A SURVEY ON DIAGNOSIS, MONITORING AND PREDICTION OF COVID-19

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Abstract—Coronavirus has turned out to be deadlier than anyone expected. Though the real solution is the successful implementation of vaccines and that might take time, therefore, the application of technology to handle the whole process from early identification, tracking the ones affected, predictions and monitoring of new cases to reduction of human interaction comes into picture. Nowadays, infrared thermometers are being used to check the body temperature in places where there are a large number of people. But this method is not really effective and it might cause the spread of the coronavirus from the infectious people to the person who does the screening process. So in order to avoid this, a reliable method is required. A quick and an identifiable proof of detecting infections plays an essential part in granting the necessary treatments, maintaining people's lives and avoiding rapid spread. The followed up papers signifies the use of the Internet of things (IOT), wearables, Machine Learning models and AI for detection and diagnosis of COVID-19.

Keywords—Internet of things, AI, Machine Learning Infrared, Thermometers, Covid-19, Diagnosis, drones, smart helmets.

Introduction—Internet of Things is a field enjoying much success in recent years. What started as a smart device being used to dispense Coca-Cola drinks has now transformed into a huge bustling research area with a big spotlight. The fact that IOT enables devices to form a network and employ transmission if data over to various devices without the need of a human overseeing body has been a huge benefit to the many widely disparate areas. IOT has become especially important in both academic and industrial environments and this relevance has penetrated the healthcare industry as well. IOT is

Being employed as a solution to problems ranging from healthcare monitoring to symptom and disease prediction models. Perhaps the most obvious example of an IOT smart device is an Apple Watch. The fact that the newest Apple watch highlights the usage of its ECG and blood oxygen sensor is enough to show how important smart devices are in this field.

Moreover in the current pandemic crisis, the importance of an IOT based system for use in different facets of COVID-19 control is a very essential aspect for development. This is not only because of the current difficulties but also because creating and enabling a robust system now will invariably be beneficial for combat against any future maladies. In a future where everything will possibly be linked to one another and where the world population might reach new heights, the need for a framework for predicting, detecting and containing the growth of a disease using available smart IOT devices is a necessity. Companies such as Google and Apple have already used Bluetooth based techniques to enable exposure warnings. Countries such as India have deployed mobile apps like Aarogya Setu to combat the growing cases but work still needs to be done. IOT should be further utilized to create systems for remote monitoring of patients especially in developing countries that are overflowing with a flux of patients due to a lack of knowledge and awareness about the disease. Having remotely accessible patient data can help enable an overburdened hospital staff to perhaps collaborate with more doctors across regions and distribute load. All this can happen while reducing expenses and increasing the quality of service to a patient.

Our goal through this research paper is to evaluate IOT based frameworks and architectures in three different processes. We review platforms and survey researches that are working on machine learning based prediction models, COVID-19 detection systems and monitoring based applications. Through studying these areas, we aim to enable future researchers in creating a generic disease control framework that can take up all the computational power and smart devices accessible to us and propose a possible methodology that can be implemented by different national health teams in decreasing any loss of life and property. Perhaps systems such as the Internet of Medical Things (IOMT) can be revised and refined to generate even more robust creations.

I. DIAGNOSIS MODELS

A. Drone based COVID-19 Detection

This paper uses IOT based drone technology to detect coronavirus with minimal human interaction from the obtained thermal images. The design also has the capability to use virtual reality, therefore live scanning by video processing would be monitored through virtual reality screens. This system covers large areas and gain more data. The system is interfaced with GSM and IOT based technologies. The system sends an independent emergency call to the base if the temperature of an individual is found to be on the higher side of the typical range. Then, it tags the position coordinated by a GPS module and sends the informed data to a previously assigned android App through a GSM. This system comprises 3 main parts. 1) Mechanism of input source 2) Processor development 3) Mechanism of output source

The microcontroller processor is integrated by Arduino IDE to code the source code. The output source consists of the integration of the mechanical segments. The UAV has 2 types of cameras- optical camera and thermal camera for recognizing the face and capturing the temperature. If the temperature of the body is found to be high, it then produces high intensity levels of the infrared spectra. The cameras will be operated by virtual reality, combining with IOT and drone. Virtual reality is being used along with live video to control the camera in order to scan people. The drone after arriving at a location will record body temperature of the people. The cameras will transmit the live video monitoring to the smartphone. The live video is connected with an application on smartphone so the user is able to receive a continuous live scanning from the entire flight by the drone. It will also create realistic search operations during the flight but less interaction with people. The Arduino IDE includes a code editor with several features such as matching of brace, syntax highlighting, and auto indentation. It also gives the basic mechanism of one-click for compiling and uploading various programs into an Arduino board. The Arduino IDE delivers a Wiring which is a software library by exploiting the wiring project, which gives numerous well known input and output approaches. In addition, Proteus software includes schematic, simulation and circuit design. It is mainly used for drawing several schematics and performing real time circuit simulation that empowers humans to get access during the running phase, and thus creating real-time simulation.

B. Smart Helmet based COVID-19 Detection

This study aims to have a design by virtue of which detection of coronavirus is possible using thermal images with minimal human interactions using smart helmets with Mounted Thermal Imaging System. The thermal camera system is integrated with the smart helmet and is used by combining it with IOT technology for enhanced screening of the real time data.

