SMART COVID-19 TREATMENT

TECHNICAL ANSWERS FOR REAL WORLD PROBLEMS (TARP)

Final Project Report

V.I.T. UNIVERSITY CHENNAI, TAMILNADU, INDIA

Link of Demo : https://youtu.be/KeR91ofPIvQ
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TABLE OF CONTENTS

List of Abbreviations

1. COVID-19 – Coronavirus Disease 2019
2. AI – Artificial Intelligence
3. ML - Machine Learning
4. NLP - Natural Language Processing
5. WHO - World Health Organization
6. SARS-CoV-2 - Severe Acute Respiratory Syndrome Coronavirus 2
7. LMICs - Low and Middle-Income Countries
8. SDGs - Sustainable Development Goals
9. CT - Computed Tomography
10. PET - Positron Emission Tomography
11. MRI - Magnetic Resonance Imaging
12. CXR - Chest X-rays Radiography
13. RT-PCR - Real-Time Polymerase Chain Reaction
14. ZSL - Zero-Shot Learning
15. CFP - Certified Financial Planner
16. SEIR - Susceptible Exposed Infectious Recovered
17. 2D - Two Dimensional
18. 3D - Three Dimensional
19. ARDS - Acute Respiratory Distress Syndrome
20. ALT - Alanine Transaminase
21. PUI - Persons Under Investigation
22. OpenCV - Open-Source Computer Vision Library
23. HTA - Hierarchical Task Analysis
24. ROI - Region of Interest
25. FFT - Fast Fourier Transform
26. BPM - Beats Per Minute
27. WIFI - Wireless Fidelity
28. HTML - Hypertext Markup Language
29. CSS - Cascading Style Sheets
30. DOM - Document Object Model
31. FAQ - Frequently Asked Questions
32. EEG - Electroencephalogram
33. ECG - Electrocardiography
34. CPBMI - Cellular Phone-Based Medical Informatics

Abstract

COVID-19 disease was identified in December 2019 in China and declared a global pandemic by the WHO on 11 March 2020. After the declaration of the global pandemic, many AI experts have been trying to find Artificial Intelligence (AI) as a powerful tool in the fight against the COVID-19 pandemic. The COVID-19 outbreak has cost millions of deaths with current death tolls till date by 9,24,000 and affected the population of nearby 29 million populations worldwide. Since the outbreak of the pandemic, there has been a scramble to use AI. This article provides an early, and necessarily selective review, discussing the contribution of AI to the fight against COVID-19, as well as the current constraints on these contributions. Six areas where AI can contribute to the fight against COVID-19 are discussed, namely i) early warnings and alerts, ii) tracking and prediction, iii) data dashboards, iv) diagnosis and prognosis, v) treatments and cures, and vi) social control. It is concluded that AI has not yet been impactful against COVID-19. Its use is hampered by a lack of data, and by too much data. Overcoming these constraints will require a careful balance between data privacy and public health, and rigorous human-AI interaction. It is unlikely that these will be addressed in time to be of much help during the present pandemic. In the meantime, extensive gathering of diagnostic data on who is infectious will be essential to save lives, train AI, and limit economic damages. So, to overcome with this global pandemic we propose a model which will be helpful for healthcare organizations, governments, as well as citizens of the respective nations. Currently our prototype focuses on providing the proposed methodology to help our country India but also can be implemented to other nations as worldwide.

Chapter 1 – Introduction

1.1 About the Project

COVID-19 disease, caused by the SARS-CoV-2 virus, was identified in December 2019 in China and declared a global pandemic by the WHO on 11 March 2020. Artificial Intelligence (AI) is a potentially powerful tool in the fight against the COVID-19 pandemic. AI can, for present purposes, be defined as Machine Learning (ML) , Natural Language Processing (NLP), and Computer Vision applications to teach computers to use big data-based models for pattern recognition, explanation, and prediction. These functions can be useful to recognize (diagnose), predict, and explain (treat) COVID-19 infections, and help manage socio-economic impacts. Since the outbreak of the pandemic, there has been a scramble to use AI, and other data analytic tools, for these purposes. In this model, we provide an early, rapid review of this AI scramble, discussing the actual and potential contribution of AI to the fight against COVID-19, as well as the current constraints on these contributions. The methodology aims to draw quick take-aways from a fast-expanding discussion and growing body of work in order to serve as an input for rapid responses in research, policy, and medical analysis. The cost of the pandemic in terms of lives and economic damage will be terrible; at the time of writing, great uncertainty surrounded estimates of just how terrible, and of how successful both non-pharmaceutical and pharmaceutical responses can be. Improving AI, one of the most promising data analytic tools to have been developed over the past decade or so, so as to help reduce these uncertainties, is a worthwhile pursuit. Encouragingly, data scientists have taken up the challenge. The key take-aways are as follows. We conclude that AI has not yet been impactful against COVID-19. Its use is hampered by a lack of data, and by too much noisy and outlier data. Overcoming these constraints will require a careful balance between data privacy and public health concerns, and rigorous human-AI interaction. It is unlikely that these will be addressed in time to be of much help during the present pandemic. Instead, AI may "help with the next pandemic" (Heaven, 2020). In the meantime, gathering extensive diagnostic data on who is infectious will be essential to save lives and limit economic damages.

Chapter 2 – Related Work

2.1 Literature Study

● Artificial intelligence and the future of global health, The Lancet, 2020; 395 (10236): 1579 DOI: 10.1016/S0140-6736(20)30226-9

Conclusion from above research, the global health community will need to work quickly to: incorporate aspects of human-centered design into the development process, including starting from a needs-based rather than a tool-based approach; ensure rapid and equitable access to representative datasets; establish global systems for assessing and reporting efficacy and effectiveness of AI-driven interventions in global health; develop a research agenda that includes implementation and system related questions on the deployment of new AI-driven interventions; and develop and implement global regulatory, economic, and ethical standards and guidelines that safeguard the interests of low and middle-income countries (LMICs). These recommendations will ensure that AI helps to improve health in low and middle-income settings and contributes to the achievement of the SDGs, universal health coverage, and to the coronavirus disease 2019 (COVID-19) response.

● Artificial intelligence vs COVID19: limitations, constraints and pitfalls, Wim Naudé, AI & SOCIETY (2020), 28 April 2020. https://doi.org/10.1007/s00146-020-00978-0

The above citation helps us in many aspects such as by providing knowledge overview on 1.tracking and prediction, 2.diagnosis and prognosis, 3.treatments and vaccines, 4.social control and depicts limitations, constraints and pitfalls based on the research.

● "Review of Artificial Intelligence Techniques in Imaging Data Acquisition, Segmentation and Diagnosis for COVID-19." IEEE Reviews in Biomedical Engineering, 2020. doi: https://doi.org/10.1109/RBME.2020.2987975

The research above is primarily focused on Medical imaging such as X-ray and computed tomography (CT) plays an essential role in the global fight against COVID-19, whereas the recently emerging artificial intelligence (AI) technologies further strengthen the power of the imaging tools and help medical specialists. We hereby review the rapid responses in the community of medical imaging (empowered by AI) toward COVID-19. For example, AI-empowered image acquisition can significantly help automate the scanning procedure and also reshape the workflow with minimal contact to patients, providing the

best protection to the imaging technicians. Also, AI can improve work efficiency by accurate delineation of infections in X-ray and CT images, facilitating subsequent quantification. Moreover, the computer-aided platforms help radiologists make clinical decisions, i.e., for disease diagnosis, tracking, and prognosis. In this review paper, we thus cover the entire pipeline of medical imaging and analysis techniques involved with COVID-19, including image acquisition, segmentation, diagnosis, and follow-up.

We particularly focus on the integration of AI with X-ray and CT, both of which are widely used in the frontline hospitals, in order to depict the latest progress of medical imaging and radiology fighting against COVID-19.

● "The role of imaging in the detection and management of COVID-19: a review." IEEE Reviews in Biomedical Engineering, 2020. doi: https://doi.org/10.1109/RBME.2020.2990959

The above publication of research describes how Coronavirus disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is spreading rapidly around the world, resulting in a massive death toll. Lung infection or pneumonia is the common complication of COVID-19, and imaging techniques, especially computed tomography (CT), have played an important role in diagnosis and treatment assessment of the disease. Herein, we review the imaging characteristics and computing models that have been applied for the management of COVID-19. CT, positron emission tomography - CT (PET/CT), lung ultrasound, and magnetic resonance imaging (MRI) have been used for detection, treatment, and follow-up. The quantitative analysis of imaging data using artificial intelligence (AI) is also explored. Our findings indicate that typical imaging characteristics and their changes can play crucial roles in the detection and management of COVID-19. In addition, AI or other quantitative image analysis methods are urgently needed to maximize the value of imaging in the management of COVID-19.

● "Digital technology and COVID-19." Nature Medicine, 2020. doi: https://doi.org/10.1038/s41591-020-0824-5

The citation above discusses the Monitoring, surveillance, detection and prevention of COVID-19 also gives us a brief idea on Mitigation of COVID-19's impact.

"A British Society of Thoracic Imaging statement: considerations in designing local imaging diagnostic algorithms for the COVID-19 pandemic." Clinical Radiology, Volume 75, Issue 5, May 2020, Pages 329-334 doi: https://doi.org/10.1016/j.crad.2020.03.008

The research above is based on how CT thorax contributes to patient diagnosis after a rapidly available RT-PCR result and also discusses how the imaging can help via chest radiography (CXR) to depict the novel coronavirus disease.

● "Detection of Covid-19 From Chest X-ray Images Using Artificial Intelligence: An Early Review." arXiv, 2020.

Similarly, as per the prior one this citation also provides us value research based on Detection of Covid-19 From Chest X-ray Images Using Artificial Intelligence.

● "Curbing the AI-induced enthusiasm in diagnosing COVID-19 on chest X-Rays: the present and the near-future." medRxiv 2020.04.28.20082776, 2020. doi: https://doi.org/10.1101/2020.04.28.20082776

The above citation was intended to create and validate an ML software solution able to discriminate on the basis of the CXR between SARS-CoV-2-induced bronchopneumonia and other bronchopneumonia etiologies. A systematic search of PubMed, Scopus and arXiv databases using the following search terms ["artificial intelligence" or "deep learning" or "neural networks"], and ["COVID-19" or "SARS-CoV-2"] and ["chest X-ray" or "CXR" or "X-ray"] found 14 recent studies. Most of them declared to be able to confidently identify COVID-19 based on CXRs using deep neural networks. Firstly, weaknesses of artificial intelligence (AI) solutions were analyzed, tackling the issues with datasets (from both medical and technical points of view) and the vulnerability of used algorithms. In addition, the authors intended to raise public awareness about the quality of AI protocols and algorithms and to encourage public sharing of as many CXR images with common quality standards.

● "Computer Vision For COVID-19 Control: A Survey." arXiv, 2020.

The above research was done focusing mainly for a smart covid-19 control heuristic approach based on computer vision techniques with 3 major goals included.

1. Diagnosis - using X-Ray, CT

2. Prevention and control – Diagnosis and prognosis, Thermography, Pandemic Drones, Germ Screening,

3. Clinical Management and Treatment – Critical Patient Screening, Support Vaccination and Development.

● "Artificial Intelligence against COVID-19: An Early Review." IZA Discussion Papers 13110, Institute of Labor Economics (IZA), 2020.

The referenced research is based on how Artificial Intelligence (AI) is a potentially powerful tool in the fight against the COVID- 19 pandemic. Since the outbreak of the pandemic, there has been a scramble to use AI. Thus, this research provides an early, and necessarily selective review, discussing the contribution of AI to the fight against COVID-19, as well as the current constraints on these contributions. Six areas where AI can contribute to the fight against COVID-19 are discussed, namely

i) early warnings and alerts,

ii) tracking and prediction,

iii) data dashboards,

iv) diagnosis and prognosis,

v) treatments and cures, and

vi) social control.

● "Systematic review and critical appraisal of prediction models for diagnosis and prognosis of COVID-19 infection." medRvix 2020.03.24.20041020, 2020. doi: https://doi.org/10.1101/2020.03.24.20041020

The citation reveals the Systematic review and critical appraisal of prediction models for diagnosis and prognosis of COVID-19 infection based on the various models of Machine Learning(ML) and which algorithm will be more efficient towards the heuristic approach towards the COVID-19 treatment.

● "Zero-Shot Learning and its Applications from Autonomous Vehicles to COVID-19 Diagnosis: A Review." arXiv, 2020.

The challenge of learning a new concept, object, or a new medical disease recognition without receiving any examples beforehand is called Zero-Shot Learning (ZSL). One of the major issues in deep-learning-based methodologies such as in Medical Imaging, Autonomous Systems and other real-world applications is the requirement of feeding a large annotated and labelled dataset, prepared by an expert human to train the network model. ZSL is known for having minimal human intervention by mainly relying only on

previously known concepts and current auxiliary information. This is an ever-growing research for the cases where we have very limited or no datasets available and at the same time, the detection/recognition system has human-like characteristics in learning new concepts. Therefore, it makes it applicable in real-world scenarios, from developing autonomous vehicles to medical imaging and COVID-19 Chest X-Ray (CXR) based diagnosis. In this review paper, we present the definition of the problem, we review over fundamentals, and the challenging steps of Zero-Shot Learning, including state-of-the-art categories of solutions as well as our recommended solution, motivations behind each approach, and their advantages over each category to guide the researchers to proceed with the best techniques and practices based on their applications. Inspired by different settings and extensions, we introduce a novel and broaden solution called one/few-shot learning. We then review through different image datasets inducing medical and non-medical images, the variety of splits, and the evaluation protocols proposed so far. Finally, we discuss the recent applications and future directions of ZSL. We aim to convey a useful intuition through this paper towards the goal of handling complex computer vision learning tasks more similar to the way humans learn.

● "Fighting COVID-19 with Data and AI: A Review of Active Research Groups and Datasets"

This is a blog posts article Literature Review of Active Research Groups and Datasets - Fighting COVID-19 with Data and AI. The article comprises on the problem of COVID-19 and about various AI-Based Systems Detecting COVID-19 such as -

1.DAMO Academy (Alibaba Group) Detects Coronavirus Cases in CT Scans

2.Lung Infection Quantification

3.Abnormal Respiratory Pattern Classification for Large Scale Screening

4.Convolutional Neural Networks for COVID-19 and Pneumonia Screening

5.COVID-19 Identification and Patient Monitoring Using Deep Learning for CT Image Analysis

6.Drug Screening for COVID-19

7.Computational Predictions of Protein Structures with AlphaFold

8.Prediction of Criticality of Patients with Severe COVID-19

● "COVID-19 Imaging-based AI Research Collection"

The above GitHub repository comprises of COVID-19 Datasets, Imaging methodology techniques like CT-based methods, CXR-based methods, and Other imaging methods. COVID-19 Special Issue CFP:

IEEE Transactions on Medical Imaging:

Special Issue on "Imaging-based Diagnosis of COVID-19"

IEEE Journal of Biomedical and Health Informatics:

Special Issue on "AI-driven Informatics, Sensing, Imaging and Big Data Analytics for Fighting the COVID-19 Pandemic"

Medical Image Analysis:

Special Issue on "Intelligent Analysis of COVID-19 Imaging Data"

Pattern Recognition:

Special Issue on "Special Submission Stream on AI for Combating COVID-2019"

● "Mapping the Landscape of Artificial Intelligence Applications against COVID-19" arXiv, 2020.

Executive Summary

There is a broad range of potential applications of AI covering medical and societal challenges created by the COVID-19 pandemic; however, few of them are currently mature enough to show operational impact.

From a molecular perspective, AI can be used to: estimate the structure of SARSCoV-2-related proteins, identify existing drugs that may be repurposed to treat the virus, propose new compounds that may be promising for drug development, identify potential vaccine targets, improve diagnosis, and better understand virus infectivity and severity.

From a clinical perspective, AI can support COVID-19 diagnosis from medical imaging, provide alternative ways to track disease evolution using non-invasive devices, and generate predictions on patient outcomes based on multiple data inputs including electronic health records.

From a societal perspective, AI has been applied in several areas of epidemiological research modeling empirical data, including forecasting the number of cases given different public policy choices. Other works use AI to identify similarities and differences in the evolution of the pandemic between regions. AI can also help investigate the scale and spread of the "infodemic" to address the propagation of misinformation and disinformation including the emergence of hate speech.

Sharing and hosting data and models, whether they be clinical, molecular, or scientific, is critical to accelerate the development and operationalization of AI to support the response to the COVID-19 pandemic.

Applications targeting critical applications – such as clinical ones – should consider existing regulatory and quality frameworks to ensure the validity of use and safety as well as minimize potential risks and harms.

International AID cooperation based on multidisciplinary research and open science is needed to accelerate the translation of research into global solutions which can be tailored and adapted to local contexts.

● "Modified SEIR and AI prediction of the epidemics trend of COVID-19 in China under public health interventions"

Methods: China has integrated population migration data, before and after January 23 and most updated COVID-19 epidemiological data into the Susceptible-Exposed-Infectious-Removed (SEIR) model to derive the epidemic curve. We also used an artificial intelligence (AI) approach, trained on the 2003 SARS data, to predict the epidemic.

Results: They found that the epidemic of China should peak by late February, showing gradual decline by the end of April. A five-day delay in implementation would have increased epidemic size in mainland China three-fold. Lifting the Hubei quarantine would lead to a second epidemic peak in Hubei province in mid-March and extend the epidemic to late April, a result corroborated by the machine learning prediction.

Conclusions: Our dynamic SEIR model was effective in predicting the COVID-19 epidemic peaks and sizes. The implementation of control measures on January 23 2020 was indispensable in reducing the eventual COVID-19 epidemic size.

● "Rapid AI Development Cycle for the Coronavirus (COVID-19) Pandemic: Initial Results for Automated Detection & Patient Monitoring using Deep Learning CT Image Analysis"

The main purpose quantified in the above citation is to –

Develop AI-based automated CT image analysis tools for detection, quantification, and tracking of Coronavirus; demonstrate they can differentiate coronavirus patients from non-patients.

Materials and Methods:

Multiple international datasets, including from Chinese disease-infected areas were included. We present a system that utilizes robust 2D and 3D deep learning models, modifying and adapting existing AI models and combining them with clinical understanding. We conducted multiple retrospective experiments to analyze the performance of the system in the detection of suspected COVID-19 thoracic CT features and to evaluate evolution of the disease in each patient over time using a 3D volume review, generating a Corona score. The study includes a testing set of 157 international patients (China and U.S).

Results:

Classification results for Coronavirus vs Non-coronavirus cases per thoracic CT studies were 0.996 AUC (95%CI: 0.989-1.00) ; on datasets of Chinese control and infected patients. Possible working point: 98.2% sensitivity, 92.2% specificity. For time analysis

of Coronavirus patients, the system output enables quantitative measurements for smaller opacities (volume, diameter) and visualization of the larger opacities in a slice-based heat map or a 3D volume display. Our suggested Corona score measures the progression of disease over time.

Conclusion:

This initial study, which is currently being expanded to a larger population, demonstrated that rapidly developed AI-based image analysis can achieve high accuracy in detection of Coronavirus as well as quantification and tracking of disease burden.

- "Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)"

The above is a report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19) discussing the virus, the outbreak, the transmission dynamics, the signs, symptoms, disease progression, and severity. Along with the assessment – The China Response & Next Steps, The Global Response & Next Steps.

● "Towards an Artificial Intelligence Framework for Data-Driven Prediction of Coronavirus Clinical Severity"

The research above presents a step towards building an artificial intelligence (AI) framework, with predictive analytics (PA) capabilities applied to real patient data, to provide rapid clinical decision-making support. COVID-19 has presented a pressing need as

a) clinicians are still developing clinical acumen to this novel disease and

b) resource limitations in a surging pandemic require difficult resource allocation decisions.

The objectives of this research are:

(1) to algorithmically identify the combinations of clinical characteristics of COVID-19 that predict outcomes, and

(2) to develop a tool with AI capabilities that will predict patients at risk for more severe illness on initial presentation.

The predictive models learn from historical data to help predict who will develop acute respiratory distress syndrome (ARDS), a severe outcome in COVID-19. Our results, based on data from two hospitals in Wenzhou, Zhejiang, China, identified features on initial presentation with COVID-19 that were most predictive of later development of ARDS. A mildly elevated alanine aminotransferase (ALT) (a liver enzyme), the presence of myalgias (body aches), and an elevated hemoglobin (red blood cells), in this order, are the clinical features, on presentation, that are the most predictive.

● RSNA Publishes Expert Consensus on COVID-19 Reporting

The above citation discusses the Routine screening CT for the identification of COVID-19 pneumonia is currently not recommended by most radiology societies. However, the

number of CTs performed in persons under investigation (PUI) for COVID-19 has increased. We also anticipate that some patients will have incidentally detected findings that could be attributable to COVID-19 pneumonia, requiring radiologists to decide whether or not to mention COVID-19 specifically as a differential diagnostic possibility. We aim to provide guidance to radiologists in reporting CT findings potentially attributable to COVID-19 pneumonia, including standardized language to reduce reporting variability when addressing the possibility of COVID-19. When typical or indeterminate features of COVID-19 pneumonia are present in endemic areas as an incidental finding, we recommend contacting the referring providers to discuss the likelihood of viral infection. These incidental findings do not necessarily need to be reported as COVID-19 pneumonia. In this setting, using the term “viral pneumonia” can be a reasonable and inclusive alternative. However, if one opts to use the term "COVID-19" in the incidental setting, consider the provided standardized reporting language. In addition, practice patterns may vary, and this document is meant to serve as a guide. Consultation with clinical colleagues at each institution is suggested to establish a consensus reporting approach. The goal of this expert consensus is to help radiologists recognize findings of COVID-19 pneumonia and aid their communication with other healthcare providers, assisting management of patients during this pandemic.

2.2 Proposed Methodology

COVID-19 disease was identified in December 2019 in China and declared a global pandemic by the WHO on 11 March 2020. After the declaration of the global pandemic, many AI experts have been trying to find Artificial Intelligence (AI) as a powerful tool in the fight against the COVID-19 pandemic. AI Technology, which includes Machine Learning (ML), Natural Language Processing (NLP), Deep learning, and Computer Vision technologies can be provided with automated intelligent capability like pattern recognition, explanation, and prediction. It can be useful to recognize (detect and diagnose) and predict COVID-19 infections.

In our project we will be designing a web application for which UI will be designed in such a way that it can be implemented as a website as well as mobile application. Our motto is to help the country by providing an approach for the COVID-19 outbreak.

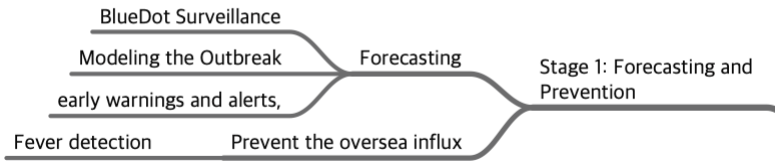
In this model we will be giving the login system to the actors as Admin, Hospital/doctor, patient/home mates to our application in which first of all they can manually do the Registration for hospital/doctors as per their wish, for this they have to provide some details as symptoms, COVID-19 lab report(if have) and if the patient wasn't tested before we will be providing as the Lab facility under user menu from their he can request for testing, and for samples the patient can provide for testing either by direct visiting to the lab or if possible (means if we are having enough of lab technician in the city so they can go and collect the sample of patient from his home) the Lab technician will collect the user sample and the reports can be sent to user to his lab report directory under the patient login. If once the report has generated the user/home mate/doctor is required to choose the dataset or report which have been tested for predicting the patient diagnosed analysis using Machine learning model, such as Random forest Algorithm. And will be using the webcam proctored driven approach which will be showing at runtime of the patient heart rate system and for plotting the graph will be using OpenCV through ML. If the heart rate impulses show abnormal behavior the system can directly set an emergency or alert to the patient as well as to the hospital/doctor.

Thus, this model can help to control this COVID-19 pandemic by keeping the patient as home quarantined so the disease could not be able to infect other healthy bodies, by providing them a facility to see their medical diagnosis and health report at runtime. This will also help the hospital/doctors by getting the information of their patients regularly which in case of emergency the bed facilities/ambulance can be arranged, and patients can be treated with distant treatment by implementing our model.

