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Application of New TOPSIS Approach to Identify the Most Significant Risk Factor and Continuous Monitoring of Death of COVID-19

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ABSTRACT

A pandemic is a disease that spreads across a large area like multiple continents or worldwide. More than 211 nations are already affected by Covid-19. The World Health Organization (WHO) on 11 March 2020 declared Covid-19 a pandemic. There are more than 1,282,931 cases of the coronavirus illness over 211 countries and territories around the world. Currently coronavirus has no proper treatment in Medical Science, increasing the number of affected people day by day with the number of cases worldwide of novel coronavirus surpassing 1,282,931, with some 72,616 deaths approximately. That is why the main objective of the present investigation is to identify the significant risk factor. Also, in this study we are continuously monitoring the spread of coronavirus. In this study we use a new TOPSIS MCDM approach and GMDH apply to select the significant risk factor and continuous monitoring of death due to Covid-19. Result indicates that “contamination due to contact with the infected person” is the main responsible factor behind the pandemic COVID-19. Also, in this investigation we get an optimal model by which we can monitor the death from Coronavirus within the affected person continuously.

Keywords: Coronavirus, risk factor, continuous death monitoring, new TOPSIS approach, GMDH

INTRODUCTION

In the world of 2020, where WHO has declared Covid-19 to be Pandemic (1), where there is chaos everywhere, people are quarantined, the times square is empty, and so are the other crowded places, where one can find anybody wearing a mask, and with a fear in their eyes–we are literally living through the pages of history books of the future days.

Coronavirus has horribly spread across the stretches of the world and too many people are suffering. It’s declared Pandemic by WHO as it is a disease that people are not immune to, spreading throughout the world beyond expectation. Almost 211 countries are suffering (2). More than 72,616 people across the world have lost their lives, and thousands of people are fighting everyday for their lives (2). Countries all over the world are declaring Health emergencies and taking whatever possible steps to keep the citizens safe (3).

As the virus is spreading beyond the borders of the countries, we try looking for any possible escape route. Medical Science is doing its best in the search of a possible solution. Doctors and medical staffs all over the world have truly proved themselves to be the unsung hero in this time of chaos by putting themselves in the front line, and by making sacrifices for the sake of humanity (4). So while being in the non–medical field, we still have tried to do our part by trying to contribute a little in the quest. Through the data we have collected do far from Literature surveys, Media websites and by taking medical suggestions, we have chosen three major cause of the spread of Covid-19. It’s mainly spreading through Verbal contamination, contamination through eatables, and contamination due to contact with the infected person. Since we know about quarantine , a situation where a person is asked to isolate or distant himself from crowded places in order to have a safe distance from everyone else, so that there is not contact between him and the outside world, we understand how Contamination through one person to another is taken seriously. Countries all over the world are declaring to keep the schools, colleges closed, to keep down the social gatherings, and suggesting to stay at home. This is very much important not only for others, and for ourselves as well. People are also asked to keep on wearing a mask, to wash their hands again and again. Here hygiene becomes an important thing. The risk factors are leading to panic among the people, creating more chaos as a result. So, our main object of this study to identify the most significant risk factors behind the spread of Coronavirus. Using Multi Criteria Decision Making (MCDM) technique we select that significant risk factor of COVID-19.

Multi Criteria Decision Making (MCDM) is most important branch of Operation Research by which people take their complex decision daily life. There are many MCDM tools are modelled by so many researchers. All this MCDM Models are based on behaviour of the decision-making problem. In MCDM process people select the best alternatives with respect to certain criteria. Recently this MCDM tools are used in Economical, Social, Environmental etc (5-7). In MCDM techniques some methods give priority value and some methods give rank of indicators.

One of the ranking based MCDM tool is Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) which is proposed by Hwang and Yoon in 1981 (8). The logic behind computational process is easy to understand. The main phase of this method is to find the minimum metric from the best-performing solution (the best case) and the maximum distance from each of the worst-performing solution (the worst case) (9). Factors have only a negative or positive side. The positive aspect of a factor is profit, and expense is the negative aspect. So, decision maker easily determines the ideal solution. In this way, identify the best value from positive ideal solution, and the worst value from negative ideal solution (10). The outcome value of these two metrics is conveyed in terms of a closeness coefficient, which is depends on the fact that the alternatives with a numerical value of a larger coefficient of attraction is known as the preferred alternative (10). This TOPSIS method has consisted eight stages (11).

