A Check on WHO Protocol Implementation for COVID-19 Using IoT

Abhinav Sharma, Jayant Dhingra, and Parul Dawar

1 Introduction

COVID-19, which is also known as coronavirus disease, causes a situation of emergency in all over the world from March 2020, and every country was under lockdown to control its rigorous spread. While other people are self-conscious about their looks, they hide their emotions from the public by hiding their faces. Scientists proved that wearing face masks works on impeding COVID-19 transmission [1]. Since the outbreak, the WHO suggested some measures to control the spread, and the governance bodies all over the world are adopting measures suggested by the WHO. The essential precautions that the World Health Organization suggested are to maintain personal hygiene and social distancing and to wear a face mask in public places. Wearing a mask in public areas is one of the most effective methods, and it actually reduces the growth rate of COVID-19 by 40%. However, wearing a mask for a very long time could be exhausting and frustrating, and this is the main reason that people do not follow it [2]. The lawmakers and the governments worldwide are facing a lot of difficulties in controlling the spread of this deadly virus [3]. To ensure that this protocol is followed, an IoT system is proposed, which will ensure a correct way to wear a face mask and thus can result in a controlled situation when it comes to the spread of the coronavirus pandemic.

The coronavirus epidemic has given rise to an extraordinary degree of worldwide scientific cooperation. Artificial intelligence (AI) based on machine learning and deep learning can help to fight COVID-19 in many ways [4]. The advancements in the area of machine learning and data analysis have allowed various researchers and

A. Sharma · J. Dhingra · P. Dawar (✉)
Department of Electronics and Communication, Guru Tegh Bahadur Institute of Technology, New Delhi, India
e-mail: paruldawar@ieee.org

S. Nandan Mohanty et al. (eds.), *Internet of Things and Its Applications*, EAI/Springer Innovations in Communication and Computing,
https://doi.org/10.1007/978-3-030-77528-5_3

scientists around the globe to assess extensive amounts of data to predict the dispensation of the novel coronavirus, which can be an early warning and help in damage control of this deadly virus.

Due to expeditious enhancements in machine learning techniques, various breakthroughs are obtained in deep learning. Really helpful information and attributes can be gathered by convolutional neural networks (CNN) when they are trained on various images. The convolutional neural network acquired its popularity due to its efficiency in detection and recognition of problems. The dataset on which the CNN was trained underwent three stages that included preprocessing, training, and, finally, testing. After completion of all the three stages, it gave an accuracy of 97.8% by taking account of overfitting and underfitting for the data.

The trained CNN was executed on a Raspberry Pi model 3B to capture the face of the person via the Pi camera and identify whether the person is wearing a face mask or not. The proposed model also noted the body temperature of the person via the MLX90614ESF contactless temperature sensor.

Raspberry Pi model 3B is a very compact sole and tiny computer that weighs only about 23 g. It utilizes a power rating of 5 Volts, 1.2A, and on top of that, it is cost-effective when compared to a traditional computer. There are various boards such as model A, model B, and a more advanced version model B+. The B model has 1 GB random access memory and runs on Quad Core 1.2 GHz Broadcom BCM2837 64 bit CPU. All kinds of monitors like projectors, LCD screens, and TVs can be connected using an HDMI port. Some additional features include the audio jack and the camera connector to interface the camera [5].

The camera module used in the proposed IoT system was a 5 megapixel Raspberry Pi 3 camera module Rev. 1.3 with a flex ribbon cable for attaching with Raspberry Pi 3 model B. This module is a custom add-on that is designed for the Raspberry Pi and is connected via the CSI port. The CSI bus that is used for data transfer is exceedingly efficient and carries pixel data flawlessly.

The MLX90614 is an infrared thermometer for contactless temperature measurements which was ideal for the proposed model.

Section 2 summarizes some of the previous works in the field of face mask detection and IoT studies related to it. Section 3 presents the proposed IoT model and its setup and explanation. Section 4 presents the algorithm behind the proposed IoT model. Section 5 summarizes all the conclusions and findings of this chapter.

2 Literature Survey

The spread of COVID-19 is a serious challenge for the governments to deal with. One of the most efficacious methods to control this outspread, which is even suggested by the World Health Organization, is to wear a face mask. A serious action must be taken to ensure that people wear a face mask when in public places. One of the solutions for this problem can be to automate the face mask check with the amalgamation of IoT. Many authors have contributed in the IoT domain to solve this problem. This section summarizes the literature available along with comparative accuracies and recognition rate.

Son Ngoc Truong proposed a low-cost artificial neural network using Raspberry Pi. The proposed algorithm used MNIST dataset to train, and testing showed a recognition rate of 94%. The proposed algorithm gave a recognition rate of 89% when tested for real-time objects, which is around 2.7 times faster than the conventional neural network for MNIST image recognition [6].

Brian H curtin et al. proposed a system to classify wildlife for their better study and which are inexpensive, unobtrusive, and optimal in remote environments. The proposed model uses TensorFlow library and Keras API to create the CNN that run on Raspberry Pi model 3B+. The proposed system successfully detected snow leopards with between 74% and 97% accuracy [7].

Abdel Magid et al. juxtaposed algorithms for image classification. The proposed algorithm collated mainly three algorithms, which were linear regression, Gaussian's process, and random forest. The results indicated that the random forest's performance outnumbered the other two algorithms with an R-squared value of 0.79 and 0.95 for two different datasets [8].