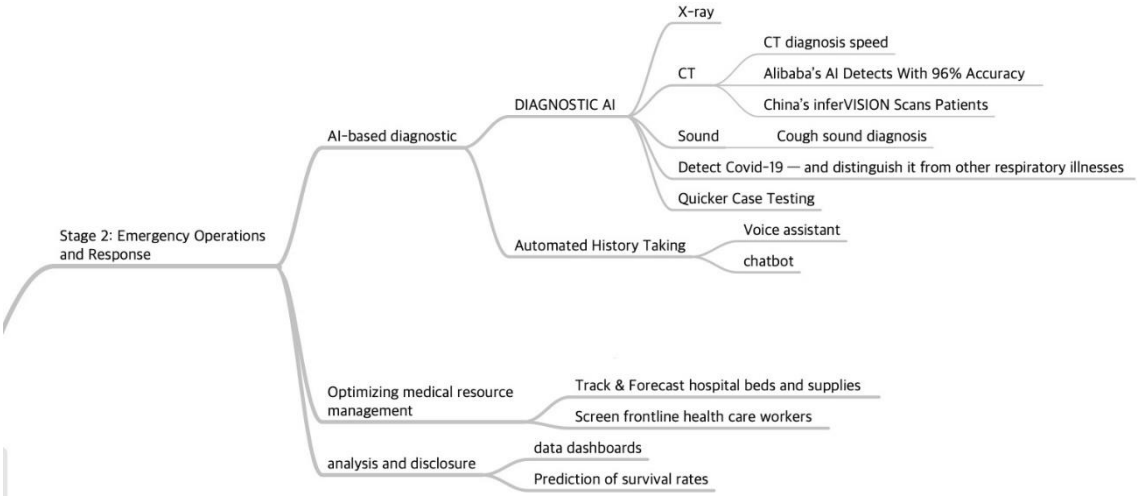
Chapter 3 – Design and Implementation

3.1 Architecture/Framework

Stage 1.



Stage 2.



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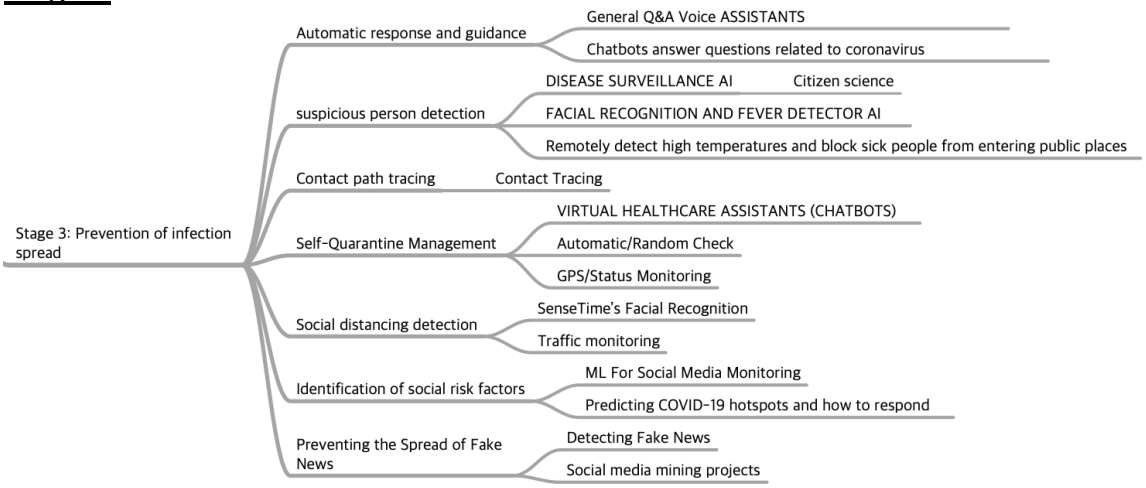

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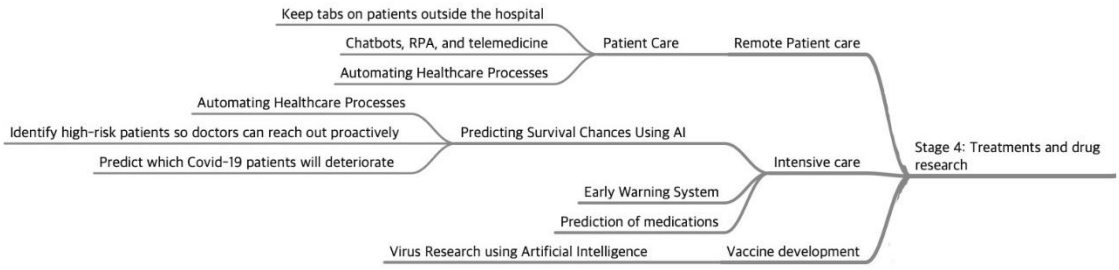
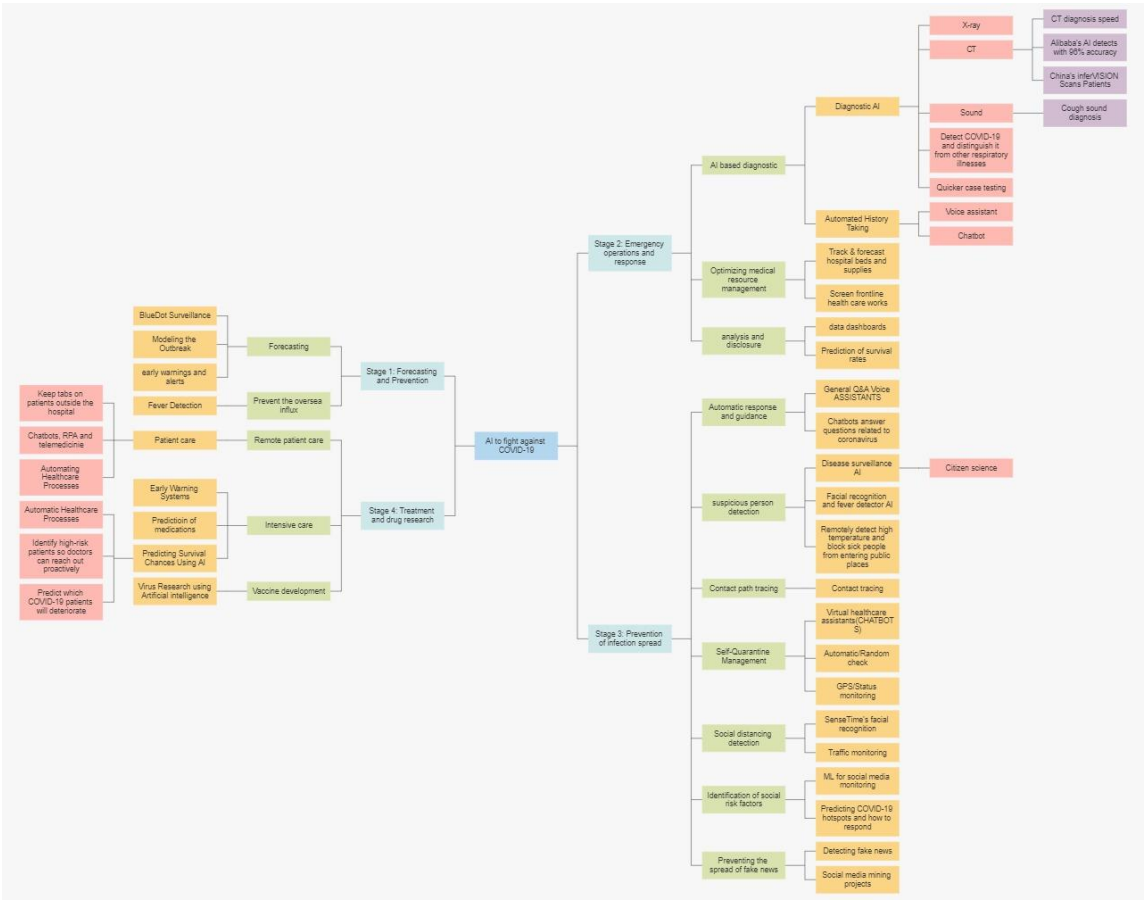


Proposed System – Flowchart



As we all know that COVID-19 is a viral disease originated in Wuhan, China in the year of 2019. Around 1.23 million people are dead due to this epidemic in the world till now and definitely this figure will increase in future. There is a total of 8.36 million found cases and 124K deaths due to this disease in India only and of course this figure is going to increase in future. So, the devastating nature of this disease makes us think “How to stop or handle this epidemic?”. And after doing hours of debate, we came up with an awesome idea.

With the help of great technologies like machine learning, deep learning, full-stack development, embedded system design etc. we are going to provide a robust environment to handle this epidemic properly. Our proposed model basically consists of *five modules* which are really going to blow your mind.

Our first module name is COVID-19 Detection. It is a smart way of detecting COVID-19 from our chest X-ray. Our machine learning model will be trained to effectively classify between non COVID-19 pneumonia X-ray and COVID-19 pneumonia X-ray. Our idea is to update the system such that it does both non COVID-19 pneumonia detection, using separate convolutional neural network models, via two different drop list options. This will seek to increase the robustness of the predictions made by the system. It should also produce results with high accuracy and have a user-friendly interaction. Our goal is to achieve >=85% sensitivity, >=70% specificity and 77% accuracy for the discussed mode.

Our second module name is Heart Rate Monitoring System. Proposed application consists of a non-contact-based system to measure heart rate in real time using a camera. Our machine learning model will produce heart rate information from the scanned facial skin colour variation caused by blood circulation. Signal processing will be used to get more clear and accurate information with nice graphs. It will be of great importance for a quarantined patient.

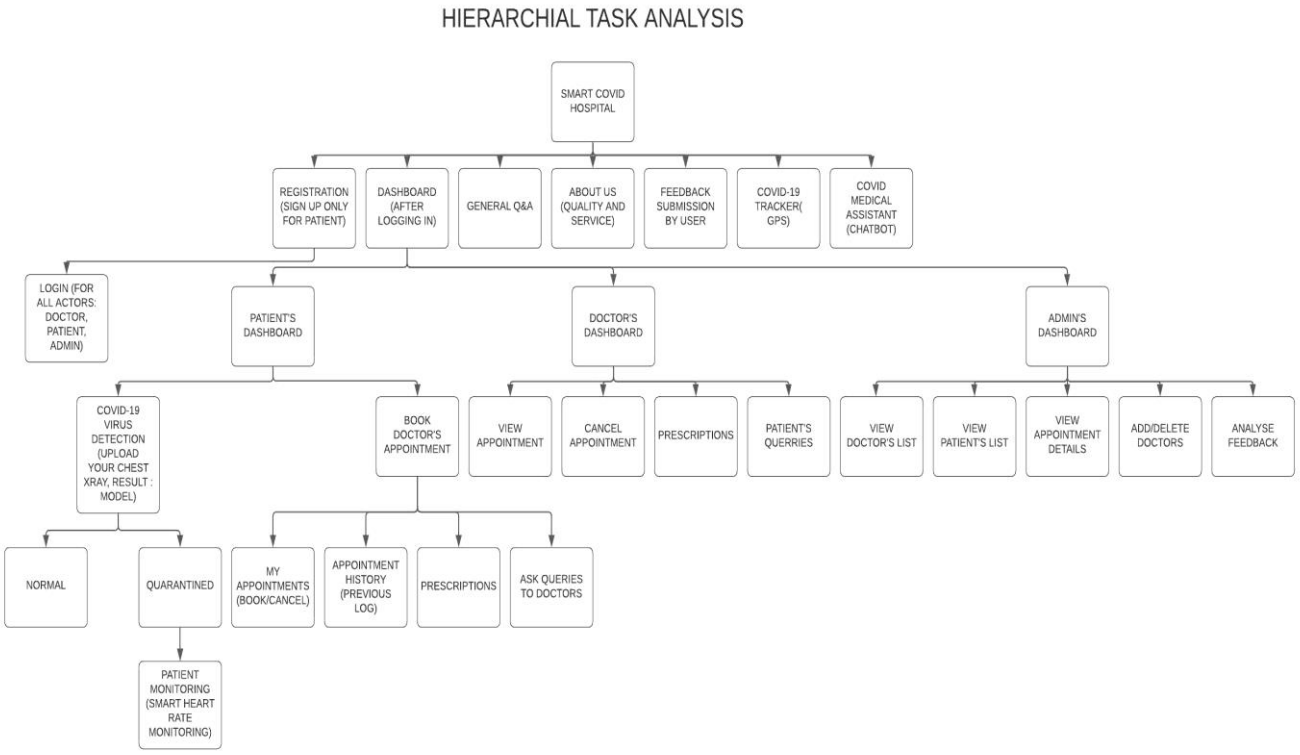
Our third module name is Fever Detection System. It will be designed using hardware components like Arduino uno, ESP8266 WIFI Modules, female to male wire, LM35 temperature sensor etc. We will be using Twilio as a third-party SMS functionality provider to alert the patient about fever. Actually, Twilio allows software developers to programmatically make and receive phone calls & also send and receive text messages using web services. So, when the temperature sensor crosses a certain threshold then it would send an alert to the respective doctor handling the case for immediate attention and in this way home quarantine could be effective and risk free.

Our fourth module name is Virtual Medical Assistant. It is nothing but an advanced AI-based automated healthcare chatbot. It will be built with the predefined library of the python i.e. nothing but ChatterBot which is a machine-learning based conversational dialog engine built in Python and makes it possible to generate responses based on collections of known conversations. The language independent design of ChatterBot allows it to be trained to speak any language. It is going to produce the best results.

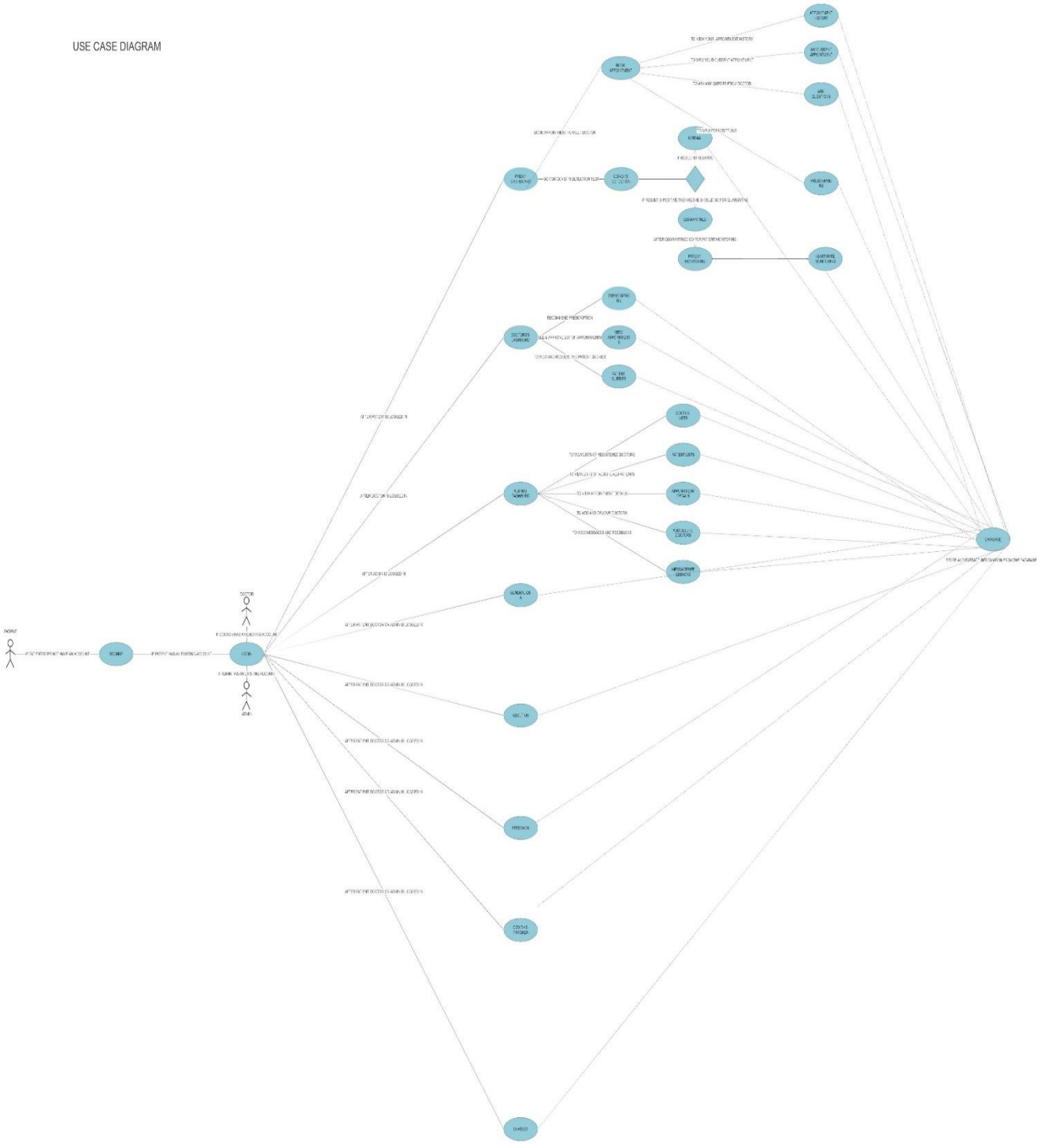
Our fifth and the final module name is Smart COVID Hospital. This is going to be a web-application with the user interface which will be designed to facilitate the users such as patients, doctors and admins (or Receptionist). It will be fully fledged and well-designed with the basic functionalities as a hospital management system where the patient can book appointments, doctors can approve or cancel the appointments and admin can view all the lists of doctors currently available and has the privilege access to view the appointment history and many other functionalities. It will have tabs like feedback, home, about us, COVID-19 tracker, general Q & A etc. with all the specifications.

Other tests which are used to detect the COVID-19 takes up to 2 days before testing is verified but our proposed COVID-19 testing method takes a few minutes to produce the accurate results. Also, an online health monitoring system to monitor quarantined patients has never been implemented but we are going to implement it to provide better care to the patient by following social distancing norms. Not only this our fever detection system will alert the doctor in the case of abnormal body temperature by sending a message which is like an imagination comes to be true. We can get a great knowledge by chatting with our virtual medical assistant chatbot and the smart COVID hospital can solve all the problems related to COVID-19 which was invented by us. All the five modules together are going to change the complete scenario and of course it will provide the complete solution for the COVID-19 which is not available in this universe up to now.

1. Hierarchical Task Analysis (HTA) – Diagram



2. Use Case – Diagram



3.2 Design/Modules

As shown above in section 3. We are implementing our model in the 4 stages –

Stage 1: Forecasting and Prevention

In this stage, we are using blue dot surveillance for forecasting and then modeling the outbreak and model will set early warnings and alerts, after detecting any sort of fever or abnormal behavior changes in the patient health, so in case of emergency or critical situation the proper action can be taken on time by the appointed doctors for further procedural of the treatment

Stage 2: Emergency Operations and Response

AI-based diagnostics will be followed in this stage using X-ray(chest radiography), CT scan diagnosis, Sound alert on detection of cough sound diagnose, further it will detect the COVID-19 based on the patient condition as well as provided test sets of the patient – and distinguish it from other respiratory illness after having a quick case testing. The Automated History Taking will report the user via voice assistant or the chatbot as a virtual assistant. Then the system will optimize the medical resource management by tracking & using forecast models to provide the hospital beds, and supplies. Finally, it will showcase the user report analysis and disclosure on the data dashboard and will run the prediction system of the survival rates of the patient.

Stage 3: Prevention of infection spread

- This stage system will contain the Automatic response and guidance as General Q&A Voice assistants, and chatbots answer questions related to coronavirus.
- Suspicious person detection – As per the Arogya Setu by MHRD or the COVID-19 Tracker we will be using the disease surveillance AI, also based on the facial recognition and fever detector AI, it can be also be used for Remotely detecting high temperatures and block sick people from entering public places.
- Contact path tracing.
- Self-Quarantine Management – it can be managed by virtual healthcare assistants(chatbots) and can be diagnosed by Automatic/Random Check. Also, the people affected (anomalies bodies) by this viral disease can be monitored using GPS/Status Monitoring.
- Social Distancing detection – via SenseTime's Facial Recognition and Traffic monitoring.
- Identification of social risk factors – By using ML for Social Media Monitoring and thus predicting the COVID-19 hotspots and how to respond.
- Preventing the Spread of Fake News – By Detecting Fake News and via Social media mining projects.

Stage 4: Treatments and drug research

a. Remote Patient care –

It can be used like keeping tabs on patients outside the hospital on the multi-screen. Chatbots, RPA, and telemedicine system implementation. Automating the complete Healthcare Processes.

b. Intensive care –

- Predicting the survival chances Using AI – Automating Healthcare Processes, identifying high-risks patients so doctors can reach out proactively, predicting which COVID-19 patients will deteriorate.
- Early Warning System.
- Prediction of Medications.

c. Vaccine development –

Virus Research using Artificial Intelligence and then recommending the appropriate remedial measures with proposed medicines or vaccines.

As we have already discussed that our project consists of five modules which can be implemented only using advanced technology like machine learning, deep learning, artificial intelligence, signal processing, image processing, embedded system design etc. We are going to break the implementation of our five modules part by part in this section.

1. COVID-19 DETECTION

The smart covid detection would help in easy detection of corona and pneumonia using X-rays which would provide a great help in differentiating the COVID and non-COVID patients.The accuracy of detection is found to be significantly acceptable in the range of 90 %.

Our first module name is COVID-19 Detection. Here, we are going to use the verified COVID-19 dataset with pneumonia and without pneumonia (consists of chest X-ray images) from recent COVID-19 study. We will be training two convolutional neural networks one with COVID-19 dataset with pneumonia and other with COVID-19 dataset without pneumonia using image classification method in Python language. After the model is trained, we will be providing a drop-down menu to select one of the required trained neural networks to get the more accurate results.

