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Utilization of Grid Neural Network Model and RT-PCR test to detect the COVID-19 Patients and to avoid the Spreading of SARS-CoV-2

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***Abstract:** In December 2019, a new virus, also named a novel coronavirus, started as an emerging pathogen for humans and resulted in a pandemic. World Health Organization (WHO) called this novel coronavirus as COVID-19 on 11 February 2020, and the virus responsible for causing COVID-19 is SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), which is a positive-stranded RNA virus. This paper proposed an artificial neural network model in a grid computing system to identify COVID-19 patients. It can help us to identify the suspected patients and shortlist those patients who need to check by the RT-PCR test kit. The purpose of this research is to increase the time efficiency to test those patients, which has a higher chance of getting affected by COVID-19. Increasing the time efficiency in this type of pandemic situation can make a huge impact on reducing the fatality rate. This is because, according to ICMR, 1,191,946 samples have been tested as of 5 May, and 46,433 individuals have been confirmed positive. It means that only 3.85% of persons get positive results and 96.15% persons with a negative result. It implies that the time to test this 96.15% of cases is wasted. Hence we aim to detect the COVID-19 patients in less time and utilize this large amount of time to test those at higher risk of being affected by this epidemic (COVID-19). This model will also help those countries to overcome the problem of the shortage of this type of test kits such as - RT-PCR.*

***Keywords:** Artificial Neural Network (ANN), Grid Computing, SARS-CoV-2, Reverse Transcription Polymerase Chain Reaction (RT-PCR) test.*

I. INTRODUCTION

Coronaviruses is a set of viruses that cause sickness such as respiratory or gastrointestinal diseases [11, 18, 26]. This virus (coronavirus) are enveloped non-segmented positive sense RNA virus that is distributed broadly among birds, humans and other mammals, which can cause hepatic, enteric, respiratory and neurologic diseases [11, 26]. There are mainly six types of coronavirus species, four of them are prevalent and can cause common cold symptoms in immune-competent individuals whereas the remaining coronavirus species are zoonotic in nature and have been linked to fatal illness [26]. The species named as- 229E, OC43, NL63 and HKU1 are prevalent and the remaining coronavirus species are zoonotic and these species are SARS-CoV and MMERS-CoV [26]. The virus MERS-CoV was the pathogen responsible for severe respiratory disease outbreaks in 2012 in the Middle East whereas the virus SARS-CoV was highly responsible agent of the severe acute respiratory syndrome outbreaks in 2002 and 2003 in Guangdong province, China [26, 18]. The range of these respiratory diseases can be from common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV) [11, 18]. Coronavirus disease 2019 (COVID-19) is an infectious disease caused by SARS-CoV-2 also known as a novel Coronavirus that has not been identified in human previously [26]. It was first identified in Wuhan, Hubei province (China) where the cluster of cases of pneumonia has come from an unknown cause which was reported to World Health Organization (WHO) in December 2019 [11, 14, 21]. COVID-19 has been declared as a pandemic on 11th of March 2020 [21]. As of May 9th 2020, 4.02 million cases are confirmed worldwide and 279000 death cases have been announced. In most of the cases the virus can be spread between people during close contact often via small droplets produced by coughing, talking and sneezing [15, 23, 26]. People may also become infected by touching contaminated surfaces and then touching their face [15, 18]. The most common symptoms of SARS-Cov-2 are fever, shortness of breath, loss of smell, cough and fatigue [14, 18]. In most of the study we found that the time to show onset of symptoms is typically around five days but it may also take around two to fourteen days and the virus may spread before the symptoms appear [1, 11, 12, 15, 18]. But the real cause to worry is those patients who do not show any of these symptoms generally known as asymptomatic patients and also those patients who have other more diseases with this coronavirus. Most of the studies across worldwide have suggested that the association of hypertension, diabetes and cardiovascular in patients with COVID-19 is highly responsive to increase the case fatality rate (CFR). A summary report on COVID-19 was given by the Chinese centre for disease and prevention in which they state that the CFR increases in hypertension, diabetes and for cardiovascular diseases by 6%, 7.3% and 10.5% respectively [21].

