A WEB-BASED PREDICTION SYSTEM FOR COVID-19 USING NEURAL NETWORK

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Abstract

The global outbreak of COVID-19 in 2019 opened up the interest for research to address diagnosis, prediction and medication for the disease. The disease grew to a widespread pandemic as a result of its ability to be transferred through contact. It has a way of affecting the respiratory, circulatory and excretory organs of the human body. Different approaches have been used to diagnose the disease but are not robust and fault tolerant to address large prediction data. In this research, a web-based prediction system was used to predict COVID-19 using neural network. The framework was implemented using ReactJS, Figma and Visual studio. The application showed how easy and user-friendly process of carrying out the prediction process. As employed in this paper, stakeholders can easily identify the likely rate at which the disease can become prevalent in an environment. Hence, providing a means to plan and see how to tackle the spread.

Keywords: COVID-19, Prediction, Neural network, Web-based, Recommendation

Introduction

Machine learning is an evolving field of computer algorithms with the purpose to emulate human intelligence by learning from the environment (Dong, 2020). They are considered the flagship products of the new period of so-called big data (He et al, 2018). Procedures based on machine learning have been applied with optimum results in multiple fields ranging from pattern recognition, computer vision, spacecraft engineering, finance, entertainment, and computational biology to biomedical and medical applications (Zhang et al, 2021). More than 50 percent of the patients diagnosed with cancer receive ionizing radiation (radiotherapy) as a major aspect of their treatment, and it is the main recovery modality at advanced stages of disease. (Abdo et al, 2021). A machine learning algorithm can be defined as a computational procedure that makes use of input data to perform a specific action or complete a given task without being explicitly programmed to exact a particular outcome (Connor et al., 2021). These algorithms traditionally learn from actual historic data that can include text, pictures, tables e.g. CSV files, and even voice and video data. (Jiménez-Ramírez et al, 2020). Coronaviruses are enveloped, non-negative single-stranded huge RNA viruses that contaminate human beings, but can also infect a wide spectrum of animals (Irinyi et al., 2015). Coronaviruses were first documented in 1966 by the scientists: Tyrell and Bynoe, who extracted and maintained the viruses from common-cold infected patients. Based on their morphology as spherical virions with a core shell and surface projections that were similar to a solar corona, they were dubbed coronaviruses. (Arunachalam et al., 2022). In December 2019, a huge number of pneumonia cases were reported in the Wuhan province of China. Many of these cases reported visiting seafood and live animal markets. Investigations found that the disease was caused by a new strain of the coronaviruses. The disease was subsequently named COVID-19. This virus later spread to China and other parts of the world (Morens et al., 2021). Coronaviruses are large groups of viruses and they consist of a core of genetic material enveloped by a liquid covered in protein spikes. This gives them an appearance of a crown. Crown in Latin is ‘Corona’. Hence the name, coronavirus

(Jeevanandam et al., 2020). These viruses can cause respiratory disorders ranging from the common cold to more severe viruses including SARS (first discovered in China in 2003), MERS (First discovered in Saudi Arabia in 2012) and SARS-COV2 (discovered in China in 2019) (Daniel and Bamidele, 2020). The disease spreads between humans when an infected person comes in contact with an uninfected person. It can also spread through droplets (Islam et al, 2020). COVID has different symptoms at different stages in the human body. The incubation stage of the virus (ranging from 5-6 days) include symptoms such as fever, fatigue, cough, and loss of smell or taste, sore throat (Mahase, 2021). There can also be more severe symptoms like pneumonia. However, some people may remain asymptomatic (show no symptoms of infection) (Petrosillo et al., 2020).