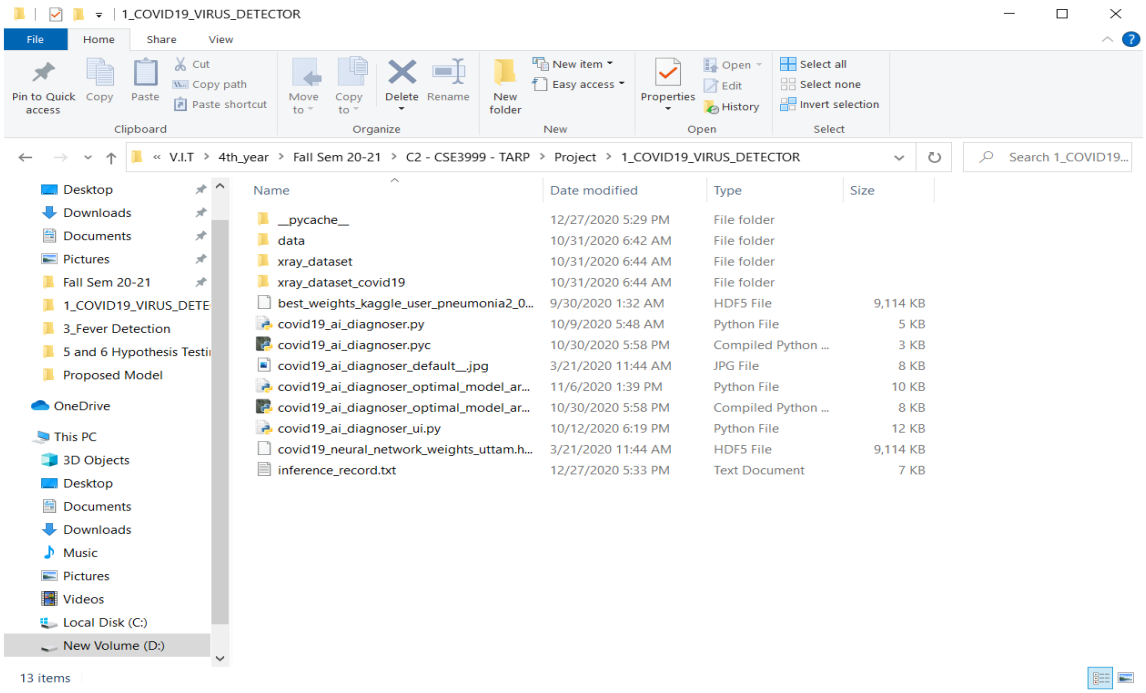


Fig 1(a) : Covid-19 Detection Project Directory

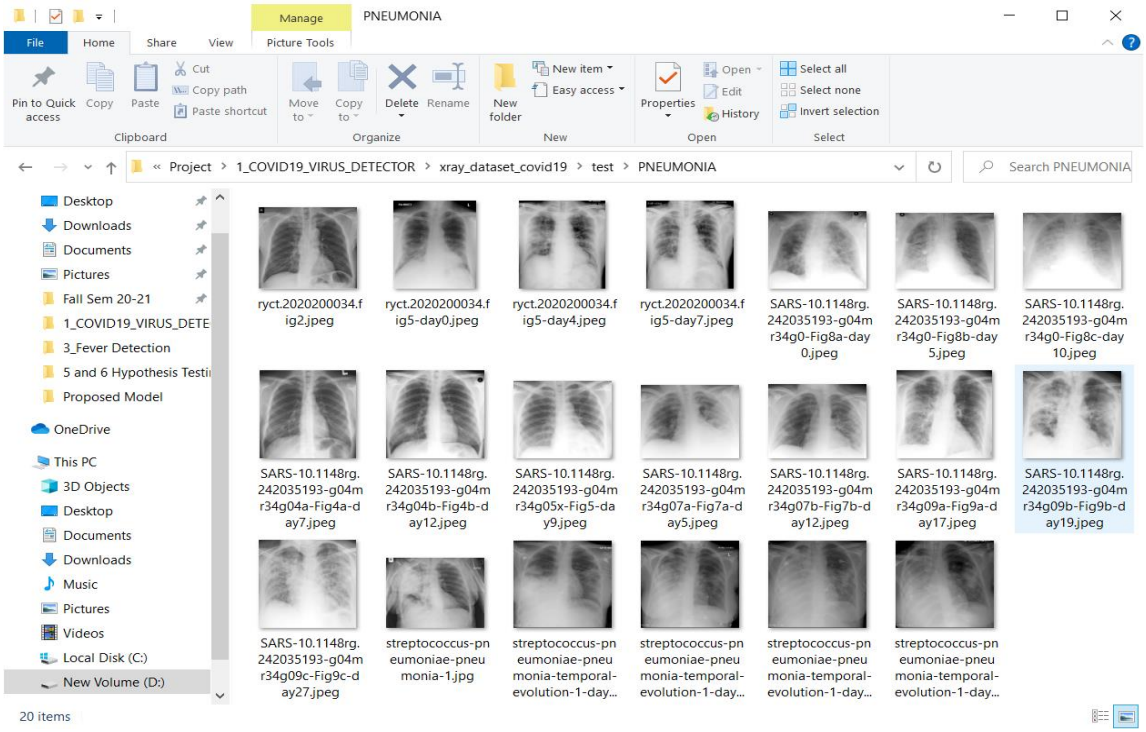


Fig 1(b) : X-ray Test Images

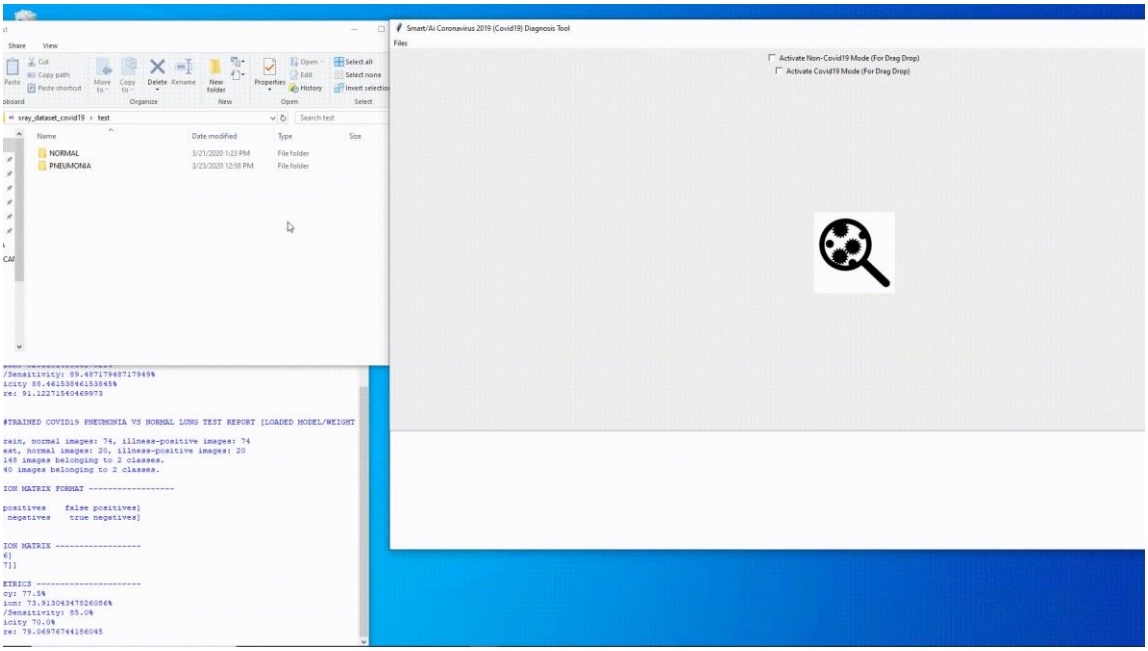


Fig 1(c) : Covid-19 Detection Application (.gif)

covid19_ai_diagnoser_ui.py - D:\V.I.T\4th_year\Fall Sem 20-21\C2 - CSE3999 - TARP\Project\1_COVID19_VIRUS_DETE...

File Edit Format Run Options Window Help

```
#Author: Uttam Keshri
#Note: Simple ui to use Ai based coronavirus2019/covid19 diagnosis tool

import covid19_ai_diagnoser


####Drag and Drop imports
#This must be imported before PIL imports below, to avoid Image Opening error
from TkinterDnD2 import *
try:
    from Tkinter import *
except ImportError:
    from tkinter import *
####

from tkinter import Frame, Tk, BOTH, Label, Menu, filedialog, messagebox, Text
from PIL import Image, ImageTk

import os
import codecs

screenWidth = "1560"
screenHeight = "840"
windowTitle = "Smart/Ai Coronavirus 2020 (Covid-19) Diagnosis Tool"

import cv2
from random import randint
class Window(Frame):
    _PRIOR_IMAGE = None
    #establish variable to keep track of images added to Frame, for purpose of p
    #by using destroy() on each old image instance @ addition
        #Added by Uttam Keshri, on a note that xray images should not stack as n

    DIAGNOSIS_RESULT = ""
    DIAGNOSIS_RESULT_FIELD = None
    #Uttam_note: Added to facilitate output window data
```

Fig 1(d) : Covid-19 AI Diagnoser Sample Code

Fig 1(e) : Training the X-rays dataset : image classification for non-covid-19

Fig 1(f) : Training the X-rays dataset : image classification for covid-19 images

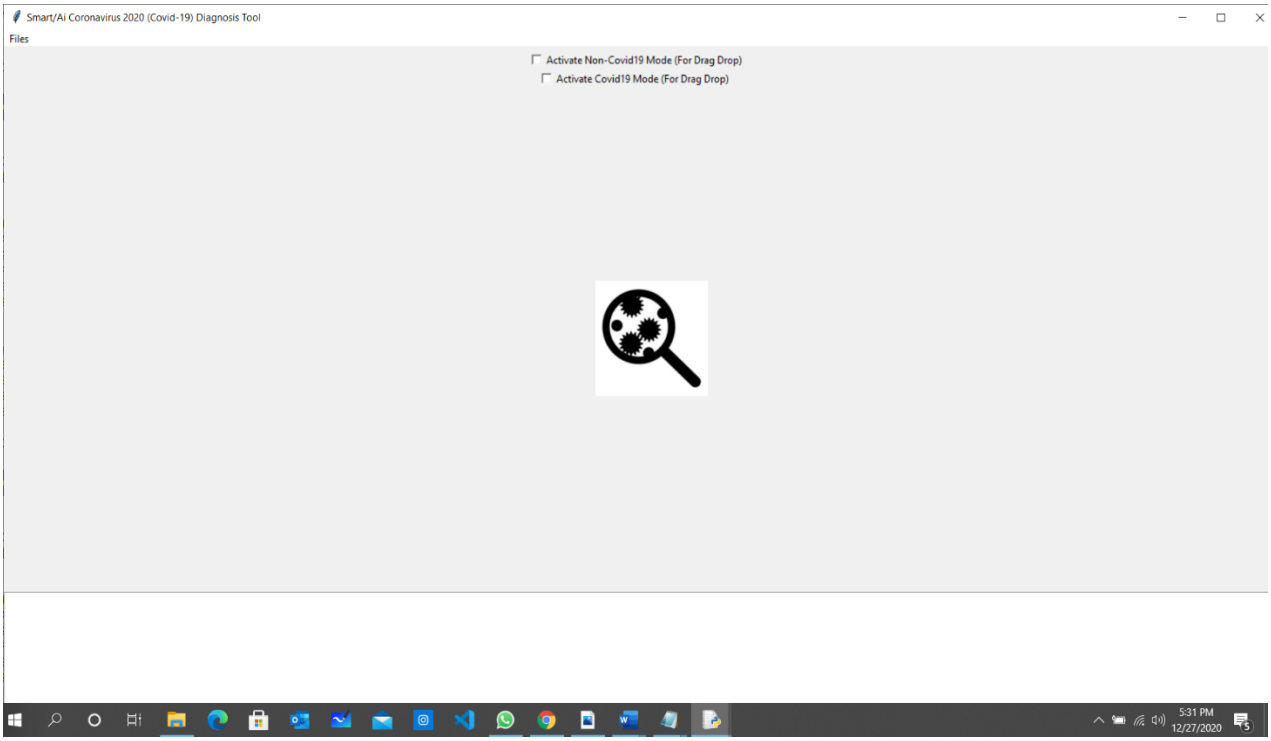


Fig 1(g) : First Look of Covid-19 Virus Detector on Startup

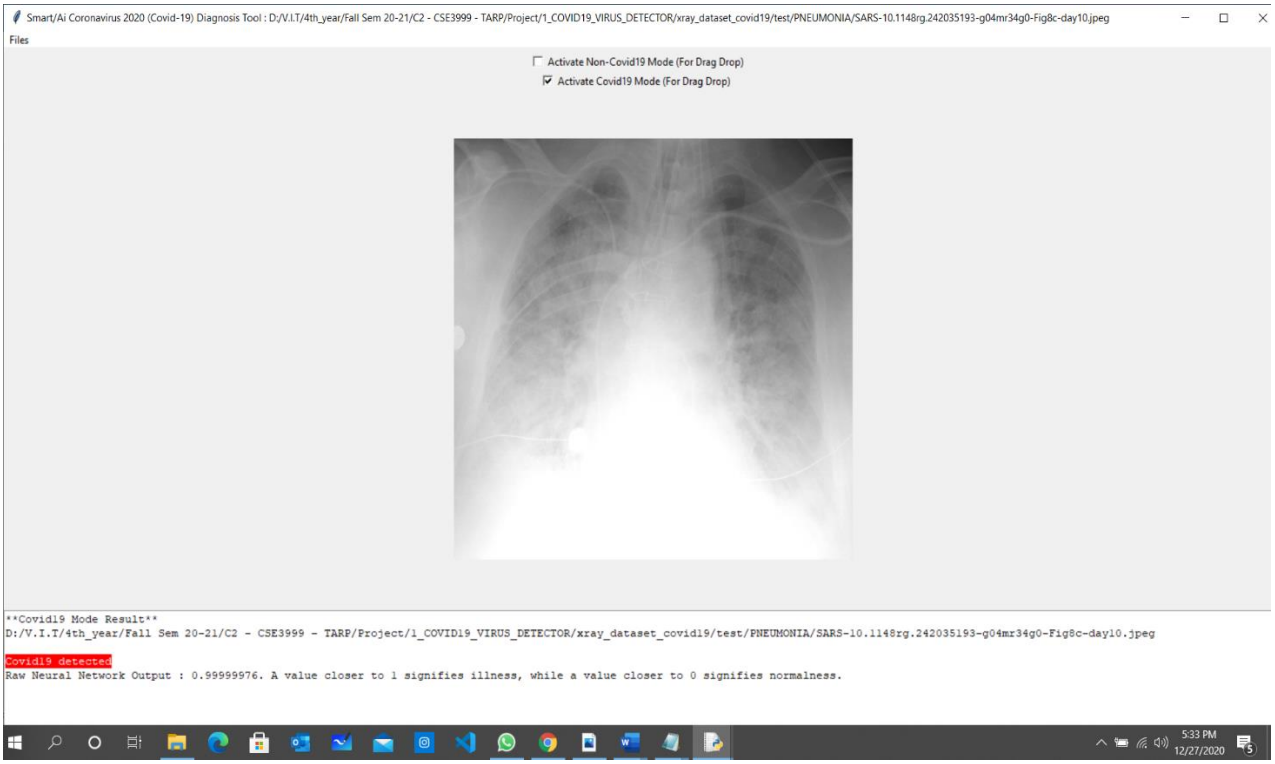


Fig 1(h) : Covid-19 Detected

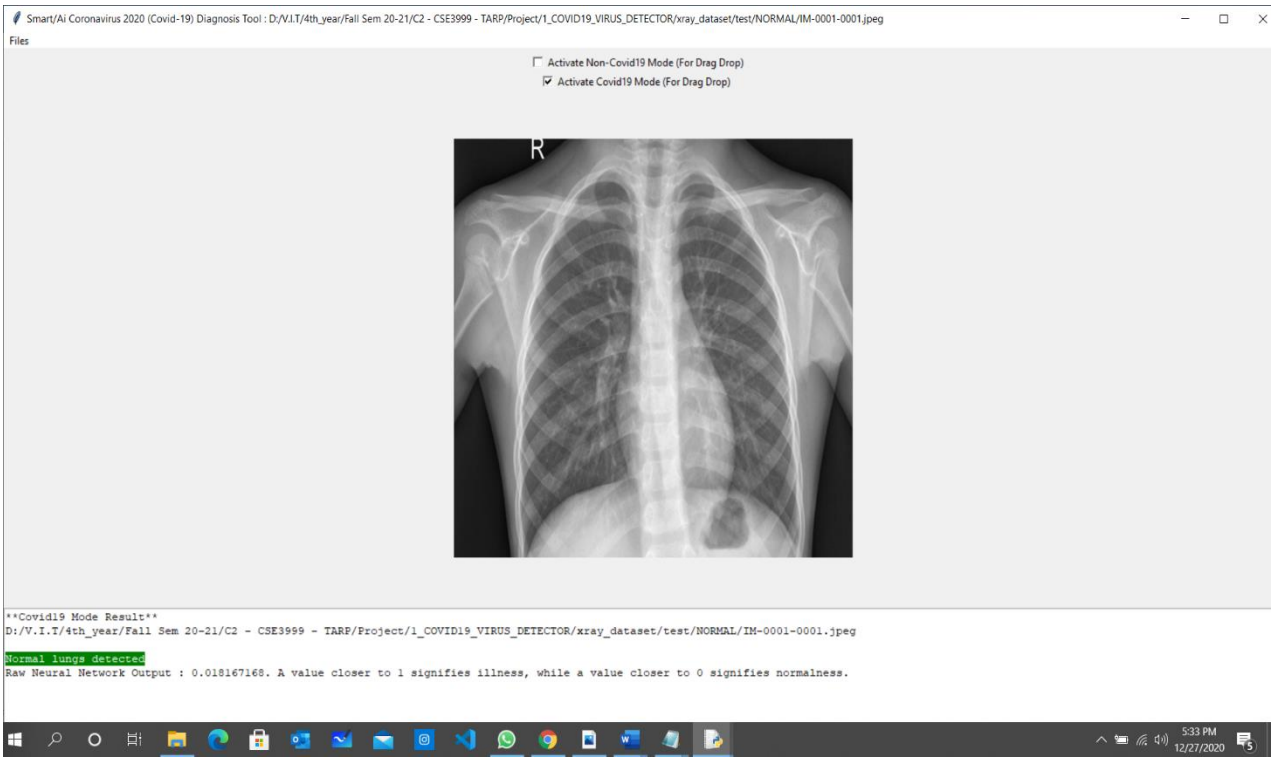


Fig 1(i) : Normal Lungs Detected

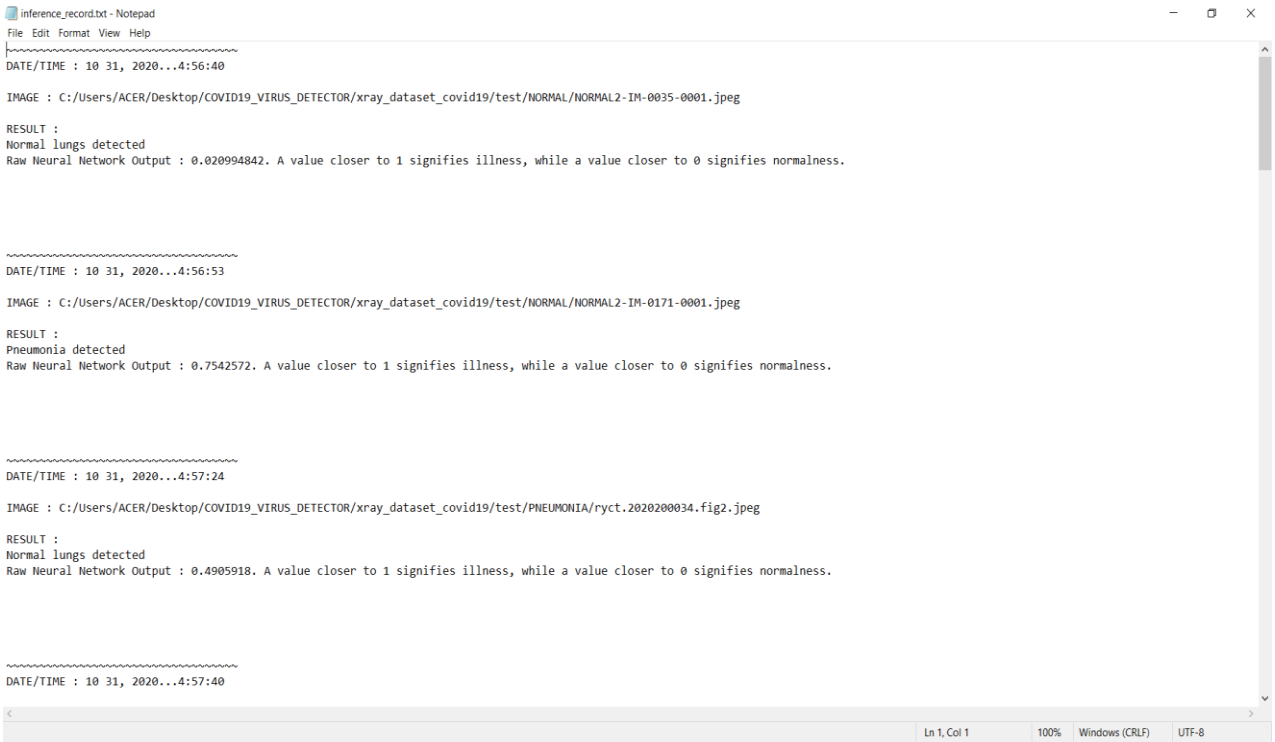


Fig 1(j) : Inference Records gets saved for each detection in .txt file

2. HEART RATE MONITORING USING WEBCAM

This module measures the heartbeat for patients who are quarantined at home with mild systems. And thereby monitors the health for the patients without actually involving any contact and machines and thus preventing the risk and spread of corona for the person in charge of taking care.

Our second model name is Heart Rate Monitoring System. We will be again using Python language to design required machine learning models because of the availability of different required packages. Here we will scan the facial image of a quarantined patient using a camera. Then we will detect the face, align, and get ROI using facial landmarks from the scanned images. After that we will apply a band pass filter with fl=0.8 Hz and fh=3 Hz, which will be 48 and 180 bpm, respectively. Then the average colour value of ROI in each frame will be calculated and pushed to a data buffer which is 150 in length. Then FFT of the data buffer will be done and the obtained highest peak will be the heart rate. The amplification of the colour is done to make the colour variation visible. Also, accurate graphs will be produced using signal processing.

