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AI Powered Holistic Solution for Travelers during Pandemic

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Abstract: As the world is engulfed with COVID-19 pandemic and the glimpse of vaccine is still a distant dream, taking precautions and maintaining the norms suggested by WHO will keep us safe. With this, we present in this paper a solution that would help travelers induce confidence in traveling while keeping in mind the guidelines that must be followed. The solution focuses on an end to end service that will not only help the travelers to make informed and safe decisions but also allow the hospitality industry to monetize from this application. This paper is focused on a detailed analysis of the solution that is being presented to tackle the problems faced by various industries and their fear of resuming the work. A software-based approach is taken for providing a simple and engaging user experience to the user along with an AI approach to detect and predict the COVID trend in various cities. Along with this, a system that detects if people are wearing a mask or not will also be verified by the algorithm.

Keywords: Angular, Node JS, Ma- chine Learning, Recurrent Neural Networks, Convolu-tional Neural Networks, MobileNet, ResNet

I. INTRODUCTION

It's been nearly a century since pandemics have globally affected not only the lives of the people but also the economy of many countries. It's proven that vaccines can take a lot of time to release. From previous pandemics like the plague of Justinian, Smallpox which wiped out a large number of populations, COVID too can have a disastrous effect on mankind if proper precautions are not taken into account. With COVID being a deadly pandemic, people are precarious to travel during and post COVID situation. It has called for following WHO norms like a compulsion of wearing masks. Apart from this, there is a prevalent uncertainty in the mind of people regarding the date of commute and travel. People are not sure about future trends and the situation of the place of travel. The main aim of this project is to induce confidence in people and to encourage them to travel along with helping the hospitality industry to function properly. For this, an easy to use the website is made for all the travelers so that they can be sure about the COVID trend and the news of COVID and other important updates of the place of travel. Using machine learning we can come up with a trend of high accuracy that predicts and plots the future COVID trend of the number of cases. Also, by using Convolutional Neural Networks we achieved the task of detecting if people are wearing masks or not. This service can be used up by the hospitality industry like hotels and museums so that people visiting such places have an idea about the extent to which the WHO guidelines are being followed. This will enable travelers to make a safer decision about visiting a particular place for business or leisure

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II. LITERATURE SURVEY

As per the reports by the World health organization (WHO) [1], it is evident that infections caused due to the corona virus disease 2019 (COVID-19) have crossed over 13 million people and the total deaths has crossed 580,000 globally. Furthermore, several other widespread detrimental respiratory diseases like the Middle East respiratory syndrome and severe acute respiratory syndrome have affected the global population and economy in a similar way. This has led to a rise in concern levels amongst people about their health. Public health has also been taken into consideration as the topmost priority for governments. Fortunately, works have shown that wearing face masks can prevent the spread of corona virus [2]. WHO has recommended that people who display respiratory symptoms, or the ones that are looking after symptomatic patients, should wear face masks [3]. Furthermore, strict guidelines have been issued and many public service providers are mandating the wearing of masks for the customers to use the service [4]. Therefore, the detection of face masks has become an imperative computer vision task to help society across the globe, but there exists limited research related to face mask detection. The underlying aim of the face mask detection process is to detect if a mask is being worn by a person or not along with detecting a face and providing a probability as an output [5]. Face detection, just like general object detection, detects an object of a particular class, i.e. face [6,7] and classifies it. Object and face detection have numerous applications that can be found in many domains, such as autonomous driving [8], education [9], surveillance, and many more. Standard object detectors usually rely on manually made feature extractors. Viola-Jones detector uses Haar features [10], while other famous methods include different feature extractors, such as scale-invariant feature trans- form, histogram of oriented gradients and many more [11]. Object detectors based on deep learning techniques have also demonstrated excellent performance and have surpassed standard object detectors. With the advent of Deep learning, neural networks can learn patterns and features relevant to a particular task [12]. There are two types of deep learning-based object detectors, namely, one- stage and two-stage.

One-stage object detector detects objects using a single neural network like you only look once (YOLO) and single shot detector (SSD) [13] and [14].

On the other hand, two-stage detectors use two networks to perform the task of object detection like region-based convolutional neural network (R-CNN) [15]. In a similar way, the architecture followed by face detection is similar to a general object detector. The presence of additional face related features, for example, facial landmarks can improve the overall accuracy of the face detection task. With all this, face mask detection is a less researched application. It is imperative to come up with a solution that accurately detects face masks. In this paper, we have therefore presented a face mask detector, which detects face masks and, in this way, the transmission of COVID can be checked and reduced. One of the approaches in this domain is Retina Facemask which has used multiple feature maps along with feature pyramid network (FPN) and transfer learning. The above model was trained on a face mask dataset [16]. For our model, data sets have been custom-made to diversify the images and produce sufficient images to train. A total of 1400 images were used for the training purpose. By using transfer learning and tuning the value of output stride, an accurate face mask detection model was made.