There are 3 subsystems which are inter related to perform the entire operation. The smart helmet is required for data collection. The IOT communication link and the GSM are interlinked. The system sends an independent emergency call to the base if the temperature of an individual is found to be on the higher side of the typical range. The first subsystem consists of the input source i.e. thermal camera, optical camera and the mobile phone application. In the second subsystem, the microcontroller processor is integrated using Arduino IDE software to source the source code. The third subsystem deals with the output source for the mechanism. The smart helmet is equipped with 2 different types of cameras- Optical camera and infrared thermal camera. Thermal cameras use infrared radiation to create images similarly to traditional cameras that utilize visible light to produce images. If the temperature of the body is found to be high, it then produces high intensity levels of the infrared spectra. This system is simpler than the IOT based drone technology and works on similar principles. The face detection process is done by EMGU CV cross platform. Cascade classification algorithm is used for face detection which is based on hair features. The open CV library already has the Cascade object detection that recognizes the face of the captured image. Common features are extracted from the human face to make a standardized size rectangle to enable image processing algorithms to grayscale image and histogram equalizations. After getting information from the recognized face, body temperature and GPS position is delivered by Arduino. The microcontroller transfers the value over the web for getting access to this information. An exterior server is utilized for this purpose. When the thermal camera detects a high temperature body, the system notifies the authorities to alert them about the threat. At the same time the system will take a picture and send it to the health officer.

C. Medical Consensus on IoT based COVID-19 models

The paper aims to diagnose covid-19 and tries to improve the treatment by applying medical technology, with the help of intelligent assistant program based on the Internet of Things, particularly called MOIT (medical IOT). This system performs different functions for diagnosis and treatment of coronavirus based on the Internet of Things.

Functions	Significance
Online monitoring	For online monitoring, guiding graded diagnosis
Location tracking	To locate COVID-19 patients which can lead to guided treatment whenever problems occur
Alarm linkage	Gives and alarm whenever a COVID-19 patient is nearby
Command and control	Helps in the diagnosis and consultation of patients.
Plan management	Timely treatment of suspected and confirmed cases in a graded manner.
Security privacy	Deals with data privacy and other cyber-attacks.
Remote maintenance	Possible when the patient is regularly monitored via the app.
Online upgrade	Can be improved with new features to accommodate new changes to the treatment mechanism.
Command management	Help the doctors to investigate based on the large amount of data available.
Statistical decision	Can help data science and machine learning to reach to a better diagnosis criteria based on the statistical data available.

For comprehensive perception leading to reliable transmission which ultimately leads to intelligent processing, the IOT technology assists the GPU to manage the system assisted three-level linked cloud plus terminal platform. For deep mining and intelligence, 15 questions are required to answer by the users in order to track the present conditions. A similar app is also designed by the Indian government to track covid-19 called 'Aarogya Setu'. This technology also takes in account the travel history of the users and by using GPS, it also points out how many suspected persons one has met. Based on the questionnaire and the travel history and other factors, the diagnosis is estimated by physicians who use the data transmitted on their smartphones to automatically respond to the prompts generated to assist patients in their diagnosis and treatment, while ensuring safety and effectiveness. Apart from that, this system collects a large amount of data which can further be engineered for intelligent use by machine learning algorithms and statistical methods. The data can also be collected and analyzed to bring about a robust distinction between suspected and confirmed cases in patients.

D. Use of wearables in COVID-19 detection

This paper lays emphasis on Telehealth and Telemedicine technology along with wearables in tackling the coronavirus issue. The wearables include devices for respiratory assessment which track oxygen saturation i.e. how much oxygen is pushed from air into the bloodstream. The most commonly used device is an oximeter. Respiratory rates and lung sounds are also checked. Acoustic transmission of frequencies changes in the thoracic cavity. Other types of monitoring include cardiovascular and clinical symptom monitoring. The electrocardiogram records the rhythm and activity of the heart of covid patients. Blood pressure is also measured incessantly. Clinical symptoms include temperature and cough monitoring. Wearable devices provide continuous recording of status by attaching a sensor or device to the body, whereas unobtrusive sensing could provide home monitoring or in public spaces. The advantages include pervasive monitoring at home as well as a noncontact way to measure vital signs in public places and monitor mobile passengers unobtrusively while eliminating contact. Telemedicine when combined with wearables and augmented by IOT can bring about a paradigm shift in the way we manage healthcare, especially in the corona days.

Mobile Health Monitoring- wearables connected to mobile phones can send the data to the cloud server, where it is processed by big data analytics and useful information is extracted. Contact tracing technology by using GPS can help bend the curve in our favor.

Telemedicine means using telecommunication to manage patients. It means reduced exposure and similar services as offline. Tele imaging is used to monitor internal organs which can be damaged by covid 19. X Rays, MRIs can be performed at a local healthcare or even at home and the data can be sent to a cloud server where it can be checked by AI or a doctor to provide further actions to be taken. Tele ICU can be beneficial where there is a huge increase in cases and shortage of beds. Finally, Tele rehabilitation is also necessary to check if the recovered patient is getting better day by day and every organ is working fine. Tele robotics is still far away from wholesale implementation, but a full-fledged research is going on in this particular field. The need of the hour is to integrate all these devices, so that common, robust and wholesome facilities are available at a single place, while also checking for data privacy and other ethical issues.

E. ML based CT classification

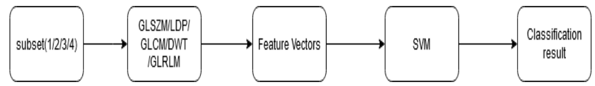
This paper deals with the detection process based on abdominal Computed Tomography (CT) images. The radiologists have detected that the CT images derived from a COVID 19. The expert radiologists detected from CT images that COVID-19 shows certain different behavior from other viruses. 4 different datasets were created by taking patches for detection of the COVID-19 by taking patches of size 16x16, 32x32, 48x48, 64x64 from 150 CT images. Different algorithms are used for extraction methods. Support Vector Machines (SVM) are used to classify the extracted features. For this classification, 2-fold, 5-fold and 10-fold cross-validations are used. Different parameters like sensitivity, specificity, accuracy, precision, and F-score metrics are used for evaluation of the performance. The development of computer vision systems has boosted the medical applications, for e.g. increasing the image quality, organ texture classification etc.