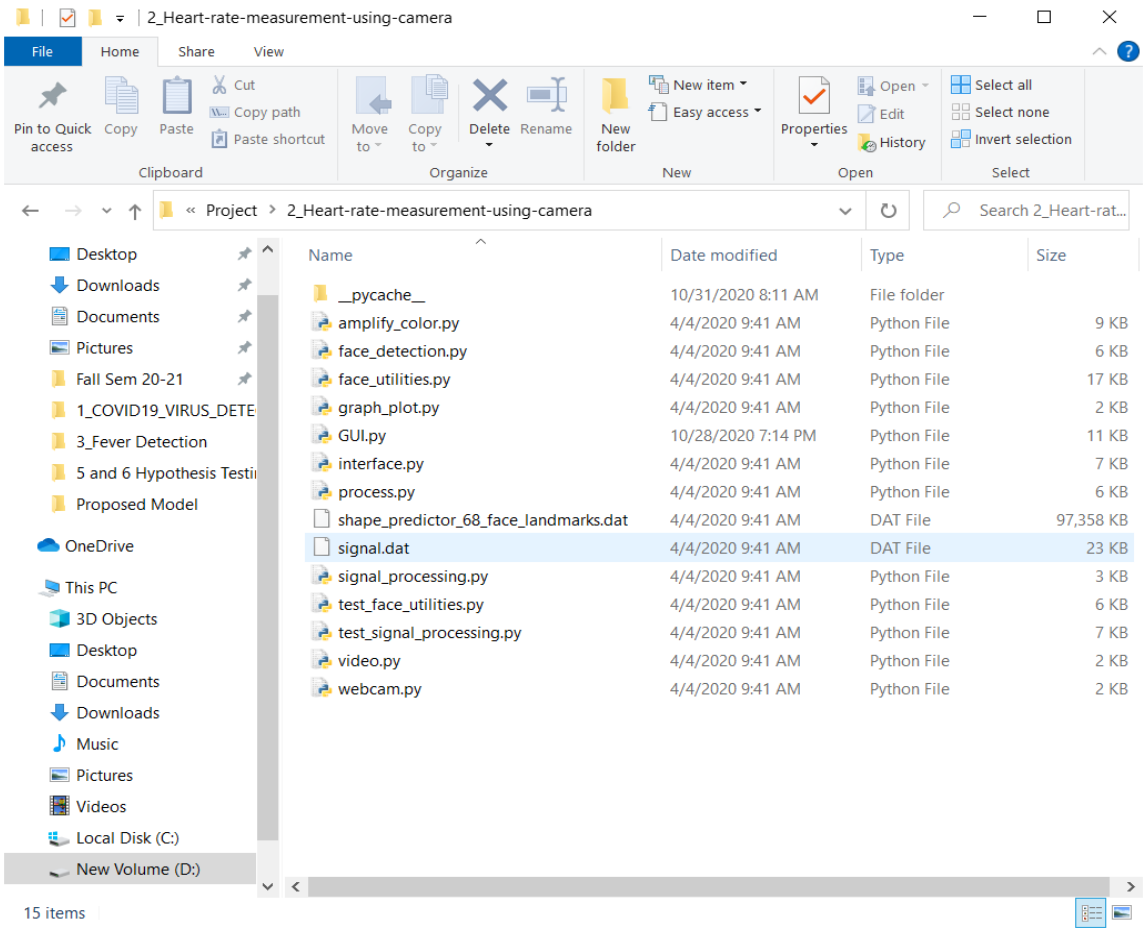


Fig 2(a) : Heart Rate Monitoring Project Directory

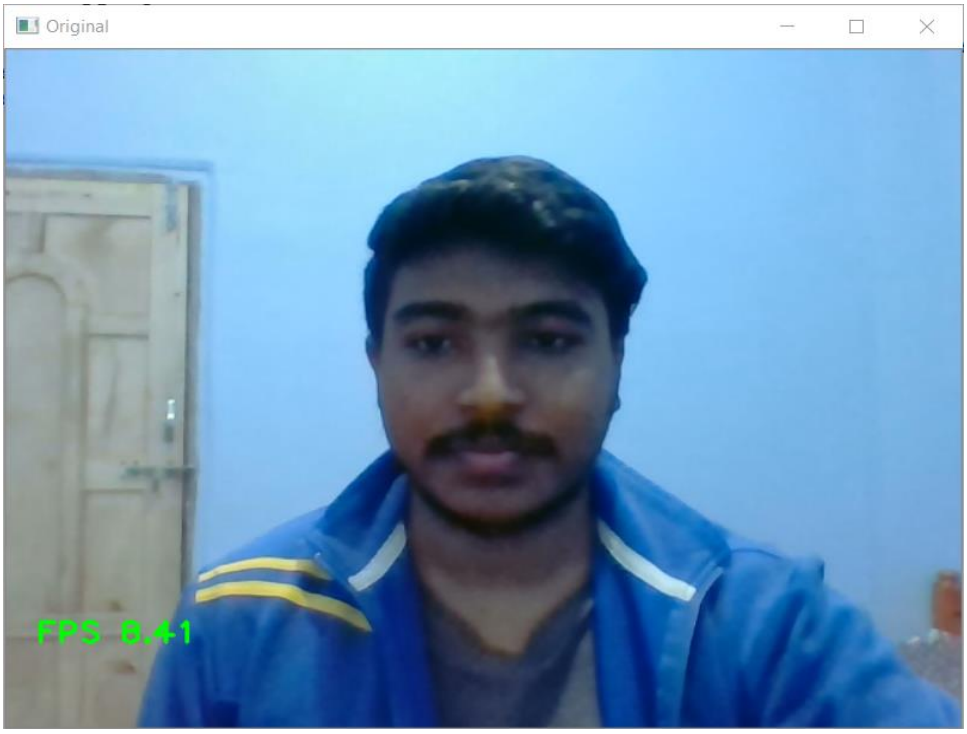


Fig 2(b) : Face Cam Original Live Footage Process

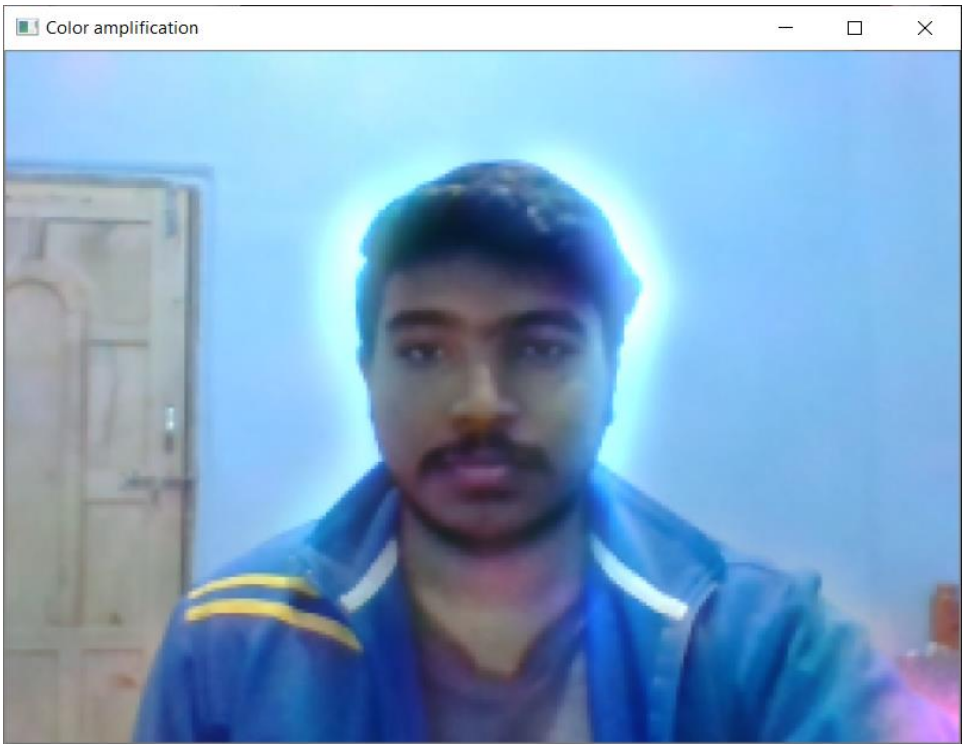


Fig 2(c) : Colour Amplification process

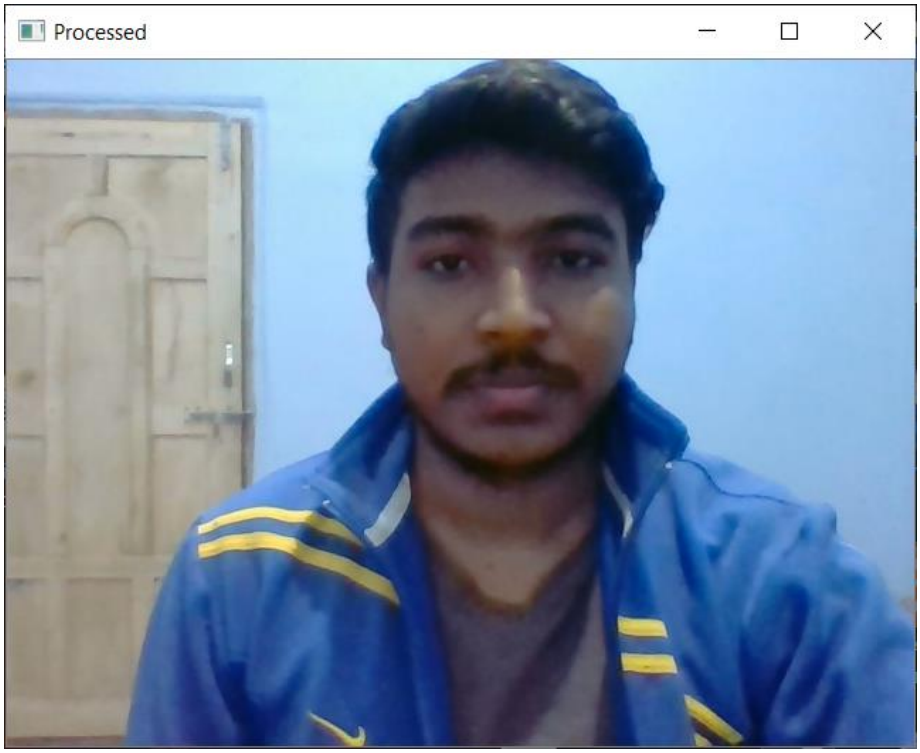


Fig 2(d) : Processed Face Recognition

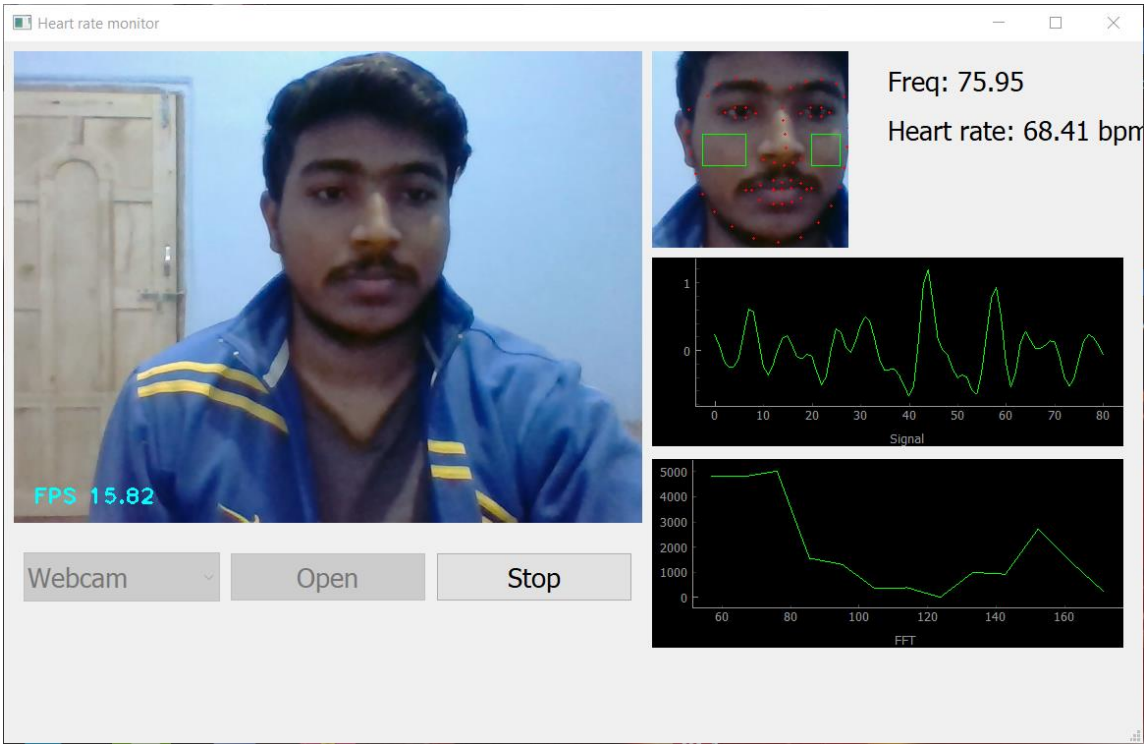


Fig 1(e) : Real-Time Heart Rate Monitoring using Webcam & processing signal output

3. FEVER DETECTION PATIENT MONITORING

Fever detection module uses a temperature sensor to detect the possibility of fever and thus measures one of the most common symptoms of corona in case of deteriorating health condition and sends an alert to the doctor if it reaches a certain threshold.

Our third model name is Fever Detection. Here we will read the body temperature of the patient using the LM35 temperature sensor. Then the data will be pre-processed by the Arduino-uno. Also using the ESP8266 WIFI-module, we will be posting the value to the Twilio platform. If the body temperature will become greater than a particular threshold then an alert message will be sent to the respective doctor to take necessary and required action with the help of Twilio platform.

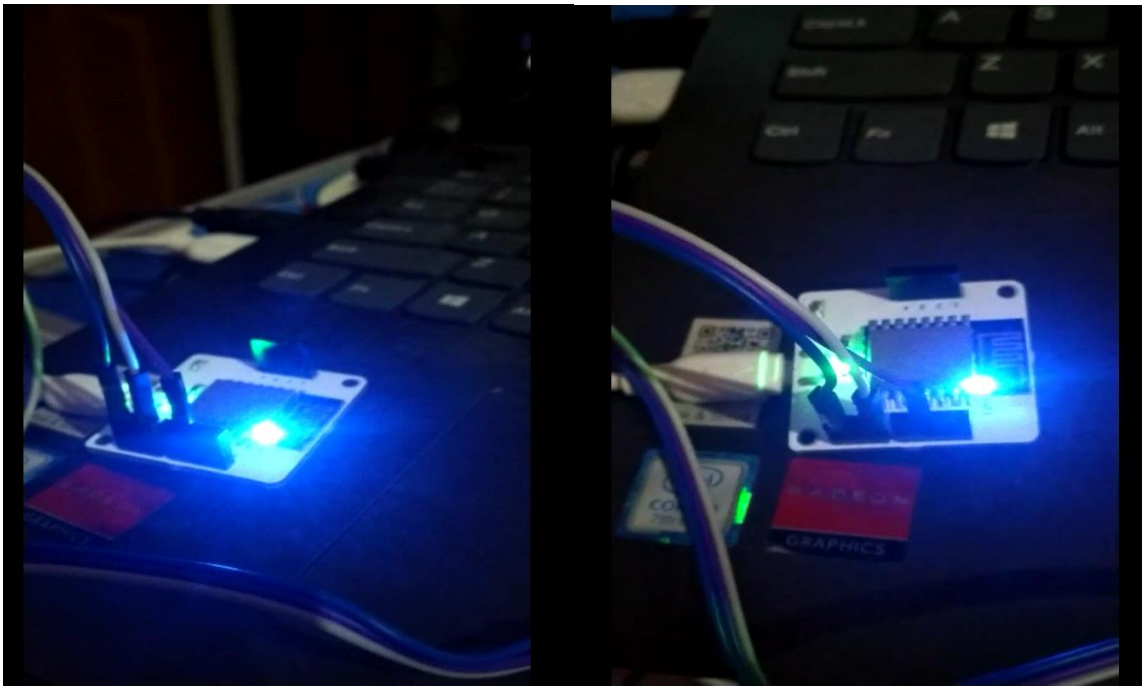


Fig 3(a) : IoT Devices – LM35 Temperature Sensor & ESP8266 WIFI Module

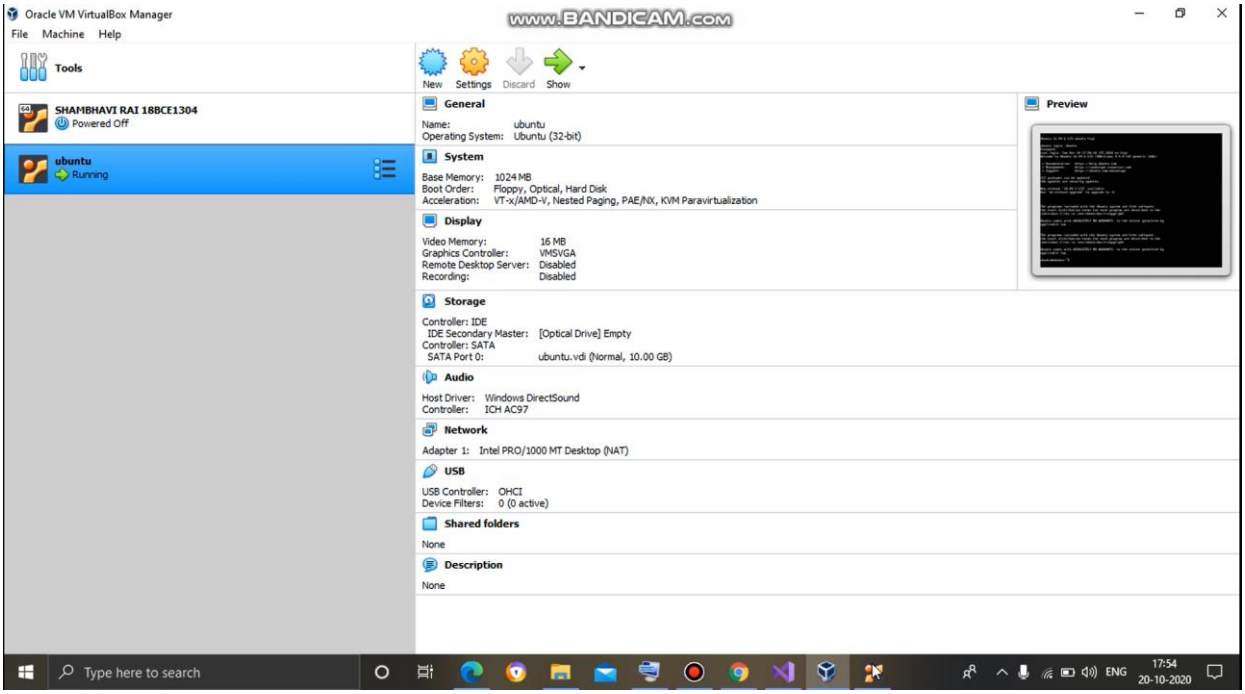


Fig 3(b) : Deploying on Oracle VM VirtualBox Manager

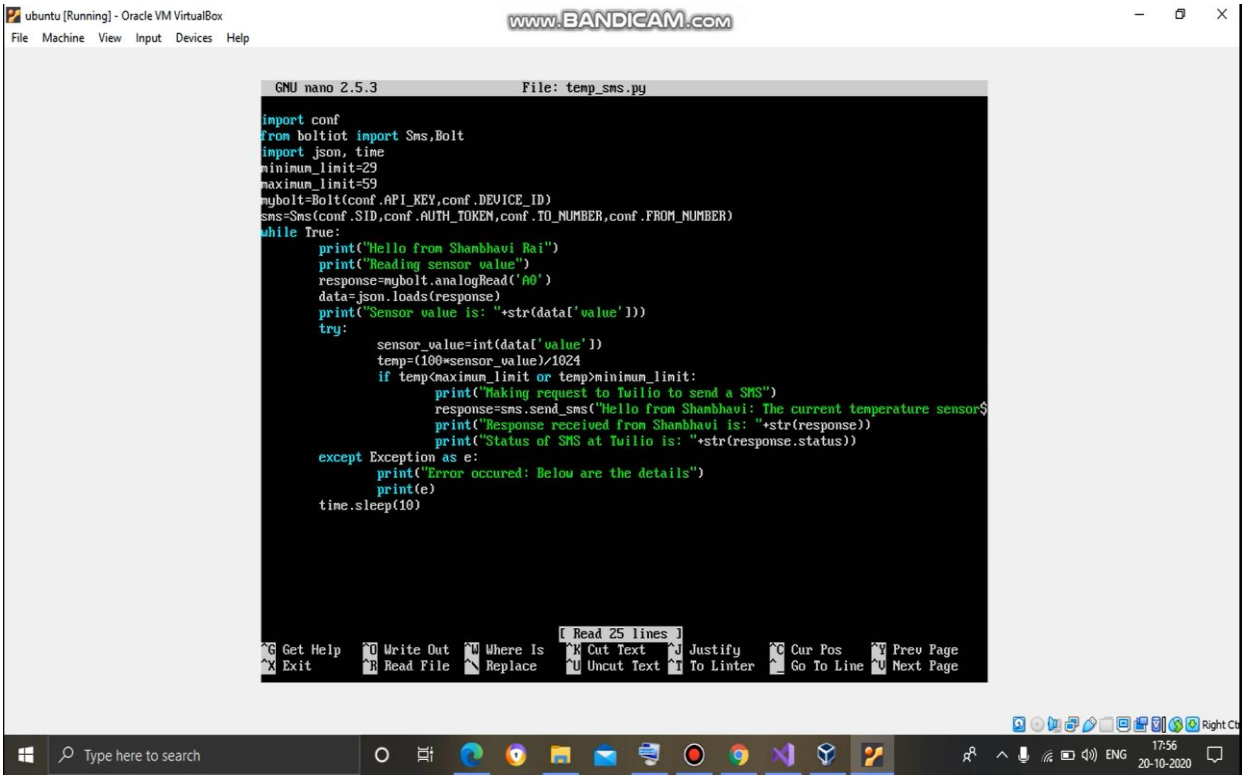


Fig 3(c) : Code configuration for Fever Detection Module

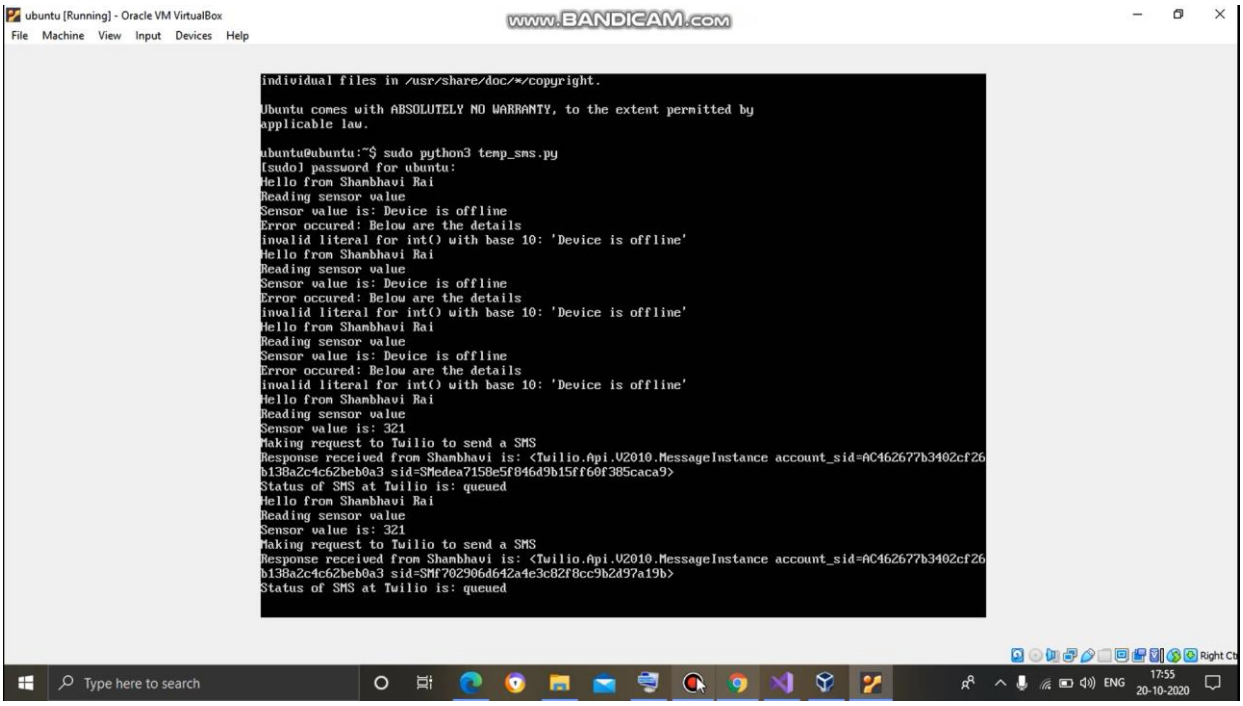


Fig 3(d) : Connecting the IoT Device & Twilio For Alert Messaging

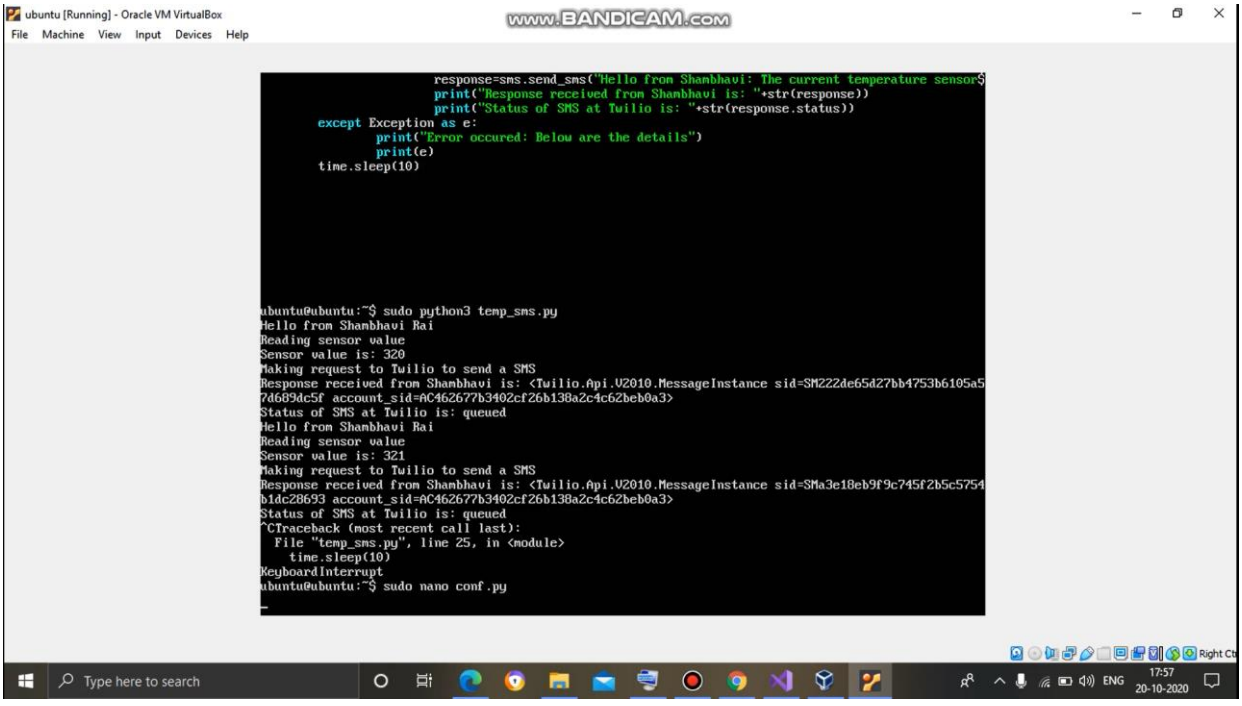


Fig 3(e) : Sending Alert for Certain Threshold Value in Case of fever

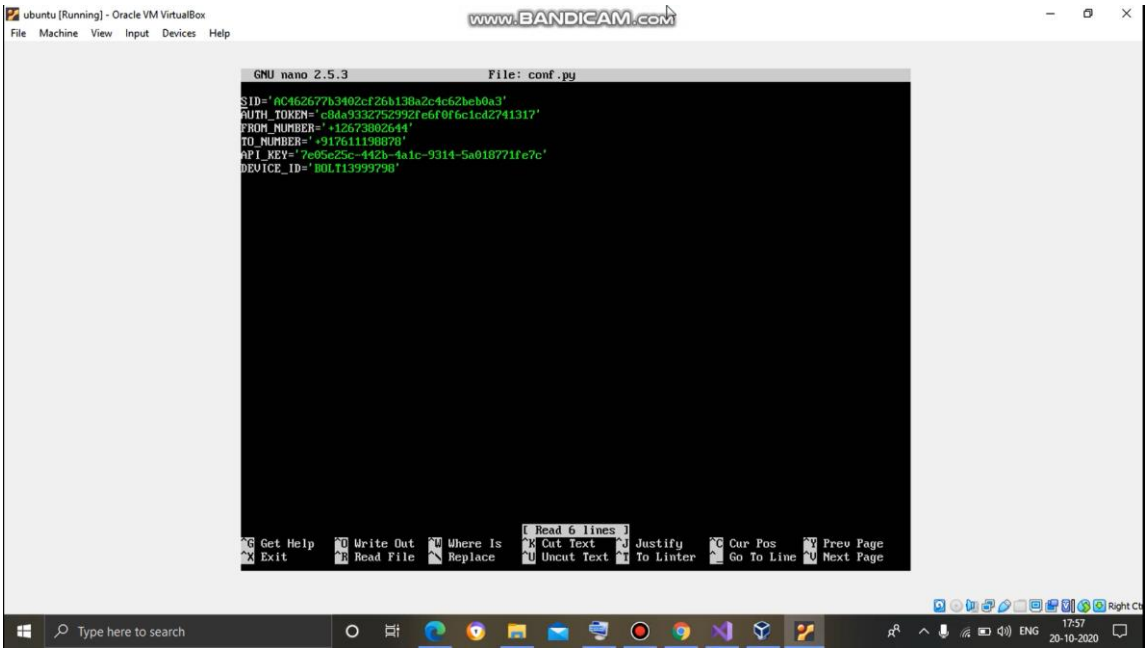


Fig 3(f) : Getting the SID, API-Key, Mobile Number, Device-Id & Authorization Token to connect Virtual Machine & IoT Devices

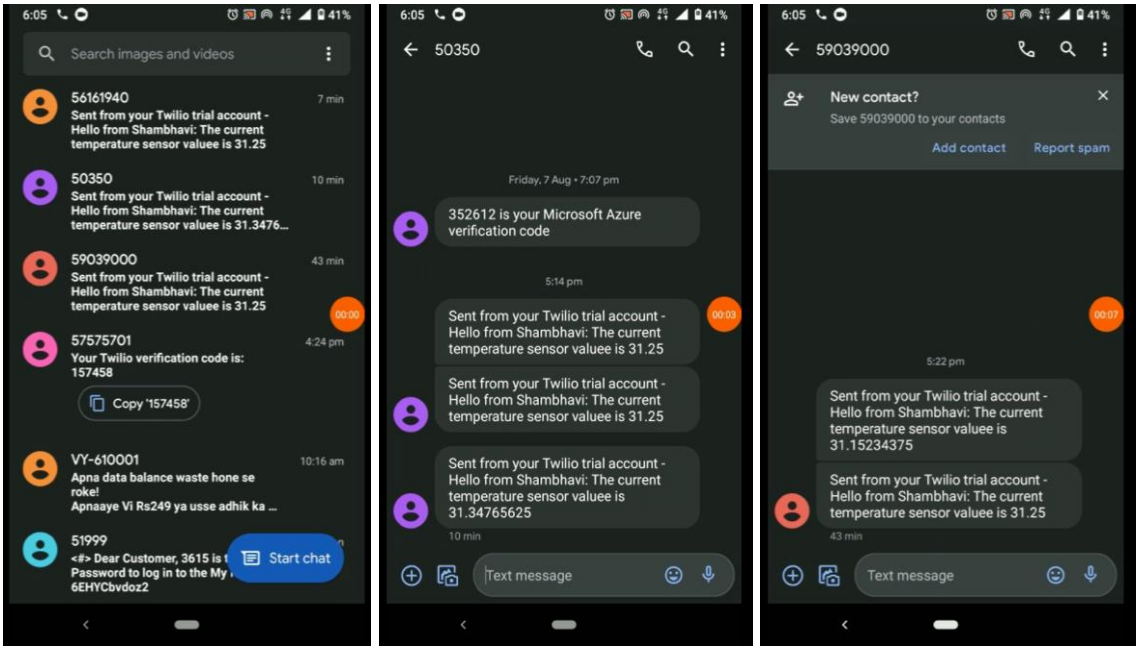


Fig 3(g) : Sending Messaging Alert via Twilio for High Fever Detection

4. VIRTUAL MEDICAL ASSISTANT

This is a specially designed chatbot to answer the COVID related queries and thus help in spreading the required awareness and knowledge related to this outbreak.