The most popular COVID test is Reverse Transcriptase-Polymerase Chain Reaction (PCR), this test identifies the virus via its genetic fingerprint (Iravani, 2020). Treatment for COVID is majorly based on supportive care. There is currently no cure for the virus. The preventive measures for the virus include Covering the mouth and nose while sneezing, washing hands regularly with soap and water, maintaining social distance and appropriate use of masks and hand gloves (Kaple et al., 2020). Contacting a medical personnel as soon as you experience symptoms guarantees the greatest chance of recovery from the virus (SeyedAlinaghi et al., 2020). The study will aid the enactment of lockdown and isolation rules. It will also reduce the impact of the virus in regional localities by determining the lockdown rules - if applicable - to be enacted. It will enable organizations to efficiently operate even with infected members of staff. Remote working has enabled many organizations to continue functioning with slight difficulty during the pandemic period (Khan et al., 2021). It will give a better understanding of the spread of the coronavirus. The knowledge of the pandemic is insubstantial. A better understanding of the nature of the virus and how it spreads from patient to patient will aid health workers in minimizing the transmission (Pedrosa et al., 2020). Patients who are currently in the incubation phase of the virus can receive immediate care for enhanced chances of recovery (Khan et al., 2021). A number of techniques have been put in place by respective governments, world organizations and private companies to counter the spread of the virus, however as humanity still has a lot to learn from COVID-19, many of these techniques are flawed. According to the World Health Organization, there is no cure for the disease (Chang and McAleer, 2020). High cost of manufacturing, distributing of testing kits, vaccines and preventive measures like hand sanitizers, face-masks etc. (Ige, 2020). The risk of infection and transmission of the disease is higher when individuals go to testing centers. The risk of uninfected patients contacting the disease is increased when they visit testing centers. The risk of spread on infected people to others is also increased when they journey out to get tested. An alternative to this is home/office delivered testing kits, but this is one of the most expensive means of getting tested (Chiang et al., 2021). The objectives of this study is to perform a critical analysis on existing systems for detecting the coronavirus in patients using only symptoms, design a system for predicting coronavirus test results and validate system performance and reliance.

Related Works

Table 1 shows the summary of related works considered in the

Table 1: Summary of Related Works

Title	Methodology	Results	Strengths	Limitations
Alsunaidi et al, (2021)	Placed sensors on certain areas of patient's body to gather information including: temperature, blood pressure etc. Made use of tools like MATLAB, MS Excel, Python & R to analyze the information acquired	They provided a taxonomy structure which grouped the possible applications of COVID-19 into four spheres: diagnosis, estimate or predict risk score, healthcare decision-making, and pharmaceutical.	Due to the increase in the volume of data over time as the pandemic continues to effect various countries over the world, the credibility of the author's work will continue to scale globally leading to a rise in the accuracy.	Confidentiality within patients with the virus lead to limited clinical data available depending on the category. The difficulties involved in sharing data with other researchers to enhance their work.
Mei et al, (2021)	Use of Chest CT Scan data and other clinical information from a survey to detect COVID-19	Comparison of accomplishments of diagnosing patients who are ill with the virus with normal CT scans yielded 13/25 for the CNN model, 16/25 for the MLP model and 16/25 for the Joint model	Test analysis for result prediction is 68% valid and this rapidly reduced the time taken averagely to detect COVID patients without AI	Detection of COVID in patients by the CNN model yielded only a 52% probability of success as from 25 patients, only 13 were detected
Abbasi et al, (2021)	Created a model based on Deep Learning Techniques and three separate machine learning-based classification procedures: classical Support Vector Machine (SVM), Random Forest (RF), and Gradient Boosting Machine (XGBoost)	Improved performance over already existing methods including methods proposed by Kang et al, where models were trained using handmade features and produced an accuracy of 86%	The proposed system is made easily available to the public through an open-cloud based webserver and open source code. The system detects not just the presence of COVID in a person but also determines the severity to determine counter measures	The proposed methodology using CT scans causes certain problems like inability of very symptomatic patients to hold breath CT scans can also lead to bone damage around the scanned area, this limits the number of scans the average human can run
Abdel-Basst et al, (2020)	The authors made use of the BWM (Best Worst Method) to assess a group of surrogate options with consideration to a group of decision parameters. The BWM is based off a systematic pairwise comparison of the decision criteria	The model can differentiate COVID-19 from four other viral chest diseases with 98% accuracy	Model requires primary symptoms for its training	Method of application and consensus findings are applicable to a certain geographic region, leading to possible inaccuracy of the model in other locations

