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ORIGINAL PAPER

Multilayer Neural Network Design for the Calculation of Risk Factor Associated with COVID-19

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Abstract
Coronavirus disease 2019 (COVID-19) is a public health emergency and is of international concern. Till now, there is no effective pharmaceutical treatment available for this disease. This paper presents a multilayer neural network algorithm to calculate the risk factor of getting COVID-19 to the individual based on the symptoms described by World Health Organization. The aim of this study is to provide an approximate risk factor of getting COVID-19 to an individual that helps for further treatment.

Keywords Artificial neural network · Feedforward NN · Multilayer neural network

Introduction

At present, the whole world is facing an outbreak of a new virus disease that is killing people more rapidly than any other chronic virus disease. World Health Organization (WHO) named it coronavirus disease 2019 (COVID-19) on January 10, 2020. The common symptoms of COVID-19 are fever, tiredness and dry cough. COVID-19 disease, like any other flu, is highly communicable and spreads from one person to another when a person comes in contact with an infected person. It also spreads when a person touches a surface or object that has the virus on it and then accidently touches their eyes, nose or mouth and rarely from facial contamination. This virus has affected not only society but also economics around the world, and it will permanently rephrase the living of world as it continues to unfold. A numerous number of people have been infected by this disease, and millions have been died in the world till now (https://www.int/health-topics/coronavirus2020). Scientists around the world are engaged in searching the medicines for the cure of this disease and vaccines to prevent individuals from getting COVID-19. We hope that scientist will be successful in making its effective vaccine in future [11, 12].

"Artificial neural network" is very connotative term. It is proposed that machines are similar to brain and likely laden with the science fiction connotative of the Frankenstein myths. One of the main features of artificial neural networks is that it has been vaguely inspired by the biological neural network that constitutes brain and nervous system. It is very useful in many branches like science, engineering, mathematics, etc. In neural network, the main objective is to do this in a nontechnical way as possible, while some mathematical notations are necessary for specifying certain rules, procedures and structures significant. A unique feature of artificial neural network is that its ability to establish empirical relationships between independent and dependent variables, and further extract important information and complex knowledge from representative datasets. Ability of this network is stored in the inter-unit weights, connection strengths acquired by the adaptive process, or learning from a set of training patterns [13].

Artificial neural network is generally used in statistical analysis and data modelling, where their role is to recognize as a substitute to standard nonlinear regression or cluster analysis techniques (Cheng and Herington 1994). Neural networks have been applied in diverse fields such as speech recognition, temporal character recognition, medical diagnosis, geological survey for oil, and financial

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market indicator predictive. Perhaps artificial neural network is a thought of simplified model of neurons that occur naturally in the animal brain. From the biological angle, the necessary requirement for the neural network is that it allows learning by example from representative data that describes a physical phenomenon or a decision process. For an engineering purpose, this correspondence is not necessary and it offers an alternative form of parallel computing. The straightforward artificial neuron is the threshold logic unit. Its basic operation is to perform a weighted sum of its inputs which comes under threshold logic unit and then gives output as "1," and if this sum exceeds a threshold logic unit, then it gives output as "0." Threshold logic unit is the basic model of Integrate-and-fire mechanism of actual neuron [13, 14].

Background Information

Artificial Neural Network Architecture

ANN neural network uses the processing of the brain as a basis to develop algorithm that can be used to model complex patterns and prediction of problems. A neural network is an accumulation of highly interconnected processing elements called neurons that have the capability to understand the problem and thereby knowledge being used by the network to solve that problem. A difficult task with ANN involves choosing the architecture parameter of the network. In a single layer network, there is only one layer of connection weight, where the units can be distinguished as input units, which receive signals from the outside world and there are output units from which the output of the network can be deliver.

A feedforward ANN with single layer is assumed in this research. In feedforward network, information flows from input units to the output units. A neural network may be viewed as a collection of communicating simple processing elements or units. These units are a serviceable abstraction of the neurons in the central nervous system. A unit is a simple processing element, connected to other units by its "weighted" (dendritic) connections, as shown in Fig. 1.