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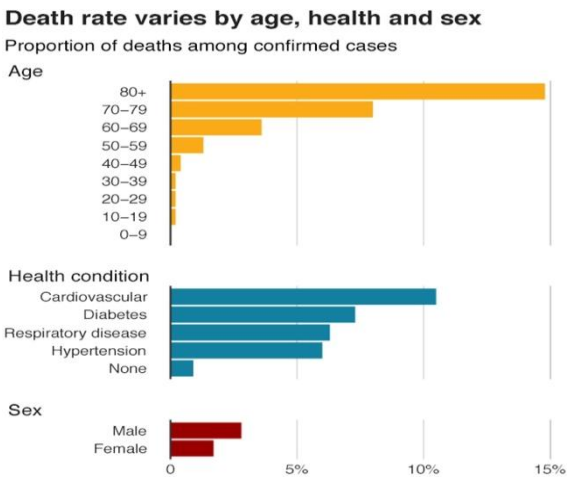
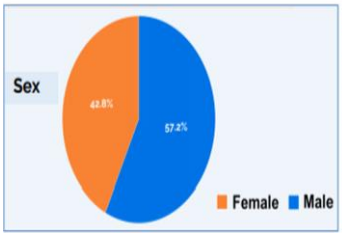


Fig.1. Source: Chinese Centre for Disease Control and Prevention, February 2020.

Fig (1) clearly shows that, the mortality rate varies by age, health condition and gender. The people above age 60 with existing chronic medical condition could be at greater risk of becoming seriously ill with COVID-19 [12, 15, 18]. Understanding the gender and age can make huge impact to understand the risk factors of poor health, health inequities and early death in this type of pandemic situation. Since, there is no clear answer to the question of the extent to which gender and which age groups are getting affected with COVID-19 but on the basis of evidences and experiences from country like china and Italy we can conclude that both age and gender are important drivers of risk and response to the infection and disease. Fig (2) shows the fatality rate of COVID-19 patients on the basis of their age and gender. This research has been done by an Italian source in which the data has been taken till March 26, 2020.



Age (years)	Deaths [n (%)]
0-9	0 (0%)
10-19	0 (0%)
20-29	0 (0%)
30-39	18 (0.2%)
40-49	72 (0.9%)
50-59	275 (3.6%)
60-69	873 (11.5%)
70-79	2660 (35%)
80-89	3010 (39.7%)
>=90	681 (9%)
Not reported	1 (0%)
Total	7590 (100%)

Fig.2. Fatality rate by gender (left) and age (right) of Italian COVID-19 patients on March 26, 2020. Source: Istituto Superiore di Sanita, (modified last updated, March 26) [15].

https://www.epicentro.iss.it/coronavirus/bollettino/Infografica_25marzo%20ENG.pdf.

Therefore the first step to stop this type of pandemic is to detect those patients who are at higher risk of affecting with COVID-19 and should be checked by RT-PCR test kit as soon as possible. This test is mainly used to detect the nucleic acid from SARS-CoV-2 in upper and lower respiratory specimens (such as nasal, nasopharyngeal or oropharyngeal swabs, sputum, etc…) which is to be collected from the suspected patients by their healthcare provider [12, 18, 26]. RT-PCR test can give much accurate result as compared to any other test available till present date. According to the guidelines of WHO and ICMR, the test kit effective to test the COVID-19 patients is RT-PCR test kit but most of the countries are facing the problem of shortage of this type of test kit [12, 18]. Let us take an example of country like India where the number of test kits available is only 10, 63,500 and about 6.3 million test kit order has been placed but as the population the country like India has and if it has worst case scenario the number of test kits are available is not sufficient [12]. Therefore the first step is to identify the suspected patients and then to use RT-PCR test. We cannot use this test blindly to any other patients because of the shortage of these types of test kits to the hugely populated country like India. Hence to overcome this type of problem we have proposed a new artificial neural network model in grid computing system. This is an information based model in which the information about their health conditions, their travelling history, age and gender has been taken.