From the previous discussion it is clear that, TOPSIS method is based on the concept of best alternatives should have the shortest distance and maximum distance (12). Shortest distance measured in TOPSIS by Euclidean distance (8). But Euclidean metric always does not give shortest distance between two points. Supremum metric always gives the better result from Euclidean distance in shortest distance in any dimensional problem. Theorem 1 represents that distance measure by Supremum metric is always less than equal to distance measure by Euclidean metric. In this theorem d_∞ and d denote Supremum and Euclidean metric respectively.

Theorem: Let $d_\infty, d: \mathbb{R}^n \times \mathbb{R}^n \longrightarrow R^+ \cup \{0\}$ define by $d(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$ and $d_\infty(x,y) = \max\{|x_i - y_i| : x_i, y_i \in \mathbb{R}\}$ then $d(x,y) \leq d_\infty(x,y)$ for all $x = (x_1, x_2, \dots, x_n)$ and $y = (y_1, yx_2, \dots, y_n)$ belongs to $\mathbb{R}^n$.

Proof: Let $x = (x_1, x_2, \dots, x_n)$ and $y = (y_1, yx_2, \dots, y_n)$ be two elements of $\mathbb{R}^n$.

Then $|x_i - y_i| = \sqrt{(x_i - y_i)^2}$ for all $x_i, y_i \in \mathbb{R}$

This implies $|x_i - y_i| \leq \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$ for all $x_i, y_i \in \mathbb{R}$

So $\max\{|x_i - y_i| : i = 1, 2, \dots, n\} \leq \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$

Hence $d(x,y) \leq d_\infty(x,y)$ for all $x, y \in \mathbb{R}^n$

Objective of the Present Study

This study consists of multiple objectives. The objectives of the present study are

(i) Identify the most significant risk factor of COVID-19. So, in this study we used new TOPSIS approach. Because in TOPSIS method shortest distance use to find the ideal solution measured by Euclidean distance ($d(x,y)$) (8). From the above theorem 1 it is clear that supremum or maximum distance ($d_\infty(x,y)$) always less than equal to Euclidean distance. So, in existing TOPSIS method we replace Euclidean distance by supremum distance for ideal solution. Also, since the greatest distance used for negative-ideal solution and supremum distance always give less than from Euclidean distance so for non-ideal solution used Euclidean distance.

(ii) In recent years, due to the Verbal contamination along with contamination through eatables, and contamination due to contact with the infected person the patient of Coronavirus increases day by day. But it has no Proper solution in Medical Science. So, death is also increasing. In the present study we are trying to predict the death of infected person. But in this study, we do not consider age of infected people because it has no proper treatment. Thus, in the current study, a new approach was made for the proposed of a continuous monitoring of death from confirmed case of Coronavirus by New TOPSIS approach and Group Method of Data Handling (GMDH) based predictive model.

(iii) Second object of this investigation is Compare the result of new approach of TOPSIS with existing TOPSIS method.

Scientific Benefits of the Study

The benefits of the proposed model have been covered by the objectivity and flexibility of the techniques. This new model depends on the method becomes more accurate and consistent compared to existing regression models. Since the weight given to the factors is absent in the new predictive model so death from infected cases of unbiased assessment of Coronavirus is possible.

Novelty of the Study

The novelties of the present investigation are

(i) First time supremum metric is used for ideal solution in TOPSIS method.

(ii) Second novelty is new TOPSIS approach applies for selection of most significant risk factor of COVID-19.

(iii) Continuous monitoring of death assessment of Coronavirus is another novelty of this investigation.

In the next section, data collection is discussed.

DATA COLLECTION

Data was collected from the website of World Health Organization (WHO) (13) and some Government report of different countries. **Table 1** shows the normalized data of confirmed and death case from 31-Dec-2019 to 05-Apr-2020. Next section describes new TOPSIS approach and GMDH. In this study data are normalized by formula of $\bar{z}_i = \frac{z_i}{\sum_{i=1}^{k} z_i}$, Where $z_i, \bar{z}_i$ and k denote the actual data, normalized data and total number of date respectively.