Stojanovic et al, (2020)	The authors used symptoms (both primary and latter symptoms) of the virus. These symptoms were recorded using sensors placed on the patient's body. The information was used to train a model for prediction	The methodology gave ground to good and reliable outputs and can be enhanced to absorb the use of more sensors to diagnose other COVID-19 symptoms.	The paper presents a low cost and flexible design of a medical device for purposes of detecting and tracking symptoms of COVID_19. Requires only a simple configuration	The model requires extensive patient input to obtain data which the authors used for model training
Lan et al, (2020)	The authors performed a retrospective study of HCWs undergoing both COVID-19 telephonic symptom screening and nasopharyngeal SARS-CoV-2 assays during the period, March 9—April 15, 2020	Some of the strongest symptoms of COVID discovered in their research included: Fever, anosmia, and myalgia while no symptoms were only peculiar to nasal congestion/sore throat associated with negative cases	Screening of patients was conducted with phones over the internet, this ensured that patients could isolate while performing necessary tests	Accuracy of prediction compared to other researches which made use of CT scans or bodily sensors was much lower than using phone-based symptoms tests
Brown et al, (2020)	The authors gathered data from users via web apps and mobile apps and used convolutional neural networks (CNNs) to detect cough within ambient audio, and diagnose three potential illnesses (bronchitis, bronchiolitis and pertussis) based on their unique audio characteristics	The authors presented an ongoing effort to crowdsource respiratory sounds and study how such data may aid COVID-19 diagnosis	The mobile app built reminds users to provide samples every couple of days: as a consequence, the authors have a number of users for whom they could study the progression of respiratory sounds in the context of the disease. This is very relevant for COVID-19.	The authors have no ground truth regarding health status, and so took users from countries where COVID-19 was not prevalent at the time as likely to be truly healthy when self-reporting as such. shown a limited investigation of the difference between cough sounds in COVID-19 and asthma
Quiroz-Jua´rez et al, (2021)	Created machine learning algorithms that were trained using data obtained from the Mexican Government	Their technology enables rapid identification of high-risk patients. The authors also showed that the training of their neural networks can accomplish the highly non-trivial task of determining an optimal estimator to be used as part of the standard hypothesis testing method	The Accuracy, specificity, and sensitivity of their neural network reaches values up to 93.5%, 90.9%, and 96.1%, respectively	Estimators can only apply in an advanced clinical stages where the patients are already in need of specialized care

Research Methodology

A simple neural network consists of *n* number of inputs, only one neuron and one output, where *n* is the number of features available in the dataset. A feature in a dataset can simply be defined as a input variable or a column in the dataset. The features for our neural network are discussed in table X. The process of passing the data through the neural network is termed: *Forward Propagation* and the forward propagation carried out will be explained below: for every input, multiply the input value *Xi* with weights *Wi* and add all the values. Weights – represent the strength of the connection between neurons and determine how much influence the given input will have on the neuron's output. If the weight *W1* has a greater value than *W2*, then the input *X1* will have a greater influence on the output than *W2*.

$$\sum = (x_1 \times w_1) + (x_2 \times w_2) + \cdots +$$

(1)

The row vectors of the inputs and weights are $x = [x_1, x_2, \ldots, x_n]$ and $w = [w_1, w_2, \ldots, w_n]$ respectively and their dot product is given by

$$x.w = (x_1 \times w_1) + (x_2 \times w_2) + \cdots + (x_$$

(2)

Therefore, the summation is equal to the dot product of the vectors *x* and *w*

$$\sum = x.w$$

(3)

A bias *b* is added to the summation of multiplied figures and is termed *z*. Bias (also called the offset) is necessary in most of the cases, to move the entire activation function to the left or right to generate the desired output values

$$z = x.w + b$$

(4)

The value of *z* is passed to a non-linear activation function. Activation functions are used to bring a concept of non-linearity into the output of the neurons, without which the neural network will be simply a linear function. Moreover, they have a massive impact on the learning speed of the network. We shall use a popular function known as logistic function as out activation function

$$\hat{y} = \sigma(z) = \frac{1}{1 + e^{-z}}$$

(5)

In the above equation, the output of the neural network after the forward propagation is known as the predicted value *y*

Development Components

The following components & tools will be required for the system:

i. Datasets from the Israeli Ministry of Health containing data that will help identify whether a person is positive with the virus or not based on some predefined standard symptoms set by the WHO.