A unit collects weighted (w_1 to w_n) numerical information from other units (x_1 to x_n). This knowledge sometimes increased with time and is summed to the net input (y_in). The y_in is passed through an activation function F, resulting in the activation Ai of the unit. After the summed input has been passed through the activation function, the activation (A_i) is connected by other units that are connected to other units. Activation function can be (non) deterministic binary or (non) deterministic continuous. The activation function has been chosen according to the functionality required in the neural network. Neural network has two basic functions: First they can be trained to remember some information [7], and they can be used to perform constraint satisfaction and optimization task [4, 6]. Neural network being used as learning tools has demonstrated their ability to capture the relationship between variables that are usually difficult to relate each other analytically by learning, recalling and generalizing from training patterns as data. In other words, they are universal function approximations and are attractive for automatically learning of (nonlinear) functional relationship between the input and output variables.

Multilayer Neural Network (MLNN)

A multilayer neural net has more than one layers of nodes between the input units and the output units. Thus multilayer neural network possessing an input and output layer also has one or more intermediary layer called hidden layer. Between the two adjacent levels of neurons layer (input, hidden and output), there is a layer of connection weight which carries information in terms of synaptic weight. The input layers neurons are linked to the hidden layer neurons through synaptic weight, and the weights on these links are stated as input–hidden layer weights [9]. Also, the hidden layer neurons are linked to the output layer neurons, and the equivalent weights are stated as hidden–output layer weights. MLNN can solve complicated and difficult problems, which are very time taken or sometimes impossible to solve by using single layer networks.

As the number of input and output units are verbalized by the dimensionality of the input vectors and the number of classifications, respectively. The number of hidden layer is not simply related to such obvious properties of the classification problem. The number of hidden units depends of the complexity of the decision boundary [10]. If the patterns are well separated or linearly separable, then few hidden units are required. But if the patterns are drawn from complicated compactness that are highly interspersed, then more hidden units are required. A multilayer neural network with P input neurons, Q hidden layer neurons and R output neurons in the output layer is written as P–Q–R, as shown in Fig. 2.

Learning Methods

Setting the weights based on training patterns and desired output is the fundamental problem. The basic methodology used in learning the neural network is to start with an untrained network, present a training pattern to the input layer, pass the signals through the network and determine the output at the output layer. The weights cannot be initialized as zero, else learning cannot takes place. Therefore,

Fig. 1 The artificial neural network model

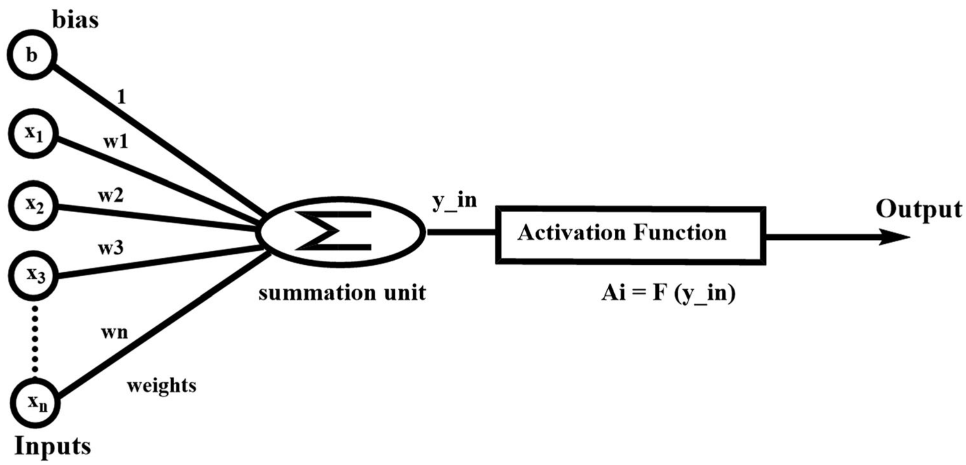
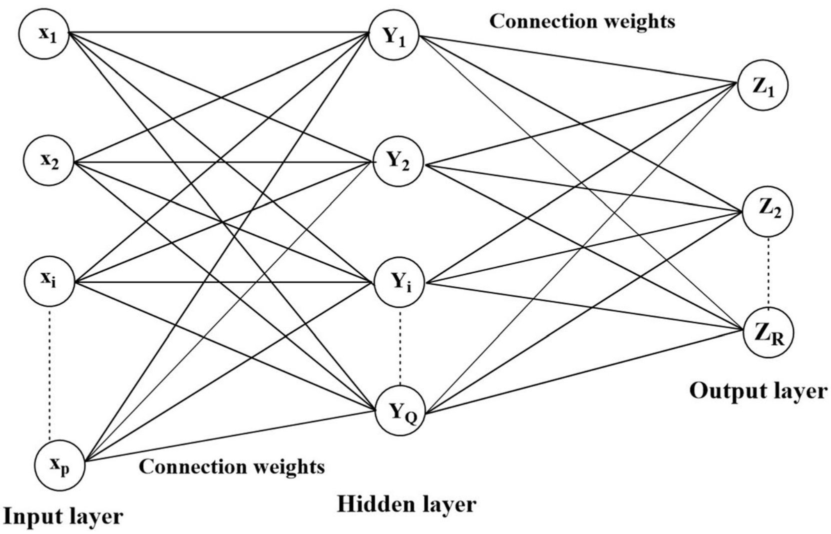


