A Medical Decision Support System To Detect Covid – 19 Pneumonia Using CNN

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Abstract - Due to the pandemic by the spread of the COVID virus, there has been a mandatory demand to screen patients. Predominantly RTPCR test is used to detect the virus. The RTPCR test is the most commonly used technique to detect COVID – 19 viruses. The test takes a minimum of 12 hours which is time-consuming and might put a patient's life at stake. This detection method for COVID screening is said to have a false detection rate. CT scans have been used for COVID-19 screening and using CT has several challenges especially since their radiation dose is considerably higher than x-rays. Hence, CXRs are a better choice for the initial assessment. Detection of COVID-19 pneumonia is a fine-grained problem as doctors cannot detect it just by looking at the x-ray images. Moreover, the radiologists visit many patients every day and the diagnosis process take significant time, which may increase errors in screening notably. Therefore, a medical decision support system for screening COVID-19 patients is of utmost importance. Our proposed system is a web application that helps to screen COVID-19 patients effectively.

Keywords— X-Ray (Chest images), Detection of COVID-19 pneumonia, Deep Learning, Convolutional Neural Networks.

I. INTRODUCTION

Novel COVID is currently a significant crisis around the world. The infection is transmitted through air or close contact with a tainted surface. Amidst the escalation of the number of COVID-19 patients throughout the world, there is a rapid increase in demand to distinguish patients affected by the Coronavirus from normal patients within a short period. Around the world, medical researchers are engaging persistently to bring out effective diagnostic methods for medicating COVID-19 patients. Scientists are hastening the development of effective vaccines. At present, there exist three renowned methods for the detection of COVID-19: the RTPCR diagnosis method, using Computed Tomography (CT) scans-based assessment, using Chest X-Ray (CXR). RTPCR test detects viral RNA from sputum or nasopharyngeal swab. Though the RTPCR test is the most widely used method among the three, it has severe drawbacks such as the availability of equipment and has a long turnaround time of at least 12 hours to provide the diagnostic results. Also, this test occasionally yields False negatives - detection of viral RNA in a person need not mean that the individual is infectious and likely to transmit the virus to another person. Observation is carried out for 14 days to confirm the test correctness by taking multiple RTPCR tests. Therefore, this method makes patients restless as they are subjected to long awaiting of results and expenses. In accordance with the limitations of RTPCR, the alternatives for screening COVID-19 patients by radiology imaging and Computed tomography scan-based assessment came to deliverance of better diagnostic methods. Portable radiology equipment for chest x-ray imaging is widely available for diagnosing confirmed and suspected patients. Compared to other methods it is time-efficient as well as a gateway for instant diagnosis. CT scans-based assessment involves analysing 360-degree views of the body structure with a much higher level of detail and it takes only 15-20 minutes to provide the diagnostic results per patient. CT scans have been used for COVID-19 screening and using CT has several challenges especially since their radiation dose is considerably higher than x-rays. Hence, CXRs are a better choice for the initial assessment.

Detection of COVID-19 pneumonia is a fine-grained problem as doctors cannot detect it just by looking at the x-ray images. Moreover, the radiologists visit many patients every day and the diagnosis process may take significant time, which may increase errors in screening notably. Therefore, a medical decision support system for screening COVID-affected patients is the topmost priority. From the beginning of the pandemic, the domain of deep learning has been widely explored to detect patients affected by COVID. Our proposed system is a web application that serves as a decision support system and helps medical staff to screen COVID-19 patients effectively. A simple CNN is built in order to display how the web application works. This paper summarises and organizes the research contributions of various CNN-based detection of COVID-19 pneumonia from CT scan and CXR imaging.

The next section deals with the review of a variety of CNN architectures used for COVID-19 detection. The sections following this will elaborate on the proposed model specifying the system architecture, CNN construction, and training. After that, the description of the working of the functional web application where anyone around the world can use a simple URL to access the web application and upload the x-ray image to know the detection results.

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II. LITERATURE REVIEW

JOAQUIM DE MOURA [1] proposed a COVID-19 detection method using Chest X-ray images with DenseNet – 161 Convolutional Neural Network. In the training process, the ImageNet dataset is used for pre-trained weights. They initialized a dense network architecture. Then with the given data dimensionality, the augmentation of the data is done with the increase in training samples provided. They have also improved the generalization of the network due to which they obtained more robust models which also avoided overfitting. It would be necessary to add more X-ray images into the dataset for providing a comprehensive validation of this proposed method.