ii. ML5.JS: ML5 is a free to use machine learning package that was built on Tensorflow. ML5 runs in the browser on the frontend and can be used for Neural Networks for classification or regression tasks

iii. Python library: Since Python is the primary programming language for data science activities, it will be used to process the dataset obtained. Python contains several libraries that allow developers to work with large sets of data. Pandas is the most popular library for handling data. Pandas will be used to work with the data obtained, convert it to a JSON (Javascript Object Notation) format before it will be used in ML5

iv. JavaScript: The development of both the Frontend and Backend of the application will be done using JavaScript frameworks: React and NodeJS. React will be used to write JSX that will compile down to the

standard HTML, CSS and Vanilla JS for frontend UI development.

v. NodeJS which is simply JavaScript on a server (backend) will handle the API creation and will become the server which we will make requests to from the frontend

vi. MongoDB: MongoDB is the most popular database for NodeJS applications. Unlike SQL, MongoDB does not store data in tables and rows and columns. Instead, data is stored in JSON format which is a better structure for data that may contain undefined values. MongoDB provides a free hosting tier which will be used in the initial stages of the applications

vii. Github: All frontend and backend code will be stored on Github. The workflows for CI/CID (Continuous Integration/Continuous Deployment) will be instantiated from Github when we integrate with Azure Static hosting

viii. Microsoft Visual Studio Code: VS Code is an Integrated Development Environment that will be used to write locally sourced code during the staging phase.

Figure 1 describes what the typical architecture is. The datasets contain cleaned data on patients who recorded their symptoms Using the Python library in Jupyter Notebooks, Pandas, a Notebook will be created so we can convert out dataset files from CSV to JSON. We can then proceed with creating and training the model with ML5 on the browser. When the model has been built, NodeJS will be used to handle API calls as seen in Figure 2. All API requests handled by NodeJS will enable the storage of data in the popular database MongoDB. When API requests are made by the Node server, responses can be sent to the React frontend which will serve as the User Interface on the Client Side.

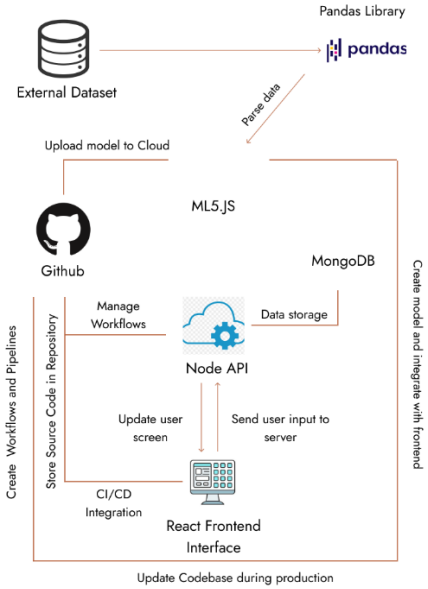

Figure 1: Architecture of the System

System Specifications

The system will be required to perform the following:

i. Display COVID-19 guidelines by the WHO: The WHO has laid out certain guidelines for the world concerning the pandemic. Some of these rules include: Keeping physical distance of at least 1m from others, avoiding crowds, wearing a properly fitted mask, Disinfecting hands and surfaces in your house and workplace with an alcohol-based sanitizer. The system must display these guidelines to users when the open the application even before they run a test.

ii. Determine the probability that a user is positive with COVID-19: This will be done by collecting data from the user including: Symptoms, Travel history, Medical history, Isolation & Social distancing patterns, Exercise and work routines, possibility that user has come in contact with an ill patient, geographic location, number of ill patients in geographic location,

pandemic severity in region, age group.

iii. Suggest responsive measures for users: The system should be able to suggest measures that users can take including: Finding available medical centers based on the users location, isolation and social distancing guidelines, alerting medical authorities depending on the users results from the model.