Fig. 2 Multilayer neural network architecture diagram



there is a need to confront the problem by selecting the starting/initial value. For setting weights in a given layer, there is a need to set weights randomly in a uniform distribution which helps in uniform learning. As data standardization gives positive and negative values equally, and on an average, there is also a need of positive and negative weights, hence weights were chosen from an uniform distribution $-w < w < (w + w)$ for some w that are yet to be determined. If w is set to too small, then the linear model will be implemented. Alternatively, if w is set too large, the hidden unit may saturate even before learning originates. Since net activation at a hidden unit (net_j) = ± 1 is the limits to its linear range, value of w *w*as set as such that the net activation at a hidden unit is in the range $0 <$ net_$j < +1$. The method of choosing the values of the weights (training) is an important individual characteristic of different neural networks. Supervised learning is used in this paper. In supervised learning process, every input pattern that is used to train the network is associated with a target or desired output vector. The weights are then adjusted according to the learning algorithm. A teacher is supposed to supervise during the entire learning process to determine the error, when a comparison is made between the network's computed output and the correct likely output. In this type of learning process, the output is binomial element, i.e., either 1 if the input vector belong to the class or 0 if the input vector does not belongs to the class. Multilayer neural networks can be trained to perform a non-linear mapping from an n-dimensional space of input vectors to an m-dimensional output space.

Formulation of the Problem

A novel human coronavirus, named as severe respiratory syndrome coronavirus subsequently named as SARS-COV-2, was first reported in Wuhan, China, in December 2019 [1, 2, 5]. COVID-19 is spreading rapidly throughout the world, almost in all developed and developing countries. The first case of COVID -19 was reported in INDIA on January 30, 2020. At present, the nucleic acid test (NAT) can be considered as the most reliable clinical method for the diagnosis of COVID-19. However, the first step for any nation to fight with this disease is to detect it. If doctors already know that the particular individual is at low or high risk of getting COVID -19, then it would be beneficial for them to treat that individual.

The aim of this MLNN model is to calculate the low or high risk factor of getting the disease to an individual on the basis of parameters described by the World Health Organization. Common signs and symptoms of COVID-19 infection include fever, coughing and shortness of breath. The virus that causes COVID-19 is mainly transmitted through microdroplets generated from an infected individual when they coughs, sneezes or exhales. When the person comes in contact with the infected person, then there is an urgent need for medical treatment. Hence, identification, tracing and elimination of factors that are responsible for the spreading COVID-19 are very much required [8].

Notations

Following notations are used in this paper.

ANN:	Artificial Neural network
MLNN:	Multilayer neural network
X_i:	Input neurons, i = 1, 2, 3,Input neurons…11
Y_i:	Hidden neurons, i = 1, 2, 3,…11.
Z_i :	Output neurons.
Y_{j_in}:	input values for the hidden neuron j, j = 1,2…11.
Y_k:	Net output from input neuron j, j = 1, 2, …11.
$z_{\_\text{in}}$:	Net input from hidden neuron.
$F(x)$:	Activation function.
W_{ij}:	Weights on connection links from neuron i to neuron j.
Exp:	Exponential function.

Description of Proposed Multilayer Neural Network (MLNN) Algorithm

This multilayer neural network-based algorithm is applied to get the high or low risk factor of getting COVID-19. For this, we take eleven basic symptoms as input variables for MLNN and three variables in hidden layer and one output variable. Sigmoid function is used as an activation function to determine the output value for the multilayer neural network (MLNN).

Defining various symptoms as input variable as

X_1 = Travel history.
X_2 = Contact history.
X_3 = Fever.
X_4 = difficulty in breathing.
X_5 = Sore throat.
X_6 = Fatigue.
X_7 = Cough.
X_8 = Diarrhea.
X_9 = Loss of senses of smell and taste.
X_{10} = Age.
X_{11} = Other clinical diseases.

