pixels captured by the camera.

The farther the distance of the face to the camera, the detection accuracy will also decrease. This is because the further distance of the camera to the face, the size of the face area caught by the camera will also be smaller, which means the number of pixels in the face area becomes less. The number of pixel on the face area will affect the number of features that can be extracted. The fewer the number of pixels in the face area or the smaller the resolution of the face, the fewer extractable features will be. Thus, the detection and face recognition accuracy will decrease even more.

A hybrid framework using the Restricted Boltzmann Machine consisting of a neural network following a truncated Viola-Jones cascade is constructed in an attempt to recover the undetected face region to mark the face mask wearing level. The following steps are invoked in the formation of RBM.

- The RBM structure has to be formed by regulating the network structure into bipartite graph structure.
- The bipartite graph Structure has set of vertices which are connected by the set of edges with only one relative edge.
- The term relative edge represents the edge which indicated the connectivity of the vertices and the absence of the particular edge converts the network structure into two graphs.
- In the bipartite graph, the input layer is form is formed by the nodes in the communication range.
- The probability of the nodes are distributed using the Bernoulli distribution.
- The hidden layer vector is associated by maintaining the connection between each input in the hidden layer to the current node.
- The value vector of the hidden layer is regulated by checking the values of the probability of connection in the partition function.
- The output of the partition function is validated for the conditional probability.
- The condition probability is used to derived the individual activation probability.
- The activation function requires the logistic sigmoid and the softmax function.
- The values are discretized and sampled to provide the final activation value.
- By checking the maximum activation value, the output layer is formed.
- The output layer indicates the node with maximum activation value.

Activating the Sensors and Fetching Sensed Values in Interface

The IR temperature sensor is attached to the embedded device and the corresponding pin is activated in python code. The digital value of the sensor is read from the device and which is applied to data tuning operation to identify the exact temperature value. The contactless operation validate the body temperature in certain distance and the value is stored.

Validating the Temperature and Report Maintenance

Identified temperature value is compared against the threshold level. And the corresponding value is reported on the user screen. The mask detection output is illustrated in figure 2.

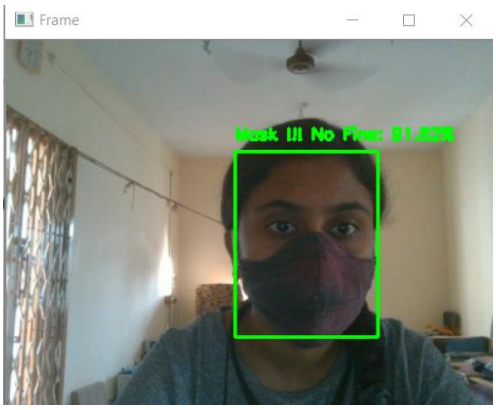

Figure 2. Face Mask Detection

The final report is generated by combining the report of the face mask detection and the level of human body temperature. This system can be connected with the existing surveillance system and installation of any additional hardware is not needed.

V. CONCLUSION AND FUTURE WORK

The face mask detection system is developed to identify the proper wearing level of the mask during the covid-19 pandemic situation. The system identifies the level of face mask wearing using the Restricted Boltzmann Machine in Deep learning algorithm. And generates the voice notification to the users using the voice synthesis circuit. The system is also determines the body temperature using the contactless IR sensor connected to the microcontrollers. The system can be enhanced by merging the biometric authentication and maintaining the log regarding their body thermal conditions. Additionally, future SMS based notification can be generated to produce the dedicated reports.

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Cite this article as :

Kamali S, Mandalapu Samhita, Srinishi S, Sindhuja P, "Face Mask Detection and Body Temperature Assessment Using IoT with Deep Learning", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 9 Issue 2, pp. 368-375, March-April 2022.

Journal URL : https://ijsrset.com/IJSRSET229268