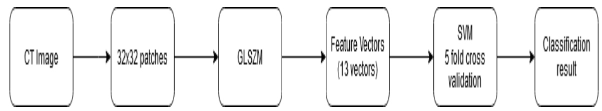
This system classifies the coronavirus in two stages. 1st stage- the process is run on four different subsets with no feature extraction process. Then the subsets are converted into vectors and then further classified by the support vector machine**.** 2nd stage- five different algorithms such as Grey Level Co-occurrence Matrix (GLCM), Local Directional Patterns (LDP) (10), Grey Level Run Length Matrix (GLRLM), Grey Level Size Zone Matrix (GLSZM), and Discrete Wavelet Transform (DWT) is used for feature extraction and classified by support vector machines, because the SVM is a strong binary classifier. SVM gives high classification accuracy. The classification is based on 2 ideas.

1) A nonlinear method is used to map feature vectors to a high dimensional space and use linear classifiers in this new space.

2) Then the data is separated with a high margin hyperplane. The cost parameter of this algo (SVM) is served as 1, the default value of this algo for classification functions.

For comparisons, different metrics are used namely sensitivity, specificity, accuracy, precision, and F-score. Based on the results, 32x32 patches, GLSZM, feature vectors, SVM (5 fold) has the best classification accuracy of 90%.





II. MONITORING MODELS

A. Robust IoT framework for COVID-19 monitoring

The paper proposes a framework for early identification of an IOT based system. The authors start with a basic overview of the extent of the COVID-19 virus at the time while giving relevant statistics about how dangerous and infectious it is by outlining the mortality and increase rate. The authors go on to justify the role of their study by writing that as the nature of the COVID-19 virus has not been sufficiently characterized, it has to be dealt with by an architecture to slow the spread while increasing attention on the creation of a suitable vaccine. The paper thus proposes a detection and monitoring system that will be able to collect real time data from different IOT based smart wearables. They propose the usage of 8 basic machine learning algorithms ranging from SVM to KNN and Naive Bayes while creating a framework consisting of 5 basic components. These are:-

1. A real time data collection architecture
2. Database creation for storage of treatment records and other relevant information
3. An analysis center where the 8 ML techniques can be utilized to effectively achieve the goal
4. A network of trained physicians on call for helping with the patients
5. A cloud infrastructure

While explaining the IOT methods, the paper highlights the limited computational capacity and the limited battery of an IOT node and also justifies the need for a network layer that can support scalability while providing a sense of security and privacy. While proposing a wide band of applications for this framework, the authors also shed light upon the sensitive issue of balancing data security and patient safety while creating an IOMT based system.

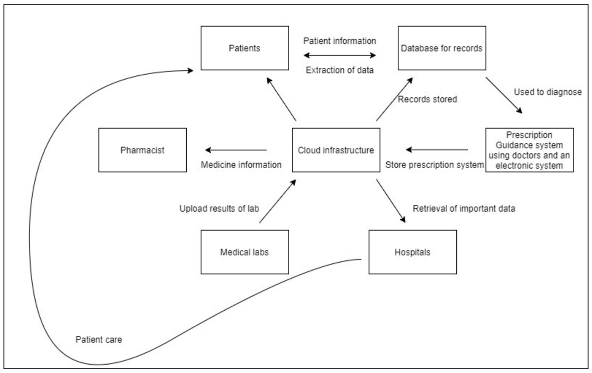
For a data collection architecture, the identification of symptoms for a disease is of the utmost importance. For COVID-19, 5 major symptoms are identified that can be easily measured using basic designed sensors. These are Fever, Cough, Fatigue, Sore Throat and Breath Shortness. Fever can be easily checked via temperature sensors, cough via audio based sensors, fatigue through motion and heart rate devices, soreness of throat using medical imaging and shortness of breath using oxygen sensors. Furthermore, the cloud infrastructure needs to be interconnected with the internet and should allow health updates and maintain health records while being able to communicate prediction results.

In the next section of the paper, the research is focused on the ML algorithms being used at the data analysis center and a detailed comparison is brought out between the 8 models when used on the CORD-19 dataset. While the paper does not suggest any preprocessing methods, it simply refers to older works done and concludes that out of a possible 80 major symptoms of the disease, there are only around 20 that are fundamentally different and based on parameter such as spectral score and interquartile range these are reduced to the 5 mentioned in the IOT sensor overview: fever, cough, sore-throat, fatigue and breath shortness. The author then gives a brief overview about how each of the 8 ml algorithms perform. The 8 algorithms are SVM, ANN, Naive Bayes, KNN, Decision stump, Decision table, OneR, ZeroR. Based on their respective confusion matrix, a reader can infer that neural networks are the best performer followed by decision table then naive bayes followed by KNN and SVm which give comparable results. Decision stump follows next and after that are OneR and ZeroR algorithms which give quite a weak performance on the dataset. Their ROC curves are also drawn for reference. This paper was one of the earliest papers submitted after the pandemic hit and lockdown ensued. The paper provides great insight for researchers in layman terms but however is not very detailed and concrete in terms of what the algorithms implemented in a Centre should actually look like.