Defining input values to above input variables as:

(i) Travel history	(a) travelling to green zone is set to 0.3
	(b) travelling to orange zone is set to 0.6
	(c) travelling to red zone is set to 0.9
	(d) no travelling with in 14–21 days is set to 0.01
(ii) Contact history	(a) recently contacted with COVID -19 patient is set to 1
	(b) Corona warrior is set to 0.5
	(c) none of the above is set to 0.01
(iii) Fever	(a) No fever is set to 0.01
	(b) 98-100F is set to 0.3
	(c) 100-102F is set to 0.6
	(d) 102-104F is set to 0.9
	(e) Above 104F is set to 1
(iv) Difficulty in breathing	(a) No difficulty is set to 0.01
	(b) Mild is set to 0.3
	(c) Moderate is set to 0.6
	(d) Severe is set to 1
(v) Sore throat	(a) No difficulty is set to 0.01
	(b) Mild is set to 0.3
	(c) Moderate is set to 0.6
	(d) Severe is set to 1
(vi) Fatigue	(a) No difficulty is set to 0.01
	(b) Moderate is set to 0.3
	(c) Severe is set to 0.7
(vii) Cough	(a) No cough is set to 0.01
	(b) Mild is set to 0.3
	(c) Moderate is set to 0.6
	(d) Severe is set to 1
(viii) Diarrhea	(a) yes is set to 0.5
	(b) No is set to 0.01
(ix) Loss of senses of smell and taste	(a) Yes is set to 0.7
	(b) No is set to 0.01
(x) Age	(a) Less than 10 years and above 50 years is set to 0.9
	(b) Age lies between 10 and 50 is set to 0.5
(xi) Other clinical diagnosis	High and low BP, diabetic, HIV positive, lung disease and kidney disorder are all set to 0.5 otherwise 0.01

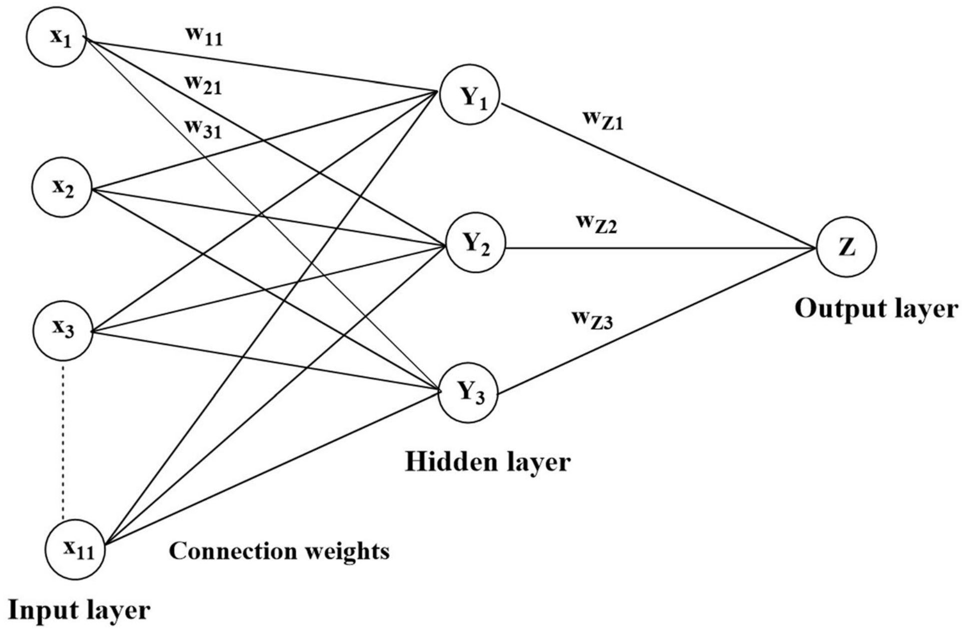


Fig. 3 Architecture diagram of proposed MLNN

Table 1 Details of the trained neural network

Type	Value/comment
Layer 1	11 neurons
Layer 2	3 neurons
Layer 3	1 neurons
Input values for input layer	Between 0 and 1
Weight on the connection links	Between 0 and 1
Function in hidden layer	Logistic sigmoid function
Function in output layer	Logistic sigmoid function

Proposed Multilayer Neural Network (MLNN) Architecture

All the information about the number of neurons in first, second and the third layer, values of the weights on the connection links and the function which are used in the hidden and output layer of the completely trained neural network is used in the present study (Fig. 3, Table 1).

