An IoT-based framework for early identification and monitoring of Covid-19 cases

PROJECT REPORT

Submitted in partial fulfilment for the Project – J Component

of

IOT DOMAIN ANALYST (ECE -3502)

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CERTIFICATE

This is to certify that the project work entitled " **An IoT-based framework for early identification and monitoring of Covid-19 cases" by Urvisha Shrivastava (18BEE0029), Advait Ravi Marathe (18BEE0164), Dhruv Chauhan(18BEE0354), Keval D.Rana (18BEE0368)** submitted to Vellore Institute of Technology University, Vellore, in partial fulfillment of the requirement for J component of the course titled **IOT DOMAIN ANALYST (ECE- 3502)** is a work carried out by us under my supervision. The project fulfills the requirement for J component as per the regulations of this Institute and in my opinion meets the necessary standards for submission.

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An IoT-based framework for early identification and monitoring of COVID-19 cases

Abstract -

CoVID-19 is a viral infection that transmits via droplets in the air. The infection has spread across 194 countries and seven seas. Apart from human beings, other animals have also been infected by the disease. The vaccines for the same are available now, but since the virus mutates rapidly, most of them are a sigh of temporary relief. So, when the vaccines and other medications provide a temporary solution, social distancing is the only way to escape from the infection. But, since the pandemic has widespread all over the world, proper tracking of CoVID patients is essential. In such a situation, IoT and ML can provide us with a better framework to effectively track infection spread. The advantage of ML and IoT is that it can help us to gather various parameters which contribute to the spread of infection. This paper proposes an interactive dashboard that predicts the severity of infection in a certain location based on parameters such as distance from the locality, number of active cases and number of deaths. This paper aims to develop a user-friendly dashboard that can be easily comprehended by all. Since the various mutations in the virus can be judged by the fatality rate and spread of the virus, this dashboard can also be used to track various other mutants. This dashboard can hence help in better treatment and thus achieving better control on the spread of infection. The dashboard can be implemented along with the existing framework or it can be deployed by using wearables to collect essential parameters of a person. The scope of the dashboard can be extended to other infectious diseases. Thus, this paper is a step forward in the battle against the pandemic and will certainly help in the future.

Keywords - CoVID, Internet of Things (IoT), Machine Learning (ML), Multiple Linear Regression, dashboard, ThingsBoard, score.

1. Introduction -

Coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus. Since its revelation in late December of 2019, there have been more than 161 million confirmed cases of COVID-19 reported in different countries, as of May 23, 2021. This novel coronavirus was described on March 11, 2020, as a pandemic by the World Health Organization. The only way the world can deal with this coronavirus is to get vaccinated as soon as possible and by following social distancing norms. Nonetheless, technology could likewise help moderate its spread, through early identification (or prediction) and checking of new cases. Technologies like big data, as well as cloud and fog computing, help us to trace new active cases.
This paper proposes a constant COVID-19 discovery and checking framework. The proposed framework would utilize an Internet of Things (IoT) structure to gather ongoing indication information from clients to early recognize suspected Covids cases, to screen the treatment reaction of the individuals who have effectively recuperated from the infection, and to comprehend the idea of the infection by gathering and dissecting important information. This paper proposes a COVID-19 identification and checking framework that would gather ongoing indication information from wearable sensor innovations. To rapidly distinguish potential CoVID cases from this ongoing information, this paper proposes the utilization of a few AI calculations. This discovery and observing framework could be carried out with an IoT framework that would screen the two possibilities and affirmed cases, just as the treatment reactions of patients who recuperate from the infection.