B. Cloud based IoT framework for COVID monitoring

This paper, while not specific to the COVID-19 epidemic, still provides an extremely compelling framework for a IOT based healthcare system, one that can be extrapolated for our benefit. The paper gives an overview similar to PAPER A about the challenges being faced by the current healthcare system. It further goes on to justify why IOT is compatible with the healthcare infrastructure and how it can improve our system for the better. The author highlights the IOT's benefits in D2M, O2O, P2D, P2M, D2M, S2M, M2H and T2R interactions. The paper further gives a well-defined background about recently developed technologies that can be efficiently used such as Wireless Body Area Sensor Networks (WBASN), Microsoft's webpage that uses Google's personal health record database and AT&T Medical imaging and information Management Solution. It also gives a case study of Newhall Hospital in California that has recently implemented wide spread IOT technologies and created an intelli-system that centralizes patient data and allows more patient doctor interaction. These changes were well received and beneficial results of the program such as availability of new previously unrecorded data and efficient working of the new system compared to the previous cumbersome architecture were highlighted.

The paper then proposes a cloud based IOT healthcare system naming it Cloud-IOT. After the identification of various stakeholders present in the healthcare scenario, the author goes on to list what the proposed model would benefit each one of them by providing numerous application potentials. An example of a patient wearing a smart sensor has been given to elaborate the construction and working of the above Cloud-IOT model. The author proposes the creation of a WBASN by placing wireless sensors or RFID tags throughout the body of a patient and then uploading the data for subsequent manual scheduled upload. This data will be stored as patient specific and can be used to improve the quality of care provided while also enabling the doctors to keep up to date with how a patient is doing. There can even be an area for attachments where blood reports, X-rays and other medical files can be uploaded for convenience. By creating such a system that encompasses medical history, relevant diagnosis files and allergies, etc. Data can be transferred with ease and patient monitoring and diagnosis can become a much easier task. Again this paper talks in much generality and does not give adequate cloud infrastructure or construction methodology while providing a good platform for laymen to understand the technology.



C. Fuzzy Inference system for COVID monitoring

The given paper proposes an IOT based system for smart coronavirus monitoring. The model has two distinct parts consisting of a training and variation part. The training layer has been divided into sensory, preprocessing and application subparts. The raw data comprises attributes such as influenza, headache, soreness of throat, etc. and it needs to be preprocessed before any operation can be performed on it. The fuzzy inference system (FIS) has been used in the prediction layer part of the application layer to predict what the output will be. The input to the above layer has been altered and created as a fuzzy set.

The paper further proposes a membership function. A membership function is a relationship between the input and output parameters akin to a transfer function. The program defines different MF's with one for COVID-19 as well. The rest are those of Flu, Headache, Cough, sore throat and fever. The program tabulates the fuzzy parameters for No and Yes for the above 6 variables. An inference engine is also defined for FIS which takes care of the connections and sources interlinking the variables.

A defuzzification model has also been enlisted that enables the conversion of a fuzzy into fresh set. It also compared different membership degrees and a centroid defuzzifier used in the FIS model based system has been used to create varying rule surfaces for IoTSMCFIS for the 6 maladies. In the rule surface, yellow demonstrates good results, green is moderate and Blue represents a weak simulation result. The o/p of the prediction will be then fed to a layer that will define whether COVID is detected or not, giving out a "Yes" or a "No". MATLAB has been utilized to create a novel lookup table studying the dependence of COVID-19 and the 5 symptoms identified.

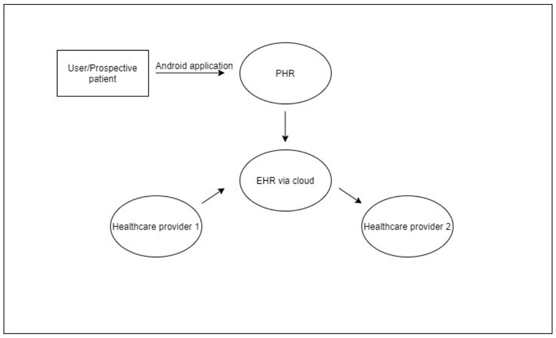
D. A unique ML model for COVID tracking

This paper discusses the integration of IOT and Machine learning algorithms to track covid-19. The IOT devices can capture and measure externalities like temperature, state, location, etc. using sensors all while being connected to the internet. Healthcare personnel can easily access a patient's data which help them to monitor and track them. Using the data, they can recognize unusual patterns in various externalities. Right now, there are 2 pre trained models that the ML practitioners use

1. CheXNET
2. CovNet

The transferred data needs to be authenticated in order to protect the signal from unauthorized access. Therefore, the signal is watermarked for security purposes. The classifier extracts the data and the encryption is sent to the cloud. The data then is transferred to a healthcare professional where it is analyzed and a decision is sent to the cloud server. Every patient needs to be treated differently, therefore travel history along with wearables' parameters becomes important whether a visit to the radiologist is needed or not. Parameters-1) Temperature Monitoring- The most common symptom of the virus is high fever and it becomes important to monitor body temperature for quick diagnosis. 2) Heart Monitoring- Wearable Pressure sensors, including artery pressure sensors will monitor the cardiovascular pulse pressure waveforms. 3) Blood Glucose Recording- A diabetic person is more likely to be severely affected and needs urgent medical treatment 4) Oxygen saturation- The intake of oxygen drops when one is affected by covid-19.

The architecture is divided into 3 layers namely input layer, transport layer and application layer. As the symptoms of coronavirus is close to that of normal flu, a form is filled by the end user to differentiate by having a questionnaire round. After reading the form, the doctor will suggest to take an x-ray in the nearby center and the images will be sent to the CheXNET algorithm for processing and suggesting if a proper test is required or not. By this, the model also becomes more efficient by the use of preprocessed data and the system also becomes effective in predicting if they need to go to the test center or not.