Algorithm

The aim of multilayer neural network is to calculate the parameter that describes the high and low risk factor of COVID-19 for an individual.

Step 1: Give values to all input variables x_i for all $i = 1,2,\ldots,11$ accordingly as defined above.

Step 2: Compute the values of weights on the connection links of the hidden neuron as.

- For the first hidden neuron, divide each input value by 10.
- For the second hidden neuron, divide each input value by 100.
- For the third hidden neuron, divide each input value by 1000.

Step 3: Calculate the activation values of net input y_{j_in} for the first, second and third hidden neurons by using.

$y_{j_{-in}} = \sum_{i=1}^{11} x_i w_{ij}$.

Step 4: Calculate the output values y_k by using the following functions.

$Y_k = F(y_{\_in})$ $k = 1, 2, 3$.

where $F(x) = \frac{1}{1+\exp(-x)}$

Step 5: Input values for the output neurons are obtained by Y_K, $k = 1, 2,3$**.**

Step 6: Compute the value of weights on the connection links from hidden neurons to output neurons as:

$w_{z1} = y_1/10$, $w_{z2} = y_2/100$, $w_{z3} = y_3/1000$.

Step 7: Calculate the activation values of net input $Z_{\_in}$ for the output neuron by using

$Z_{\_in} = \sum_{i=1}^{3} y_{\,i} w_{iz}$.

Step 8: Compute the final output values Z_k by using the following function.

$Z_k = F(Z_{\_in})$.

where $F(x) = \frac{1}{1+\exp(-x)}$

Step 9: End.