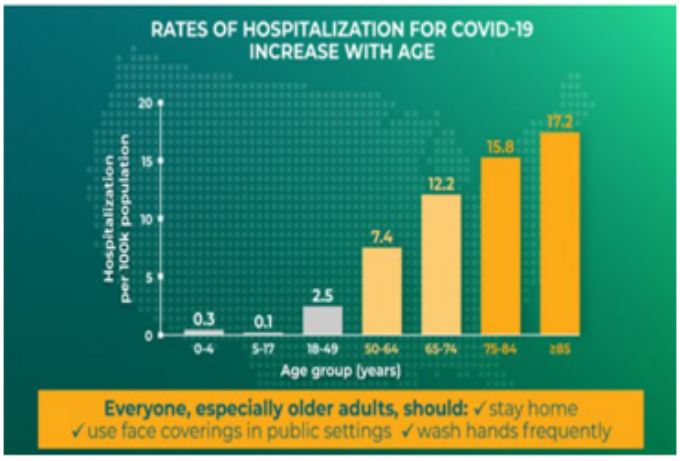


Fig.Rates of Hospitalization for Covid-19 Increase with Age [1]

This paper proposes a real-time COVID-19 detection and monitoring system. The proposed system would employ an internet of things(IoT) framework to collect real-time symptom data from users to early identification of suspected coronavirus cases and understand the virus's nature by collecting and analyzing relevant data. This framework aims to reduce the mortality rates through early detection, following up on recovered cases, and a better understanding of the disease.
This paper is working on a pre-processed dataset to build a predictive model for our identification system. The function of this model is to estimate the likelihood that a given person is infected by COVID-19. Several learning algorithms could have been used for this purpose. These classifiers can be categorized into multiple categories. Weka software categorizes the classifiers into six categories.

[1]- Function-Based Classifiers
[2]-Lazy Classifiers, such as K-nearest neighbours
[3]-Bayes Based Classifiers
[4]-Rule-Based Classifiers, such as Decision Tables
[5]-Tree-Based Classifiers such as Decision Stump
[6]-Meta Classifiers

The system likewise imparts these outcomes to medical care doctors. Utilizing the proposed. the continuous system might diminish the effect of transmittable infections, just as death rates through early recognition of cases. This structure would likewise give the capacity to circle back to recuperated cases, and a superior comprehension of the illness. Early location will assist us with giving plasma treatment to recently identified crown cases.

The proposed system comprises of five fundamental segments: (1) continuous manifestation information assortment (utilizing wearable gadgets), (2) treatment and results from records from isolation/Quarantine centres, (3) an information examination focus that utilizations AI calculations, (4) medical care doctors, and (5) a cloud infrastructure. The point of this system is to lessen death rates through early location, circling back to recuperated cases, and a superior comprehension of the disease.

2. Background -

IoT(Internet of Things) is a network of things that can be embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the Internet. The scope of IoT is not limited to just connecting things (devices, applications, machines) to the internet. IoT allows these things to communicate and exchange data while executing applications that work towards a common goal.

Fig. Things, people and cloud services getting connected
via the Internet to enable new use cases and business models
Source: NASSCOM

IoT has become a very important and extensively used part of our lives. Security cameras, sensors, vehicles, buildings, software, smartphones, home automation systems, GPS systems in cars, etc. are examples where IoT is implemented, data is shared among things and analysed, processed over the Internet. IoT has a wide application in our day-to-day life, apart from this several Industries leverage IoT to make work easier and save time as well. A few of them are-Automobile industry, Manufacturing, Agriculture/AgroTech, Hospitality, Retail, Finance, Transportation, Energy & Utilities industry, Smart homes & buildings, Healthcare.