Development of the Model

The following steps will be taken in developing the prediction model

i. Data Collection: This is the first process in developing the model. The primary dataset used in the training of this Model was obtained from a publicly available dataset by the Ministry of Health in Israel. The data contains the records of more than 1 million patients who were tested for COVID-19. Many of the patients were symptomatic. While some of the patients, after testing were found to not havve the virus, their records were kept thus increasing the accuracy of the data for data scientists. The symptoms on which this data was based can be found on the official WHO website. The data consists of the cough, Age, Current Symptoms, gender, and result outcome.

ii. Preparation of Data/ Data Wrangling: The data format which is going to be used in creating the ML5 neural network is JSON (Javascript Object Notation) format. It will be converted from CSV (Comma Separated Values) to JSON first. The only required field for the training is the "data" which will be imported into the neural network.

iii. Choose the Model: Since the model will use Neural Network algorithm, the appropriate one will be selected, then the desired task which is classification will also be defined

iv. Train the Model: The model will be using the dataset obtained. It will recognize and deduce if a user could be positive with the virus using the variables listed in Table 1

v. Evaluation of the model & Tune Parameters

vi. Prediction and Inference

Build the Frontend Interface

The frontend development process is divided 4 into major modules (as shown in Figure 2):

i. The UI/UX design

ii. The Implementation of the Design

iii. Mobile-responsive view

iv. Testing the developed frontend

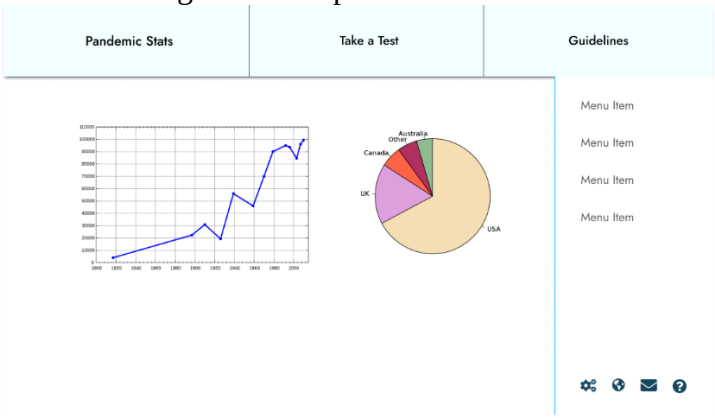

Figure 2: Sample prototype of the User Interface

The UI/UX design is typically performed after requirement gathering and analyzing. The requirement gathering stage is complete upon development of the model, so we proceed to the design of the interface. In this case, we will use Figma although there are numerous alternatives available including Illustrator, Framer etc. Next, we will implement the design in the popular frontend framework ReactJS. As is seen in the Architecture Diagram in Figure 1, React will serve as the interface the users will interact with. After the React implementation with

the aid of certain modules including: MUI and js-ccokie, we will design a mobile-first version of the frontend. As at November 2021, more than 46 percent of the total activities done on the web are done with mobile devices, compared to approximately 50.4 percent coming from desktops and PCs (Legan and Zupan, 2022). The final stage of the frontend development is the Evaluation and Testing. Testing will ensure that there are no glitches or bugs hidden in the interface and we need to the design to ensure that the constraints from the UI are applicable in the code. The frontend of the application should be complete.

Implementation

The research aims to show a documented diagnosis system for COVID-19 using neural network. Conducting this comprises of the following activities: recognizing the testing and training data, training the model, obtaining result and classifying outcomes. The dataset used were gotten from the Israeli Ministry of Health available on Kaggle (Kaggle dataset). Table 2 shows the crisps input features employed in the model.

The gender input accepts either "Male" or "Female" and transforms it into binary inputs: 0 or 1. If user is male, gender = 0, else if user is female, gender = 1. All inputs have to be converted to numerical values between -1 to 1. So values can range between -1, 0 and 1. 0 represents false, 1 represents true and -1 can be "mid" or "other". The model generates a single array of possible output for each classification: "negative", "positive", and "other". The array contains objects for each possible output listed above. The objects will also contain a "confidence" value. The total of all confidence values will equal to 1. This means that the output with the highest classification will be the classification decision. Figure 3 shows a sample output of the model. Figure 4 shows the output of the model on ML5. Upon testing the model trained with the top half of the dataset with the bottom half, we yielded a 94.5% model accuracy. Figure 5 shows the test page for the diagnosis system with the input process for diagnosis.

```
[
  {
    label: "negative",
    confidence: 0.9655,
  },
  {
    label: "positive",
    confidence: 0.0247,
  },
  {
    label: "other",
    confidence: 0.0098,
  },
];
```