Table 1. Data of Total Confirmed and New Confirmed case from 31 December 2019 to 05 April 2020

Date	Total confirmed cases of COVID-19	Total confirmed deaths due to COVID-19
31-Dec-19	1.82E-06	0
01-Jan-20	1.82E-06	0
02-Jan-20	1.82E-06	0
03-Jan-20	2.97E-06	0
04-Jan-20	2.97E-06	0
05-Jan-20	3.98E-06	0
06-Jan-20	3.98E-06	0
07-Jan-20	3.98E-06	0
08-Jan-20	3.98E-06	0
09-Jan-20	3.98E-06	0
10-Jan-20	3.98E-06	0
11-Jan-20	3.98E-06	1.53E-06
12-Jan-20	3.98E-06	1.53E-06
13-Jan-20	4.05E-06	1.53E-06
14-Jan-20	4.05E-06	1.53E-06
15-Jan-20	4.12E-06	3.06E-06
16-Jan-20	4.12E-06	3.06E-06

Table 1 (continued). Data of Total Confirmed and New Confirmed case from 31 December 2019 to 05 April 2020

Date	Total confirmed cases of COVID-19	Total confirmed deaths due to COVID-19
17-Jan-20	4.46E-06	3.06E-06
18-Jan-20	5.6E-06	3.06E-06
19-Jan-20	1.48E-05	4.58E-06
20-Jan-20	1.61E-05	4.58E-06
21-Jan-20	2.65E-05	9.17E-06
22-Jan-20	3.61E-05	2.6E-05
23-Jan-20	4.26E-05	2.6E-05
24-Jan-20	6.06E-05	3.97E-05
25-Jan-20	9.12E-05	6.26E-05
26-Jan-20	0.000137	8.55E-05
27-Jan-20	0.00019	0.000124
28-Jan-20	0.00031	0.000162
29-Jan-20	0.00041	0.000202
30-Jan-20	0.000528	0.00026
31-Jan-20	0.000664	0.000325
01-Feb-20	0.000807	0.000396
02-Feb-20	0.000983	0.000466
03-Feb-20	0.001173	0.000553
04-Feb-20	0.001392	0.000652
05-Feb-20	0.001656	0.000753
06-Feb-20	0.001909	0.000863
07-Feb-20	0.002127	0.000975
08-Feb-20	0.002359	0.001106
09-Feb-20	0.002536	0.001242
10-Feb-20	0.002738	0.00139
11-Feb-20	0.002911	0.001555
12-Feb-20	0.003051	0.001703
13-Feb-20	0.004074	0.002093
14-Feb-20	0.004358	0.002113
15-Feb-20	0.004531	0.002333
16-Feb-20	0.004677	0.002549
17-Feb-20	0.004817	0.002711
18-Feb-20	0.004952	0.002861
19-Feb-20	0.005077	0.003073
20-Feb-20	0.005113	0.003251
21-Feb-20	0.005181	0.003432
22-Feb-20	0.005254	0.003603
23-Feb-20	0.005322	0.003762
24-Feb-20	0.005358	0.004001
25-Feb-20	0.005411	0.004121
26-Feb-20	0.005469	0.004219
27-Feb-20	0.005544	0.004277
28-Feb-20	0.005629	0.004364
29-Feb-20	0.005754	0.004462
01-Mar-20	0.005877	0.004551
02-Mar-20	0.006015	0.004653
03-Mar-20	0.006122	0.004763
04-Mar-20	0.006285	0.004891
05-Mar-20	0.006436	0.005013
06-Mar-20	0.006629	0.005171
07-Mar-20	0.006897	0.005328
08-Mar-20	0.007146	0.005476
09-Mar-20	0.007407	0.005826
10-Mar-20	0.007714	0.006145
11-Mar-20	0.008009	0.006556
12-Mar-20	0.008475	0.007054
13-Mar-20	0.009039	0.00759
14-Mar-20	0.009672	0.008259
15-Mar-20	0.010221	0.0088
16-Mar-20	0.011305	0.009938
17-Mar-20	0.012161	0.010849
18-Mar-20	0.013157	0.012054
19-Mar-20	0.014393	0.013507
20-Mar-20	0.016366	0.015097