Table 2 Details of data received from tricity

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
1	Chandigarh	Age lies between 11 and 50	Traveling to orange zone	I am a corona warrior	No	No	No	No	No	No	No	Lung disease
2	Chandigarh	Age lies between 11 and 50	Traveling to orange zone	I am a corona warrior	No	No	No	No	No	No	No	High blood pressure
3	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	Moderate	None of the above
4	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	Yes	No	No	None of the above
5	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
6	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
7	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
8	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
9	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
10	Mohali	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
11	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
12	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
13	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
14	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	Diabetic
15	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	Yes	No	No	High blood pressure
16	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
17	Chandigarh	Age lies between 11 and 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
18	Mohali	Age lies between 11 and 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
19	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
20	Chandigarh	Age lies between 11 and 50	Traveling to green zone	None of the above	No	Mild	Mild	Mild	Yes	No	No	Lung disease
21	Chandigarh	Age lies between 11 and 50	Traveling to orange zone	I am a corona warrior	No	No	No	No	No	No	No	None of the above
22	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	98-100F	No	Mild	No	No	No	Moderate	Low blood pressure
23	Chandigarh	Age lies between 11 and 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
24	Chandigarh	Age lies between 11 and 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
25	Chandigarh	Above 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
26	Chandigarh	Age lies between 11 and 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
27	Panchkula	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	Diabetic
28	Chandigarh	Age lies between 11 and 50	Traveling to orange zone	None of the above	No	No	Mild	Mild	No	No	No	None of the above
29	Chandigarh	Age lies between 11 and 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
30	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
31	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
32	Mohali	Age lies between 11 and 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
33	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	98-100F	No	No	Mild	No	No	No	None of the above
34	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	98-100F	No	No	Mild	No	No	No	None of the above
35	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
36	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
37	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
38	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
39	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
40	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	High blood pressure
41	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
42	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
43	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
44	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
45	Mohali	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	High blood pressure
46	Mohali	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
47	Chandigarh	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
48	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
49	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	Moderate	None of the above
50	Chandigarh	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
51	Mohali	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
52	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
53	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
54	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
55	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
56	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
57	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
58	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
59	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
60	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
61	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
62	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
63	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
64	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
65	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
66	Chandigarh	Age lies between 11—50	Traveling to red zone	None of the above	No	No	No	No	No	No	No	Low blood pressure
67	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
68	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	High blood pressure
69	Panchkula	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	Diabetic
70	Chandigarh	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
71	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
72	Mohali	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
73	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
74	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
75	Panchkula	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	Diabetic
76	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
77	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	Mild	Mild	No	No	Moderate	High blood pressure
78	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
79	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
80	Chandigarh	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
81	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
82	Chandigarh	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
83	Chaandigarh	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
84	Panchkula	Age lies between 11—50	None of the above	I am a corona warrior	No	No	No	No	No	No	No	None of the above
85	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	Low blood pressure
86	Mohali	Above 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
87	Mohali	Above 50	None of the above	None of the above	No	No	Mild	No	No	No	Moderate	High blood pressure
88	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	Low blood pressure
89	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
90	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
91	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
92	Mohali	Age lies between 11—50	Traveling to red zone	I am a corona warrior	98-100F	No	Mild	Mild	No	No	No	None of the above
93	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
94	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	Moderate	None of the above
95	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
96	Mohali	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	Moderate	None of the above
97	Panchkula	Age lies between 11 and 50	Traveling to orange zone	None of the above	No	No	No	Mild	No	No	No	None of the above
98	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
99	Panchkula	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
100	Chandigarh	Age lies between 11 and 50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
101	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
102	Panchkula	Above 50	None of the above	I am a corona warrior	No	No	No	No	No	No	No	Diabetic
103	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	98-100F	No	No	Mild	No	No	No	None of the above
104	Chandigarh	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
105	Panchkula	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
106	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	Moderate	None of the above
107	Chandigarh	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
108	Panchkula	Age lies between 11—50	None of the above	I am a corona warrior	No	No	No	No	No	No	No	None of the above
109	Panchkula	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
110	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
111	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
112	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	High blood pressure
113	Chandigarh	Age lies between 11—50	Traveling to green zone	None of the above	No	No	Mild	No	No	No	No	None of the above
114	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
115	Panchkula	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
116	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	Mild	No	No	No	None of the above
117	Panchkula	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
118	Chandigarh	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
119	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	Mild	No	No	No	Moderate	None of the above
120	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
121	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
122	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
123	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
124	Chandigarh	Age lies between 11—50	None of the above	None of the above	100-102F	No	No	No	No	No	No	None of the above
125	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
126	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
127	Chandigarh	Age lies between 11—50	Traveling to red zone	None of the above	No	No	No	No	No	No	No	None of the above
128	Chandigarh	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
129	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
130	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
131	Chandigarh	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
132	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No		No	None of the above
133	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
134	Mohali	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	High blood pressure
135	Chandigarh	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
136	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
137	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
138	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
139	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
140	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	Yes	No	No	None of the above
141	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	Mild	No	No	No	No	None of the above
142	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
143	Chandigarh	Age lies between 11—50	None of the above	I am a corona warrior	No	No	No	No	No	No	No	None of the above
144	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
145	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
146	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
147	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
148	Panchkula	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
149	Chandigarh	Above 50	None of the above	None of the above	98-100F	No	No	No	No	Yes	No	None of the above
150	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
151	Panchkula	Age lies between 11 and 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
152	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
153	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
154	Mohali	Age lies between 11—50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	None of the above
155	Chandigarh	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
156	Panchkula	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
157	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
158	Chandigarh	Age lies between 11—50	Traveling to red zone	None of the above	No	No	No	No	No	No	No	None of the above
159	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
160	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
161	Panchkula	Age lies between 11—50	Traveling to green zone	None of the above	No	No	No	No	No	No	No	None of the above
162	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
163	Mohali	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
164	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
165	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
166	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
167	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
168	Chandigarh	Above 50	Traveling to orange zone	None of the above	No	No	No	No	No	No	No	Diabetic
169	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
170	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	Mild	No	No	No	No	None of the above

Table 2 (continued)

S. no.	Where do you live	Age	Travel history	Contact history	Fever	Difficulty in breathing	Cough	Sore throat	Diarrhea	Loss of smell and taste	Fatigue	Other clinical disease
171	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
172	Chandigarh	Above 50	None of the above	None of the above	No	No	No	No	No	No	No	High blood pressure
173	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
174	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
175	Chandigarh	Above 50	None of the above	I am a corona warrior	No	No	No	No	No	No	No	High blood pressure
176	Chandigarh	Age lies between 11—50	None of the above	None of the above	No	Mild	Mild	Mild	No	No	No	None of the above
177	Chandigarh	Above 50	None of the above	I am a corona warrior	No	No	No	No	No	No	No	High blood pressure
178	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
179	Mohali	Age lies between 11—50	None of the above	None of the above	No	No	No	No	No	No	No	None of the above
180	Panchkula	Above 50	None of the above	I am a corona warrior	No	No	No	No	No	No	No	Diabetic

Study Area

India is a second most populous country and seventh largest country by area in the world. So far, the cases of COVID-19 pandemic are under control in comparison with USA, Italy, France, Iran, etc. Still, India needs to be more focus towards minimizing the cases and fight against COVID-19 pandemic. In the present research, three different cities, viz. Chandigarh, Panchkula and Mohali, were selected and approximately 180 peoples were randomly selected and were diagnosed on the basis of COVID-19 symptoms described by the World Health Organization. The proposed multilayer neural network model correctly gives everyone's results of high and low risk factor of COVID 19 (Table 2).