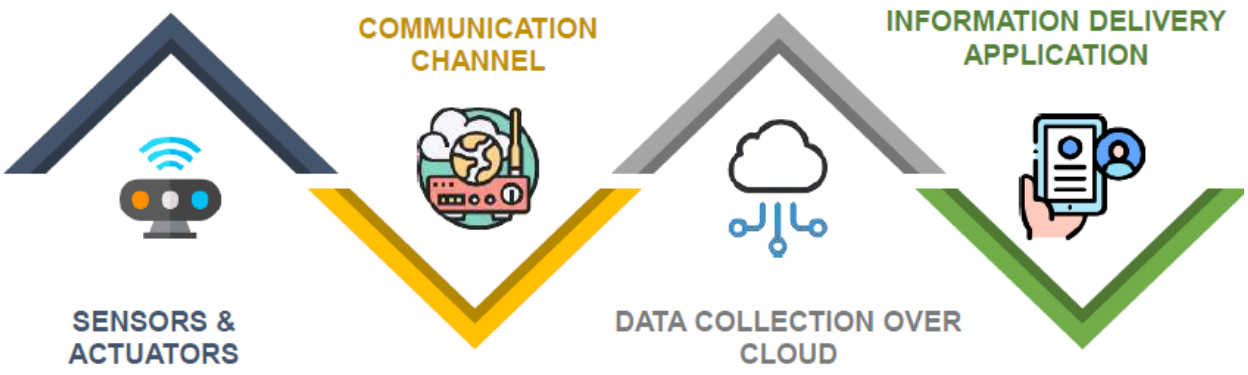


Fig. Physical object + Controller/ Sensor/ Actuator + Internet = IoT
Source: NASSCOM

IoT has revolutionised our lives. According to reports submitted by P&S Market Research, there will be a compound annual growth rate (CAGR) of 37.6 per cent in the healthcare Internet of Things (IoT) industry between 2015 and 2020. If one thing is certain, IoT has transformed healthcare in a variety of ways over the past several years and will continue to do so for years to come. [2]

Some of the applications are - Implantable Glucose Monitoring Systems, Activity Trackers, During Cancer Treatment, Heart Monitors with Reporting, Medical Alert Systems, Ingestible Sensors, Medication Dispensers, Wireless Sensors, Trackable Inhalers, Wearables to Fight Depression, Connected Contact Lenses, Location Services, Remote Monitoring etc. It has also been of help to tackle the pandemic of COVID-19 combined with Artificial Intelligence(Machine Learning).

According to Wikipedia “ Machine learning (ML) is the study of computer algorithms that improve automatically through experience and by the use of data. It is seen as a part of artificial intelligence. Machine learning algorithms build a model based on sample data, known as "training data" to make predictions or decisions without being explicitly programmed to do so. Machine learning algorithms are used in a wide variety of applications, such as in medicine, email filtering, and computer vision, where it is difficult or unfeasible to develop conventional algorithms to perform the needed tasks.”

Machine Learning combined with IoT increases their advantage by many folds. Together they can be used to improve lives in many ways.

According to a study, there will be more than 55 billion IoT devices by 2025, up from about 9 billion in 2017. Machine learning for predictive capabilities is now integrated with most industrial_IoT platforms, such as Microsoft Azure IoT, Amazon AWS IoT or Google Cloud IoT Edge.[3]

Machine learning for IoT can be used to process the huge volume of data generated by IoT sensors and project future trends, detect anomalies, and augment intelligence by ingesting image, video and audio.AI for IoT can be extended in the domains in which IoT is already employed such as in Businesses, User Experience, Smart Homes, Voice-enabled Services, Better Economic Management, Education Sector, Legal Firms, Healthcare, Transportation etc.