Table 1 (continued). Data of Total Confirmed and New Confirmed case from 31 December 2019 to 05 April 2020

Date	Total confirmed cases of COVID-19	Total confirmed deaths due to COVID-19
21-Mar-20	0.018307	0.017183
22-Mar-20	0.020604	0.019765
23-Mar-20	0.022833	0.022301
24-Mar-20	0.02552	0.024995
25-Mar-20	0.028149	0.028356
26-Mar-20	0.031606	0.032062
27-Mar-20	0.035639	0.036157
28-Mar-20	0.039956	0.041225
29-Mar-20	0.044357	0.046512
30-Mar-20	0.048306	0.051286
31-Mar-20	0.052523	0.056933
01-Apr-20	0.057487	0.063981
02-Apr-20	0.062695	0.071616
03-Apr-20	0.067544	0.07869
04-Apr-20	0.073068	0.088813
05-Apr-20	0.079321	0.098374

METHOD USED

The main objective of the present study is to identify the most significant risk factor of Coronavirus. So in the present study we developed a new approach of TOPSIS MCDM. Also another aim of the present investigation is real time monitoring of spread of this virus. For continuous monitoring we use GMDH. In sub-section “New TOPSIS Approach” and “Group Method of Data Handling (GMDH)” describe the New TOPSIS Approach and GMDH.

New TOPSIS Approach

The main aim of this present study to develop an existing ranking based MCDM techniques. The existing MCDM technique is TOPSIS. Existing TOPSIS method, shortest distance is required to find ideal solution which is measured by Euclidean metric. But Euclidean metric between any two points always give greater than or equal to supremum metric. So, in the present study we replace Euclidean metric by supremum metric for ideal solution. The name of this new TOPSIS method is TOPSIS 1.

Metric space

Let X be a non-empty set and a mapping $d: X \times X \longrightarrow R^{+} \cup \{0\}$. Then the function d is a metric (or distance) on X if d satisfies following condition:

(i) Non-negativeness: Distance between any two points of X always non-negative

i.e., for every pair $(x, y) \in X \times X, d(x, y) \in R^{+} \cup \{0\}$

(ii) Identification: Distance between two points of X is vanishing if and only if that two points are equal.

i.e., $d(x, y) = 0$ iff $x - y = 0$, if $(x, y) \in X \times X$

(iii) Symmetry: If $x, y \in X$ then distance between x and y is equal to y and x.

i.e., for all $x, y \in X$ then $d(x, y) = d(y, x)$

(iv) Triangular inequality: Three points of X always satisfy triangular inequality under the function d.

i.e., $d(x, z) \leq d(x, y) + d(y, z)$ for all $x, y \in X$

Then the pair (X, d) is called metric space.