Marco Grassi et al. proposed a neural network system that helps in the recognition of the human face and various additional applications by introduction of a linear shaded elliptical mask centered over the face for preprocessing which was used in association with DCT, for feature extraction, and MPL and RBF neural network for classification [9].

Amirhosein Nabatchian offered a method that is very sturdy and is designed for face recognition and is automated. The proposed method can work with systems under differing conditions of noise levels and occlusion. The proposed technique uses reciprocated information and entropy of the pictures to produce varying weights for a group of ensemble classifiers based on the input image quality [10].

Loey et al. proposed a model that uses classical machine learning and some parts of deep learning for face mask recognition; the framework uses ResNet50 for feature extraction and algorithms like decision tree and various ensemble methods for classification process using RMFD, SMFD, and other datasets that are similar. The SVM classifier achieved 99.64% testing accuracy in RMFD. In SMFD, it achieved 99.49%, while in LFW, it achieved 100% testing accuracy.

Bosheng Qin and Dongxiao Li proposed a face mask wearing condition identification method in combination with image super-resolution with classification network (SRCNet). Identification was trained and tested on Medical Masks Dataset [11].

Ejaz et al. presented an implementation of PCA on face mask recognition. In this model, a statistical approach has been adopted on both masked and unmasked face recognition [12].

Park et al. put forward a unique method that helped in the detection of optical glasses on human face and gave the region occluded by the glasses. Furthermore, the model helped in bringing an intuitive perspective of the face without the glasses by recursive error compensation using PCA reconstruction, and the proposed method showed an effective solution [13].

Chong Li, Rong Wang Li, and Linyu Fei proposed face detection based on YOLOv3, which is a popular algorithm and is both fast and accurate. The model uses SoftMax as the loss function instead of the logistic classifier to maximize the difference of inter-class features and decrease the dimension of features on detecting layers to improve speed. The YOLOv3 model has obtained great performance on small face, speed, and accuracy for the face detection task [14].

Nizam Ud Din et al. proposed a GAN-based network for unmasking of masked faces. The objective was to remove mask objects in facial images and regenerate the image by creating the image by itself in the void that is created. The output of the proposed model is a complete face image that looks natural and realistic [15].

Nieto-Rodriguez et al. proposed a system to detect the presence or absence of mandatory medical masks in hospitals. The final objective of the model is to minimize the false-positive face detections. The model achieved an accuracy rate of 95% [16].

Maksimovic et al. presented a comparative analysis of Raspberry Pi with some of the current IoT prototype platforms like Arduino, and Raspberry Pi outperforms all its peers and remains an inexpensive computer with its very successful usage in a diverse range of research applications in IoT vision [17].

Cruz et al. developed a device that performs iris recognition using Daugman's algorithm on Raspberry Pi. The preprocessing of the image was based on the tests implemented like false acceptance rate (FAR) and false rejection rate (FRR) [18].

Shah et al. put forward a biometric system that was based on cloud technology; authentication node was implemented on Raspberry Pi. The proposed system can capture multimodal biometric traits such as fingerprints and send them to cloud service by end-to-end encryption [19].

Anoop Mishra and Arshita Dixit proposed embedded image capturing and digital converting process in which a camera module is interfaced with Raspberry Pi 2 model B and a defined digital image processing algorithm converts it into a gray image. The result is compared with Raspberry Pi 1 model B, and Raspberry Pi 2 model B outperforms the other [20].

Md. Maminul Islam et al. proposed Raspberry Pi and image processing-based electronic voting machine (EVM) in which the Raspberry Pi is used as host and it has the ability to do image processing and control a complete voting machine system. A camera was used to take pictures of a citizen's national ID card and identify the user [21].

Param Popat, Prasham Sheth, and Swati Jain proposed an animal as well as an object identification model that uses deep learning on Raspberry Pi where they have implemented convolutional neural network (CNN) to detect and classify an animal/object from an image by using it on Raspberry Pi, which has relatively low GPU and computational power. The model used a Python-based program with libraries like TensorFlow [22].

Durr et al. proposed a model that uses deep learning on Raspberry Pi for face recognition, and it is performed in real time where authors trained convolutional neural network (CNN) on a desktop PC and deployed on Raspberry Pi model B for classification procedure. OpenCV's results were outperformed, and an astounding accuracy of 97% was observed [23].

Khan et al. proposed a model in which there is an interactive removal of microphone from the images. The microphone is removed from images having faces, and the void created by the removal is filled with facial features already present in the photo. The interactive method used here is MRGAN in which the user roughly provides the microphone region, and for filling the holes, a generative adversarial network-based image-to-image translation approach was used [24].

Dr. Shaik Asif Hussain and Ahlam Salim Abdallah Al Balushi presented a real-time face emotion classification and detection using deep learning models. The facial features were captured in real time and processed using Haar cascade detection. The input image is analyzed using Keras convolutional neural network model [25].

2.1 *Literature Survey Conclusion*

A comparative analysis based on the literature review in the previous section, comprising various face mask and related techniques and methods with the proposed method, is shown in Table 1.