Results and Conclusion

The final output value of the output neuron lies between 0 and 1. The output neuron value can be categorized into two categories, i.e., one is low risk of getting COVID-19 and second is high risk of getting COVID-19. The minimum and maximum values of output neuron from artificial neural network are observed as 0.5070 and 0.5127, respectively. If the output value of the output neuron lies between 0.5070 and 0.5094, then it comes under low risk of COVID 19, and if it lies between 0.5095 and 0.5127, then it come under high risk of COVID 19. Based on some random samples, numerical calculations are shown in Table 3.

Table 3 shows that the output neuron values of randomly taken sample lie within the range and give approximately appropriate result. The study shows the applicability of multilayer neural network (MLNN) to real-world problem. The future directions of this study are to train the different networks based on neural network that will help to cure COVID-19.

Table 3 Details of numerical calculations

S.no	Input values x_i, $i = 1,2\ldots11$	Net input Y_{j_in}, $j = 1,2,3$	Hidden neuron input value Y_k, $k = 1,2,3$	Net input $Z_{\_in}$	Output neuron value(z)	Low/high risk of getting COVID-19
1	$X_i = 0.01$, $i = 1,2,..9$, $x_{10} = 0.5$, $x_{11} = 0.01$	$Y_{1\_in} = 0.0251$, $Y_{2\_in} = 0.00252$, $Y_{3\_in} = 0.000251$	$Y_1 = 0.50627$, $Y_2 = 0.50062$, $Y_3 = 0.500065$	0.02838	0.5070	Low risk
2	$X_i = 0.01$, $i = 1,2,..9$, $x_{10} = 0.9$, $x_{11} = 0.01$	$Y_{1\_in} = 0.0811$, $Y_{2\_in} = 0.00811$, $Y_{3\_in} = 0.000811$	$Y_1 = 0.5202$, $Y_2 = 0.5020$, $Y_3 = 0.5002$	0.02981	0.5074	Low risk
3	$X_i = 0.01$, $i = 1,2,..7$, $x_8 = 0.5$, $x_9 = 0.01$, $x_{10} = 0.9$, $x_{11} = 0.01$	$Y_{1\_in} = 0.10609$, $Y_{2\_in} = 0.010609$, $Y_{3\_in} = 0.0010609$	$Y_1 = 0.5265$, $Y_2 = 0.5026$, $Y_3 = 0.5002$	0.03049	0.5076	Low risk
4	$X_i = 0.01$, $i = 1,2,..7$, $x_8 = 0.5$, $x_9 = 0.7$, $x_{10} = 0.9$, $x_{11} = 0.01$	$Y_{1\_in} = 0.15508$, $Y_{2\_in} = 0.015508$, $Y_{3\_in} = 0.0015508$	$Y_1 = 0.5387$, $Y_2 = 0.5038$, $Y_3 = 0.5004$	0.03179	0.5079	Low risk
5	$X_i = 0.01$, $i = 1,2,..6$, $x_7 = 0.6$, $x_8 = 0.5$, $x_9 = 0.7$, $x_{10} = 0.9$, $x_{11} = 0.01$	$Y_{1\_in} = 0.19107$, $Y_{2\_in} = 0.019107$, $Y_{3\_in} = 0.0019107$	$Y_1 = 0.5476$, $Y_2 = 0.5047$, $Y_3 = 0.5005$	0.03277	0.5082	Low risk