Our fourth module name is Virtual Medical Assistant. It will be using the predefined library of the python i.e. nothing but ChatterBot which is a machine-learning based conversational dialog engine built in Python and makes it possible to generate responses based on collections of known conversations. The language independent design of ChatterBot allows it to be trained to speak any language. We will be training it using the required dataset and it will produce accurate and efficient chat messages.

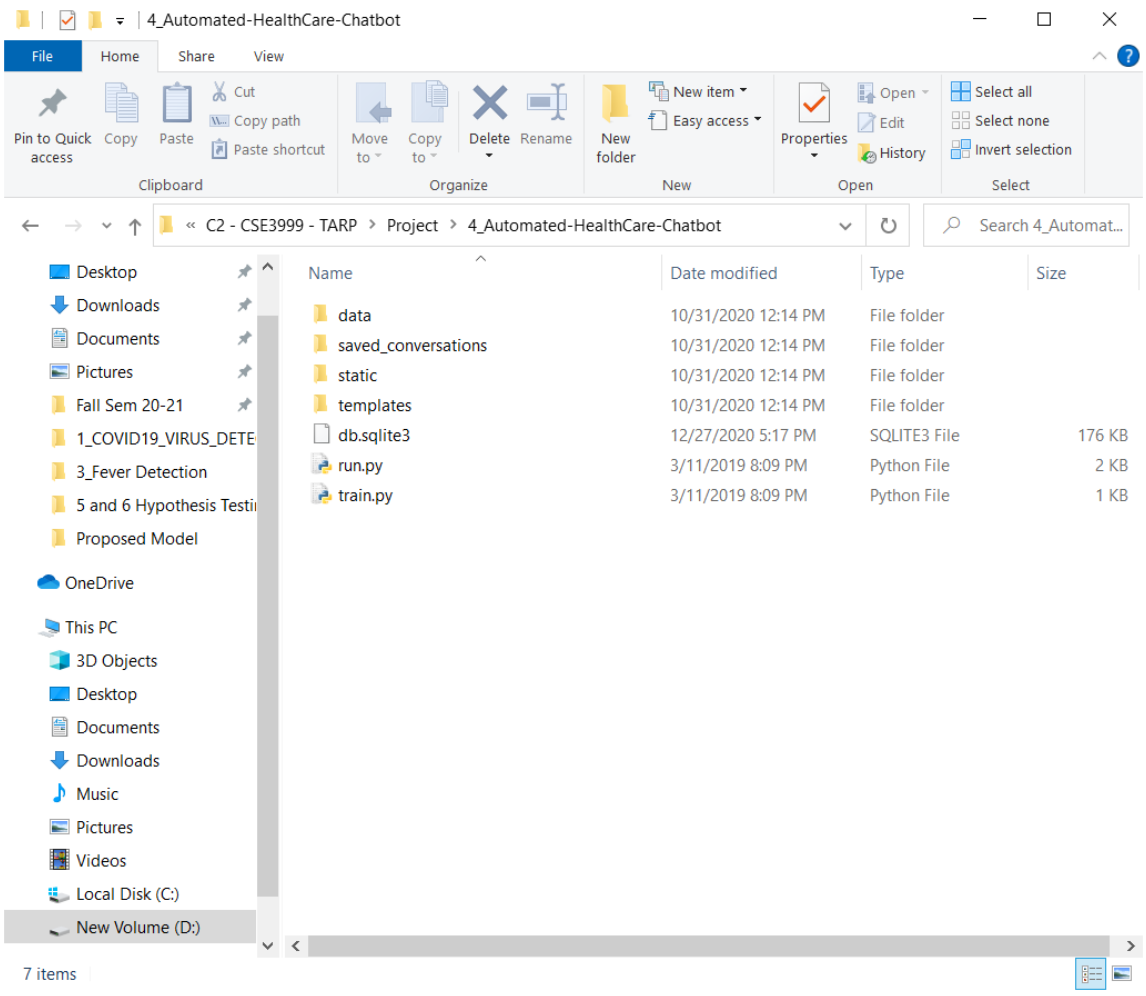


Fig 4(a) : Virtual Medical Assistant Code Directory

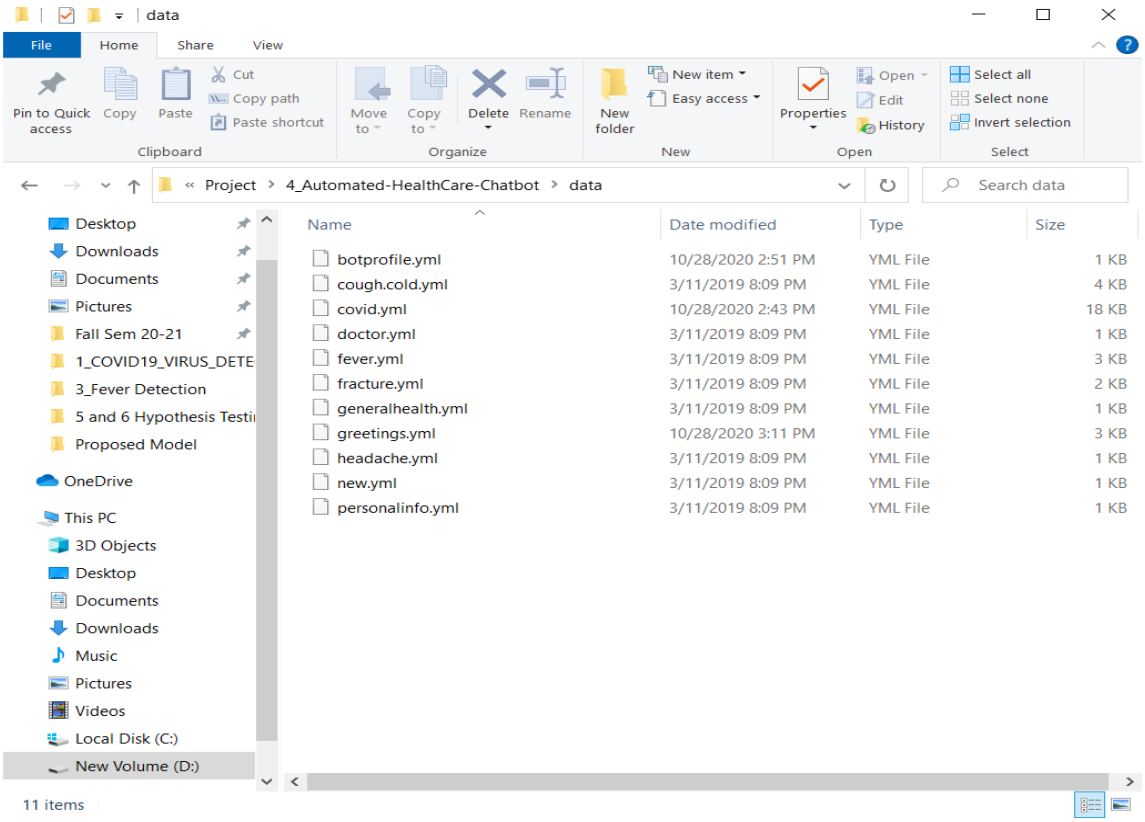


Fig 4(b) : Data Corpuses Stored in .yml Format for Chatbot Training

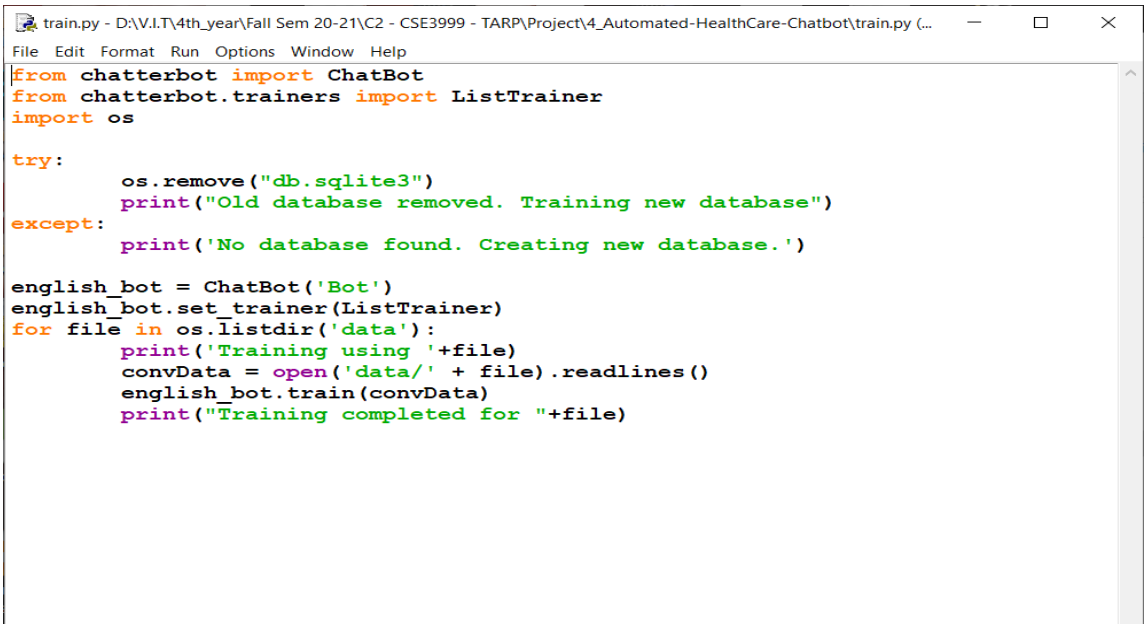


Fig 4(c) : Train.py Code for Chatbot Training

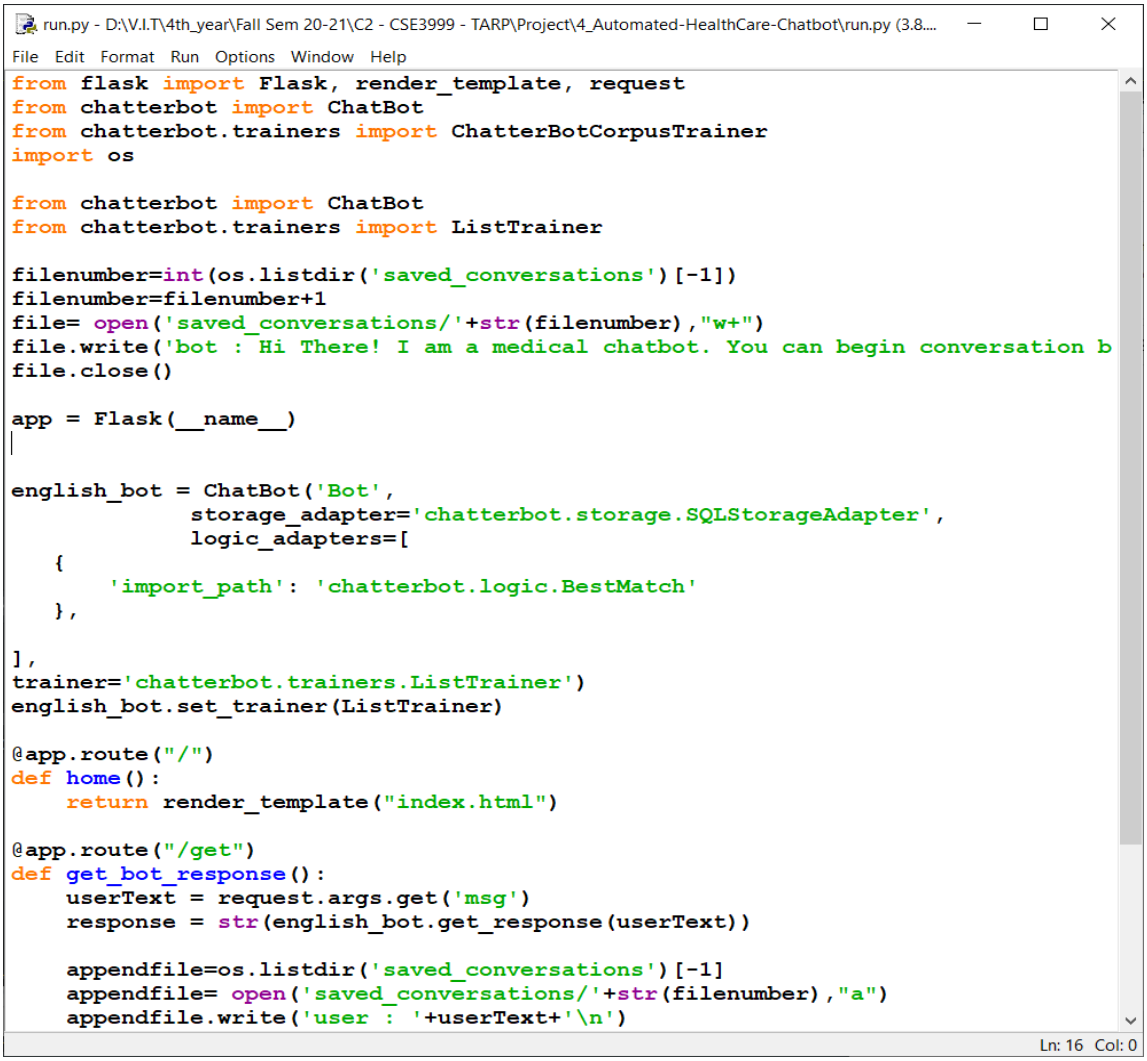


Fig 4(d) : Main Code for Chatbot

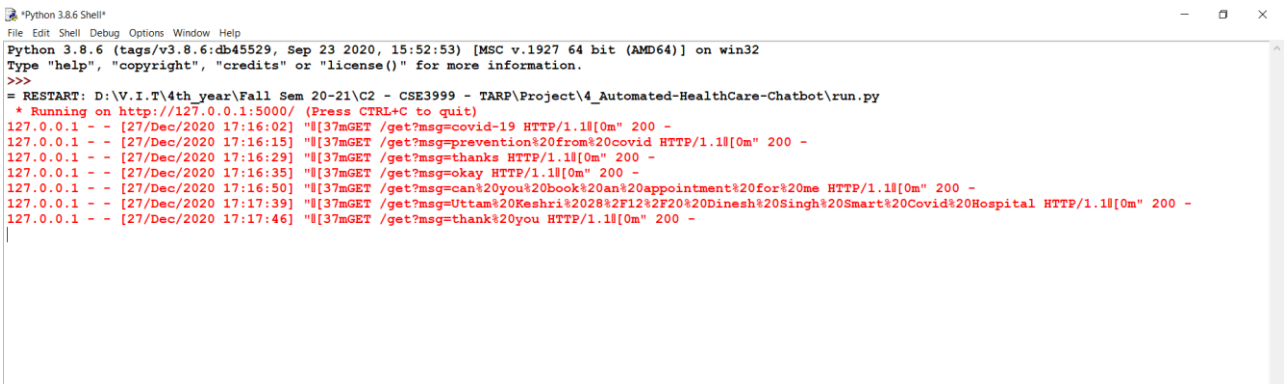


Fig 4(e) : Getting Execution Summary of Chatbot from Python Shell

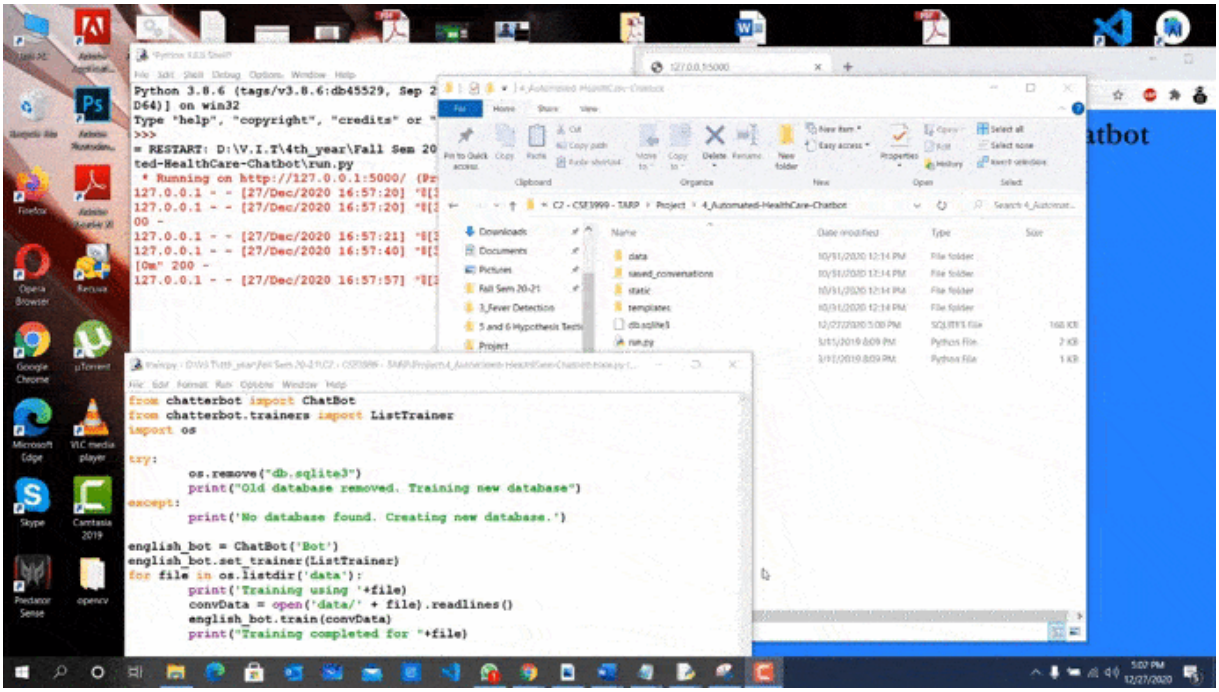


Fig 4(f) : Training the Automated HealthCare Chatbot

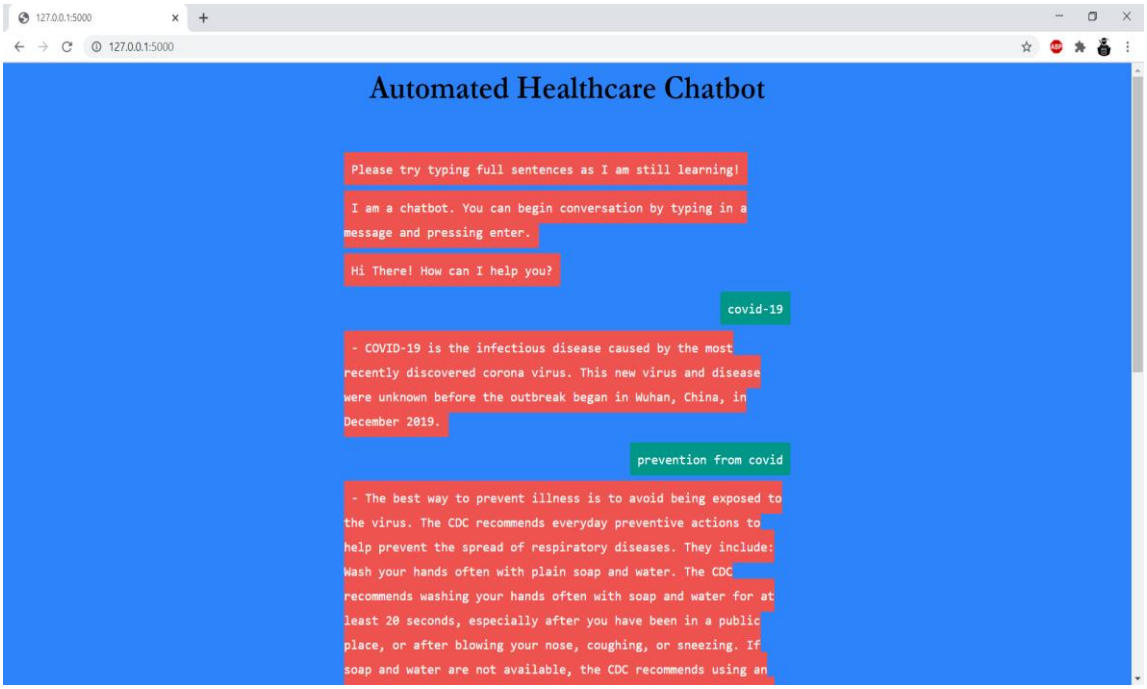


Fig 4(g) : Conversation with Automated HealthCare Chatbot

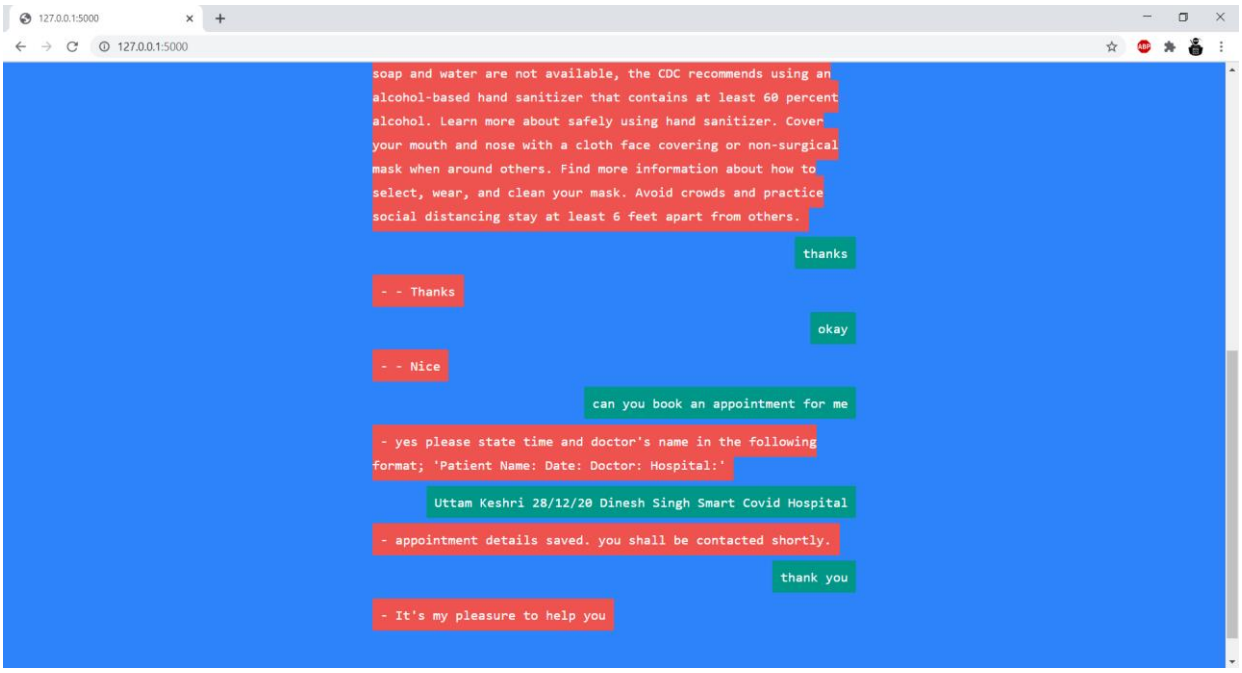


Fig 4(h) : Booking an Appointment with Doctor through Chatbot

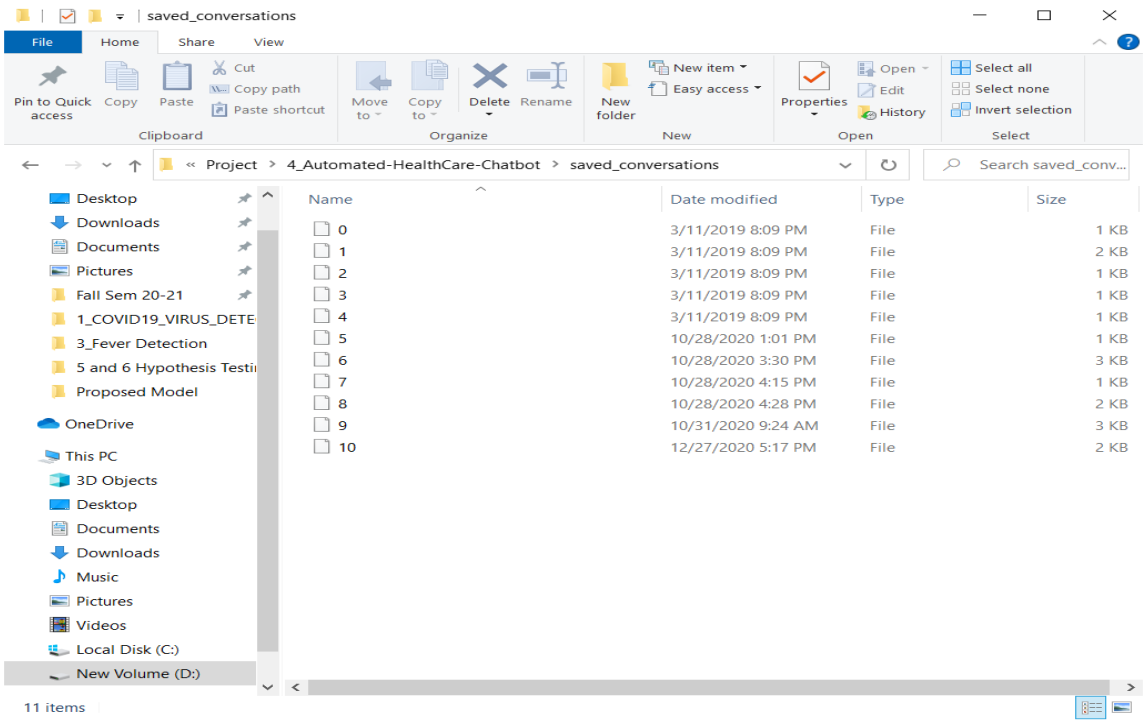


Fig 4(i) : Saving the conversations of user's & chatbot : Can be used for improvising the chatbot limitations

5. SMART COVID-19 HOSPITAL

This is a website designed which not only saves time in the hospital but also is cost-effective in decreasing the number of people working on the system of manual entry of data and paperwork. The implementation will decrease the human intervention into the system thereby avoiding human-caused errors. It is basically for the registrations and fixing appointments with doctors.

Our fifth and the final module name is Smart Covid-19 Hospital. This is going to be a web-application with the user interface which will be designed to facilitate the users such as patients, doctors and admins (or Receptionist). It will be fully fledged and well-designed with the basic functionalities as a hospital management system where the patient can book appointments, doctors can approve or cancel the appointments and admin can view all the lists of doctors currently available and has the privilege access to view the appointment history and many other functionalities. It will have tabs like feedback, home, about us, COVID-19 tracker, general Q & A etc. with all the specifications. We will be using HTML, CSS, and JavaScript to design front-end and PHP to design back-end. Of course, we will be using facilities like DOM, Bootstrap etc. to make our website more responsive and user-friendly.

So, finally our designed project will work like this patient can find he/she is COVID-19 positive or negative using our user-friendly COVID-19 detection. If he/she is COVID-19 positive, then he/she can contact a doctor by using our website after logging in. Also, he/she can clear the doubt by chatting with a medical assistant and reading FAQ on our website. Then he/she can book an appointment with a doctor, can see appointment history, can see prescriptions etc. using our website. Also, doctors can monitor the quarantined patient using the Heart Rate Monitoring system and Fever Detection system. Other required facilities are also available on our website to make it more user-friendly and convenient.