Forecasting of the COVID-19 pandemic is very crucial in determining its future effects.[1][2]. It can provide insightful information to the front-line workers in case of a peak in cases. Such information will also help travelers decide the travel dates and help revive the travel and tourism industry [6]. Therefore, AI- based predictive and statistical models play an important role in determining their future impact [7]. Linear Regression is widely used to foresee the spread of COVID-19[2][4]. Alongside this, Vector Autoregression (VAR) is also used for forecasting models [2]. Another important machine learning model used the Johns Hopkins University dataset for predicting the spread using the Multilayer Perceptron neural network [2][5]. The achieved results are evaluated using R2 and the RMSE metric. Therefore, in order to overcome the barriers faces by statistical methods and minimize error, a deep neural network (LSTM) was used to forecast the COVID infection using the Canadian dataset [3].

III. WORKING

The proposed solution consists of three main parts:

1) Detecting if people are wearing mask or not.
   (a) Collecting and making custom data set for 'mask' and 'non mask' images.
   (b) Predicting if people are wearing mask or not using convolutional neural networks (CNN) and transfer learning.
2) Predicting the trend of COVID using long short-term memory (LSTM).

A. Creating Dataset

Due to the paucity of the 'mask' data set online, data set containing 700 images of 'mask' and 700 images of 'no mask' was created. The process involves collecting normal images of people and identifying facial landmarks so that section was mask can be easily overlaid. With facial landmarks, positions of nose, jawline, eyebrows, eyes, and mouth can be inferred. After the collection of normal images of people, a deep learning method was used to perform face detection with OpenCV. Many implementations for detecting faces are based on using on the histogram of oriented gradients (HOG) followed by a linear SVM or pre-trained networks such as YOLO or suing Single Shot Detection (SSD). For this implementation, a face detector based on CNN (Convolutional Neural Network) available in dlib was used. The main advantage of this method over the HOH+SVM method is that it can detect faces from all angles. Having detected the face or the region of interest (ROI) using OpenCV and NumPy slicing, facial landmarks were detected using dlib so that we know where to place the mask on the face (along the regions of the chin and the nose). After resizing and rotating the mask, the mask was placed on the faces of people data set and data set containing 1400 images was created. The entire process is shown in Fig. 1 and Fig. 2

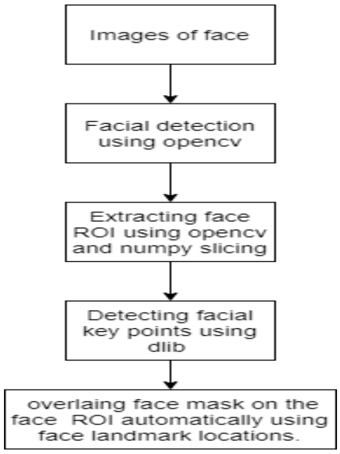

Fig. 1. Flowof creating dataset

Fig. 2. Flow of creating dataset for one person

B. Mask detection model

Once the data set of face mask was created, TensorFlow and Keras were used to train a classifier.

The classifier trained detects whether a person is wearing a mask or not.

To accomplish this task, MobileNet V2 architecture is used. It is a highly efficient architecture that is compatible with embedded devices which have limited computational power like the devices-Raspberry Pi, NVIDIA Jetson, etc. Deploying this model to various embedded devices available can reduce the cost of face mask detection systems. MobileNet was used as a standard backbone for our model, but ResNet as a backbone was also implemented for comparison study. MobileNet which was pretrained on the ImageNet weights was used excluding the head of networks. New set of fully connected heads was appended in place of the old network head. While back propagation, it is the head layer weights that are updated keeping the base model weights unchanged. In the training process, stochastic gradient descent (SGD) was employed and a learning rate of 0.003, momentum value of 0.7, and 150 epochs as an optimization algorithm was used. The dataset was split into three parts, namely, training, validation, and test set with 800, 400, and 200 images respectively. The training process was carried out for both the backbones- ResNet and MobileNet V2 networks and the results were noted. Once the classifier has been trained, the model has to now detect in a given image or a video stream if people are wearing masks or not. For this, firstly, the face is detected and the classifier is used to classify the face as wearing a mask or not wearing a mask. After reading frames from the video feed, using dlib library, we have detected the presence of a face along and the coordinates of the face is obtained. After this, by cropping just the face region from each frame, the cropped image(s) is sent to the trained classifier. The model then generates a prediction based on the image fed to it and the final result is displayed whether people are wearing masks or not. After a comparative study between ResNet and MobileNet backbone models, the model was then evaluated for two values of output stride(hyper-parameter) withing the MobileNet backbone model for further evaluation of the model. The entire process can be summarized in the Fig. 3