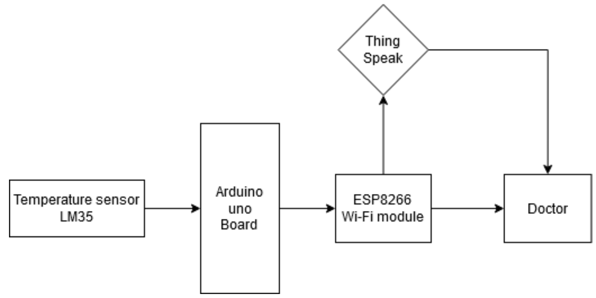


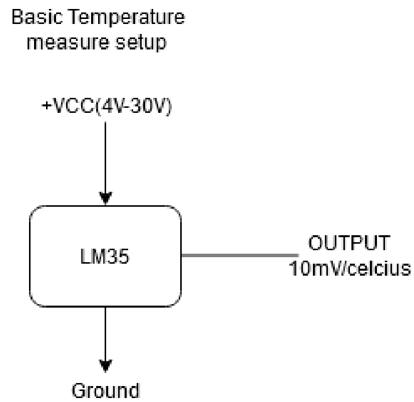
E. WSN and IoT based COVID-19 model

This paper prepares a design and simulation of COVID-19 Symptoms Monitoring Mechanism which is based on IOT and wireless sensor networks. This system by combining WSN and IOT, measures parameters in real time. The WSN has many sensors that can sense temperature and humidity and IOT can present it in real time. In this mechanism, temperature is a vital sign and is sensed by an appropriate sensor. The data which is sensed is read by an Arduino board, which then processes the data using a microprocessor and sends it via Wi-Fi module to the IOT based cloud server. This process is continuously running and the medical staff via the IOT based cloud server can easily monitor a patient.

Arduino- Arduino is a hardware device supported by software which has a microcontroller and an IDE. The IDE uses C++ to upload the program code to the board, used for digitization of analog data. An Arduino Uno board can be connected to the PC by using a USB cable. It has 6 analog pins for sensors. It then converts the received signal into digital data.

LM35 temperature sensor is used to sense temperature. LM35 sensor measures the temperature in Celsius and provides an analog output. LM35 has 3 pins: VCC- Supply voltage Out- Analog output voltage GND- Ground. The LM35 output pin is connected to the pin A1 of the Arduino which converts it into digital data. This data is processed to give the reading of the temperature. Then the ESP8266 Wi-Fi module sends the processed data to an IOT application which shows the data graphically. Then the receiver side (doctor) can read and interpret it and act accordingly. An effective IOT platform is ThingSpeak, used in this case. An account can be created on ThingSpeak, after which reading and writing data on it can be done. After all this process, the doctor can give its feedback and a successful monitoring of the quarantined can be done on a real time basis.





F. Raspberry Pi's usage in COVID monitoring

This paper deals with a hardware platform which consists of a sensor and Raspberry Pi 3 Model B. It can contact a doctor over a smartphone through the internet via devices linked to the same server. Medical information of the patient is measured i.e. heart rate, blood pressure and pulse rate. A camera is then used to monitor the patient through the raspberry kit. All this information is stored in a medical server. In this setup, Raspberry Pi is used as a data aggregator as well as a processor. The smartphone or computer of the doctor is used as a monitoring system. Sensors take the signal and these signals are sent for processing to Raspberry Pi, which is the IOT module. The pi shows the info on the monitor and also holds the info on the cloud.

Mouse and Keyboard is connected to the USB port of Pi. The Monitor is connected to the HDMI video port of pi. The GPIO pin is used to connect the sensors and then the data from pi is transferred to the server. The pi also acts as a processor and the output digital data is displayed on the Monitor. The IP address of the server is the same as the IP address of the pi. The camera output from pi is displayed on the server. The cloud server is used to store health reports for future references. Using this there will be no need to carry different files while visiting a doctor. If any parameters, say, blood pressure is found greater than 120, an alert is sent for medication.

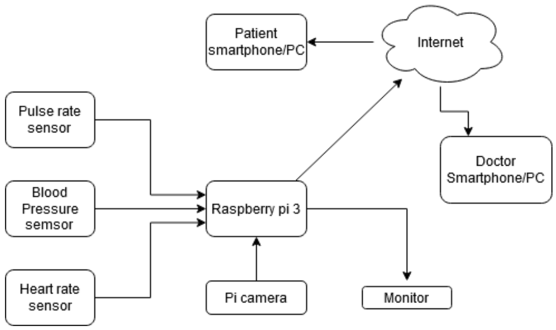


Fig1

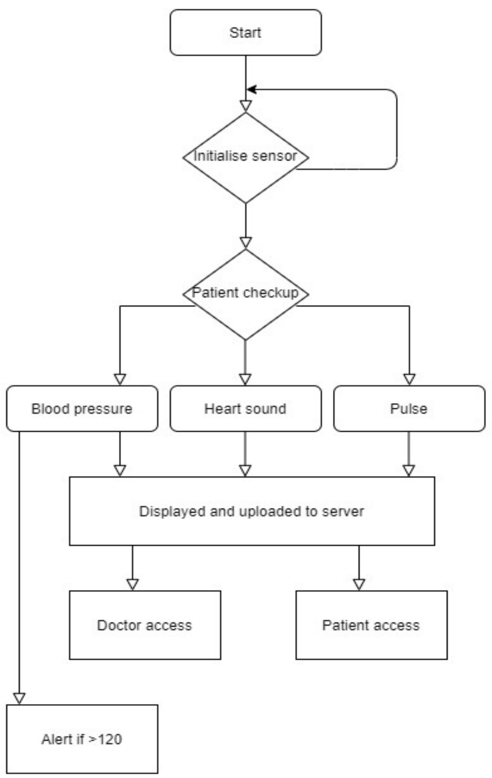
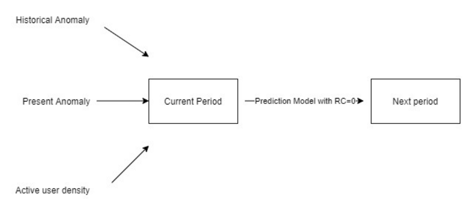