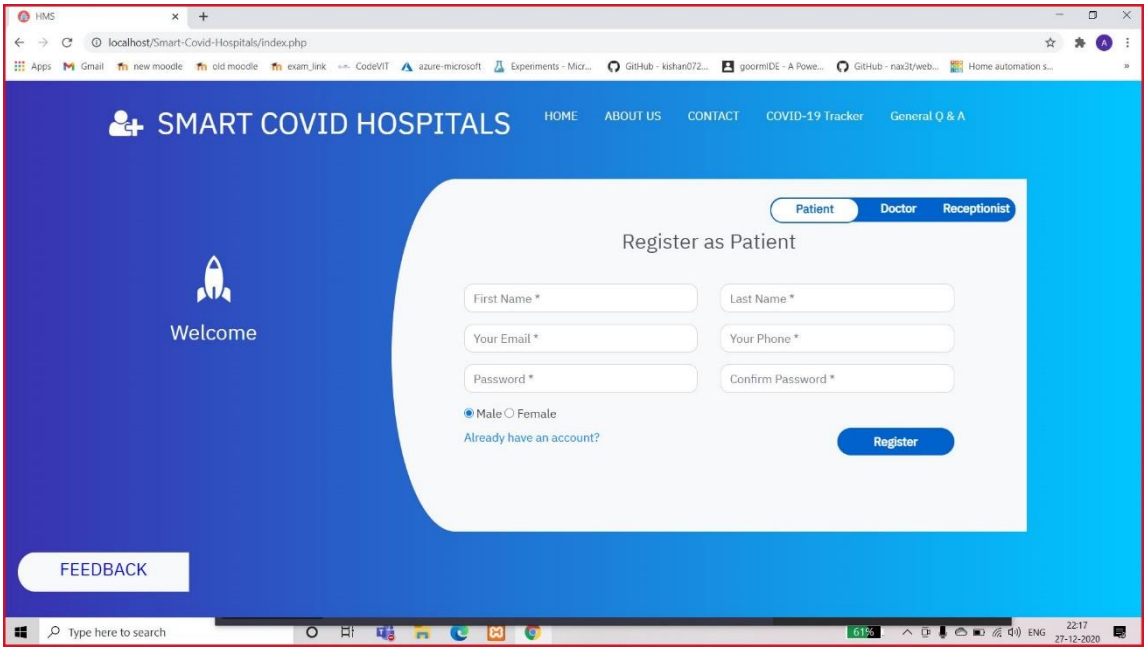


Fig 5(a) : Signup/Login for Patient

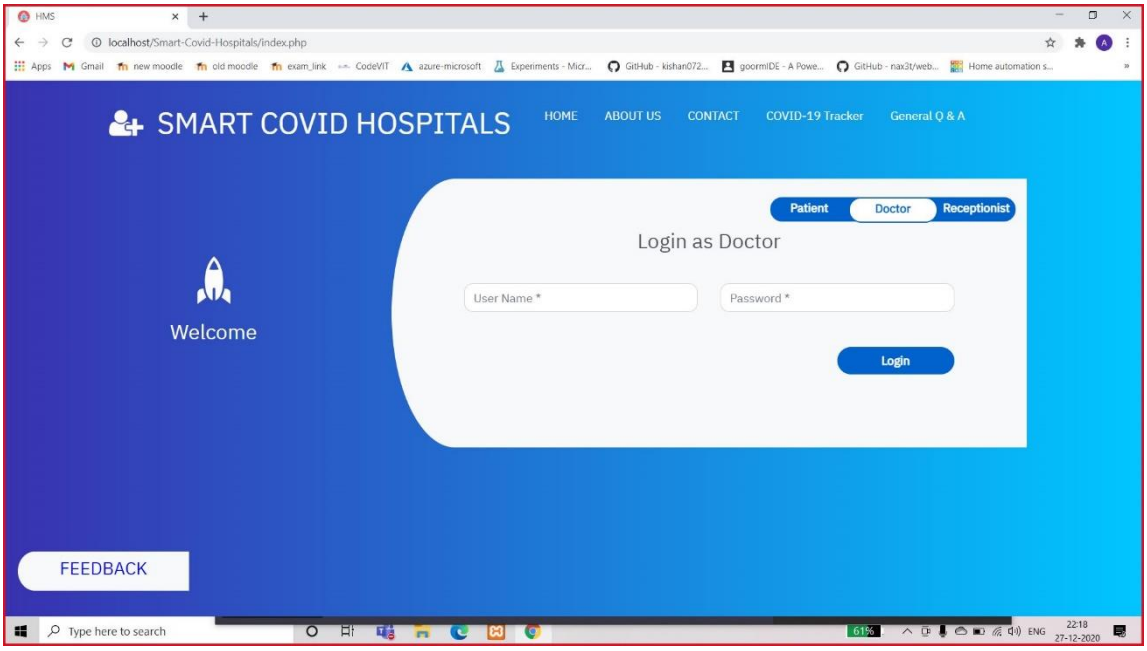


Fig 5(b) : Login for Doctor

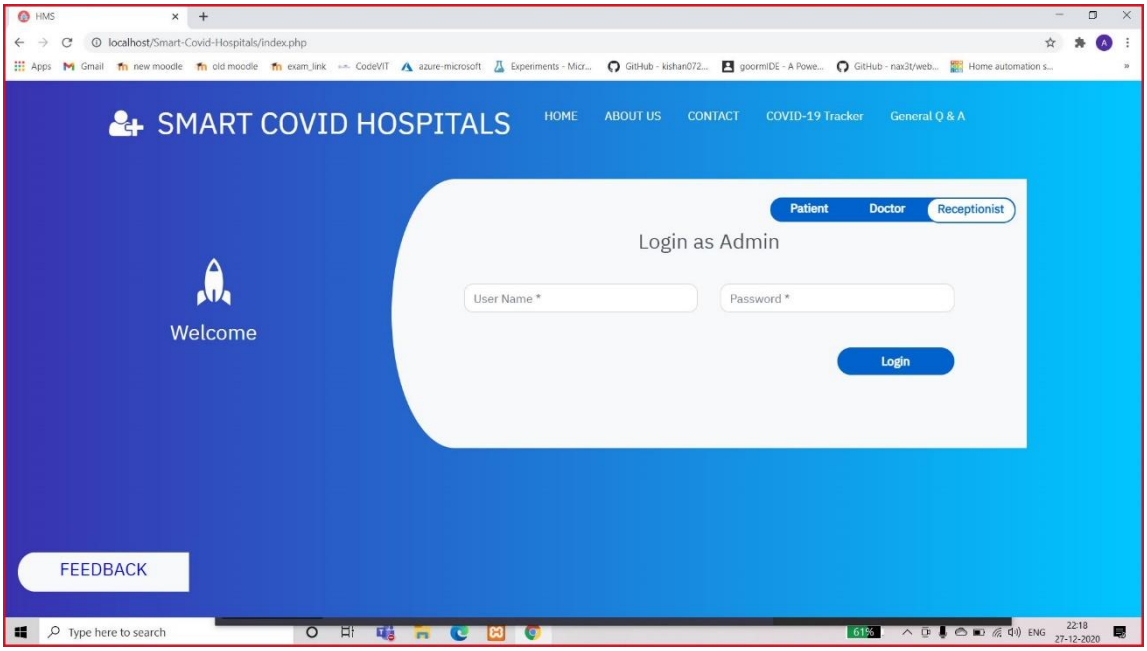


Fig 5(c) : Login for Admin

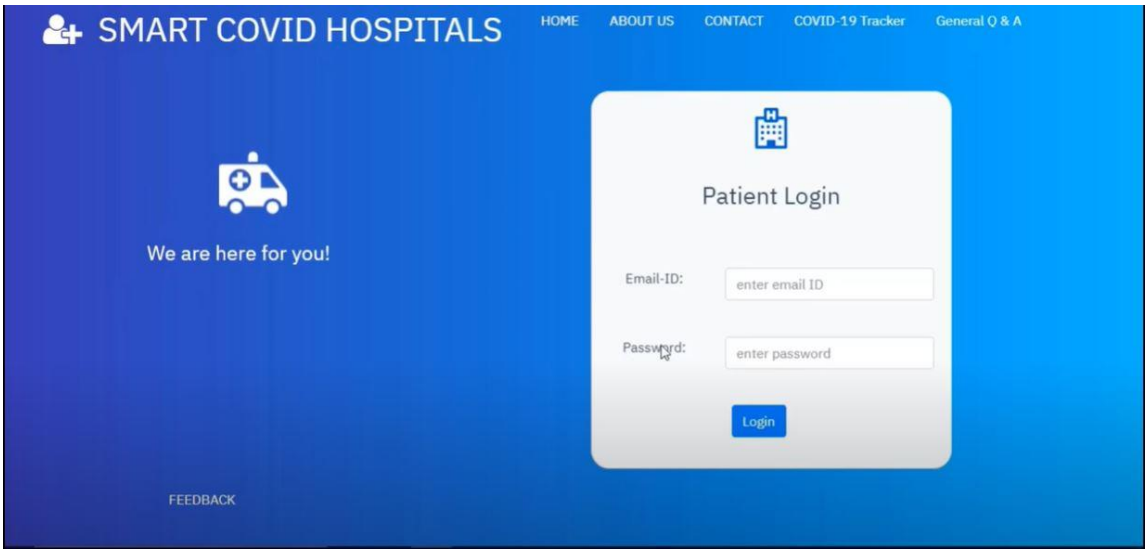


Fig 5(d) : Patient Login Form

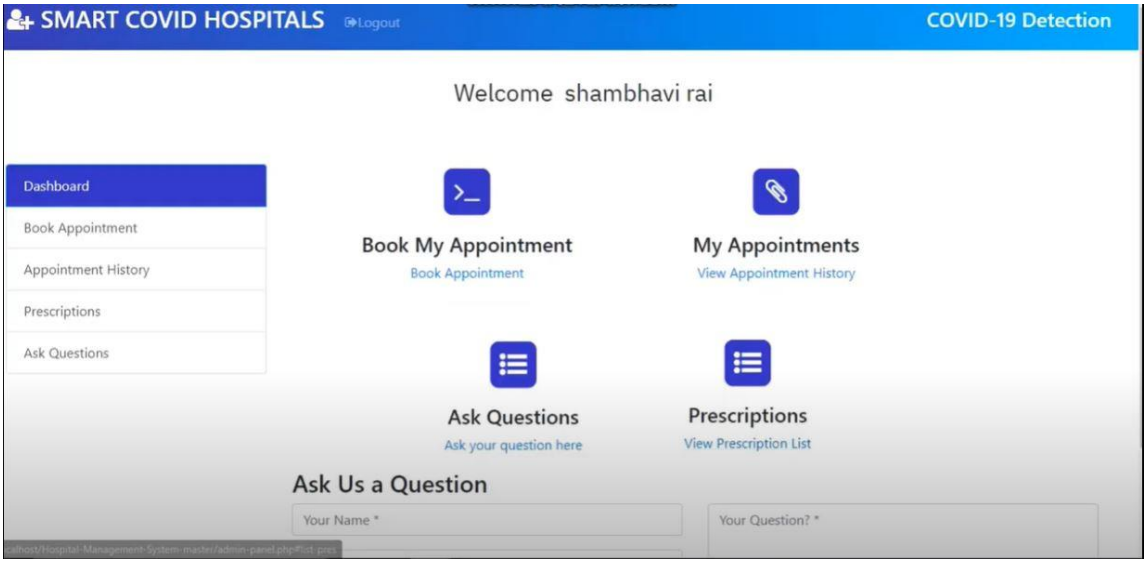


Fig 5(e) : Patient's Dashboard

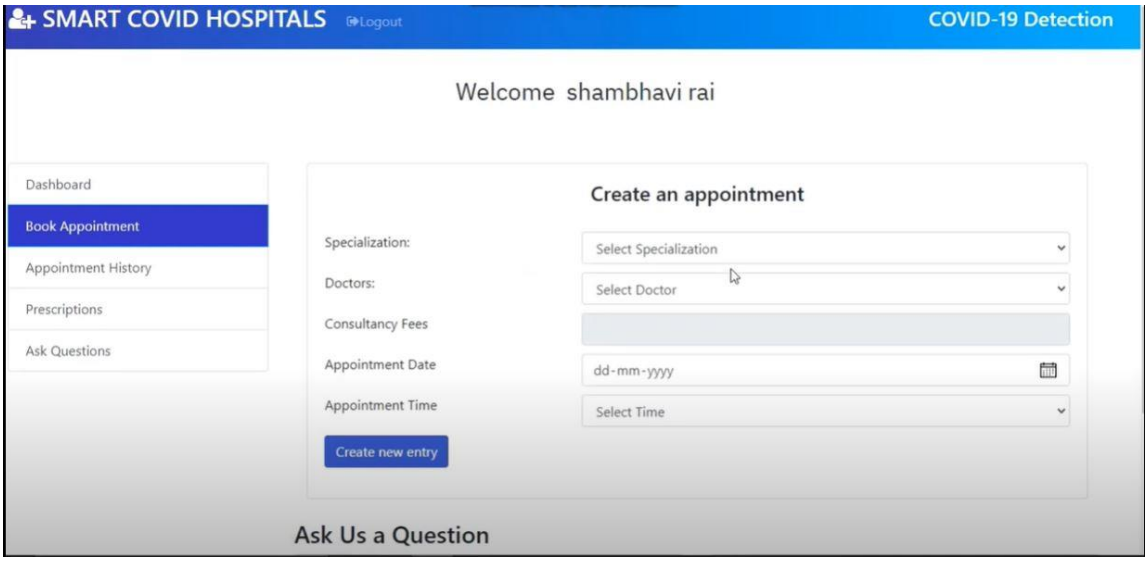


Fig 5(f) : Patient's Dashboard : Book an Appointment

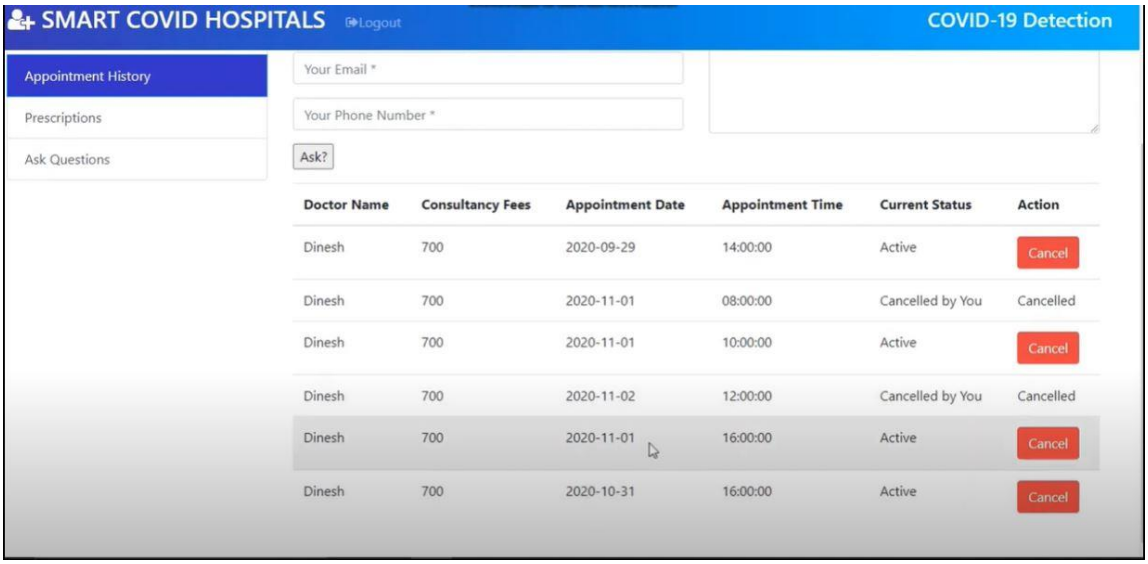


Fig 5(g) : Patient's Dashboard : Check Appointment History

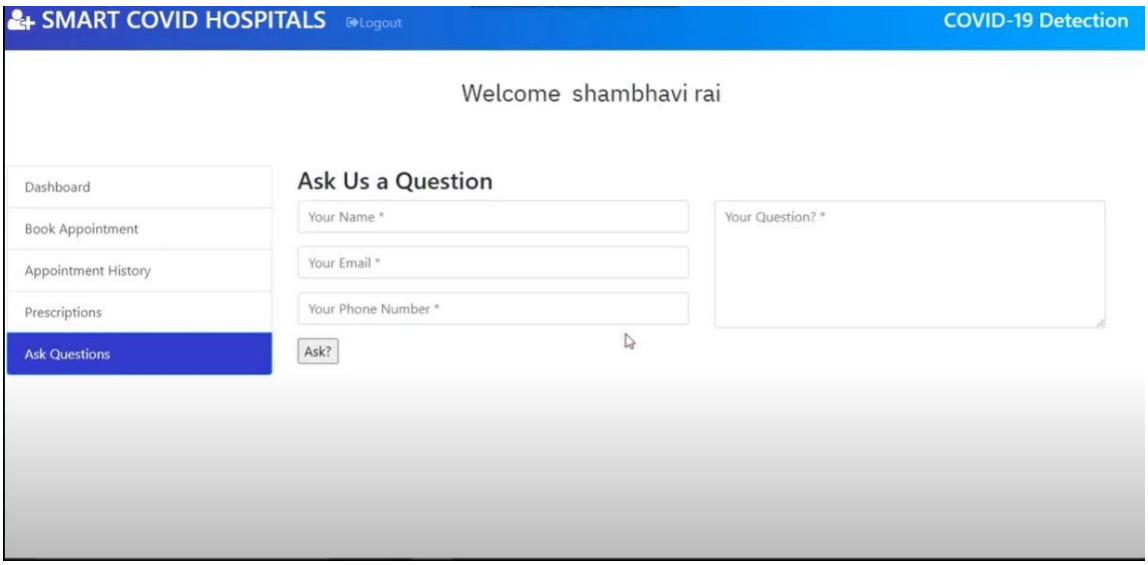


Fig 5(h) : Patient's Dashboard : Ask Query's to the Doctor

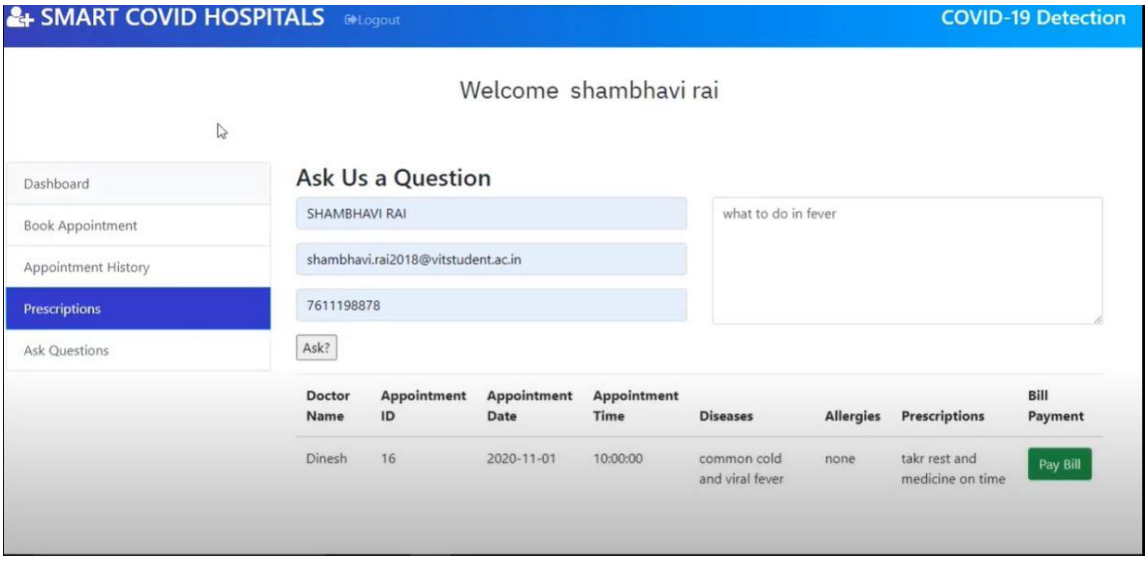


Fig 5(i) : Patient's Dashboard : Check Prescriptions suggested by the Doctor

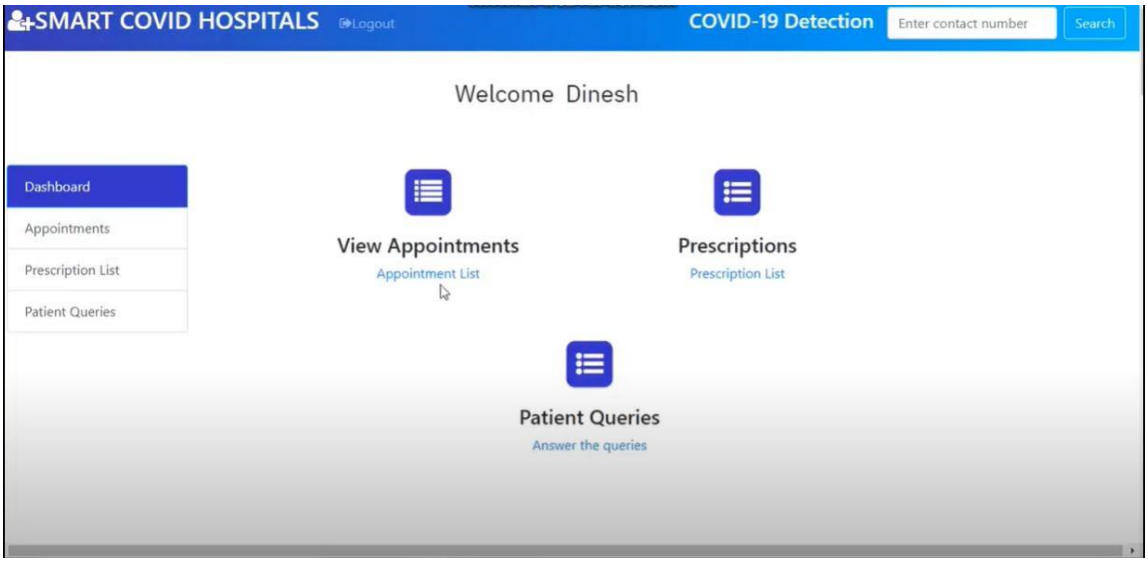


Fig 5(j) : Doctor's Dashboard

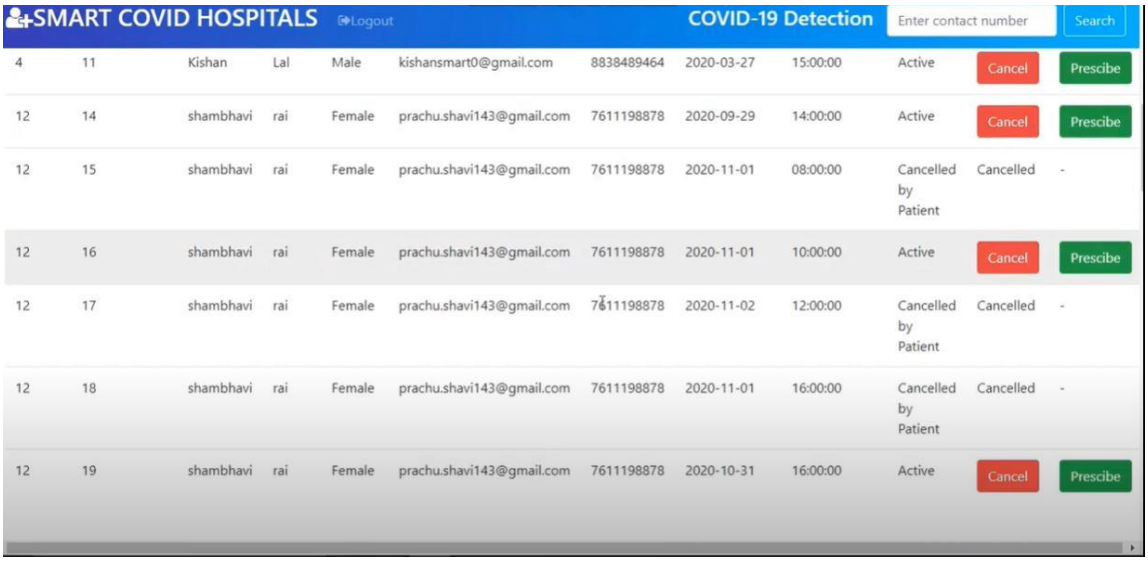


Fig 5(k) : Doctor's Dashboard : View Appointments

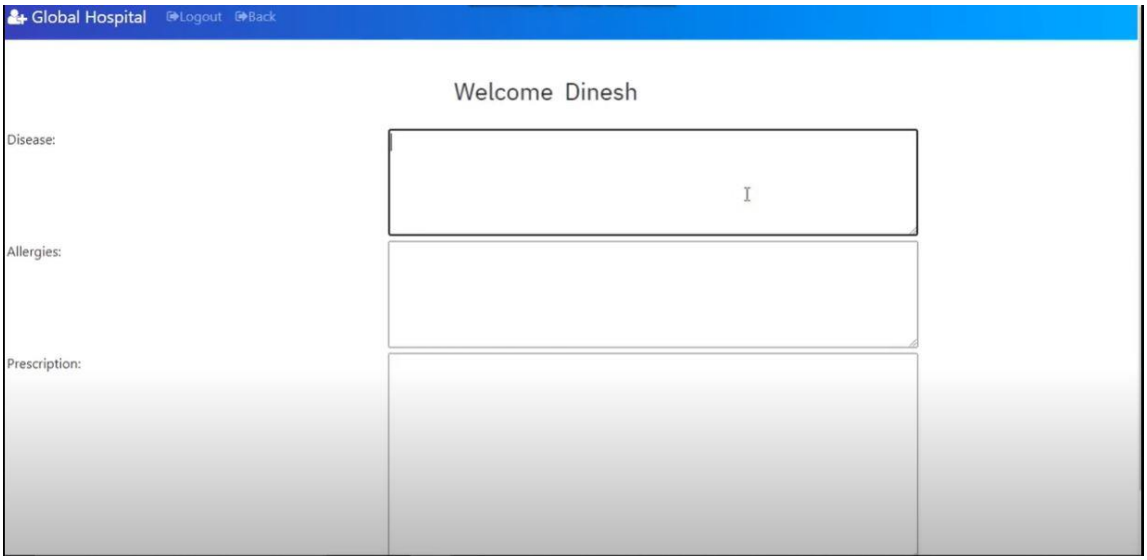


Fig 5(l) : Doctor's Dashboard : Suggest Prescriptions