Table 1 Comparison of the proposed methods with literature

Reference number	Title	Technology used	Inference
Son Ngoc Truong [6]	Healthcare based on IoT using Raspberry Pi, International Conference on Green Computing and Internet of Things (ICGCIoT)	Artificial neural network using Raspberry Pi	Accuracy – 89%
Brian H. Curtin and Suzanne J. Matthews [7]	Deep learning for inexpensive image classification of wildlife on the Raspberry Pi	Convolutional neural network using Raspberry Pi 3B+	Accuracy varying from 74% to 97%
Abdel Magid et al. [8]	Image classification on IoT edge devices: Profiling and modeling	Linear regression, Gaussian process, and random forest	R-squared value of random forest – 0.95 and 0.79 for two different datasets
Nieto-Rodriguez et al. [16]	System for medical mask detection in the operating room through facial attributes	ADA boost along with a mixture of Gaussian techniques	Accuracy – 95%
Proposed method	A check on WHO protocol implementation for COVID-19 using IoT	Convolutional neural network using Raspberry Pi 3B+	Accuracy – 97.80%

This literature review adumbrates the trend and advancement in the methods and accuracies which ranges from 78% to 97%, and the method proposed in this chapter attained an accuracy of 97.80%.

3 Dataset

The dataset used in the model consists of real images of people, out of which 755 images are of people with a face mask and 754 images are of people without a face mask. The dataset is an amalgamation of the real-world masked face dataset (RMFD) and web scraped data with people wearing masks and people without masks. Figures 1 and 2 show some of the images from the dataset where people are wearing masks and people are without face masks, respectively.

4 Proposed System

The proposed face mask detection method is designed using deep learning and TensorFlow and implemented on a Raspberry Pi model 3B. According to the designed model, the face is captured via the Pi camera module, which is a 5MP camera module connected to the Raspberry Pi via the CSI port. The captured image is passed through the designed CNN architecture, which decides whether the person in front of the camera is wearing a face mask or not. Meanwhile, the MLX90614

Fig. 1 People wearing a face mask

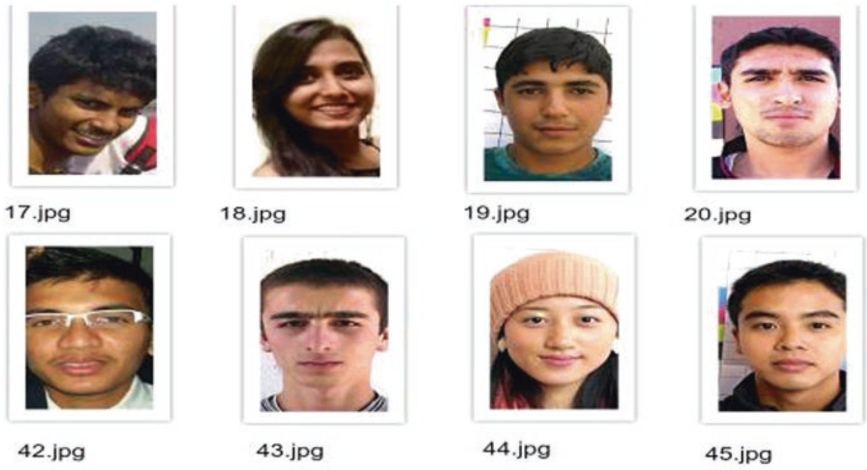

Fig. 2 People without a face mask

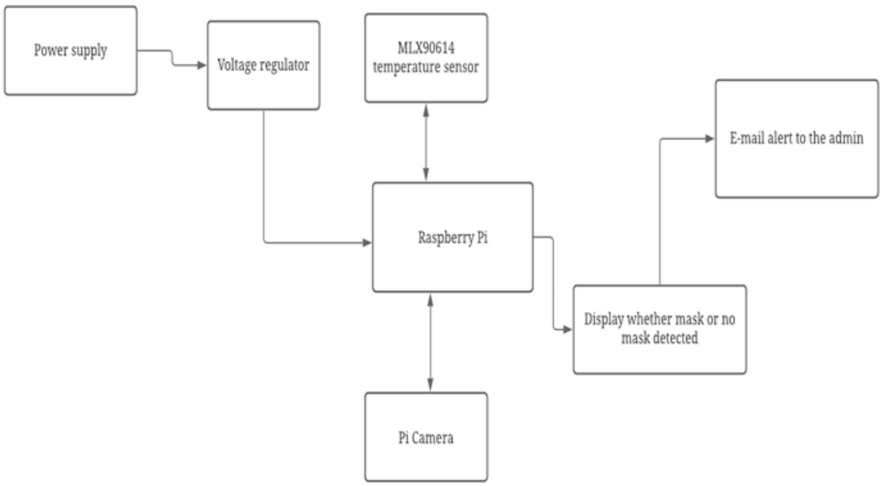

Fig. 3 Block diagram of the proposed system

notes the body temperature of the person in front of the sensor and returns the value of it. If the face mask is detected and the body temperature of the person is within the normal body temperature range, then an email is sent to the admin notifying that the person is safe and is allowed to enter the premises as shown in (Fig. 3).

4.1 Designed Convolutional Neural Network

Deep learning has many classes, out of which convolutional neural network (CNN) is one of the most liked classes. CNN is generally applied to examine visual images and related areas. In the proposed CNN model, TensorFlow was extensively used. TensorFlow is used in areas where the user needs a lot of numerical calculation needs to be done using the stream of data available. TensorFlow is an open-source library and is pretty common among data scientists. The designed model detects the face mask in three stages.