Zehra KARHAN [2] discussed detection from the chest X-ray images by classifying the cases with the ResNet-50 model along with pre-trained CNNs. For evaluation of the results, the cross-validation about five folds was performed on the dataset. It uses image augmentation techniques before classification due to the very small dataset being used. Though the accuracy of 99.5% has been achieved, the database used is small due to which false positives may occur and also overfitting becomes contentious.

Abdullah Aman Khan [3] used a hybrid 3D deep learning model for COVID-19 detection. H3DNN implements the I3D and 3D Resnet 50 to distinguish COVID-19 patients. The model proposed is found to be a cost-efficient method in terms of CT scan images. This model also uses an automatic and effective method to detect COVID-19 patients. The limitations of CT-Scan intrinsically become the limitations of this research.

In order to increase the speed of training and detect Covid-19 with higher efficiency from Chest x-ray images, a Deep multi-layered CNN architecture which is light in weight and less in complexity is designed by Rajashri Bhadra [4]. The model in this work relatively takes lesser time for training and it is performed satisfactorily when considered in blind test accuracy. Nevertheless, the lesser dropout rates result in over-fitting in the training process.

Asma Channa [5] made research displaying a CNN model to differentiate COVID-19 in comparison to other diseases such as SARS, MERS, and ARDS. They used 7 layered deep Convolutional layers after image pre-processing. This research did not consider the real-time clinical data due to which the accuracy is comparatively low.

Khandaker Foyosal [6] Haque proposed a CNN model for the detection from X-ray images, derived from the combination and comparative analysis of two other CNN. They used 330 chest X-ray images during the training. But the method is not used for clinical testing and shows lower accuracy due to the smaller dataset.

Fian Yulio Santoso [7] put forward a modification of Xception, a deep CNN for COVID-19 pneumonia detection. He came up with a couple of stacks. Dense layers and also batch normalization is used to fill the stacks. The results are compared with other models such as Resnet50, InceptionV3, and Xception model. Since batch normalization and dense layers are added to this modified Xception model, it required a longer training time resulting in increased computation cost.

Ali Narin [8] proposed a CNN architecture using ResNet - 50 to reduce the false detection rate in diagnosing COVID-19, followed by SVM quadratic and SVM cubic using feature extraction. SVM algorithm using statistical learning theory. To provide support vectors that provide clear distinctions. The dataset provided is small, which may affect the detection of false rates when more images are added here.

Buyut Khoirul Umri [9] came up with CNN combined with Contrast Limited Histogram Equalization (CLAHE) along with a transfer learning model to understand the patterns from the radiology images and compares them with the VGG16 model. They used a database consisting of 100 positive and 100 negative COVID-19 images. Since they used the pre-trained models, the accuracy becomes contentious. Due to this, changes are made in the value of epochs to enhance it.

Shanjiang Tang [10] implemented multiple models for prediction rather than using a single model. This model uses ensemble learning to overcome the shortcomings - some of the CNNs are victims of generalization errors such as overfitting and high variance due to noise. This can also be caused by the limited availability of the dataset. EDL-COVID is an ensemble model, proposed by generating many snapshots of COVID-Net convolutional architecture. These models are then ensembled with the proposed WAE ensembling approach. Despite the results achieved, the accuracy heavily pertains to COVID-Net architecture. The network could be improved by retaining model snapshots of the network for every new modification to the dataset.

Papa Abdou Karim Karou Diallo [11] proposed a model that uses EfficientNet extended architecture called K-EfficientNet. This model also uses the application of transfer learning with the help of the ImageNet dataset. The architecture can uniformly scale the network's resolution including its width and depth and also with few scaling coefficients and the regularization performed decreases training time and improves model stability. The smaller size of the dataset has limited the performance of the model.

The research work for the detection of COVID-19 by Nayeeb Rashid [12] proposes transfer learning-based CNN training. The transfer learning is over the Inception V3 network with weights of the model pre-trained on the ImageNet dataset. The lack of verified datasets of the chest X-ray images is considered the limitation of the work.