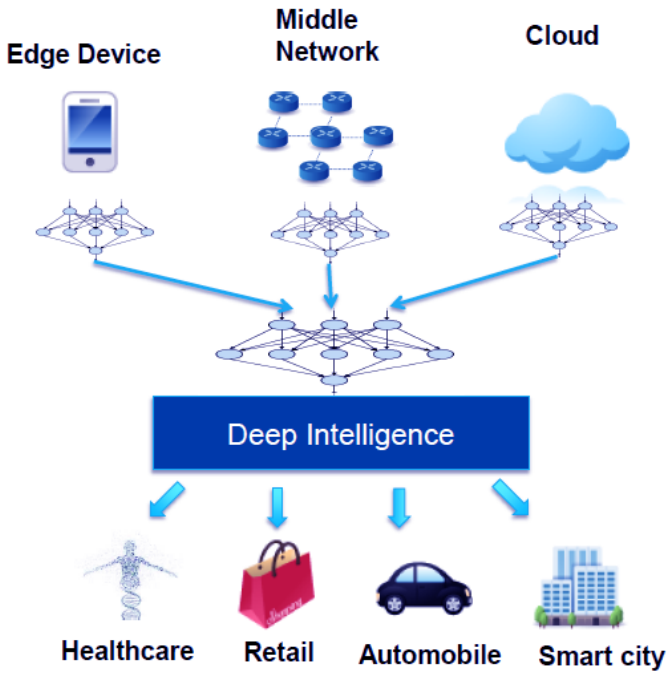


Fig. IoT with Artificial Intelligence [4]

During the recent global urgency, scientists, clinicians, and healthcare experts around the globe keep on searching for a new technology to support in tackling the Covid-19 pandemic. The evidence of Machine Learning (ML) and Artificial Intelligence (AI) application on the previous epidemic encourage researchers by giving a new angle to fight against the novel Coronavirus outbreak [5]. Machine Learning and IoT are dynamically evolving fields. There has been a boom in these technologies and a wide acceptance by several sectors to make life and work simpler.

3. Proposed Methodology -

In this paper, the aim is to develop an interactive dashboard model which helps in slowing down CoVID transmission. The model returns a score which is a parameter that depicts the severity of the infection in a certain locality. The score is calculated based on the parameters such as the distance from a certain locality, the number of active cases and the number of deaths in a certain locality. Now, since the figures for an exact location cannot be obtained, the model considers the parameters in a radius of 2.5 units.

The score of the severity is calculated by the means of multiple linear regression. The weights of various parameters are fixed based on their significance in the spread of infection. Let us look into the basics of linear regression.

I Linear Regression -

The regression problem deals with predicting the outcomes based on establishing a relation between the various input variables. The relation between the variables can be linear or non-linear. However, in the linear regression model, we consider that there exists a linear relationship between the variables. The equation governing a linear regression model is given as -

$$y = \beta x + c \rightarrow ①$$

Here, y is the output variable (aka dependent variable),
x is the independent variable based on which the output is predicted.
β is the slope of line
c is the intercept of the line

Based on the number of independent variables, the linear regression can be further classified into simple and multiple and linear regression.

II Multiple Linear Regression -

Multiple linear regression is a type of linear regression model where the output (dependent variable) is predicted based on multiple variables. The expression governing the same is given as -

$$y = BX + c \rightarrow ②$$

Here, B is the matrix of weights of various dependent variables
X is the matrix of independent variables.
c is the bias or common arithmetic error in prediction.

Let there be n independent variables -

$$B = \begin{bmatrix} b_1 & b_2 & b_3 & \dots & b_n \end{bmatrix}_{n \times 1} \qquad X = \begin{bmatrix} x_1 & x_2 & x_3 & \dots & x_n \end{bmatrix}^T_{1 \times n} \qquad \rightarrow ③$$

The weights of various independent variables can be altered according to their significance in determining the output.

III Deploying linear regression model -

There are various steps involved in deploying a linear regression model. The data needs to be scale according to the requirement of the desired output. The data needs to be split into training and testing dataset. Then, the model is trained according to the dataset available. The performance of the model is judged based on the various scores such as R - squared error, mean squared error and mean absolute error.