Figure 3: Sample response returned by a classification

Table 2: Features available in the dataset

INPUT	VALUE	REMARK
Cough	1 or 0	Does user have cough: true or false
Fever	1 or 0	Does the user have a fever: true or false
Sore_Throat	1 or 0	Does the user have a sore throat: true or false
Head_Ache	1 or 0	Does the user have a head ache: true or false
Shortness_of_Breath	1 or 0	Does the user experience difficulty in breathing: true or false
Gender	1 or 0	What is the user's gender: Male or Female
age_60_and_above	1 or 0	Is the user above the age of 60 or not

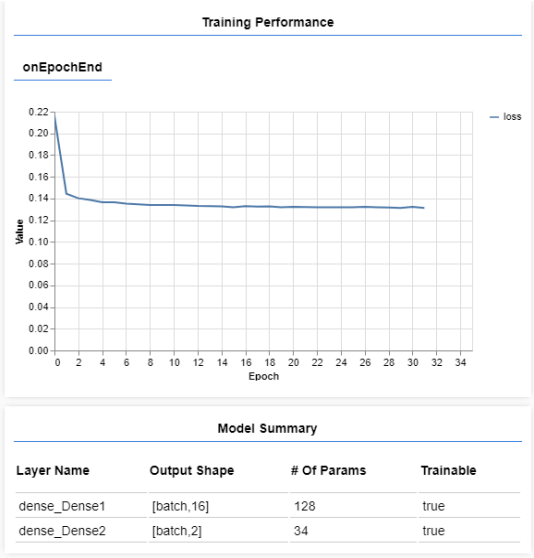

Figure 4: Visual feedback for model training using ML5.js

Conclusion

COVID-19 is a global disease that brought the world to a different way of living. This was as a result of the sporadic spread through personal contacts. This makes the need for diagnosis essential and doing so early crucial. Employing an efficient and accurate machine learning technique is essential. Neural network has been realized to be a robust and fault tolerant artificial intelligence model for prediction and diagnosis. In this research, we developed a diagnosis system for COVID-19 using neural network. Although the dataset used is linear in nature, it yielded a high accuracy of 96%. The neural network provide support for medical practitioners working on COVID-19 patients to help triage them faster for actual Reverse Transcription Polymerase Chain Reaction (RT-PCR) testing. This will reduce the strain of running numerous tests daily. The source code for the model will be made available freely online for individuals to tweak and understand. Scientists will be able to study COVID-19 related symptoms better and understand how each symptom affects patients' chances of being infected with the coronavirus. The challenge to accessing global data makes it essential to make COVID-19 related datasets available to data scientists across world. These datasets should be made public for anyone to access. Hospitals and other medical centers should adapt Artificial Intelligence in aiding the fight against COVID-19. We look forward to conducting a validation and evaluation of this model in future.

Figure 5a: Test screen for users

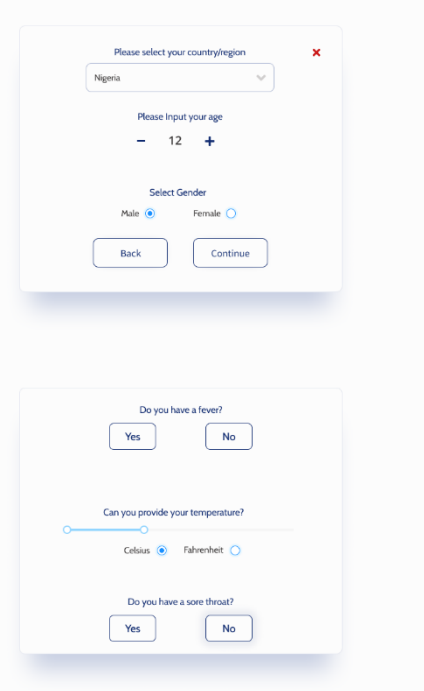

Figure 5b: Test screen for users

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