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Autonomous service for managing real time notification in detection of COVID-19 virus☆

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ABSTRACT

In today’s world, the most prominent public issue in the field of medicine is the rapid spread of viral sickness. The seriousness of the disease lies in its fast spreading nature. The main aim of the study is the proposal of a framework for the earlier detection and forecasting of the COVID-19 virus infection amongst the people to avoid the spread of the disease across the world by undertaking the precautionary measures. According to this framework, there are four stages for the proposed work. This includes the collection of necessary data followed by the classification of the collected information which is then taken in the process of mining and extraction and eventually ending with the process of decision modelling. Since the frequency of the infection is very often a prescient one, the probabilistic examination is measured as a degree of membership characterised by the fever measure related to the same. The predictions are thereby realised using the temporal RNN. The model finally provides effective outcomes in the efficiency of classification, reliability, the prediction viability etc.

1. Introduction

The innovations in the healthcare industry are reaching heights which have never ever been assumed by the professionals a century ago. The innovations in the field have taken the medical industry to a higher level with a great significance in day to day life [1]. The most important administrations of the concerned department is the gathering of information for gaining access to the problem and...
thereby reducing the health issues across the nation especially in a situation like COVID-19 [2]. This disease is caused by the SARS CoV-2 virus and is a highly infectious pathogenic and it is transmitted from one person to another person [3]. The viral infection is considered to be a significant one across the whole world especially due to its ability to infect all organs of the body unlike the other diseases which basically affect a single organ [4]. There is dire need for a strong framework with respect to the novel coronavirus, especially in the places where there is an extensive spreading of COVID-19. The disease has become the greatest challenge to the healthcare agencies of the present time. IoT devices play a vital role in working a number of healthcare monitoring systems [5]. The arising technological revolution makes the fast developments in innovation to be possible and it also develops the healthcare applications as a whole insisting a new development in the medical field. Unlike the other fields, the aid of the Internet of Things in the medical field is high, as it saves lives in real time.

With the increasing casualties of the COVID-19 virus, the incorporation of the IoTs has increased in the medical field. The developments of IoT like Fog and Cloud Computing, Embedded Framework etc. have had an enormous impact in the detection of the same. The IoT system based on Fog computing has proven to be efficient in the challenges of errands like insignificant time delay in medical care checking and result conveyance. The latest headway in the innovation related to Fog based Cloud Computing is aroused with a meticulous plan in the case of the proposed system. In the case of a typical fog layer, the sensors provide the necessary information about the fog on a real-time basis. The proposed model alerts the end client via an mobile application. The architecture of a fog layer is shown in Fig. 1.

The organization of this article starts with introduction section. Section 2 describes about review of literature. Section 3 showcases on the proposed model of the framework. Section 4 focused on implementation and results. Section 5 depicts the conclusion part.

2. Review of literature

The review of the literature section demonstrates the essential contributions and roles of the Internet of Things for monitoring viral
infections. Several researchers have worked on the field of viral infection monitoring. One of the research workers like Sood and Mahajan forecasted their works on the same. In the work of Mahajan and Sood, they focussed on the forecasting of the rising spread of a mosquito infection called Chikungunya [6]. The proposed model in IoT forecasted the data regarding the level of infection suggested Zika and the West Nile based on the side-effects faced by the people due to the disease. The researchers have produced a framework for alerting the authorities in the case of the population experiencing the symptoms of the disease. Though the study provided details with respect to the effects based alerts, it could not update the newer changes promptly with accuracy. Having in-depth knowledge of the medical service, Bhatia proposed an IoT based structure [7]. In the study, an ANN model consisting of three levels dealing with the process of anticipation, dissection and finally the screening process of the regular well-being during the exercises of everyday life has been proposed. Though the study explores the medical service, it has not explained much of the other related fields related to the same topic. These kinds of effective models and frameworks were proposed by a number of researchers. Vani and Neeralagi [8] have researched on the same and developed an effective model with the framework on distance observation. The main aim of this study is the detection of the infected and hence the researcher deployed a IoMT wearable sensor gadget. Then, the information is supplied to the fog layer for the purpose of assessment. By the deployment of air locator sensors, the cloud storage information is gathered. In this study, vital information is analysed in the case of severe illness [9]. For the purpose of studying the cases of viral sickness and diagnosing it by the application of IoT and cloud, Verma and Sood proposed a structure [10]. The study is focused on the forecasting of the infection which occurs during initial stage. The researchers have deployed various clinical sensors, grouping calculations and the UCI archive for the anticipation of the weakness and well-being of the patients. Later, the researchers have widely investigated across the world as well. Here, Bhatia developed a system for this kind of investigation of well-being status on a universal level for anticipating the probabilistic weakness in an efficient way [11]. Furthermore, the researchers have implemented the same on four people from various places for a multiday information by the deployment of the Internet of Things. Furthermore, the authors have worked the proposed system on four individuals from different demographics at different points of the day by the utilisation of the IoT sensors. For the identification of the mosquito borne diseases, a novel controller framework was proposed by some researchers [12]. In the model, the author focussed on the identification of the MBD-contaminated client by the time of the beginning of the phase. In the study, the author mainly had taken into consideration the MBD-contaminated client by the commencement of the phase deploying IoT based gadgets. Though the study provided a fog cloud space for the storage and handling of data, a decision tree for the characterisation users becomes irresistible and non-irresistible. The extraction plan of the programmed catchphrase is used for the study and much more to be explained. Later, Sareen proposed a model consisting of Internet of Things and Cloud innovation which is based on a method namely