The flowchart summarising the workflow in deploying the linear regression model is given -

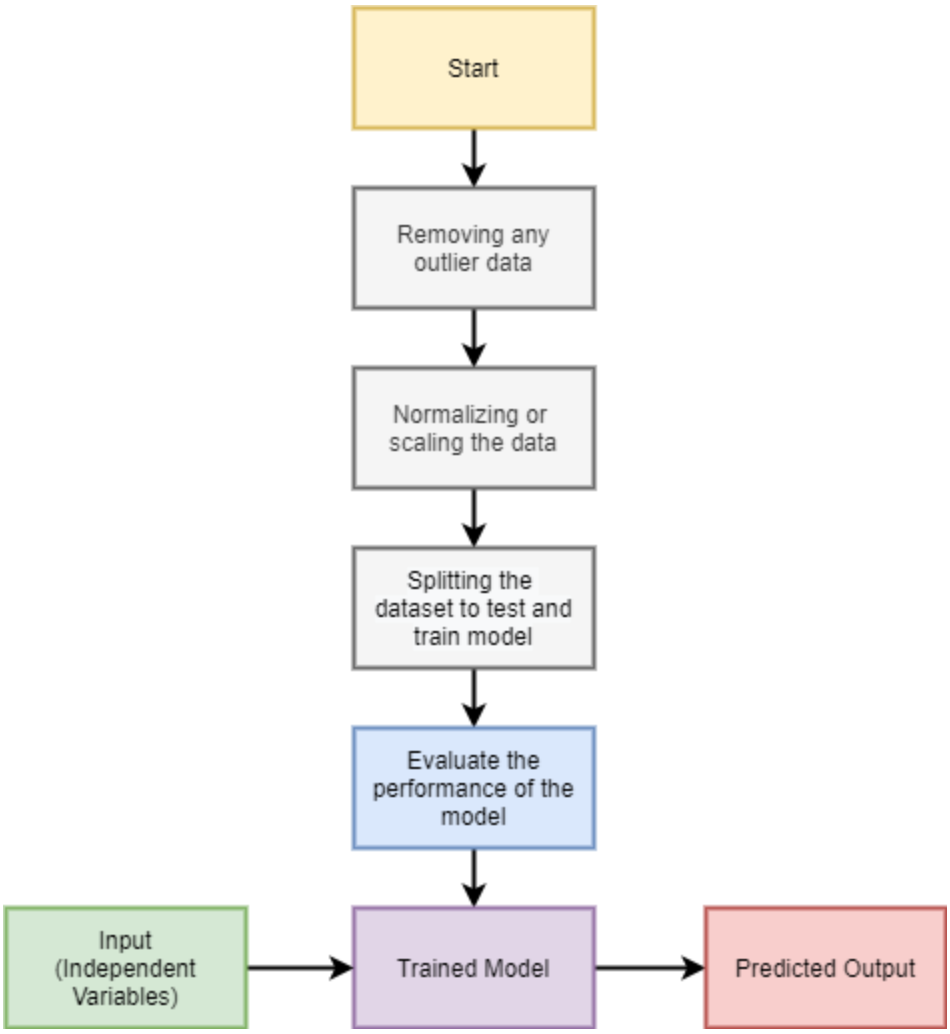


Fig. The steps involved in a linear regression model

But since our model doesn't take any readily available dataset, we just normalise or scale data for our desired output. Also, since there is no readily available dataset the model performance cannot be predicted.

4. Experiment and Results -

The model was deployed using Python and the interactive dashboard was deployed using ThingsBoard. The coordinates of the location, coordinates of the person, number of active cases in the location and the number of deaths in the location is generated via the script.

I Algorithm -

The score is calculated as follows -

$$score = 20 + 4.24264 \times (3.53553 - distance) + 0.01677 \times active\ cases + 0.77778 \times d$$

The constant non-zero constant of 20 is employed so that the person always wears the mask. The second term depicts that the lesser the distance more will be the score. The logic behind the expression is explained further.

The script generates the maximum difference between coordinates of the location and the patient as 2.5 units. Thus, the maximum value of distance can be 3.53553 units. The term $(3.53553 - distance)$ depicts the proximity of the patient from the location. Thus, the lesser the distance more will be the score. The maximum value of the term $(3.53553 - distance)$ is 3.53553 units. The weightage of 15% is given to proximity. So to upscale the term, it is multiplied by 4.24264, as $4.24264 \times 3.53553 = 15$ giving the maximum of 15 points.