The first stage in face mask detection is the preprocessing phase. During the preprocessing phase, a cascade classifier is applied on the images; this cascade classifier provides area of the face after the images are resized to 100×100 pixels to provide similar inputs for the neural network. The images are also converted from RGB to gray because color is insignificant in recognition of a face mask. After the resized images are passed through the designed neural net, it gives the user probabilities. If no face mask is detected, 0 is given as the output and 1 if the mask is detected. The images are again resized to a 4D array as the CNN takes 4D inputs after which the images are converted into categorical labels. Any exceptions are also considered in (Fig. 4).

There is a 90% and 10% split in the training and testing data when the model is learning the data. Furthermore, the data is passed through two ConvNet layers. The first layer comprises 200 kernels of 3×3 size, and the second layer comprises 100 kernels of 3×3 size. In the end, the trained model's data is flattened and passed through a layer of neurons consisting of 50 neurons. Finally, the CNN model gives an accuracy of 97.8% on TensorFlow 2.0.0.

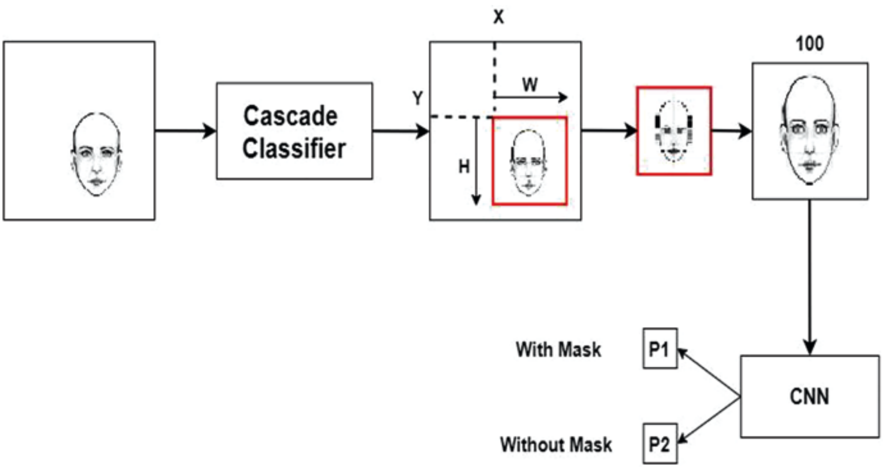

Fig. 4 Face mask detection model

4.2 Raspberry Pi's Setup

The Raspberry Pic used in the designed system was the Raspberry Pi 3 model B. It was used because of its compact form factor and its bang to the buck performance ratio. Size is an important aspect when you are trying to build a compact kiosk like this one. The Pi 3B delivers decent performance and is adequate for this face detection system. The MLX90614 sensor was connected to the Raspberry Pi via the GPIO pins. The MLX90614 has four connection pins, one for the VCC, one for the ground, one for the serial data line (SDL), and one for the serial clock line (SCL). The Pi camera module was connected to the Pi via the CSI port available on the Pi. Finally, the output was displayed on the LCD or LED display as shown in (Fig. 5).

4.2.1 Pi Camera

The camera module used in this system was the Raspberry Pi camera module Rev. 1.3, and it comes equipped with pliant cables that are attached to the Raspberry Pi's board via the CSI port. One of the main reasons this camera module was used in this system was because of its compact form factor and its high-definition camera that remits formidable photos. It is also extensively used in CCTV, drones etc. as shown in (Fig. 6)

The camera serial interface bus is capable of extremely high data rates, and it can also transport pixel data privately, making it perfect for our model.