Taking the information of a travelling history plays a crucial role to stop the spread of this epidemic disease. According to the health bulletin of Uttrakhand (India) State Control Room COVID-19, 84% of COVID-19 patients have travelling history that was detected in between 10th of May 2020 to 19th of May 2020. The detailed information during this period of time has been shown below,

Situation of Uttrakhand	10-05-2020	19-05-2020
Total positive cases	68	111
Total recovered cases	46	52
Total active cases	21	58
Total number of deaths	01	01
COVID-19 positive case detected	01	07
Doubling Rate for Uttarakhand	39 days	12 days
% Recovery for COVID-19 Patient	67.65%	50%

Source: Uttarakhand State Control Room COVID -19 Integrated Disease Surveillance Programme Directorates of Medical Health & Family Welfare, Uttarakhand, Dehradun, India.

On the basis of the daily health bulletin issued by Health and Family Welfare Department, there are 43 new COVID-19 cases have been detected during 2020-05-10 to 2020-05-19 [12]. Most of these cases have a travel history from Gurgaon, Mumbai, New Delhi, Surat and Amravati. Doubling rate and recovery rate have also been reduced during this period of time. Therefore to stop the spreading of this epidemic disease we have proposed a model that collects all the related information of each and every individual and on the basis of that it can identify high risk, low risk and average risk patients. The detailed information about the model has been described in following sections. The proposed method is described in section 2. In section 3, results and implementations have been shown. Finally, we draw some conclusion in section 4.

II. PROPOSED MODEL

In this method we utilize the ANN model with the help of grid computing. It is an information based model in which the information of the persons or patients has been collected with web information portal. The output of ANN model has been given by applying feed forward technique and on the basis of the output it has been categorized in high risk, low risk and in average risk patients. Fig (3) shows the flow chart of the proposed model and the detailed information about the model has been described below,

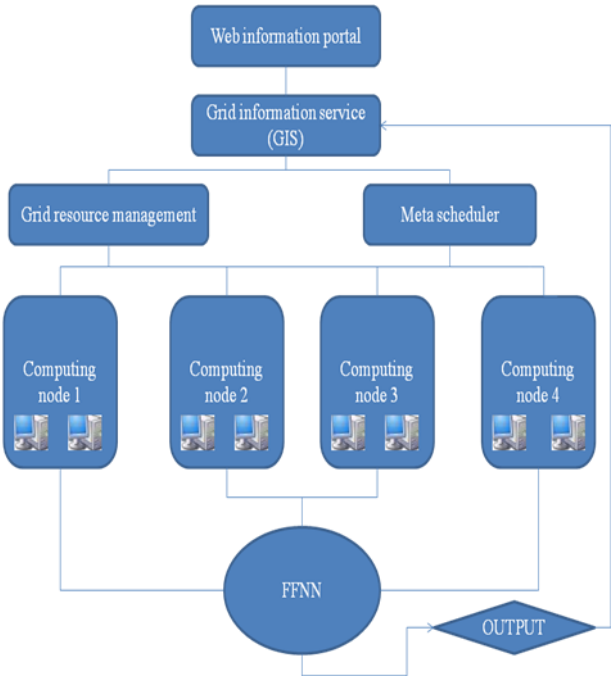


Fig.3. Flow chart of the Grid Neural Network (GNN) model

Web information portal

It is a specially designed website that brings information from different sources like emails, search engines and online forums. It is also known as a web portal and used to collect the information of an individuals or patients of that area where we are applying this model to detect the high risk patients that are affected with COVID-19. This portal generally collect the detailed information of the individuals such as- name, age, number of symptoms, number of diseases (mainly hypertension, cardiovascular disease, cancer) and information about their travelling history if they have any.

Grid information service (GIS)

It presents information service architecture on the basis of the data which is given by web information portal and sends this information to the grid resource management and Meta scheduler. GIS also categorize the patients at high risk, average risk and low risk categories on the basis of the output value.

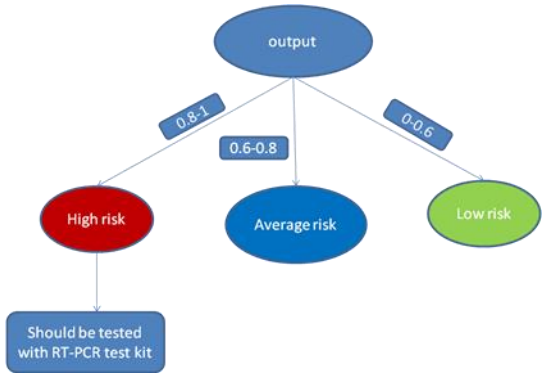


Fig.4. categorized the high, average and low risk patients on the basis of their output values

Grid resource management

It is used to run the application efficiently as possible and plays an important role in proposed model. It identifies the requirements and arranges the resources on the basis of data given by GIS.