6	$X_i = 0.01$, $i = 1,2,..5$, $x_6 = 0.3$, $x_7 = 0.6$, $x_8 = 0.5$, $x_9 = 0.7$, $x_{10} = 0.9$, $x_{11} = 0.5$	$Y_{1\_in} = 0.225$, $Y_{2\_in} = 0.0225$, $Y_{3\_in} = 0.00225$	$Y_1 = 0.5560$, $Y_2 = 0.5056$, $Y_3 = 0.5005$	0.0337	0.5084	Low risk
7	$X_i = 0.01$, $i = 1,2,..5$, $x_6 = 0.7$, $x_7 = 0.6$, $\mathrm{x}_8 = 0.5$, $x_9 = 0.7$, $\mathrm{x}_{10} = 0.9$, $\mathrm{x}_{11} = 0.5$	$Y_{1\_in} = 0.238$, $Y_{2\_in} = 0.0238$, $Y_{3\_in} = 0.00238$	$Y_1 = 0.5592$, $Y_2 = 0.5059$, $Y_3 = 0.5006$	0.0340	0.5085	Low risk
8	$X_i = 0.3$, $i = 1,3,4,5,6,7$, $x_2 = x_8 = x_{11} = 0.5$, $x_9 = 0.7$, $x_{10} = 0.9$	$Y_{1\_in} = 0.259$, $Y_{2\_in} = 0.0259$, $Y_{3\_in} = 0.00259$	$Y_1 = 0.5643$, $Y_2 = 0.5064$, $Y_3 = 0.5006$	0.03465	0.5086	Low risk
9	$X_1 = x_3 = x_4 = x_5 = x_7 = 0.3$, $x_2 = 1$, $x_6 = x_9 = 0.7$, $x_8 = x_{11} = 0.5$, $x_{10} = 0.9$	$Y_{1\_in} = 0.338$, $Y_{2\_in} = 0.0338$, $Y_{3\_in} = 0.00338$	$Y_1 = 0.5837$, $Y_2 = 0.5084$, $Y_3 = 0.5008$	0.03690	0.5092	Low risk
10	$X_1 = \mathrm{x}_3 = 0.9$, $x_2 = x_{10} = 0.5$, $x_4 = x_5 = x_7 = 0.6$, $x_6 = 0.3$, $x_8 = x_{11} = 0.01$, $x_9 = 0.7$	$Y_{1\_in} = 0.378$, $Y_{2\_in} = 0.0378$, $Y_{3\_in} = 0.00378$	$Y_1 = 0.5934$, $Y_2 = 0.5094$, $Y_3 = 0.5009$	0.03805	0.5095	High risk
11	$X_1 = x_3 = 0.9$, $x_2 = 1$, $x_4 = x_5 = x_7 = 0.6$, $x_6 = x_9 = 0.7$, $x_8 = x_{11} = 0.01$, $x_{10} = 0.5$	$Y_{1\_in} = 0.495$, $Y_{2\_in} = 0.0495$, $Y_{3\_in} = 0.00495$	$Y_1 = 0.6213$, $Y_2 = 0.5123$, $Y_3 = 0.5012$	0.04147	0.5103	High risk
12	$X_1 = x_3 = 0.9$, $x_2 = x_4 = x_5 = x_7 = 1$, $x_6 = 0.7$, $x_8 = x_9 = x_{11} = 0.01$, $x_{10} = 0.5$	$Y_{1\_in} = 0.636$, $Y_{2\_in} = 0.0636$, $Y_{3\_in} = 0.00636$	$Y_1 = 0.6538$, $Y_2 = 0.5159$, $Y_3 = 0.5015$	0.04565	0.5114	High risk
13	$X_1 = x_3 = 0.9$, $x_2 = x_4 = x_5 = x_7 = 1$, $x_6 = 0.7$, $x_8 = x_{11} = 0.01$, $x_9 = 0.7$, $x_{10} = 0.5$	$Y_{1\_in} = 0.685$, $Y_{2\_in} = 0.0685$, $Y_{3\_in} = 0.00685$	$Y_1 = 0.6648$, $Y_2 = 0.5171$, $Y_3 = 0.5017$	0.04711	0.5117	High risk
14	$X_1 = 0.9$, $x_2 = x_3 = x_4 = x_5 = x_7 = 1$, $x_6 = x_9 = 0.7$, $x_8 = x_{11} = 0.01$, $x_{10} = 0.5$	$Y_{1\_in} = 0.704$, $Y_{2\_in} = 0.0704$, $Y_{3\_in} = 0.00704$	$Y_1 = 0.6690$, $Y_2 = 0.5175$, $Y_3 = 0.5017$	0.04767	0.5119	High risk
15	$X_1 = x_{10} = 0.9$, $x_\mathrm{i} = 1$, $i = 2,3,4,5,7$. $X_6 = x_9 = 0.7$, $x_8 = x_{11} = 0.5$	$Y_{1\_in} = 0.81$, $Y_{2\_in} = 0.081$, $Y_{3\_in} = 0.0081$	$Y_1 = 0.6921$, $Y_2 = 0.5202$, $Y_3 = 0.5020$	0.05085	0.5127	High risk

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