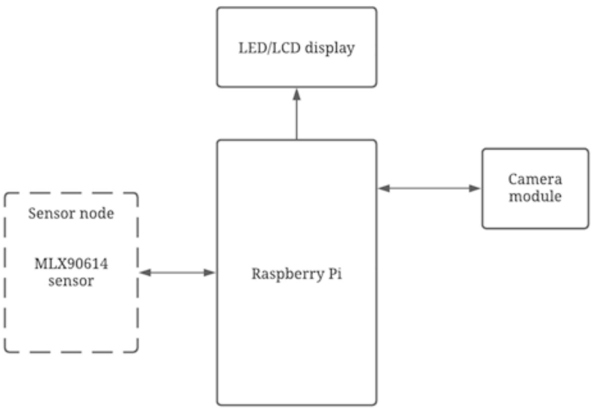

Fig. 5 Raspberry Pi setup

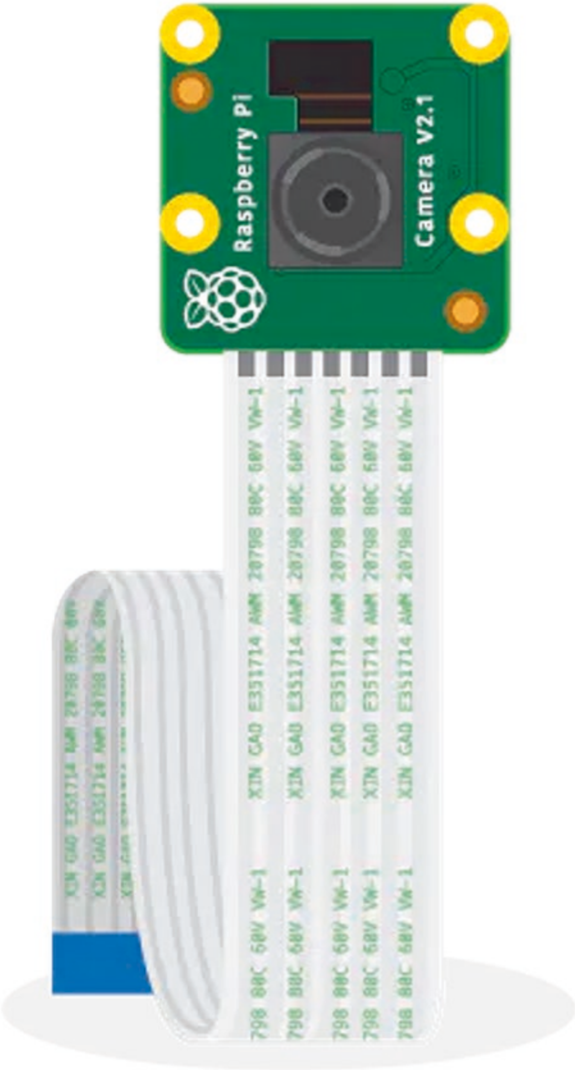

Fig. 6 Raspberry Pi camera module

4.2.2 MLX90614 Non-contact Temperature Sensor

The MLX90614ESF, which was used in our face mask detection system, is an infrared thermometer and is used for contactless temperature measurements. The MLX90614 GY-906 is a low-noise amplifier, and some of its key features are high-precision temperature measurements and livestock monitoring. The image of the sensor is shown in (Fig. 7).

The MLX90614 has an operational range of 3.3 volts to 5 volts input; also this module has a power regulator IC that is built inside the module. Some additional

Fig. 7 MLX90614 sensor module

features of the GY-906 like automotive blind angle detection and low voltage requirement make it ideal for the face mask and temperature detection model like ours.

5 Implementation

The implementation of this model is a pretty straightforward one as explained in Fig. 8. Initially, the dataset is loaded and then passed through the designed convolutional neural network where it is resized and passed through multiple layers of resizing and rescaling. After that, the model is trained and is ready to perform. The trained CNN model is tested and the Pi camera captures images and passes it through the designed neural net, and it tells whether the person is wearing a face mask or not. The mechanism of this CNN is explained in Sect. 5.1. The non-contact temperature sensor works alongside the camera to fetch the body temperature of the person in front of the IR sensor. After getting the results from the camera and the sensor, they are displayed on the LCD/LED display that is connected to the Raspberry Pi via the HDMI port, and an email is sent to the admin containing the person's picture and his/her body temperature. The setup is shown in (Fig. 9).

5.1 CNN Algorithm

Deep learning has been observed as a monumental growth in connecting humans and machines. The main motive of this field is to enable machines to view the world as humans do and discern the knowledge just like humans. The CNN architecture is shown in (Fig. 10).

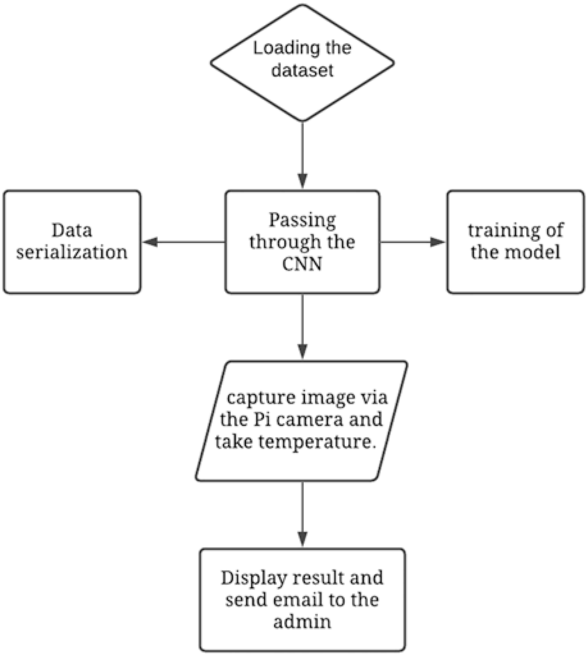

Fig. 8 Flowchart of the implementation of the model

Convolutional neural network is an integral part of deep learning that basically takes an input as an image and assigns various vital weights to different aspects in the image and is able to classify from others. The preprocessing power required in CNN is quite lower as compared to other classification algorithms that are suitable to use with Raspberry Pi. Convolutional neural network comprises various convolutional layers that are the major building block used in CNN, pooling layers, nonlinear layer (ReLU), fully connected layer, and classification layer. The initial layer works to draw out features from an input image in the convolution. This convolution further reads the input in a small square of inputs and saves the relationship between the pixels by which it remembers the image.

Nonlinearity (ReLU), which stands for Rectified Linear Unit, in convolutional neural network, is established by this ReLU layer. The matrix formed is flattened into a vector form and then fed into an FC layer or fully connected layer. Then this FC layer is concatenated to create a model.