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**Fig. 2. Basic Structure of the proposed model.**
RFID for the purpose of detecting and controlling the increase in the number of Ebola patients [13]. They have also deployed an investigation of a transient organisation for the purpose of data management. The results were yielded with much precision compared with other state of the art models and hence, demonstrated high precision in the estimation. However, the study left out certain attributes of patients which were to be included in the study. Further, the study left out the attribute of some internet of things. By using profound learning and Internet of Things technology, a Tuli, the researcher had developed a framework, based on fog related to medical services [14]. The research aimed at finding heart infections for early prediction. The study has shown an elaborate framework with so many medical benefits which effectively utilises the Internet of Things and shares the information of patients to the concerned authority offering better medical care services with profound learning for the continuous application of the medical services. In a surrounding of Fog processing, a Fog Bus structure is utilized for checking the framework with great efficiency and thereby tries to achieve higher power utilisation. Here, the preparation of data has to be followed by testing. Though the study provides a level of higher power utilisation, it requires much more accuracy. In this scenario, Yuan has actually studied a computational system for developing the identification and execution of the logical data for the discovery of traffic signs. It actually aims at the recognition of a traffic sign having adopted the technique named SOM [15]. Though the study has provided insights into the recognition, the deployment of the technique has to be clarified further.

3. Proposed model

The proposed model consists of four levels. A basic structure of the model is represented in Fig. 2. They are:

1 Data Collection
2 Classification of information
3 Mining & Extraction
4 Predication & Modelling
5 Data collection

The process of data collection takes place in the first layer. It is an IoT enabled smart network. The layer focuses on gathering the information from the patient using various sensors related to geography, health, ecology etc. Here, the fog hub becomes responsible for the analysis of information. The data collected is used in the fog hub, an intelligent device and it becomes responsible for the analysis of the information. This information is also used over the geographical area for preparing the population to be aware of the risk of spreading of the diseases. Furthermore, this information is also executed at the fog-layer for delivering the delicate alerts and thereby to be aware about the victims of the disease.

Apart from the collection of information, the security of the same becomes a point of concern for which the security of the IoT devices is also an essential part of the process. To support the same, vital protocols are used in the process of data calculation namely SSL, ECC etc. It in fact guarantees a secure corresponding over MQTP and HTTP through the user friendly applications of API like Google, Amazon, Apple etc. It further analyses the information with high accuracy and precision. Here, the framework is transformed to the product level stage [16–18]. Moreover, the APIs also restrict unapproved access.

1 Classification of information

The data hence collected from the IoT sensors in the first level are then categorised in this section. The information collected from various gadgets are concerned with different classes of the health categories. The heterogeneity of the information insists on the classification and hence four main categorisations are done and they are based on:

1 Health data

The data related to health includes those crucial indicators of the COVID-19 disease like high fever, headache, nausea, saturation, vomiting etc. [19].

The sensors deployed are:

- Airflow sensors
- Oxygen sensors
- Position sensors etc.

1 Meteorological data

The information under this category includes the pressure permissible, the level of moistness, the least temperature etc. The sensors are deployed in various areas for receiving the necessary data [19].

1 Location data

The location data shares the concentration of those with and without the symptoms and it also decides the location of irresistible locales who are more prone to the disease. Hence, various GPS sensors are installed in different locations [20].
Environmental data

For collecting the environmental data, IoT gadgets like temperature sensors are often deployed [21]. The information procured includes, air contamination, level of supplements, water quality, diet etc.. In the case of personal health it influences the same to a large extent.

Data mining & extraction

A proper information extraction of data is required for understanding the vulnerability of the COVID-19 patients [22]. Hence, the fog processing hubs are used for the examination of the heterogeneous information received from various limits of various time intervals at various geographical locations or areas and thereby make the fog-layer to act as an interface between all the gadgets in the
Fig. 4. Proposed system framework.
Internet of Things and the distributed cloud layer of computing. The health state part of the fog layer is analysed for understanding the well-being of the condition of the user.