Fig.2

III. PREDICTION MODELS

A. Wearable data to predict the spread of COVID-19

The paper proposes a novel neural network being created by concatenating two existing NN. The author in his stated methodology notes the fact that an elevated resting heart rate may be a preliminary symptom of a fever. It has been researched that the heart rate increases by about 8 and a half beats per minute for every Celsius increase in body temperature. Since the research is carried out by Huami researchers, they have a huge amount of wearable data available at their disposal that they can analyses to get needed parameters. The wearable can detect the resting heart rate (RHR) using the photoplythesmography sensor. This PPG sensor can be used to calculate the RHR via sleep status and length measurement. The study defines the RHR as an anomaly if it exceeds the mean RHR by 1.5 standard deviations and the sleep length is also considered. The proposed CDNet NN combines two powerful CatNN and DenNN. CatNN has features like activity and weather as an input parameter and DenNN contains historical COVID data such as user density and RHR anomaly rate as attributes. The sigmoid function is used as an activation function and various different models are trained to account for regional differences and disparities.



The NN is then trained extensively and prediction models are created with the official rate RC as 0 and with the availability of RC for the next instance. The prediction model performs quite well on the private Huami dataset and gives very accurate peaks. The peaks in the China model show that the rate of COVID spread should have peaked somewhere around the Chinese Spring Festival. This has been accurately mapped by the NN and there is in fact a very close matched peak to the official statistics. The curves of the predicted and the supervised models overlap considerably verifying the legitimacy of the NN prediction. For example In Wuhan the peak according to the predicted data should have been around Feb 8 while the predicted model gave a peak at Jan 28. This is extremely close and further verifies the effectiveness of the model. This peak can also be taken as a sign that perhaps forebodes the incoming wrath of COVID and maybe as a proof that wearable data might help in foreboding the advent of a pandemic. Even the European model is quite accurate, giving a peak around 1 week before the actual official statistic in Italy and Spain. The paper further studies correlation between the predicted numbers and officially reported stats through Pearson's correlation coefficient. The rho value reaches 0.68 which is an extremely good value, verifying the validity of the model. The paper succeeds in identifying a well-defined public emergency health alert model, one that can be easily implemented by technology giants across the world in collaboration with national governments.

B. Hungary based ML case study for COVID-19 trends

The paper starts with a brief outlook on why SIR models are the most trusted source of prediction models for epidemiology based projects. The SIR model mainly relies on creating a mathematical system that uses the concept of social contact to create a robust system. The SIR system considers susceptible, infected and removed population classes. The transmission probability is further modelled as a set of differential equations with rate of spread, the numerous classes and constraints used in it. The literature expands on this basic model and refers to already present literature to elaborate on various further developed models like SEIR and gives various unique ML models for other diseases like swine flu, dengue, H1N1, etc. The project implements the following algorithms on a public data set consisting of mortality rates in Hungary. A part of the dataset has been divided for training and another part has been solely kept apart for validation.

MLP has been used as a tool to analyses relatively simpler datasets with a high accuracy. Since a more robust technique is needed for applications such as COVID-19 prediction, there is a need for hybrid models which contain numerous optimizers in addition to a predictor. The paper proposes the MLP-ICA model as a prediction platform for interlinking statistics of death and predicted numbers. ICA or imperialist competitive algorithm is a very beautiful tool for solving optimization based problems. A set of random solutions called Countries are taken and then based on this array, a cost function analyses the relative power of every country. The countries having least cost function are anointed as Imperialists and therefore form major empires. The term imperialistic competition derives from the fact that there is an intense war by various imperials over colony and thus there is an intrinsic competition. Furthermore two major events called Assimilation and Revolution have been defined. Assimilation is the concept that the captured states move closer to imperial power and Revolution is a sense of randomness in this whole process. The combination of assimilation, revolution and imperialistic competition are repeated till an end state is reached or a given condition has been satisfied. This model is then combined with a present ANN with the error as a cost function and optimization parameters based on the ICA algorithm. The paper defines the various parameters of a successful ANN-ICA via a trial methodology to get the best results.

ANFIS— ANFIS is a type of artificial neural network. It is basically designed as a hybridization of a Takagi-Sugeno fuzzy system with ANNs and was created in the 1990s. It is a highly valuable system for dealing with nonlinear functions and performs best when it takes in its input from an ICA like system. ANFIS consists of 5 basic layers: the input layer which takes in different input parameters, the rule layer which works on evaluating the degree of firing needed to be enabled while considering the membership functions, the third and the fourth layer normalizes these previously evaluated firing strengths and feeds the output. The paper easily implements the model using a MATLAB toolbox where it was trained with no error tolerance and optimum back propagation.