In the above-discussed papers, there are various methods such as ResNet-50, Contrast Limited Histogram Equalization, Deep multi-layered CNN architecture, 7 layered Deep multi-layered CNN architecture, a modification of the Xception model, a modified CNN model with convolutional layers and fully connected layers, a CNN model consisting 12 weighted layers, convolutional layers followed by ReLU and max-pooling layers, 3D Deep learning-based methods that include 3D ResNets, C3D, 3D DenseNets, I3D, LRCN, EDL-COVID, an ensemble deep learning model, K-EfficientNet VGG16, VGG19, and the InceptionV3 model are used for COVID-19 detection.

III. PROPOSED MODEL

The medical decision support system is a web application accessible from anywhere in the world. The trained neural network model is integrated into a web application using Python and Flask API for user convenience. The Flask app running in Google Colab is hosted on a public IP address using the flask – ngrok package. Using the Public URL embedded

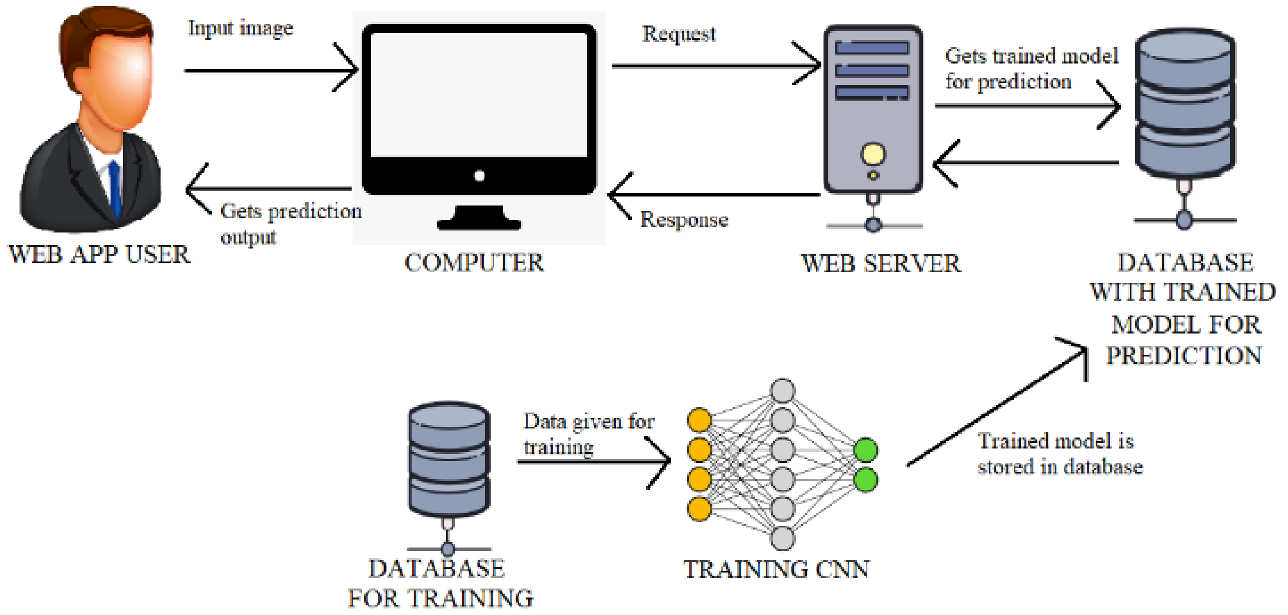

Fig 1. System Architecture of web application

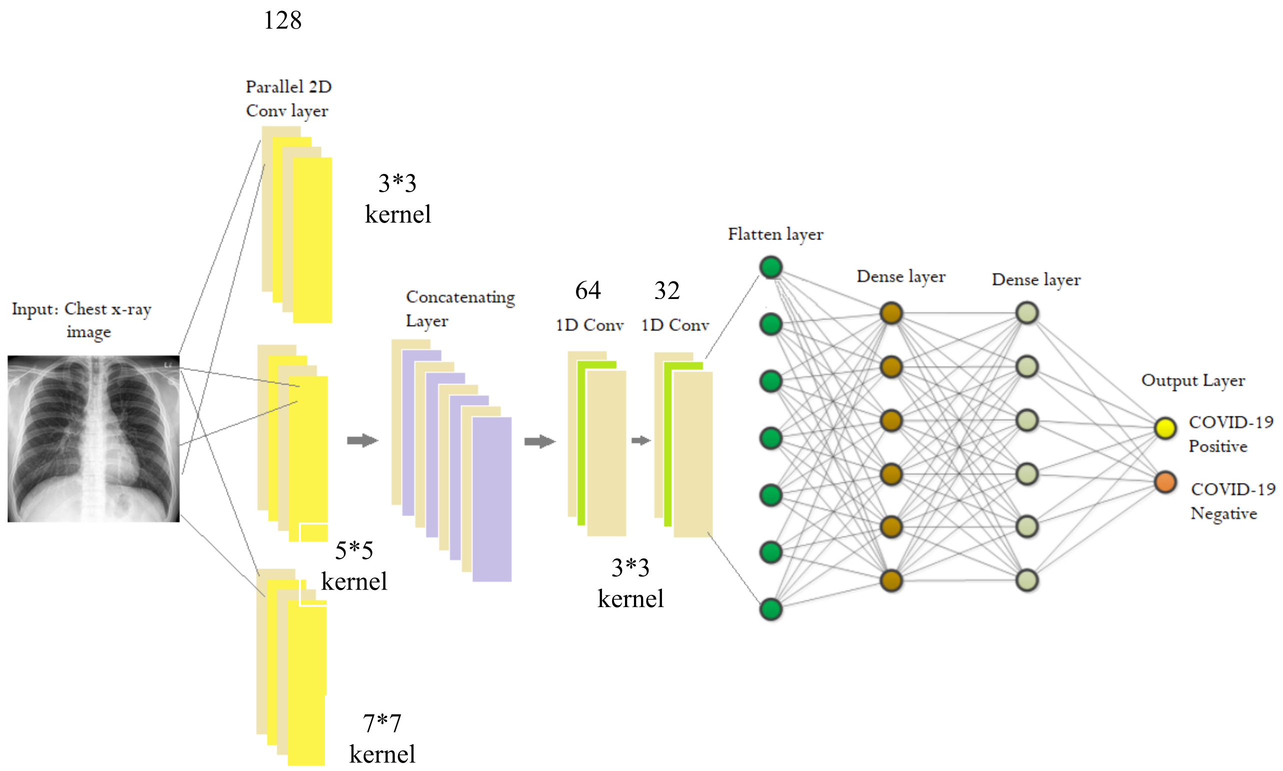

Fig 2. Architecture of the CNN model (the numbers represent the number of filters)

to the momentarily generated public IP, anyone can access the web application for COVID-19 detection from their x-ray image (the Chest region). The web application user (usually a medical practitioner) will upload the chest X-Ray image of the patient and click on the predicts button. The prediction happens in less than ten seconds. The output of the prediction can be viewed by the user on the screen immediately.