Furthermore, the script generates the maximum number of active cases as 1800 and the number of deaths as 2.5% of active cases, considering 2.5% as the fatality rate, thus making the maximum deaths as 45. The weightage of 30% and 35% is given to the active cases and the deaths in the location respectively. Thus, to downscale the values 1800 and 45 to 30 and 35, the terms “active cases” and “deaths” were multiplied by 0.01677 and 0.77778 respectively.

II Dashboard Implementation -

The dashboard was implemented using the ThingsBoard platform. ThingsBoard is an open-source platform that allows designing interactive dashboards which are user-friendly and thus completely satisfies the objective of this paper. The major advantage of the same is that it allows customising dashboards not only on the computer but on mobile devices as well. The size of the dashboard, i.e width and height, can be defined by the designer. The dashboard setup is quite simple. It righteously displays the location of suspected individuals along with the CoVID risk score on the map. It plots the score of suspected individuals and displays the same in a tabular form. Whenever the score is above a certain threshold level, it shows the entry on the map in the colour red. This threshold can be integrated with an android application to send an alert whenever the risk is grave.

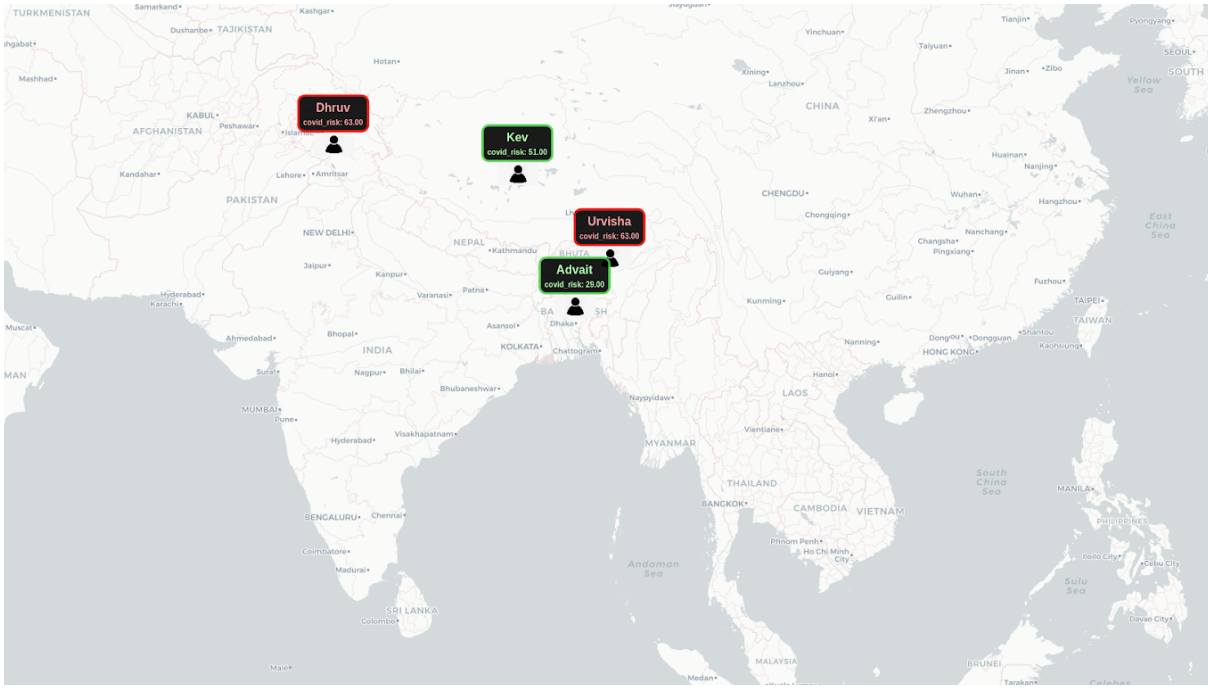


Fig. Dashboard Map Visualization.