4 Prediction decision modelling

The prediction and decision modelling basically focuses on the spatial-temporal timing with respect to the healthcare of the patients. The present study deploys an approach with TRNN for the same on the estimation of the measures related to the COVID-19 disease. This TRNN is equipped with an advanced Artificial Intelligence (AAI) model involving the deployment of the interconnected neurons using the mechanism of back propagation. It produces the results with maximum accuracy by the updation of weights of the neighbouring neurons in an appropriate manner. The working of a Spatial Temporal Recurrent Neural Network is Fig. 3 represented in Fig. 4.

Health state identification

Characterisation is an essential part of the process which helps in the identification of the health status of the individual [23]. It also produces the comparative information from a same kind of class and disparates the same into another class and thereby separates the information into two different classes namely, Infected Class and Non-Infected class, based on the COVID-19 data. Basically, this classification is a strategy which has been deployed for the investigation of measurable information.

In the case of Fuzzy C Means (FCM) with certain DOM, the data can be arranged in at least one class ranging from 0 to 1 by limiting the error assessing the informational index. It also aims at identifying the centroids till it stops changing with time. Moreover, it also arranges the classes of Class-1 and Class-2. The deployed data classes are:

1 Infected Data Class
2 Infected Disease Class
3 Infected Data Class

This particular class incorporates the information from the DOM which is low and distant to centroids. It is also likely to lie in the main classification of Class-1 utilising the information for the observation purposes of the COVID-19 virus.

1 Infected Disease Class

This consists of the information esteems with high value of DOM and near centroids lying in the subsequent classification of Class-2. The users therefore need a quick treatment or prudent for controlling the spread of the virus and receive an alarm message.

Algorithm 1. Fuzzy C-Mean (FCM) Classifier

Step 1 - No. of clusters are defined and the importance of the cluster values of fuzzy constant and threshold values are being set.
Step 2 – The $u_{ij}$ membership matrix is initialised.
Step 3 – The iteration $k$ of the cluster-centroid is estimated by updating it in the membership matrix.

$$c_{ij} = \frac{\sum_{i=1}^{N} u_{ij} f_{i}}{\sum_{i=1}^{N} t_{ij}}$$  \hspace{1cm} (1)

$$U_{ij} = \frac{1}{\sum_{j=1}^{N} \left( \frac{||f_{i} - o||}{||f_{i} - s||} \right)}$$  \hspace{1cm} (2)

Step 4 – In case of $||u^{k} - u^{k+1}||$ is greater than threshold, k is increased by 1 and it is repeated until the termination condition is attained or upto Step 5
Step 5 – Stop the process

Algorithm 2. Fuzzy classifier for predicting the category of a user

Step 1. Provide the registration number (renum).
Step 2. In case of an invalid registration number, the registration must be done by the user through a smart phone.
Step 3. Receive the binary attributes concerned to the health followed by the updation in the database.
Step 4. An expectation of the user category occurs with Algorithm 1.

4. Experimental implementation

In the proposed model, simulations are done in perfect situations certified with three regional datasets acquired from a particular location. The corresponding regional IDs are given to every place as R1, R2 and R3. The locales have been assessed using the sensors
such as SRFID, WiSense hubs, actuators etc. over the tool iFogSim. Here, ten sensors have been used for gaining the aggregate values owing to the heterogeneous climate and the hence gathered information from the various sensors are sent to the distributed storage of Amazon EC2 for the utilisation of the STATA platform. Hence, the model proposed is then actualised over the framework of PC with the arrangement of Intel i5 Quad-centre processor with 3.3 GHz of clock cycle and a memory of 8 GB using MATLAB in Windows10. The simulations have been done for around 3300 cases for a number of time periods.

The actualisation of the FCM arrangement is done for the sorting of users into two categories namely the Infection and Non-Infection. In the study, Synthetic information is therefore produced for direct investigations and the execution assessment of the proposed model is being done due to the non-accessibility of relevant datasets.

4.1. Data generation

Appropriate information is required for the in-depth assessment of the model presented in the study. For the analysis of the virus, classification of the dataset is done under non-infected and infected class. Based on the range of probabilities, the parameters for distinguishing the virus are estimated. As a result, some symptoms are recognised from the experience of the user during the week. The same has been received as a ‘yes’ or ‘no’ type of response from the user. Therefore, by the setting up of the probabilities concerned to the well-being, the dataset is produced. Initially, the dataset is used for changing the acknowledged manifestations. The arrangement for the calculation of FCM is done with ‘m’ features changing from 1 to 2. For every ‘m’ decision, the various factual features such as accuracy, review, exactness etc. are tested. The value of accurate packets for different sensor IDs are represented in Fig. 5.