In order to design the decision support system, a basic single layer CNN model is built to predict COVID – 19. The trained model of the CNN Architecture having the least validation loss is stored in the database during the training phase. In the course of each prediction, the stored model is deployed into the virtual machine provided by Google Colab. This virtual machine acts as the web server and cannot be accessed without a public URL. Therefore, the flask-ngrok package is used to map a public URL to the web server so that the web application running on the web server can be accessed from anywhere in the world. The Convolutional Neural Network architecture is partly sequential and partly parallel. It consists of three Parallel convolutional layers. The parallel layers with 128 filters and have kernels of different sizes such as 3X3, 5x5 and 7x7followed by a concatenating layer. Followed by this concatenating layer, there is two typical convolutional layers, each of 3X3 kernels, a flattening layer, and fully connected layers interleaved with Dropouts. The convolutional neural networks tend to overfit provided training dataset. Dropouts are used to reduce the occurrence of overfitting. This technique of dropout is often deployed in CNN for its features being much more of computationally cheaper regularization. Also, it is one of the remarkably effective regularization methods for reducing overfitting and for improving generalization error in all kinds of deep neural networks. This CNN model uses no pre-trained weights and hence no transfer learning. There are two output neurons each representing the classification classes (COVID-19 Positive and COVID-19 Negative) of CNN architecture. This CNN is designed basically to show how the decision support system works.