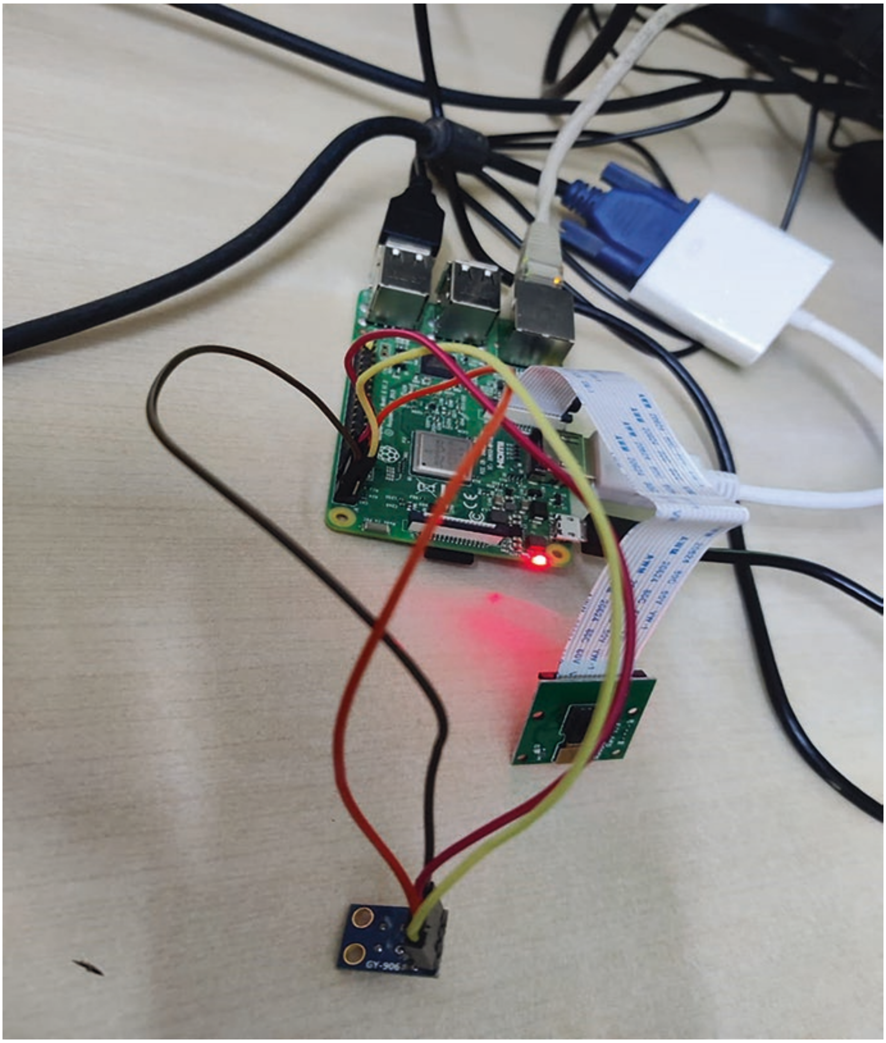

Fig. 9 Setup of the face mask and temperature detection system

6 Results

The proposed CNN model uses a TensorFlow library and detects whether a person is wearing a face mask or not and whether he/she is spreading or being affected by the coronavirus. The CNN is trained, passed through the designed neural net to finally give an accuracy of 97.80%. The results are depicted in Figs. 11 and 12.

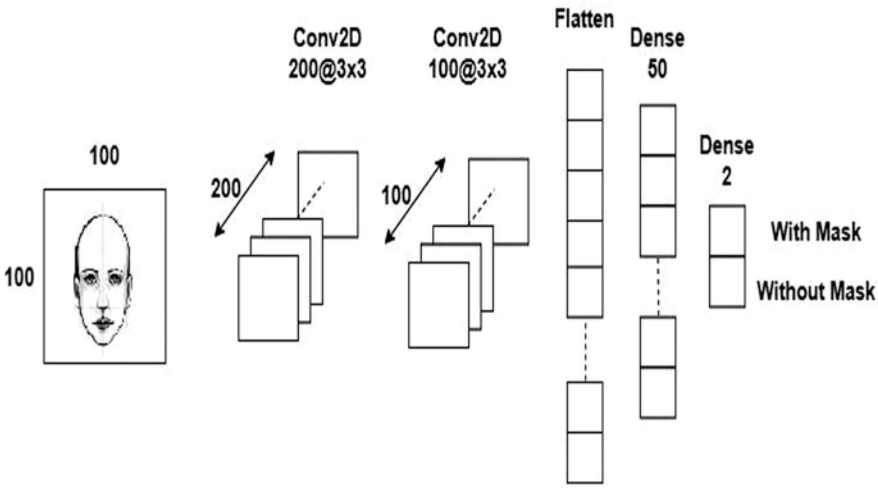

Fig. 10 CNN architecture

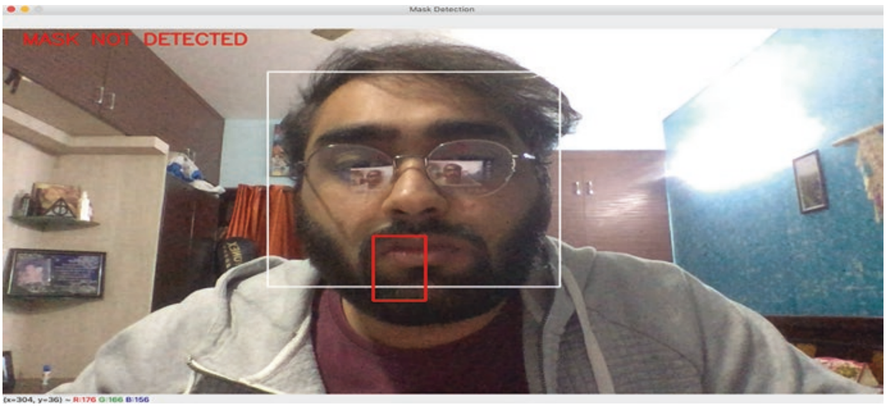

Fig. 11 Face mask not detected

Further, Figs. 13 and 14 represent the accuracy curve and loss curve, respectively.
It is quite evident in Figs. 13 and 14 that the model shows minimal signs of overfitting, but it is still pretty usable and robust. Pre-trained models like MobileNet can also be downloaded and used for tweaking the results.