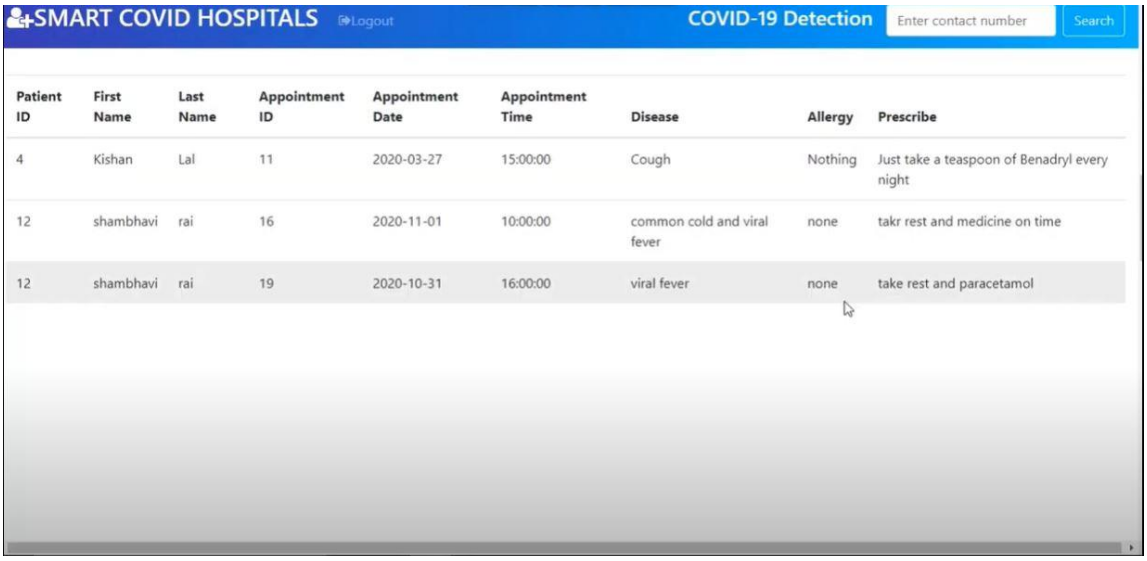


Fig 5(m) : Doctor's Dashboard : View Patient's Appointment, Queries, Disease, Allergies, Suggest prescriptions.

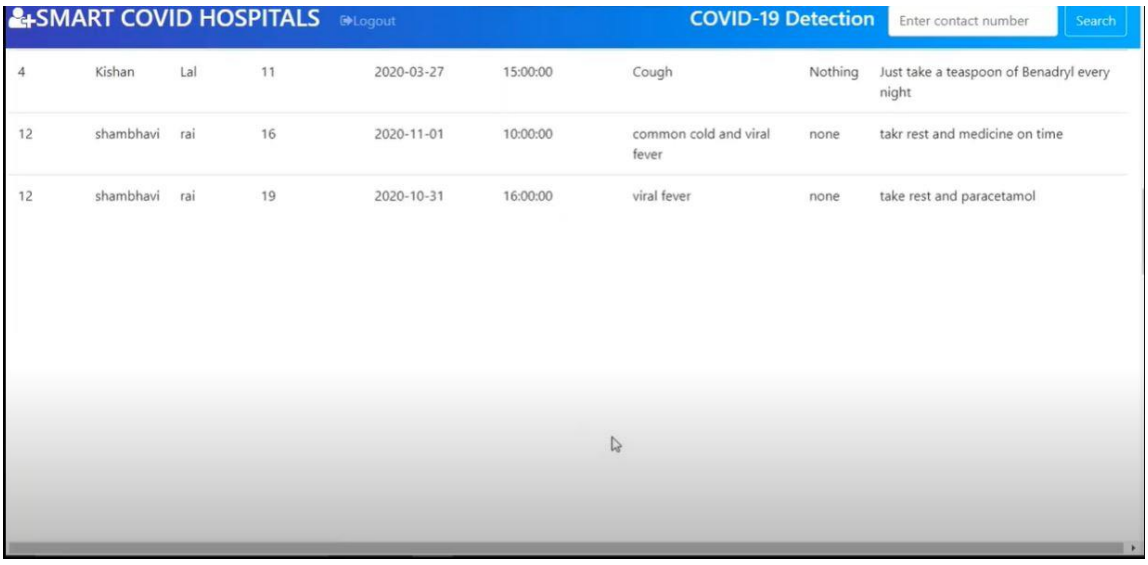


Fig 5(n) : Doctor's Dashboard : View Patient's Appointment, Queries, Disease, Allergies, Suggest prescriptions. – II

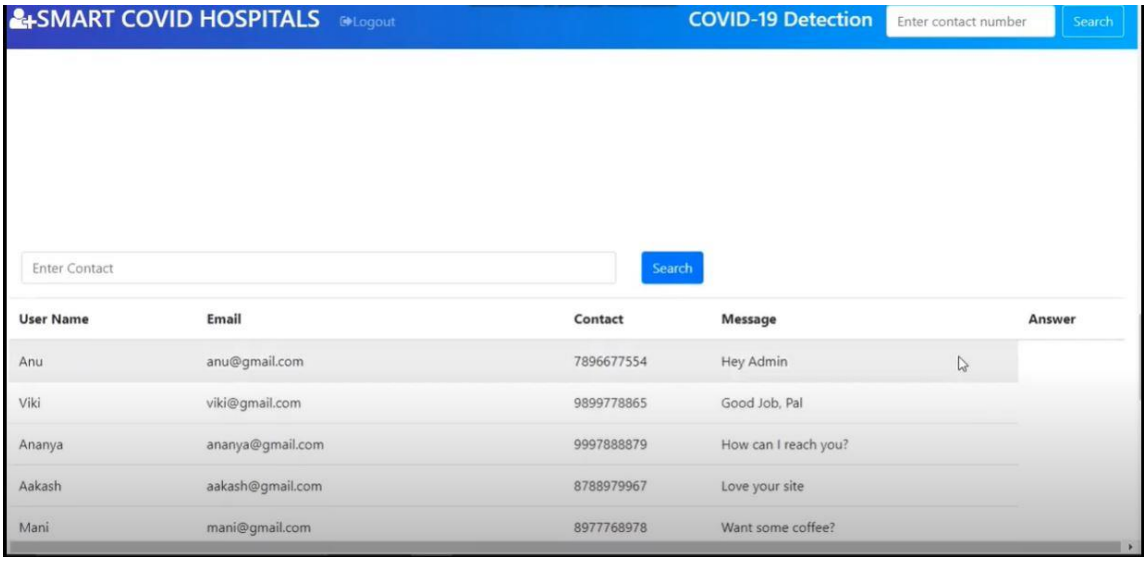


Fig 5(o) : Admin's Dashboard : Check General Feedback on Hospital.

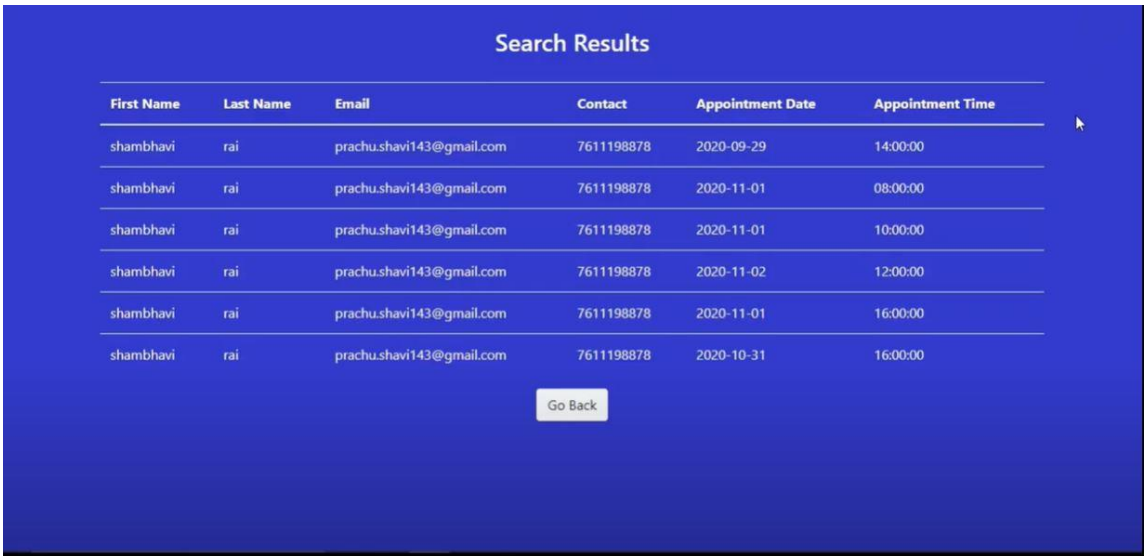


Fig 5(p) : Admin's Dashboard : Appointment History Search

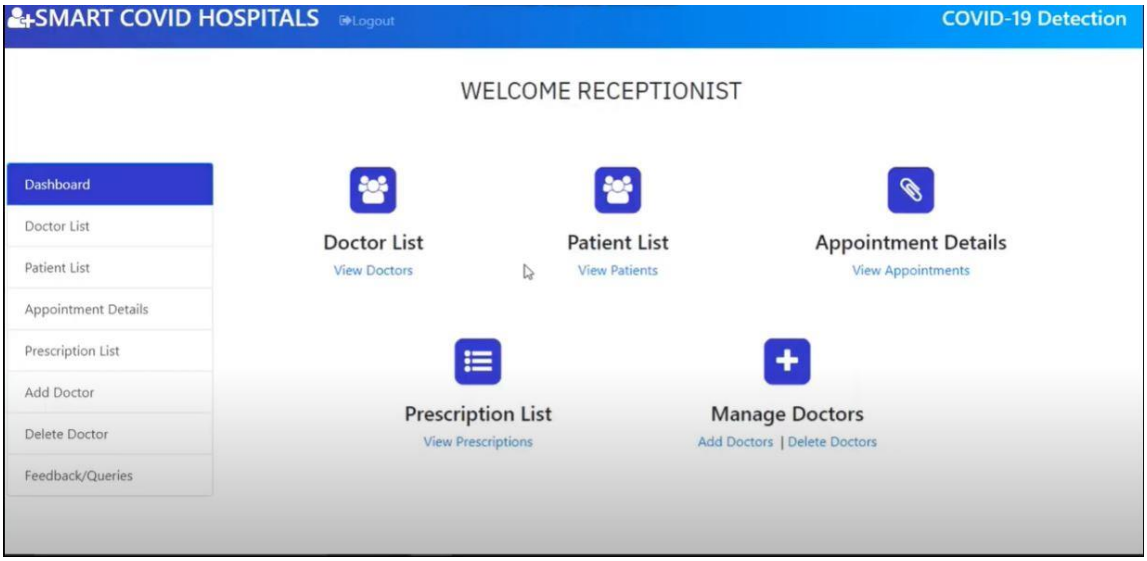


Fig 5(q) : Admin's Dashboard

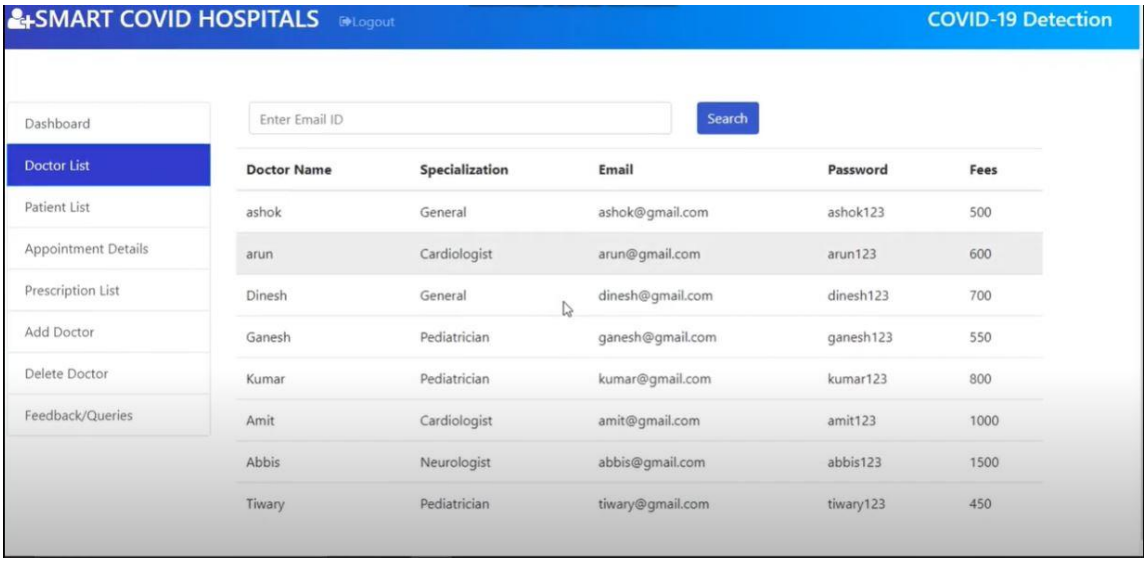


Fig 5(r) : Admin's Dashboard : View List of Doctors Available

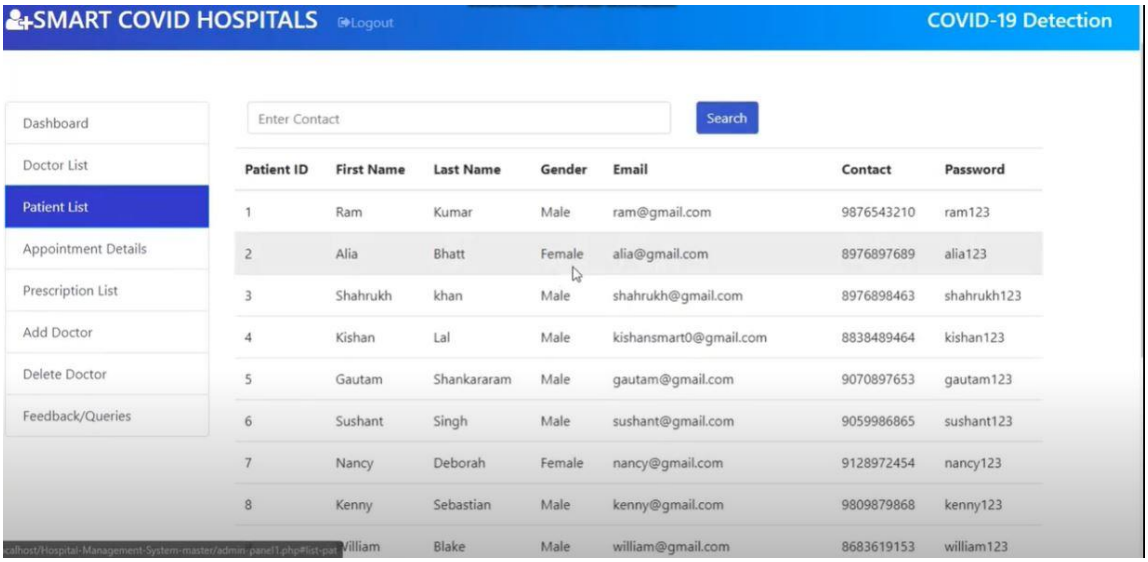


Fig 5(s) : Admin's Dashboard : View List of Patients in Hospital

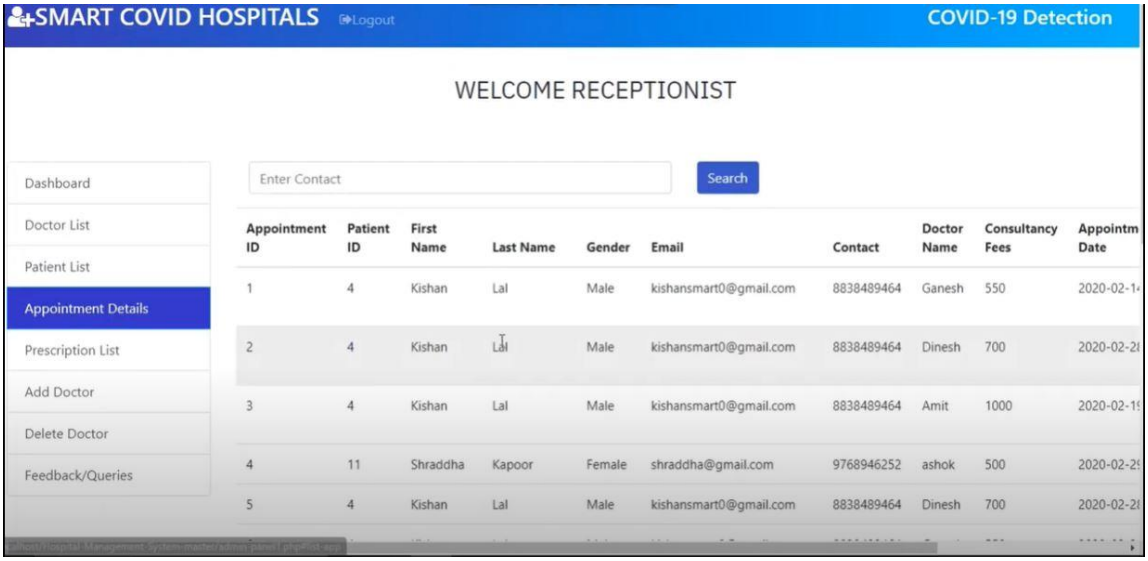


Fig 5(t) : Admin's Dashboard : View List of Appointment Details

Fig 5(u) : Admin's Dashboard : View List of Prescriptions Suggested to Patients by Doctor