For evaluation, determination coefficient, mean absolute percentage error and rms error were considered. The study used three widely disparate membership functions, triangular, trapezoidal and Gaussian. In a comparison study based on prediction data and actual mortality and cases numbers, the ANFIS and ANN algorithm perform similarly with ANFIS edging it out in certain cases and ANN in others. The proposed approach can thus outperform ANNs in certain cases. The study however does not make premature conclusions and identifies that the datasets might have inherently inaccurate and unlabeled data such as casualties in the UK that are unregistered and governments restricting access to information. The paper ends on a note that more research is essential for the validation and enhancing the results.

C. Prediction of respiratory symptoms in COVID-19 using wearables

The paper discusses a model to predict symptoms related to respiration whether a person is affected from COVID-19 or not. Tachypnea is considered to be a distinguishing feature of Covid-19. The proposed respiratory information catch will initiate with facial acknowledgment, utilization of infrared sensors and AI ways to deal with, which at long last limits as a side effect of Covid-19. It can be detected early by combining respiratory variations with other potential measures. Attaching and detaching the monitoring devices over an individual would be difficult to manage when there are more people. Therefore noninvasive techniques are preferred to detect symptoms. One fine way to do this is by using depth and thermal cameras.

Previous ways of detecting symptoms like fever is not so effective, even if we use thermal imaging because people at large use medications to suppress temperature. This has been found in many cases in India. In this method, we use thermal imaging cameras to monitor the rate of breathing and heartbeat. Analysis of respiration can be done by depth cameras by measuring the displacement periodically of the organs. The challenge is further created when a person is wearing masks as the main area of heat exchange is around the nostrils. Further deep learning and machine learning methods are also applied over the data set to further extract meaningful patterns for future classifications.

The proposed methodology starts with capturing real time data with depth cameras followed by subjecting the images into the simulated model for classification. Testing can also be done for tracking the performance over previous methods. The data set is constructed using previous knowledge of breathing patterns. For e.g. Abnormal breathing patterns can be bradypnoea, tachypnea, biots, Cheyne–Stokes and central apnea

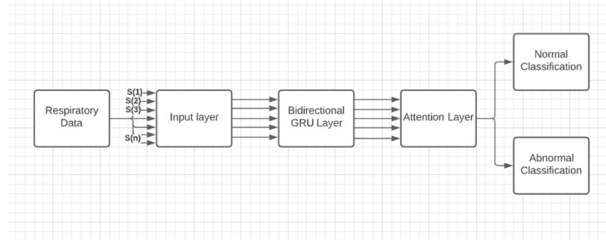
$$y_{i\varepsilon w} = a_i \sin(b_i x) + c_i + d_i x$$

The above equation describes the breathing intensity over time. bi indicates the standard respiratory signal, ci and di indicate the longitudinal deviations. Gaussian white noise is added to replicate the real world.

The proposed method uses a Gaussian feature pyramid network and extracts minimal data and converts them into full scale images. Context correlation from low level pictures are converted into high level features through this network. Images are smoothened by using a moving average filter to accommodate sudden movements. The problem created by the mask is nullified by taking into account the coordinates of the mask which is (w/r, h/2) and (3w/4, 4h/5). As it is constantly prone to heat, it is marked by a thermal scanner. Images obtained by the depth cameras are used to train the simulated system. The classification technique namely bi-GRUAT categorizes the input images into respective classes. RNN is used to organize information based on time units.

There are four layers in the network architecture

1) Input layer
2) GRU layer
3) Attention layer
4) Output layer to produce the classification.



Input layer is trained with multiple simulated information in the data collection stage. The bidirectional GRU is used to access the sequential information in both the directions. It uses neural networks for the purpose mentioned. The attention model is used for document classification. The network architecture is used to analyze the respiratory waveforms and match it with normal waveforms. The output layer determines whether it is normal or abnormal. The abnormal ones are sent to medical facilities for further confirmation

D. Comparison study of 16 countries using COVID-19 trends

This paper aims to introduce non pharmacological interventions in such a way in different countries based on their income such that various factors including their economy is not severely affected. Many countries are now beginning to lift the NPIs and therefore there is a high risk of disease resurgence. We try to introduce dynamic NPIs with intervals of relaxed social distancing which can prove to be effective in balancing the two. In the research, a multivariate prediction model is used to simulate outbreak trajectories in 16 countries from different economic categories and living habits. First the impacts are modelled over an18 month's period based on ICU interventions and deaths. (1) No intervention (2) Consecutive cycles of mitigation measures followed by a relaxation period (3) Consecutive cycles of suppression measures followed by a relaxation period

The key aims are :-(1) Case severity and fatality according to different age groups. (2) Estimate the impact if there was no intervention and having current medical facilities (3) Over an 18 month period, check whether continuous or intermittent combinations of Mitigation/relaxation are better. (4) Try to keep the number of cases requiring medical intervention as low as possible.

At first, age wise grouping was done in different countries. Then, the countries were selected from different geographical locations and lastly income was taken into account :-(HIC), (HMIC), (LMIC) and (LIC) groups. Isolation at home, voluntary home quarantine, closure of schools and universities, and social distancing is considered as a physical distance norm in this research. A basic reproduction number R0 is defined, meaning how many people an infected person can infect. It is found to be 2.2 for uncontrolled spread of the disease and when it comes to controlled interventions, R reduces to 0.8 and 0.5 for mitigation and suppression interventions, respectively. Based on this approach, 4 cases are considered. First, no intervention. Second, incessant cycles of mitigation and relaxations. Third, same with suppression and lastly continuous suppression with no relaxations. (50 days mitigation and 30 days relaxation). For every country, the factors counted were the number of people requiring ICU beds and the total number of hospitalizations and deaths in different cases mentioned above in the span of 18 months.