IV. CONSTRUCTION OF THE WEB APPLICATION

A. *Data Pre-processing*

The images for the training of the model are taken from GitHub and the Kaggle website which consists of 1545 images. The images from different datasets are pre-processed in two stages. In the first stage, images are resized to 100x100 images and in the next stage, they are converted to grey-scaled images. The pre-processed data is then transformed into NumPy files made ready to be used for training.

B. *Training Scheme*

The CNN model is designed in a basic and simple manner in order to show the working of the web application. This CNN has three Parallel convolutional layers, each of different kernels (3X3, 5x5, 7x7) with 128 filters. This is then concatenated to form a sequential layer with 64 and 32 filters.

Following this, we have a flattening layer and a fully connected layer with dropout layers being interleaved. The dataset used is split in the ratio of 9:1 for Training and testing respectively. In the training set, 10% of the data is used for validation. The described model is trained for some epochs and the training accuracy and testing accuracy are computed. The models showing minimum validation loss are autosaved by Google Colab. The model with the least validation loss is considered to be deployed in the web appliaction for real-time prediction using any given x-ray image.

C. *Web Application deployment*

The stored CNN model is deployed into the virtual machine provided by Google Colab. This virtual machine acts as the web server and cannot be accessed without a public URL. Therefore, the flask-ngrok package is used to map a public URL to the web server so that the web application running on the webserver can be accessed from anywhere in the world. The web application user (usually a medical

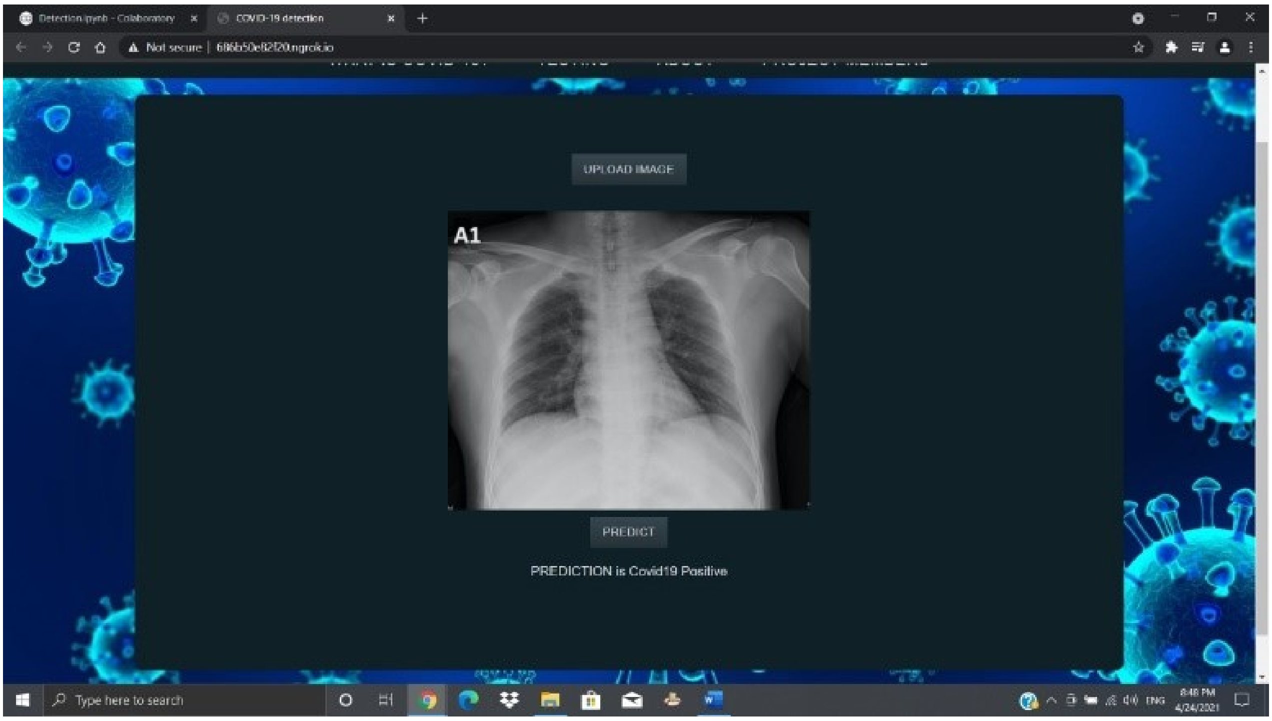

Fig 3. Screenshot of Web application for the Decision support system

practitioner) uploads the chest X-Ray image in the web application. This image is resized and converted to a grey-scaled image. Then it is subjected to prediction for detection of COVID-19 pneumonia. The results can be viewed by the user on the same web page.