Meta scheduler

It collects the information of the individuals and makes clusters of similar types which have same number of symptoms, diseases and travelling history and then schedule them to different types of computing nodes. The main aim of Meta scheduler is to optimize the computational workloads by combining and organizing multiple distributed resources in an integrated view [4].

Computing nodes

In computing nodes different type of grid clients are connected with each other to perform the FFNN method to generate the output.

FFNN method

FFNN method is generally a type of ANN model which is used to generate an output. It is a three layer neural network model.

The first layer is input layer, in which the value of input node is given as,

$$input\ value = 1 - \frac{1}{2 + number\ of\ symptoms}$$

Fever, cough, fatigue, shortness of breath, loss of smell, etc…are some major symptoms of COVID-19 [8, 14].

Symptoms	Number of patients
Fever	83-99%
loss of appetite	40-84%
fatigue	44-70%
loss of smell	15-30%
shortness of breathe	31-40%
cough	59-82%
coughing up sputum	28-33%
muscle ache and pain	11-35%

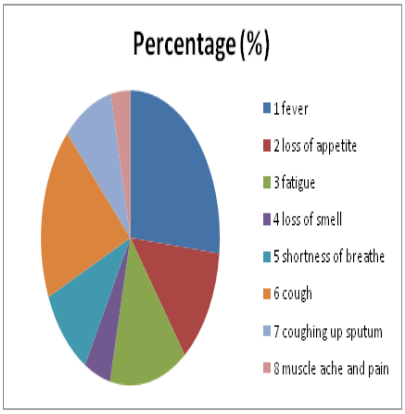


Fig.5. Data representation of Co-morbidities and symptoms of COVID-19 patients

In fact most of the people who are infected with COVID-19 have mild to moderate symptoms and some of them do not shows any of the symptoms which are known as asymptomatic patients that makes the situation even more complex. That's why to avoid this complexity we have used this input formula so that the value of input should always be greater than or equals to 0.5. The second layer is a hidden layer in which the hidden nodes represent some major diseases that can cause severe medical complications as it combines with the symptoms of COVID-19 patients. These medical complexities can increase the fatality rate. Some major diseases that increase the fatality rate are diabetes, hypertension and cardiovascular diseases [1, 6, 14, 23]. Many studies suggested that the covid 19 patients with hypertension, diabetes and cardiovascular disease increases the fatality rate or can make the situation more critical [6, 8, 23]. Table (1) shows the heath conditions of COVID-19 patients in China which were collected from different hospitals by different references.

Table.1. Characteristics of patients from different hospitals in China those are infected with SARS-CoV-2.

references	Number of patients	Hospitals	Health conditions		
			Cardiovascular diseases (%)	Hypertension (%)	Diabetes (%)
Guan et al. [9]	1099	552 hospitals in China	3.9	14.9	7.4
Wang et al. [24]	138	Zhongnan Hospital	19.6	31.2	10.1
Liu et al. [15]	137	9 tertiary hospitals in Hubei	7.3	9.5	10.2
Huang et al. [11]	41	Jinyintan Hospital	15	15	20

As we know that Italy is one of the most infected countries with COVID-19 and a study suggested that 76.1% patients in Italy who died had hypertension or diabetes or both and 33% of fatalities had heart disease [15, 18]. Hence these three conditions (cardiovascular disease, hypertension and diabetes) make the recovery of infected patients with COVID-19 more difficult and also cause lethal damage. Therefore we can say that the value of the degree of diseases varies with the symptoms of coronavirus and on the basis of that we have formulated the weighted value between input and hidden layer which has been described as,

$$w_{i,j} = \begin{cases} input + the\,\deg ree\,of\ disease; symptoms\ with\,disease\,and\,\deg ree \geq 0.6 \\ input - the\,\deg ree\,of\ disease; symptoms\ without\,disease\,and\,\deg ree \geq 0.6 \\ input - the\,\deg ree\,of\ disease\ ; no\ symptoms\ without\,disease\,and\,\deg ree \leq 0.4 \\ input + the\,\deg ree\,of\ disease; no\ symptoms\ with\,disease\,and\,\deg ree \leq 0.4 \end{cases}$$