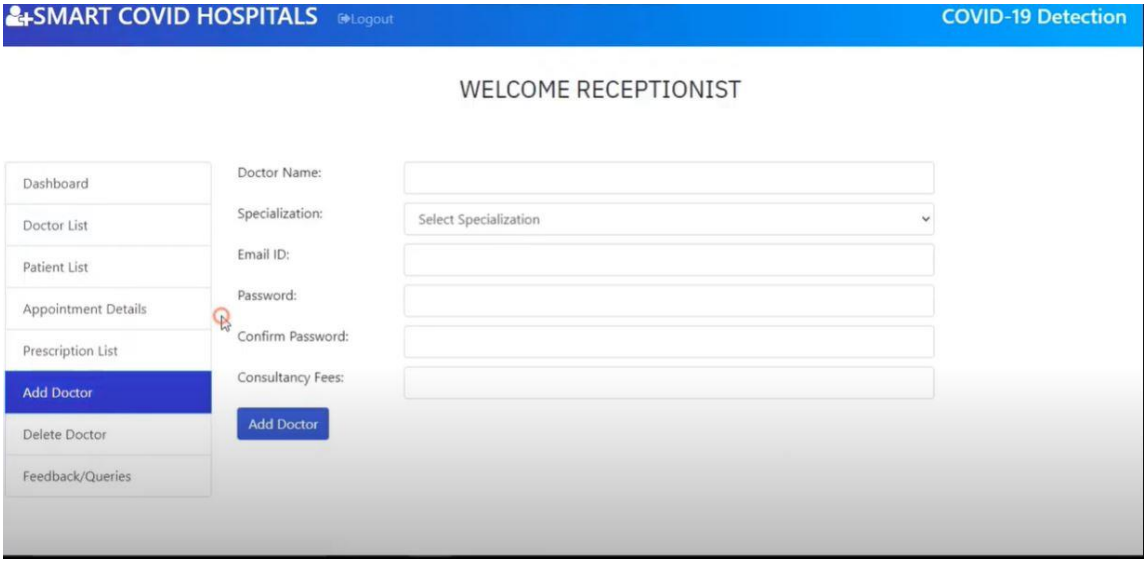


Fig 5(v) : Admin's Dashboard : Add New Doctor

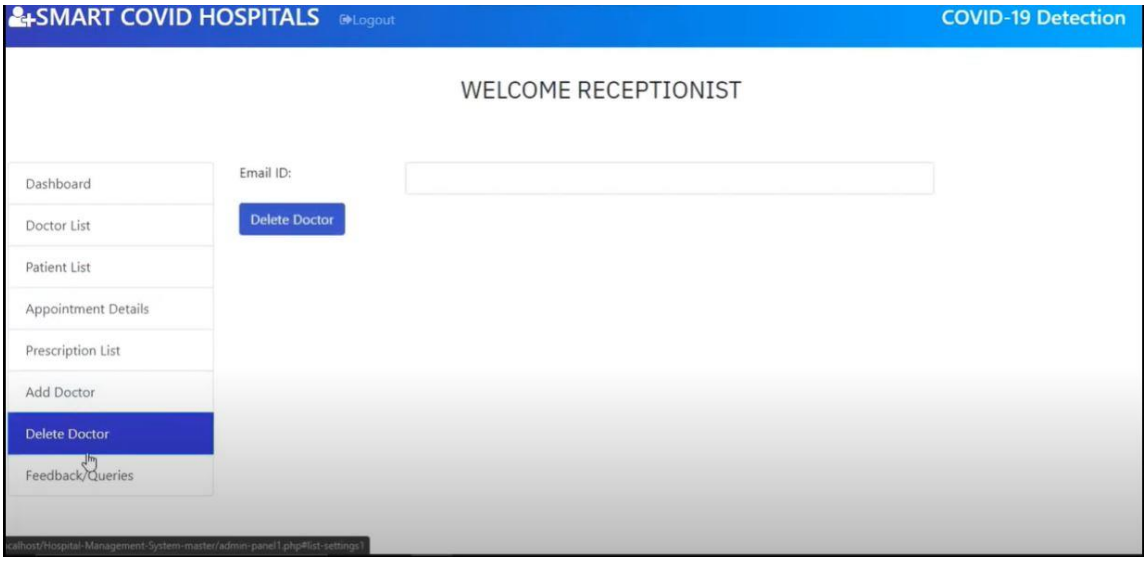


Fig 5(w) : Admin's Dashboard : Delete the existing Doctor

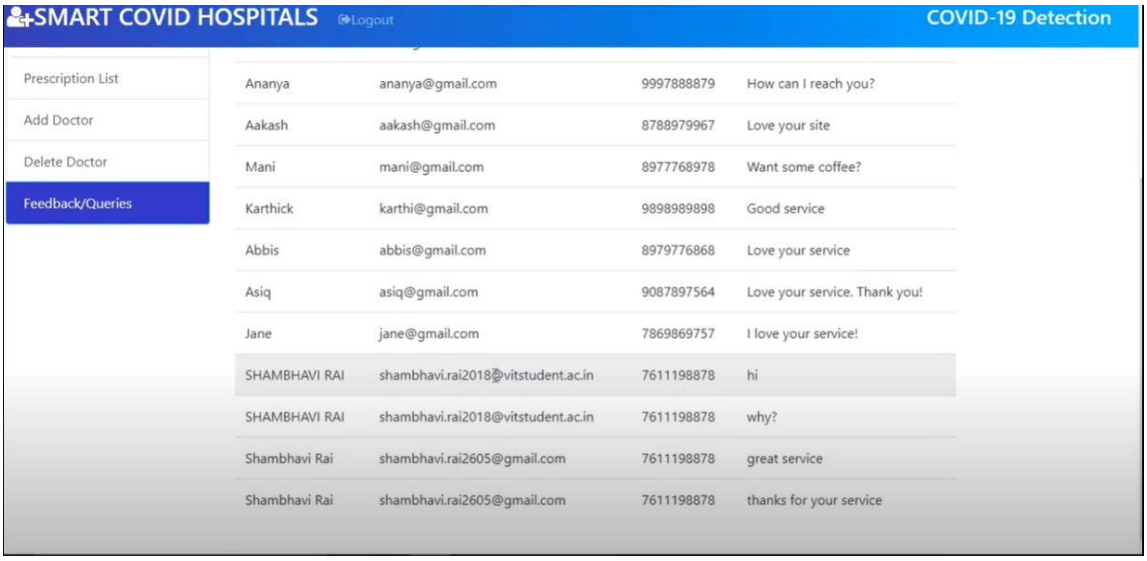


Fig 5(x) : Admin's Dashboard : View Queries by User's

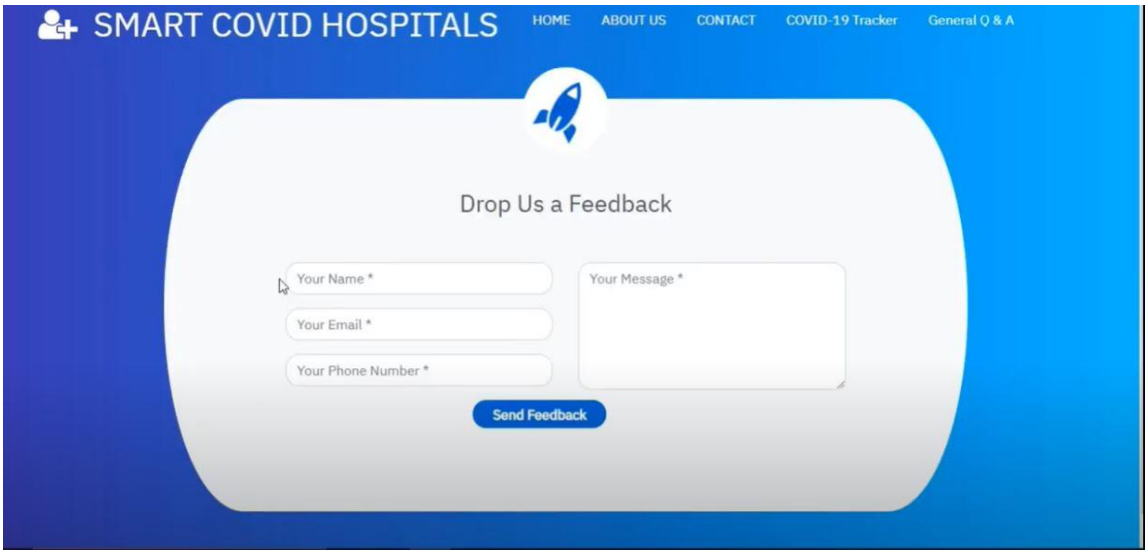


Fig 5(y) : Smart Covid-19 Hospital : Feedback

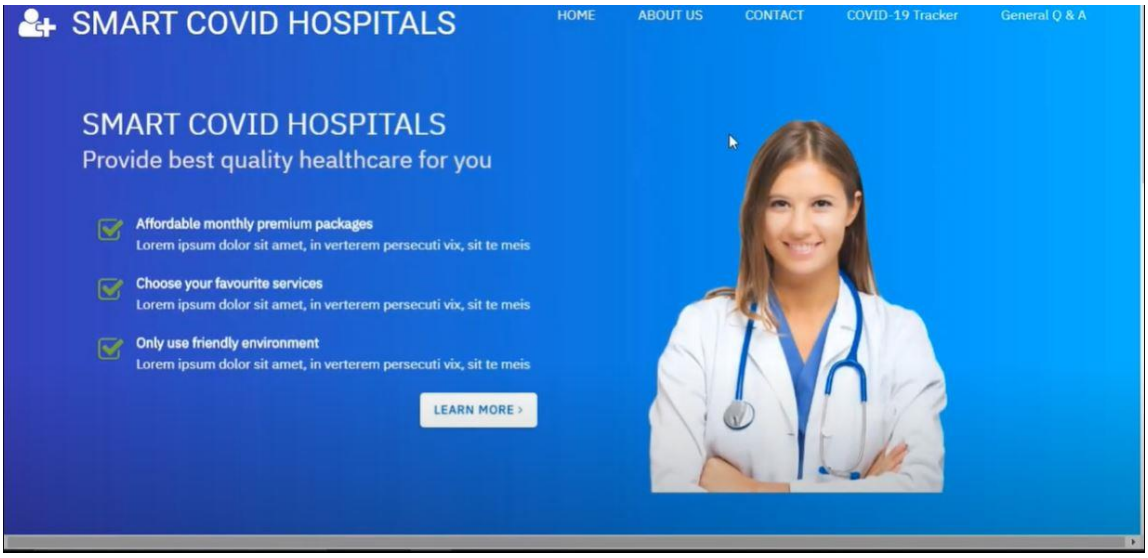


Fig 5(z) : Smart Covid-19 Hospital : Services

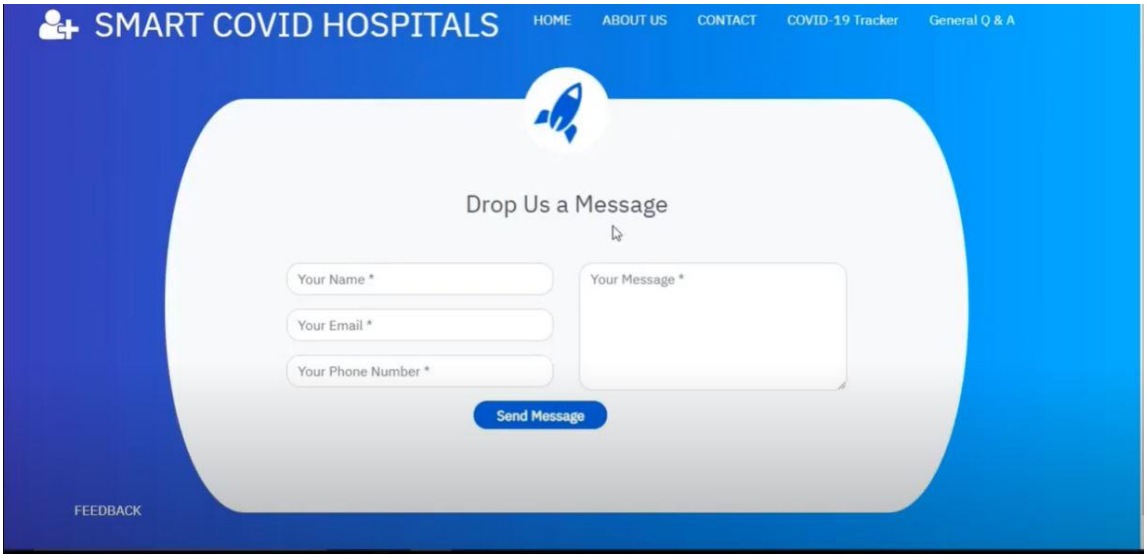


Fig 6(a) : Smart Covid-19 Hospital : Message Admin

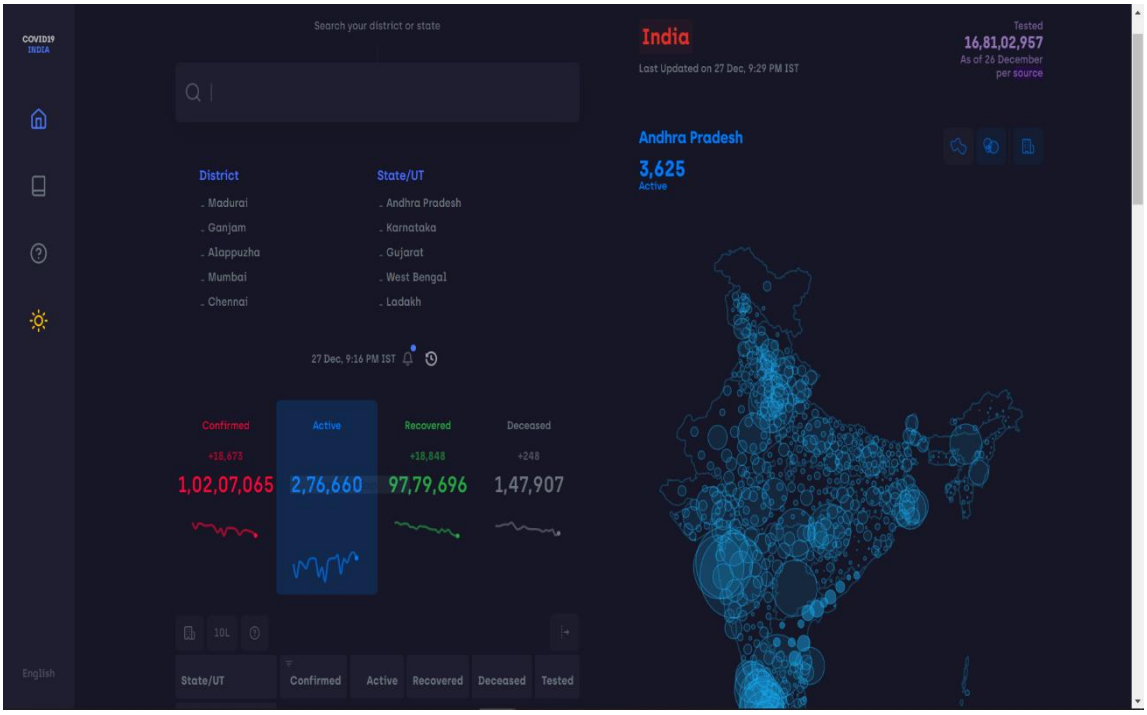


Fig 6(b) : Smart Covid-19 Hospital : Covid-19 Tracker

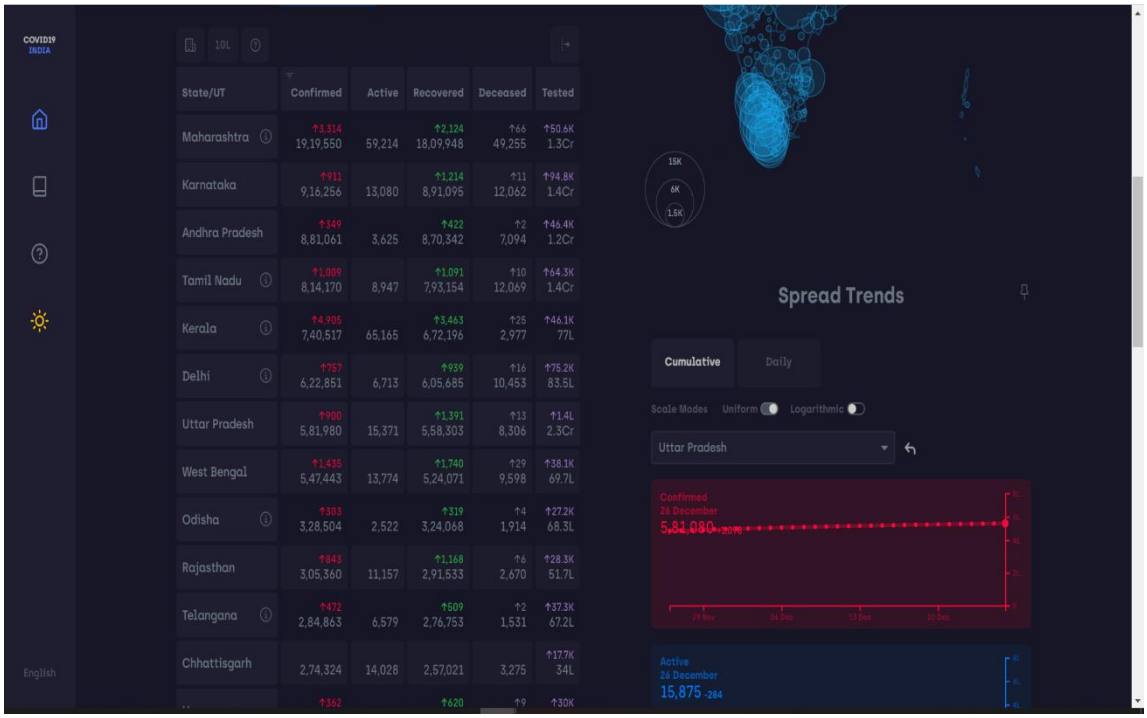


Fig 6(c) : Smart Covid-19 Hospital : Covid-19 Tracker : Statewide Cases

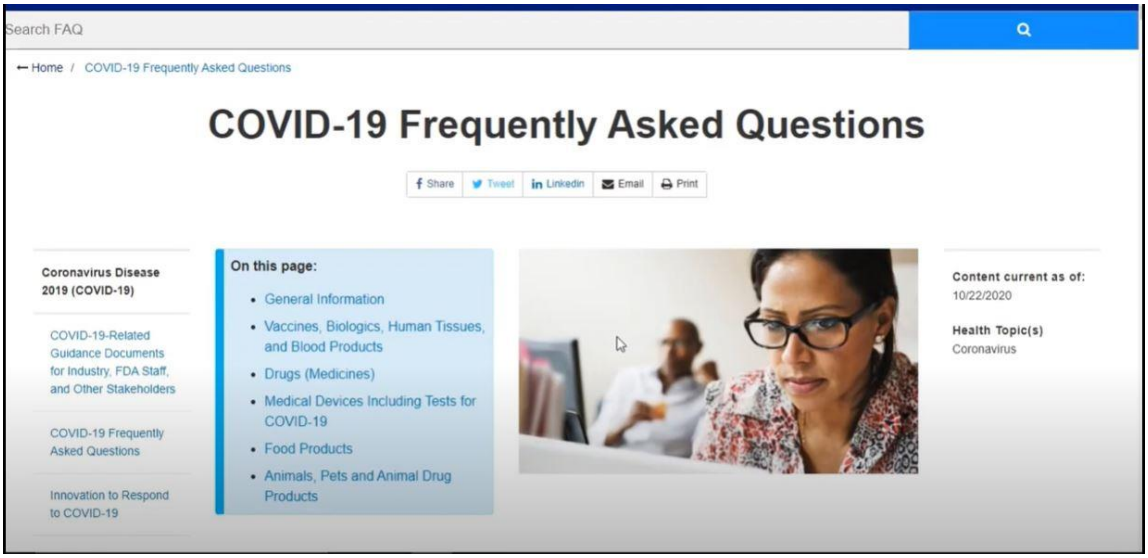


Fig 6(c) : Smart Covid-19 Hospital : Frequently Asked Questions(FAQ)

Chapter 4 – Results and Conclusions

The recent outbreak of COVID pandemic has led to everything going online and also has outnumbered the available hospital resources in terms of the increasing number of patients.A smart COVID treatment idea could be implemented to reduce the risk of spreading corona by replacing man power with machine learning and Iot.

Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus.Most people who fall sick with COVID-19 will experience mild to moderate symptoms and recover without special treatment.The virus that causes COVID-19 is mainly transmitted through droplets generated when an infected person coughs, sneezes, or exhales. These droplets are too heavy to hang in the air, and quickly fall on floors or surfaces.You can be infected by breathing in the virus if you are within close proximity of someone who has COVID-19, or by touching a contaminated surface and then your eyes, nose or mouth.

So the smart COVID treatment would come in handy to avoid physical contact and maintain social distancing by conducting the covid detection with machine learning scanning, monitoring the home quarantined patients for deteriorating health condition by smart heart rate monitoring using webcam and fever detection using IoT sensors which would send an alert to the doctor in case of any emergency and thus helping reduce the risk of corona to person taking care of the patient.

If we cannot combat the challenges that corona poses to our society, our economy and immunity will surely diminish. More research and innovation are needed to maintain our economy in this pandemic while still supporting the patients infected by corona .It is predicted by various organizations, research papers, prominent persons etc. that AI is our future. The integration of AI in the medical field will prove to be a great boon. Use of AI in COVID-19 pandemic is minimal due to various constraints but we came up with an awesome idea of using AI to tackle this problem. We have already started working on the idea and results seem to be promising as we are proceeding towards the final implementation. So far our work is designed as a patient-hospital based heuristic model on the COVID-19 disease but for future implementation it is sustainable for any other kind of diseases based on symptomatic behavior and we are pretty well sure that this will bring the digital medical field to the next level in future.

The advancements could make it possible so that EEG, ECG and other health parameters can also be monitored.Also continuous monitoring and future diagnosis can be performed via the same system .More than a single patient at different places can be monitored using a single system.The chatbot could be made voice enabled for the convenience of the patients. CPBMI and IT-based health management tools are anticipated to become useful and effective components of healthcare management in the future.

REFERENCES

1. Artificial intelligence and the future of global health, The Lancet, 2020; 395 (10236): 1579 DOI: 10.1016/S0140-6736(20)30226-9
2. Artificial intelligence vs COVID19: limitations, constraints and pitfalls, Wim Naudé, AI & SOCIETY (2020), 28 April 2020. https://doi.org/10.1007/s00146-020-00978-0
3. "Review of Artificial Intelligence Techniques in Imaging Data Acquisition, Segmentation and Diagnosis for COVID-19." IEEE Reviews in Biomedical Engineering, 2020. doi: https://doi.org/10.1109/RBME.2020.2987975
4. "The role of imaging in the detection and management of COVID-19: a review." IEEE Reviews in Biomedical Engineering, 2020. doi: https://doi.org/10.1109/RBME.2020.2990959
5. "Digital technology and COVID-19." Nature Medicine, 2020. doi: https://doi.org/10.1038/s41591-020-0824-5
6. "Detection of Covid-19 From Chest X-ray Images Using Artificial Intelligence: An Early Review." arXiv, 2020.
7. "Curbing the AI-induced enthusiasm in diagnosing COVID-19 on chest X-Rays: the present and the near-future." medRxiv 2020.04.28.20082776, 2020. doi: https://doi.org/10.1101/2020.04.28.20082776
8. "Computer Vision For COVID-19 Control: A Survey." arXiv, 2020.
9. "Artificial Intelligence against COVID-19: An Early Review." IZA Discussion Papers 13110, Institute of Labor Economics (IZA), 2020.
10. Systematic review and critical appraisal of prediction models for diagnosis and prognosis of COVID-19 infection." medRvix 2020.03.24.20041020, 2020. doi: https://doi.org/10.1101/2020.03.24.20041020
11. "Zero-Shot Learning and its Applications from Autonomous Vehicles to COVID-19 Diagnosis: A Review." arXiv, 2020.
12. "Fighting COVID-19 with Data and AI: A Review of Active Research Groups and Datasets"
13. "COVID-19 Imaging-based AI Research Collection"
14. "Mapping the Landscape of Artificial Intelligence Applications against COVID-19" arXiv, 2020.
15. "Modified SEIR and AI prediction of the epidemics trend of COVID-19 in China under public health interventions"
16. "Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)"
17. "Rapid AI Development Cycle for the Coronavirus (COVID-19) Pandemic: Initial Results for Automated Detection & Patient Monitoring using Deep Learning CT Image Analysis"
18. "Towards an Artificial Intelligence Framework for Data-Driven Prediction of Coronavirus Clinical Severity"
19. RSNA Publishes Expert Consensus on COVID-19 Reporting