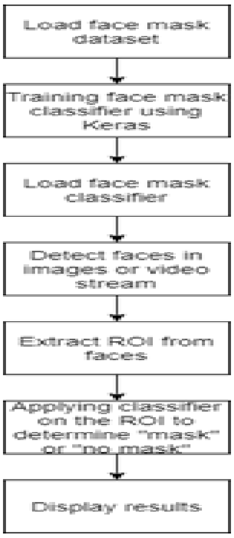

Fig. 3. Flow of creating model for mask detection

Evaluation Metrics:

For mask detection, precision and recall were employed as evaluation metrics.

$$Precision = \frac{TruePositive}{TruePositive + FalsePositive}$$

$$Recall = \frac{TruePositive}{TruePositive + FalseNegative}$$

COVID-19 Forecasting

For implementation, we collected the data set of the Ministry of Health and Family Welfare Government of India and the COVID Corona Virus India Data set from Kaggle. We worked with various predictive models such as Linear Regression and multi-layer perception but the major problem with them was low accuracy and high root mean square error in predicting future trends of COVID cases. These models ignore the prior data thus giving rise to biased predictions. These models fail to capture sudden peaks of COVID cases and therefore result in poor tracking and predictions.

We, therefore, need to use sequential networks (LSTM) for feature extraction because the COVID-19 Dataset is a time-series data. Secondly, the COVID-19 dataset which we are using is dynamic in nature, therefore statistical methods result in imprecise predictions. Thus, deep learning models such as LSTM were used for forecasting time series data for getting better predictions.

Various statistical medical parameters such as the total number of COVID cases, Number of live COVID cases, total death count, the total patients recovered and along the Dates were taken into consideration while building the model.

Linear Regression: A linear regression model is used to deducing the relationship between a dependent and independent variable. The coefficient of determination (R2) which is used in statistical analysis to evaluate how well the predicts future outcomes is used to determine the good fit of the model. The value of R2 helps in determining the correlation among the features of the dataset. The predicted trend in COVID cases was done with a 95% Confidence interval.

Multi-layer Perceptron: A multi-layer perceptron (MLP) consists of an Input layer, output layer and one or more hidden layers. It is one type of artificial neural network that is feed- forward in nature. The reason for using MLP model is its ease of implementation and less computational complexity in comparison to other deep learning algorithms. The model output was evaluated using the coefficient of determination (R2) which determines the variation between the real data and the predicted data. The trend prediction of COVID cases was done with 95% CI.

$$R^2 = 1 - \frac{S_{Residual}}{S_{Total}} = 1 - \frac{\sum_{i=0}^{m}(y_i - \hat{y_i})^2}{\sum_{i=0}^{m}(y_i - \frac{1}{m}\sum_{i=0}^{m} y_i)^2}$$

LSTM: LSTM networks have the ability to address the shortcomings of a conventional predictive model by adapting nonlinearities of given COVID-19 dataset. Each cell of the LSTM operates at separate time intervals until the last block produces the sequential output. A trend in Time series data can be seen when a specific pattern repeats after regular intervals of time. A time- series data can be classified into Stationary or Non stationary data.

Mean and variances of a stationary time series data remain constant with time. While changes in statistical properties like Mean, variance, and Standard Deviation are observed in case of Non stationary data. The Augmented Dickey-Fuller (ADF) test was performed for determining the nature of the dataset and the P-value obtained helps in determining the stationary (less than 5%) or the non-stationary nature (greater than 5%) of the dataset.
Dropout with probability of 70% was introduced to avoid overfitting of the data. The model was trained for 1000 epochs with a batch size of 64. The models were trained using the Keras Library and TensorFlow as backend. Adam Optimizer was used for dealing with gradient descent problems. Fig. 4 summarizes the LSTM architecture.

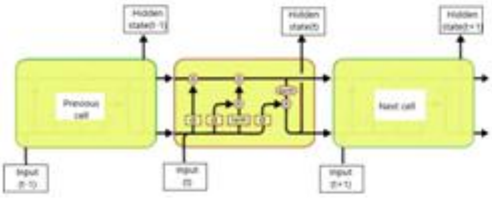

Fig. 4. LSTM Architecture

IV. RESULTS

later technique is employed as it can be easily deployed on embedded devices. Table 1 displays the result of the same.
For MobileNet architecture, after tuning output stride which is the hyper-parameter, it can be deduced that MobileNet with the output stride of 16 yields 1.1% and 2.7% higher than the MobileNet with output stride of 32 in the face and mask detection for the precision value respectively, and 4.8% and 3.9% higher for the recall value. Lower the value of output stride, higher is the resolution of the output. Table 2 above displays the result of the same. The model accurately detects and gives a prediction percentage if the person is wearing mask or not which can be seen clearly in Fig. 5 and Fig. 6