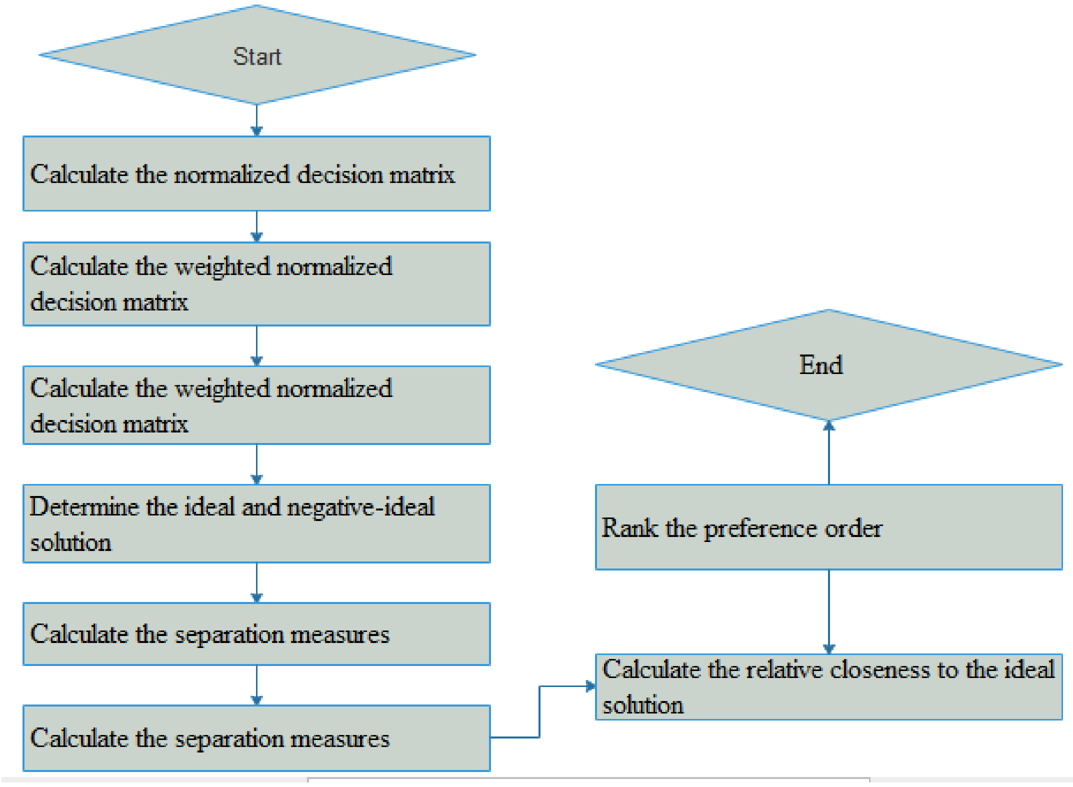

Figure 1. Flow char of TPSIS 1 method

Let $d: \mathbb{R}^n \times \mathbb{R}^n \longrightarrow R^+ \cup \{0\}$ define by $d(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$ where $x = (x_1, x_2, \ldots, x_n)$ and $y = (y_1, y_2, \ldots, y_n)$.

In the study (8) it was found that this d is a metric space. This metric is called Euclidean distance.

Also another function $d_\infty: \mathbb{R}^n \times \mathbb{R}^n \longrightarrow R^+ \cup \{0\}$ define by $d_\infty(x,y) = \max\{|x_i - y_i|: x_i, y_i \in \mathbb{R}\}$ where $x = (x_1, x_2, \ldots, x_n)$ and $y = (y_1, yx_2, \ldots, y_n)$.

Also d_∞ form a metric in $\mathbb{R}^n$. This metric is called supremum distance.

TOPSIS-I

There is only one difference between TOPSIS and TOPSIS-I. Here we only change the distance formula for ideal soluation. One of the multiple criteria approaches is Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) by which analyzing decisions for alternatives. The concept of TOPSIS is rational and understandable, and the computation involved is uncomplicated. Moreover, the inherent difficulty of assigning reliable subjective preferences to the criteria is worth noting (9). **Figure 1** represents the flow chart of TPSIS 1 method. TOPSIS-I decision making basically based on six impotent steps:

(i) Calculate the normalized decision matrix.

Consider the number of alternatives is m. Let normalized decision matrix $D = [r_{ij}]_{m \times m}$

The normalized value rij is defined by

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \forall\, i, j$$

(ii) Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as

$$v_{ij} = w_j r_{ij}, \forall\, i, j$$

Where w_j is the weight of the jth criterion, and $\sum_{i=1}^{n} w_j = 1$

(iii) Determine the ideal and negative-ideal solution:

$$A^+ = \{v_1^+, v_2^+, v_3^+, \ldots, v_m^+\} = \{(\max_i v_{ij} | j \in C_b), (\min_i v_{ij} | j \in C_c)\}$$

$$A^- = \{v_1^-, v_2^-, v_3^-, \ldots, v_m^-\} = \{(\min_i v_{ij} | j \in C_b), (\max_i v_{ij} | j \in C_c)\}$$

Where C_b is associated with benefit criteria and C_c is associated with cost criteria.

(iv) Calculate the separation measures, using the m dimensional supremum distance. In TOPSIS we calculate separation measures by Euclidean distance. The separation of each alternative and negative from the ideal solution is given as:

$$S_i^+ = \max\{|v_{ij} - v_j^+| : j = 1,2,\ldots,m\}, \forall\, i$$

$$S_i^- = \sqrt{\sum_{j=1}^{m}(v_{ij} - v_j^-)^2}, \forall\, i$$

(v) Calculate the relative closeness to the ideal solution: The relative closeness of the alternative A_i with respect to A^- is defined as

$$RC_i^* = \frac{S_i^-}{S_i^- + S_i^+}, \forall\, i$$

(vi) Rank the preference order. The index values of RC_i^* lie between 0 and 1. The larger index value means the closer to ideal solution for alternatives.