Covid suspects	covid_score	location_details	time_hrs
Advait	54	Kavaratti	11
Dhruv	43	Gadus	11
Kev	50	Digha	11
Urvisha	88	Port Blair	11

Fig. CoVID Risk Score Visualization

5. Future Scope -

The paper proposes a unique take on tackling the pandemic. Such type of interactive dashboards can help us to maintain proper social distancing in the localities which are worst hit. The scope of the project can be extended to other communicable diseases, for example tackling Ebola outbreaks in the African continent. The future goal of the project is the hardware implementation of the project with real-time data and using relevant sensors. The score generated by the application can be modified according to the number of vaccine doses administered in a locality as the risk is lesser as more people get vaccinated. The same can be extended for people with any previous comorbidities, which make them more prone to infection.

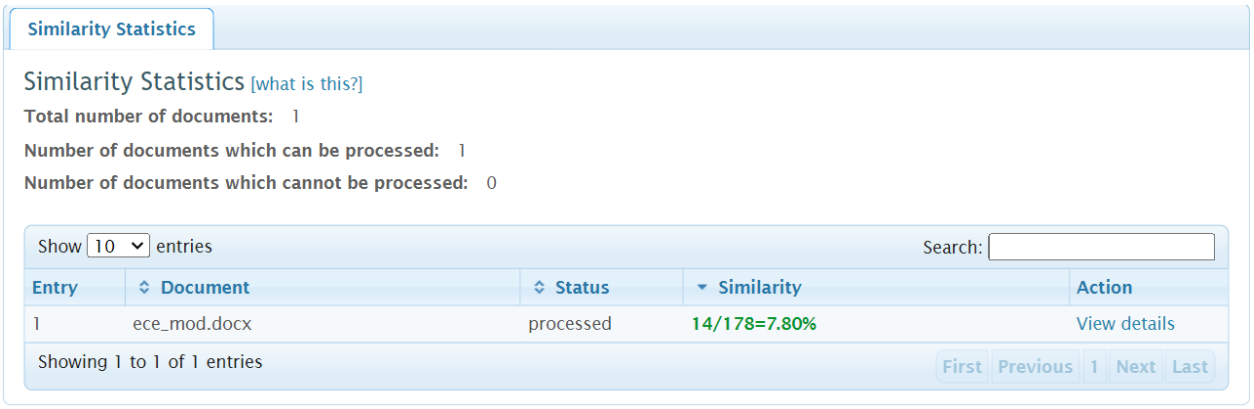
All the sensors can be embedded in form of wearable equipment. The dashboard can be integrated into an android application. This android application will intimate users about the dangers of not following proper social distancing measures. This app can also send alerts whenever the vulnerability score of a certain threshold limit is crossed. The app can also provide rewards for people, who follow proper guidelines issued by the government. All these can be developed by constructing a framework from scratch or the dashboard can be integrated into any readily available dataset on the cloud

database. In conclusion, the functioning will be similar to that of readily available Aarogya Setu ®, but the paper aims to develop a more accurate and user-friendly interface.

6. Conclusion -

In the current situation, a dire need for proper social distancing norms is identified. With new developments happening in the medical world, such type of framework can help us to effectively track the infection severity and spread in a locality. The rewards are given by the app, which motivates users of the app to follow proper norms in this pandemic situation.

Wearable technology has exponentially grown over the past few years. This technology helps to gather an iota amount of quality and accurate data. The integration of wearable tech in the project ensures proper monitoring of a person. All these data can be integrated into a gigantic database which can help to provide appropriate treatment to an individual. Such technology is boon to people with comorbidities as it can alert other members of the family whenever a person faces any medical emergency.



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