Fig. 5. Accurate prediction of a person wearing a mask

Table- I: Comparison result of using 2 different backbone architectures

Backbone	Transfer Learning	Face (Recall)	Face (Precision)	Mask (Recall)	Mask (Precision)
Mobile-Net	Imagenet	0.78	0.853	0.82	0.86
ResNet	Imagenet	0.872	0.894	0.901	0.934

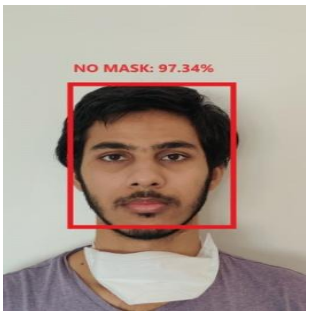

Fig. 6. Accurate prediction of a person not wearing a mask

Table- II: Comparison result after tuning output stride hyperparameter

Backbone	Face (Recall)	Face (Precision)	Mask (Recall)	Mask (Precision)
MobileNet (output stride=32)	0.78	0.853	0.82	0.86
MobileNet (output stride=16)	0.828	0.864	0.859	0.887

For the Multilayer Perceptron, the coefficient of determination (R2) for future COVID cases was calculated to be 0.94 with Root Mean Square error of 384.
The LSTM model used, was able to learn the inconsistency of the dataset with minimal loss in comparison to various statistical methods. The proposed LSTM network did not make any assumptions while selecting the hyperparameters and fit the real- time data well. We used cross- validation which was able to get rid of the problems due to the parameter assumptions and it helped us achieve better performance by decreasing the uncertainty. Lastly, we also introduced regularization in order to minimize any bias in our model. The Root Mean Square error achieved for short term prediction was 37.58 while for long term prediction was 48.32. Fig. 7 depicts the Real and predicted new COVID cases. It is evident that the model is able to rightly predict the trend in COVID cases. Table 3 displays the same result.

Table- III: Comparative study of RMSE of various model for COVID-19 forecasting

Model	RMSE
Linear Regression	705
Multilayer Perceptron	384
LSTM	48.32

ResNet Imagenet 0.872 0.894 0.901 0.934

In the COVID-19 forecasting, for the Linear regression model, the coefficient of determination (R2) for future COVID cases was calculated to be 0.911 with a Root Mean Square error of 705. The web application which was built using angular and node is helps the user choose from a wide range of hotels and other tourist places based on the prominent safety features of each place as shown in Fig 7. below. The web application will be used to display the trends in various places as depicted in Fig 8.

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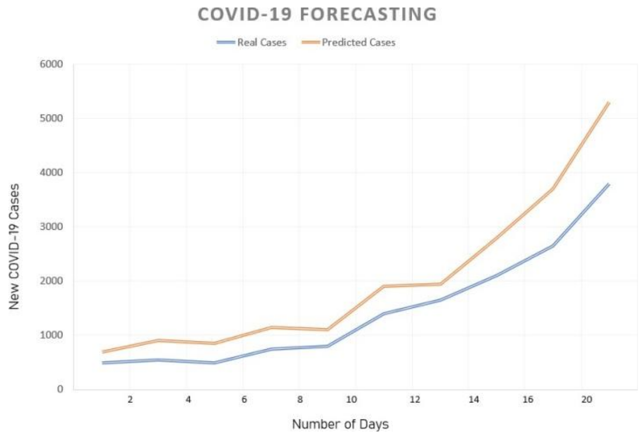

Fig. 7. Real vs Predicted cases trend prediction

Fig. 8. Safety features of a hotel on our website

V. CONCLUSION & FUTURE WORK:

In this paper, we have implemented a face detector that can be used to increase confidence in travelers so that they can travel fearlessly. This detector can also be used by public health care to verify if the COVID norms are being followed. The architecture of the detector uses MobileNet or ResNet as the backbone keeping in mind the complexity of the device. With transfer learning, the learning and the accuracy of the overall process was increased along with better feature extraction. For the MobileNet backbone, by varying the output stride from 32 to 16, significant rise in the values pf precision and recall was observed. In the future, with larger data set, better results can be achieved. Also, by employing a technique of context attention for head module, features of face and face mask can be captured. Also, using the technique of object removal cross class, we can get rid of objects whose confidence value is low. For the COVID-29 forecasting, it is seen that the LSTM model shows better result with minimum RMSE in comparison to the regression and the MLP model. With more Data available with time and by taking more parameters into consideration the accuracy of the model can further be improved. The solution focuses on providing useful insights to the travelers in deciding the date of travel with certainty.

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