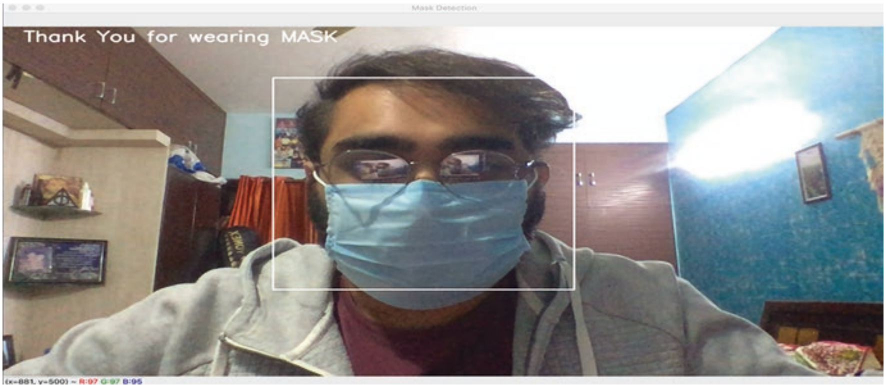

Fig. 12 Face mask detected

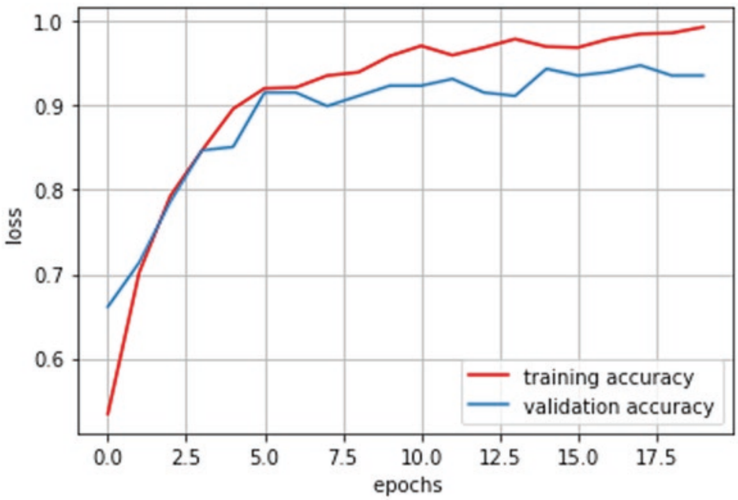

Fig. 13 Accuracy curve of the CNN

7 Conclusion

Tackling the COVID 19 pandemic is a real struggle for the world and is one of the toughest challenges that humanity has faced. Wearing a face mask can be a helpful method in controlling the outbreak of this fatal virus. In this chapter, a face mask and temperature detection IoT system was proposed. The designed CNN for the face mask detection was successfully trained and gave an accuracy of 97.80% when trained on TensorFlow 2.0.0 with minimal signs of overfitting and underfitting. The system captured the face mask's information and the body temperature of the person and sent it to the admin via email.