The reliability of various sensors are represented in Fig. 6.
4.2. Classification analysis

Based on the probabilities of the retained information of the COVID-19 virus, the proposed model is classified into various classes [24]. Therefore, the measurements of the assessment are deployed for the estimation, execution and characterisation. Basically, the assessment of the model is under four measurements such as f-measure, precision, recall and accuracy for assessing the effectiveness of FCM. A comparative analysis of the classification of data is represented in Fig. 7. The outcomes show that the corresponding framework can classify the users into the various classes.

The correlations in the study show that the FCM classifier proposed in the study yields higher proficient outcome with accuracy.

4.3. Prediction and analysis

4.3.1. Training of TRNN

The proposed model layers are executed for the purpose of pre-handling Python. In the characterisation of the classes of COVID-19, the FCM classifier is used. Amongst the hubs of the NN, the information is transmitted for the purpose of deployment. Then, testing is done for the prefixed models by tuning numerous features for recreation purposes. Here, different techniques of approximation are used in the missing information of the data collected. A portrayal of the idle component of auto encoder is being investigated with the TRNN for the missing ascription of the viral infection. In the case of actualised Recurrent Neural Network, the output layer consists of a single neuron and the information consists of six neurons. The connections between the layers of the RNN with the hubs are 15 in the first layer which is the concealed layer and the second layer consists of 10 hubs. Adam network is the enhancer used for the Recurrent Neural Network model in the initiation work which is ReLU. In this context, 479 cases have been tested using 2817 instances during the process of preparation.

4.3.2. Prediction efficiency based on TRNN model

The expectation of the efficiency is estimated continuously for the dataset and the resultant information which is heterogeneous, is created using various datasets. For an investigation of productive expectation, inspection of the details is essential. The result infers that the proposed model performs well compared to the state of the art techniques in memory networks of long short-term, CNN and generative adversarial networks. Also various factual measures are estimated for understanding the efficacy of a productive forecast. For COVID-19 virus prediction, the determined situation shows an effective T-RNN. Here, various statistical measures like MSE, NRMS, PCCE etc. are determined. When compared to the different models, the outcomes are nearly towards the efficiency line in terms of achieving higher precision levels depending on the simulations. In the study, the proposed model also shows a low level of errors. This is basically accepted by the evaluation of the rates of MSE and NRMS. By attaining the estimations of NRMS, MSE and PCCE, the scale expectation can be found to be more effective compared to the other models. As a result, it is assumed that the TRNN performs well with higher value of consistency and minimum error value.

4.3.3. Prediction latency

In this study, the analysis of the performance is done using two parameters:

Latency time – This is the rate of latency fog and cloud-computing. It is estimated by the difference of data analysing computing time and the time of conveying the warning message from the fog node to a particular user.

Response delay – Though it is more orientated towards the response time, it is basically integrated with the responsive metric for
measuring the visualisation screen prediction of the results to be produced.

4.4. Reliability

Apart from this, the general outcome is assessed for understanding the reliability of the proposed model. It quantifies the general outcome proposed by Eisenberg et al. [24]. For further confirmation, the prediction model alone is then altered followed by the examination of the same. From the results of the implementation, this model comparatively accomplishes a higher precision. An appropriate examination of the proposed model on the precision implies that due to the eventual outcome, the model scores higher precision of 91% as an average compared to the existing ones [25]. It is also inferred that the model proposed in the study is more reliable as compared to the state of the art procedures. In the reliability analysis, the proposed method shows various values with increased reliability as shown in Fig. 8.

4.5. Discussion

The proposed model shall be used all over the world in the medical and healthcare organisations. This model has also a realtime data value of health not simply restricted to body temperature, pressure, fever etc. because it can be realised by the devices of IoT in the determination of the COVID-19 disease and the symptoms can be assessed even through a smartphone. The study also provides a time sensitive real time data which is of dire need in the health care services.

5. Conclusion

The methodology provided in the study is functional, and it is mostly used for early identification of COVID-19 viral infection. The structure proposed in the study has four stages namely data collection, classification of information, mining & extraction and the final one of decision modelling. Moreover, it also shows a more successful forecast on the geographical estimation of the DoM. The diagnosis of the fever caused by COVID-19 is estimated using temporal RNN. In this context, four challenging datasets have been used and the simulations have been done accordingly. Finally, the deployed model provides higher efficiency in the case of reliability, classification of accuracy and the prediction of performance. The further mutations, and the advanced variants of COVID-19 shall be studied in future for enhanced disease or virus infection prediction.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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