V. WORKING OF THE MEDICAL DECISION SUPPORT SYSTEM

The medical decision support system is a web application that screens out the patients into two formal categories: COVID-19 Positive and COVID-19 Negative. The patient to be detected for COVID-19 pneumonia must be subjected to a Radiology scan for obtaining the chest X-Ray. The obtained chest X-Ray is then uploaded in the TESTING tab of the web application. Once the Predict button is clicked, the image is resized and converted to grey-scale for prediction. The prediction will happen within few seconds and the results can be viewed by in the same tab without any page refreshment.

VI. RESULT

Accuracy is the number of rows where the neural network correctly predicted the target class. By default, in-built functions under Keras API will return the accuracy and loss obtained by epoch during training of the CNN. The graph obtained as a result after training CNN is as follows:

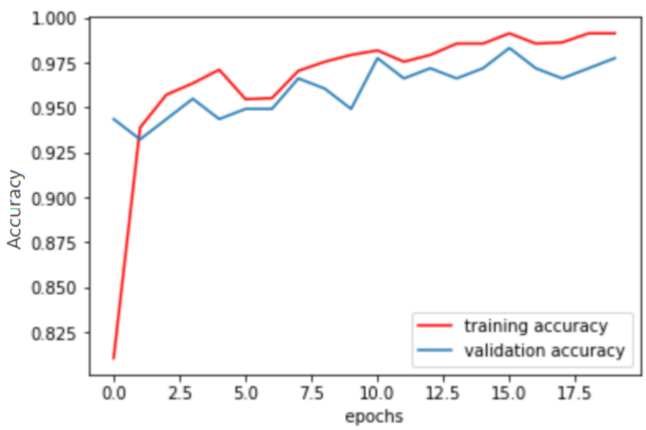

Fig 4. Graph representing accuracy through Keras API

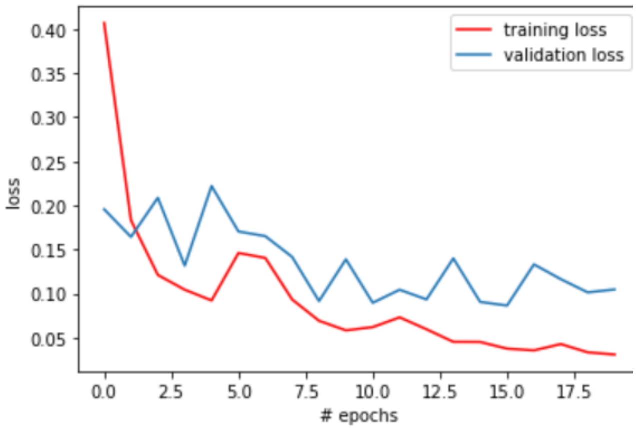

Fig 5. Graph representing loss through Keras API

Although the test accuracy of the model is 98.47%, since this CNN model is built using the basic and simple methods using a single layer, this model works the same for the X-Ray images representing Pneumonic symptoms too. However, the web application for the Decision support system will work fine with any trained model which is connected through the Flask API.

VII. CONCLUSION

In this paper, we firstly reviewed papers regarding the COVID-19 Pneumonia detection from radiology and CT-scanned images. Next, we constructed and trained an individual CNN. Next, we deployed the trained model of CNN architecture into the web application using Flask API. This CNN based web application helps to detect COVID-19 cases accurately and help medical staffs for screening of COVID-19 effectively. The underlying architecture can be provided with different datasets to detect normal pneumonia, SARS etc.

The web application for the decision support system used for COVID – 19 detection may not be reliable since the CNN is built using single layer. The future works on the prediction accuracy enhancements are entitled to availability of comparatively larger dataset and development of CNN. Underlying CNN model used for training can be replaced and worked with for more practical explorations in the COVID-19 detection mechanism from X-Ray images. Moreover, preferred pretrained weights can be used to enhance reliability and results. The web application can be expanded to be more interactive providing chat sessions with medical specialists for anyone.

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