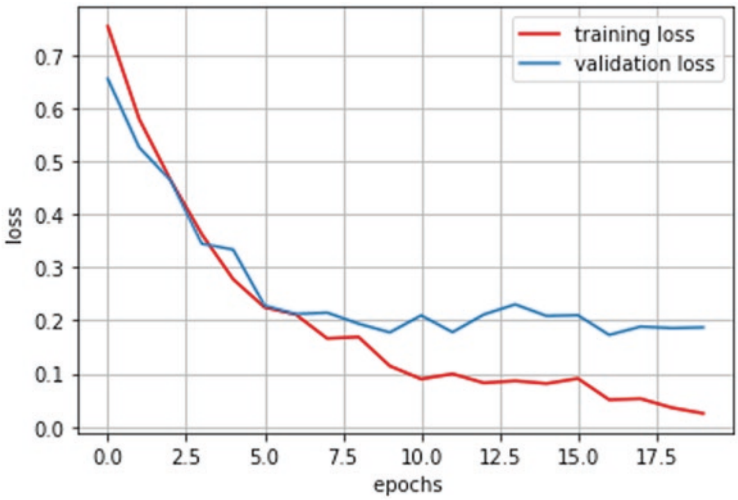

Fig. 14 Loss curve of the CNN

References

1. S. Feng, C. Shen, N. Xia, W. Song, M. Fan, B.J. Cowling, Identification of common molecular subsequences. J. Mol. Biol. **147**, 195–197 (1981) Lancet Respir. Med
2. Hindustan Times, https://www.hindustantimes.com/india-news/masks-can-reduce-covid-19-growth-rate-by-40-study/story-x3AY1QMIPvBthiertbzCZJ.html. Accessed on 20-12-2020
3. M. Jiang, X. Fan, H. Yan, *Retina Face Mask: A Face Mask Detector* (Cornell University, 2020)
4. M. Loey, G. Manogaran, M.H.N. Taha, N.E.M. Khalifa, A hybrid deep transfer learning model with machine learning methods for face mask detection in the era of the COVID-19 pandemic. Measurement: J. Int. Measure. Confeder., Elsevier **167** (2021)
5. Healthcare Based on IoT using Raspberry Pi, *International Conference on Green Computing and Internet of Things*, vol 1 (IEEE, 2015), pp. 796–799
6. S.N. Truong, A low-cost artificial neural network model for Raspberry Pi. Eng. Technol. Appl. Sci. Res. **10**(2), 5466–5469 (2020)
7. B.H. Curtin, S.J. Matthews, Deep Learning for Inexpensive Image Classification of Wildlife on the Raspberry Pi. IEEE Annual Ubiquitous Computing, Electronics and mobile communication conference (2019). https://doi.org/10.1109/UEMCON47517.2019.8993061
8. S.A. Magid, F. Petrini, B. Dezfouli, *Image Classification on IoT edge devices: profiling and modeling, Cluster Computing* (Springer, 2019)
9. M. Grassi, M. Faundez-Zanuy, *Face Recognition with Facial Mask Application and Neural Networks, International Work-Conference on Artificial Neural Networks: Computational and Ambient Intelligence* (Springer, 2007), pp. 709–716
10. AmirhoseinNabatchian, *Human Face Recognition, Electronic Thesis and Dissertations* (University of Windsor, 2011)
11. B. Qin, D. Li, *Identifying Facemask-Wearing Condition Using Image Super-Resolution with Classification Network to Prevent COVID-19* (Research Square)
12. M.S. Ejaz, M.R. Islam, M. Sifatullah, A. Sarker, Implementation of principal component analysis on masked and non-masked face recognition, in *1st International Conference on Advances in Science, Engineering and Robotics Technology*, (IEEE., 978-1-7281-3445-1/19, 2019)

13. J.-S. Park, Y.H. Oh, S. ChulAhn, S.-W. Lee, Glasses removal from facial image using recursive error compensation. IEEE Trans. Pattern Anal. Mach. Intell. **27**(5), 805–811 (2005)
14. C. Li, R. Wang, J. Li, L. Fei, *Face Detection Based on YOLOv3, Advances in Intelligent Systems and Computing* (Springer, 2020), pp. 277–284
15. N.U. Din, K. Javed, S. Bae, J. Yi, A novel GAN- based network for unmasking of masked face. IEEE Access **8**, 44276–44287 (2020)
16. M.M. Nieto-Rodriguez, V.M. Brea, *System for Medical Mask Detection in the Operating Room Through Facial Attributes, Pattern Recognition and Image Analysis* (Springer, 2015), pp. 138–145
17. M. Maksimovic, V. Vujovic, N. Davidovic, V. Milosevic, B. Perisic, Raspberry Pi as Internet of Things hardware: Performances and Constraints, in *1st International Conference on Electrical, Electronic and Computing Engineering*, (2014), p. ELI1.6.1-6
18. F.R.G. Cruz, C.C. Hortinela, B.E. Redosendo, B.K.P. Asuncion, C.J.S. Leoncio, N.B. Linsangam, W.-Y. Chung, Iris Recognition Using Daughman Algorithm on Raspberry Pi. IEEE Region 10 Conference (TENCON), 2126–2129., 978-1-5090-2597-8/16 (2016)
19. D.K. Shah, V.A. Bharadi, V.J. Kaul, S. Amrutia, End-to-End Encryption based Biometric SaaS using Raspberry Pi as a remote Authentication Node, in *International Conference on Computing Communication Control and Automation*, (IEEE., 978-1-4799-6892-3/15, 2015), pp. 52–59
20. A. Mishra, A. Dixit, Embedded Image Capturing & Digital Converting Process using Raspberry Pi system interfacing and comparison of generation 2 verses generation 1 models in Raspberry Pi. Int. J. Comp. Sci. Inform. Technol. **6**(2), 1798–1801 (2015)
21. M.M. Islam, M.S.U. Azad, M. AsfaqulAlam, N. Hassan, Raspberry Pi and image processing based Electronic Voting Machine (EVM). Int. J. Sci. Eng. Res. **5**(1) (2014)
22. P. Popat, PrashamSheth, S. Jain, *Animal/Object Identification using Deep Learning on Raspberry Pi, Information and Communication Technology for Intelligent systems* (Springer, 2018), pp. 319–327
23. O. Durr, Y. Pauchard, D. Browarnik, R. Axthelm, M. Loeser, *Deep Learning on a Raspberry Pi for Real Time Face Recognition, EG 2015 - Posters* (2015). https://doi.org/10.2312/egp.20151036
24. Muhammad Kamran Javed Khan, Nizam Ud Din, Seho Bae and Juneho Yi: Interactive Removal of Microphone object in Facial Images, 2019
25. S.A. Hussain, A.S.A. Al Balushi, A real time face emotion classification and recognition using deep learning model, in *ICE4CT 2019 Journal of Physics*, Conference Series, vol. 1432, (2020), p. 012087