The weighted value has been categorized into four different categories such as, symptoms with or without diseases and no symptoms with or without diseases. If the patients or any person shows a sign of any one symptom then the degree of disease should be in between 0.6 to 1 and if they do not show any of these symptoms then the degree should be less than 0.4. The selection of the range of degree (diseases) is heavily depends on some factors such as, symptoms, age, health condition and gender.

The final layer is an output layer in which the output is dependent on the information of the travelling history given by individuals in the forum. As we all knew that, the first case of COVID-19 has been come from china and then it spread among people who travelled across all over the world. It means that it spread people to people and to control this pandemic situation we have to know which person has travelling history. Therefore on the basis of the information given by people about their travelling history the weighted value between hidden and output layer is given below,

$$w_{i,j} = \begin{cases} output_{H(j)} + \geq 0.6; if\ the\ paitent\ has\,travelling\ history \\ output_{H(j)} - 0.1; if\ the\ paitent\ has\,no\,travelling\ history \end{cases}$$

$output_{H(j)}$ Represent the output comes from hidden node j.

Since those who have a travelling history is at high risk category because most of the cases who get positive result are those people who have a travelling history or do have contact with those people that have a history of travelling.

The value of bias for hidden and output layer is been given as,

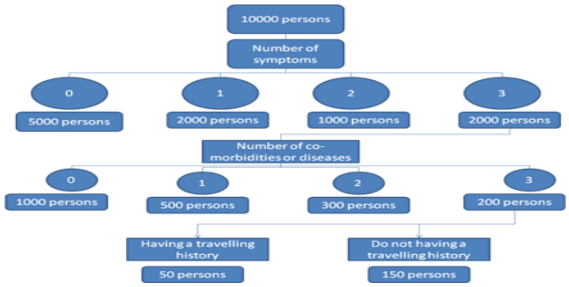
$$bias_H = \begin{Bmatrix} +0.5;\ for\ having\ any\ diseases \\ -0.5;\ for\ do\ not\ have\ any\ diseases \end{Bmatrix}$$

$$bias_O = \begin{Bmatrix} +0.5;\ for\ having\ travelling\ histroy \\ -0.5;\ for\ do\ not\ have\ any\ travelling\ histroy \end{Bmatrix}$$

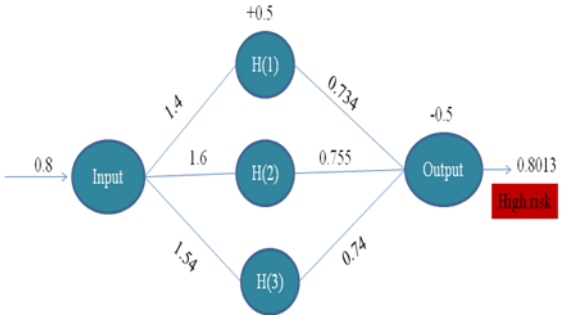
Where $bias_H$ and $bias_O$ represent the bias value for hidden and output layer respectively. In the next section we have tried to apply this method and to identify the high risk patients which have higher chances of getting affected with COVID-19.

III. RESULTS & IMPLEMENTATION

Example: let us take a city which has a population of 10000 and collected the information of peoples about their age, gender, health condition and travelling history through a web information portal.



In this example we have tried to identify the high risk persons with 3-symptoms and 3-diseases and no travelling history. These 3-symptoms are fever, cough and tiredness and the information about the diseases which we have asked to the people are hypertension, diabetes and cardiovascular diseases. The value of input node, weighted value and biased value are calculated according to the formula described above.