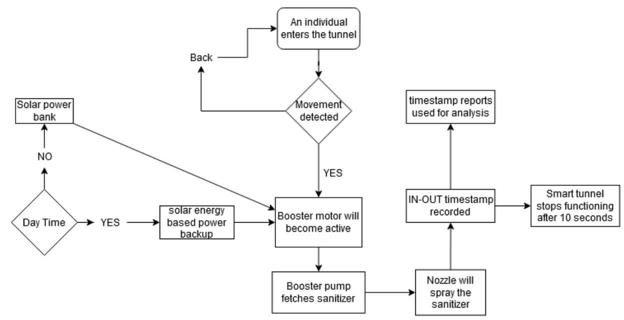
IV. PUBLIC SAFETY

A. A smart tunnel based infrastructure for COVID-19

This paper deals with a smart epidemic tunnel. This tunnel is used to disinfect people entering a public place using an automatic sanitizer spray. This solar powered tunnel is IOT based sensor fusion assistive for real time detection of individuals from a height of 1.5m and can disinfect in a time span of 10s. It also has a solar power bank to function at night. The tunnel comes with a smart sanitizer sensing unit and the information is stored in a cloud platform, such as google firebase. The disinfection process is automatically carried out by an audio based proximity sensor with a buzzer and relay circuit. The sensor is mounted in the chamber to detect entry of a person. The whole system consists of 2 photovoltaic arrays of power 200w each. PV arrays convert the DC output into AC. For increasing the voltage level, MPPT transformers are used.

The system works in a 5 layer arrangement. They are sensing layer, networking layer, cloud service layer, data processing layer and the application layer. The sensing layer consists of an ultrasonic sensing unit, LDR sensing unit modules, NodeMCU microcontroller unit. This layer detects an individual entering the tunnel. The networking layer establishes an interface between a sensing layer, MQTT broker architecture, Google Firebase and Web and mobile interfaces.

The cloud service layer stores the in and out timestamp values of all the individuals who have entered the smart tunnel. The data is fetched from the data processing layer from a Google Firebase cloud computing platform via an MQTT broker architecture. This layer also processes the received in and out time stamps values and the total number of people entering the place during the day and night. The application layer has a GUI based web and mobile interface which provides daily, weekly and monthly updates of the number of people accessing the tunnel. The interface does so with the help of a cloud platform such as google firebase. Further, an AI enabled system can be developed which can detect face masks and can provide thermal scanning.



B. Urban health monitoring using AI coupled with universal data standards

This paper approaches the subject matter from an unconventional point of view. It puts forth a perspective from an urban point of view both during the outbreak of the virus and in current circumstances. It also aims to provide an infrastructure and methodology that a prospective smart city planner and manager can use to become more robust towards the challenges presented by pandemics. The paper starts with a brief overview of how COVID-19 has affected the livelihood of different people of China and how the first response to the disease took place. It also approaches the subject matter from the point of view of a case study for urban health thematic.

The article refers to IOT as a boon in the healthcare industry. It cites Stanford Medicine as saying that by early 2021 over 2300 Exabyte's of data would be generated by the healthcare sector. This is a huge amount of data and needs to be dealt with accordingly and for things like this the need for proper security and privacy measures arise. With this statistic, the paper pivots to the issue of Big Data and how data collection, storage, management and accessibility being controlled by a small number of people is a big privacy issue.

The paper provides a high level survey of the COVID pandemic and talked about the challenges one might face when it comes to public health. The first and the most important one is that despite big cities being well prepared for outbreaks and with standardized protocols in place, the fact that these policies are not the same across the board harms the collective effort in containing the spread. Furthermore, it implies that there is a need for seamless collaboration of data over international boundaries in such situations so that the issues can be addressed directly and swiftly.

The article goes on to contrast the impact on the economy by different large scale infectious viruses such as Ebola, Zika and SARS. It also mentions the incalculable loss incurred due to COVID-19 by mentioning the Chinese New Year and how the outbreak of the virus destroyed the plans of millions of hopefuls wanting to catch a flight back come thus destroying the civil aviation industry. Although the response was fast inside China, the author takes a strong position saying that in such trying times, states should overthrow their national agendas in favor of a more global system and try not to hamper the flow of classified information. Through outbreaks like these, we all have also come to the realization that data can be sourced from a wide variety of places with enabled sensors. The author specifically mentions the examples of an airport. Where screening and monitoring makes up a huge part of the current experience. It also mentions bus terminals and subways in a similar light. Furthermore, it highlights the essentiality of basic smart city concepts where urban health sensors are installed at various places to ensure regular collection of health parameters. Furthermore smart wearables can be a helpful source of information about an individual's health. The paper goes on to say that there is an urgent need for common communication standards and data sharing places where people can openly collaborate without changing how they generally communicate. A case of collaboration against Ebola in West Africa is also presented where this was adopted successfully. This paper takes the position that it now possible to integrate technologies like the use of smart devices through IOT networks and wearable devices, data from mobile apps and others to help users to share information with accredited and certified health professionals and improve the outcomes for better cross disciplinary and more resilient protocols and policies.

CONCLUSION

This survey paper proposes different mechanisms to deal with the diagnosis, monitoring and prediction of COVID-19 cases along with smart safety mechanisms like smart tunnel, data sharing and data privacy issues which in a densely populated region can prove to be a game changer until a fully tried and tested vaccine is presented to the world. Serving the vaccine to almost 7 billion people is quite challenging especially for the developing countries. Therefore, these methods can help to narrow the curve especially when the second wave is about to hit various regions of the world.

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