For 3-symptoms the value of input node is,

$$input\ value = 1 - \frac{1}{2+3} = 0.8$$

Now next step is to find the weight between input and hidden layer which depends on the input value and degree of diseases the person has. In this problem let us assume that the value of the degree of the diseases is 0.6, 0.8 and 0.74 respectively. These values can be different for different type of disease. Hence the weights between input and hidden nodes are 1.4, 1.6 and 1.54 respectively. Now let us apply sigmoid function to calculate output of hidden nodes,

$$H_1(out) = \frac{1}{1+e^{-(0.8\times1.4+0.5)}} = 0.8347,$$

$$H_2(out) = \frac{1}{1+e^{-(0.8\times1.6+0.5)}} = 0.855\ and$$

$$H_3(out) = \frac{1}{1+e^{-(0.8\times1.54+0.5)}} = 0.849$$

After then, find the weight between hidden layer and output layer according to the formula described above, hence we get 0.7347, 0.755 and 0.749 as weights. Again apply sigmoid function to calculate the final output,

$$final\ output = \frac{1}{1+e^{-(0.8347\times0.7347+0.855\times0.755+0.849\times0.749-0.5)}} = 0.80133,$$

Hence for 3-symptoms and 3-diseases with no travelling history the final output is 0.80133, which is a category of high risk. Hence these patients should be checked by RT-PCR test kit. Similarly, we have calculated the output for different number of symptoms and different values of the degree for different types of diseases, which was shown below by Table (2).

Table.2. Calculation of the output value on the basis of person's symptoms and co-morbidities by proposed method for categorizing the patients or individuals in low, average and high risk category

Number of symptoms	Number of diseases	Travelling history	Output
3	0	Yes	0.81-0.89
		No	0.44-0.47
	1	Yes	0.90-0.95
		No	0.57-0.60
	2	Yes	0.96-0.98
		No	0.69-0.72
	3	Yes	0.98-0.993
		No	0.79-0.83
2	0	Yes	0.8-0.879
		No	0.44-0.46

	1	Yes	0.906-0.95
		No	0.56-0.59
	2	Yes	0.95-0.98
		No	0.68-0.71
	3	Yes	0.98-0.992
		No	0.78-0.80
1	0	Yes	0.81-0.876
		No	0.436-0.45
	1	Yes	0.899-0.946
		No	0.548-0.5632
	2	Yes	0.926-0.9763
		No	0.655-0.6806
	3	Yes	0.9765-0.9905
		No	0.74-0.77
0	0	Yes	0.82-0.88
		No	0.45-0.48
	1	Yes	0.894-0.942
		No	0.5297-0.56
	2	Yes	0.93-0.9608
		No	0.5989-0.63197
	3	Yes	0.934-0.98199
		No	0.664-0.698

Therefore on the basis of these output values the individuals are categorized in low risk, average risk and high risk categories. Those patients who come in high risk categories should be tested with RT-PCR test and those comes in average risk categories must be quarantined according to the guidelines of respective countries. The patients with low risk category are safe but they should follow the rules suggested by government and hence in this way we can categorized the peoples in any city or district according to their health related information. On the basis of the result shown by Table (2), we can say that the persons or individuals having a travelling history are always at high risk and hence more careful action should be taken immediately for them.

IV. CONCLUSION

From the previous study, we knew that COVID-19 is increasing in those patients who have comorbidities that include hypertension, diabetes, and cardiovascular disease mainly. Hence we have to pay special attention to those patients who have these types of comorbidities. In this paper, we have proposed a grid neural network model that is helpful to categorize the people in high risk, average risk, and low-risk category based on their health condition, age, gender, and traveling history. The main aim of this study is to detect the suspected patients of COVID-19 in the least time. The detection of suspected patients accurately can help especially those countries who have a large population and cannot afford to test unnecessarily with such types of test kit like RT-PCR. On classifying the patients in high risk, low risk, and average risk can help to avoid the problem of shortening of these types of test kits. High-risk patients should be tested with RT-PCR test kit whereas the average-risk patients should be instructed to be quarantine. According to our model, the low-risk patients do not need to be worry but they have to take precautions as per the guidelines of the government. Therefore in this way, we can test only those patients with RT-PCR test kit who are at high risk of possibility to have infected with COVID-19 which will help to check all the needed patients at least time and could avoid the spreading of this coronavirus.

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