Group Method of Data Handling (GMDH)

The GMDH model is one of the learning machine approaches based on the polynomial theory of complex systems, designed by Ivakhnenko. From this network, the most significant input parameters, number of layers, number of neurons of middle layers, and optimal topology design of the network are defined automatically. Therefore, the GMDH network is a self-organized model of active neurons. The structure of the GMDH network is configured thorough the training stage with a polynomial model which produces the minimum error between the predicted value and observed output.

The neuro-fuzzy GMDH network is a very flexible algorithm, and can be hybridized easily by other iterative and evolutionary algorithms (14). The GMDH neural network is a self-organizing, unidirectional structure with multiple layers, each of which is composed of several neurons that have a similar structure. The selection of model criterion in line with the target of modelling and information division, GMDH will confirm the model automatically. If different forms of input units are used, this modelling mechanism will produce different types of models. This automatic modelling mechanism has been successfully applied to build Bayesian networks (15) and Mamdani-type fuzzy models (16).

The main purpose of the GMDH network is actually to construct a function in a feed-forward network on the basis of a second-degree transfer function. The number of layers and neurons within the hidden layers, the effective input variables and the optimal model structure are automatically determined in this algorithm. The mapping between the input and output variables done through a GMDH neural network is a nonlinear function called the Volterra series, in the form of equation (1). The Volterra series as a two-variable second-degree polynomial is analyzed using Equation (2).

$$\hat{y} = a_0 + \sum_{i=1}^{m} a_i x_i + \sum_{i=1}^{m}\sum_{j=1}^{m} a_{ij} x_i x_j + \sum_{i=1}^{m}\sum_{j=1}^{m}\sum_{k=1}^{m} x_j a_{ijk} x_i x_j x_k \quad (1)$$

$$G(x_i x_j) = a_0 + a_1 x_i + a_2 x_j + a_3 x_i^2 + a_1 x_j^2 + a_5 x_i x_j \quad (2)$$

The aim of the GMDH algorithm is to find the a_i unknown coefficients in the Volterra series. The $a_i$coefficients are solved with regression methods for each pair of $x_i a$ nd x_j input variables (17). On this basis, taking into consideration the principle of least squares error (18), the G function is defined as follows in equation (3):

$$E = \frac{\sum_{i=1}^{M} (y_i - G_i O)^2}{M} \quad (3)$$

Where $y_i = f(x_{i1}, x_{i2}, x_{i3}, \dots \dots x_{im}), i = 1,2,3, \dots., m$

The Artificial Neural Network (ANN) based model has three parameters which must be estimated properly to produce a reliable model for prediction. The parameters are the topology of the network, value of the weights of the connections and type of activation function. Generally, the trial and error method or some cognitive search algorithms like GA, PSO are used to find the optimal value of the parameters for which accurate prediction can be possible.

But the problem with this method is a sufficient amount of iterations along with many different algorithms are required to be applied to find the optimal configuration of the parameters. Thus, the amount of storage and sophistication needed to execute such algorithms often discourages its further application and reduces its acceptability as an alternative to conventional models for estimation of highly non-linear variables.

The PNN architecture which follows the GMDH algorithms are self-adaptive and can select the topology for which an optimal model can be developed from the given training data and a preselected fitness function which represents the accuracy of the model predictions. The algorithm also utilizes more than 100 algorithms to estimate the value of the weights of the connections. Here also a fitness function is utilized to adjudge the performance of the algorithms and with the best algorithm value of connection weights are predicted.

That is why a model which uses Polynomial Neural Network (PNN) instead of ANN required less storage and computational infrastructure in developing a model compared to ANN. Thus, this architecture was utilized in the present study to identify the interrelationship between the input and output index so that an automated framework can be developed to estimate location selection potential whenever and wherever a new alternative is identified.

GMDH comes with some drawbacks. First, it tends to generate quite complex polynomials even for relatively simple systems. Second, owing to its limited generic structure (that is quadratic two-variable polynomials), GMDH also tends to produce an overly complex network (model) when it comes to highly nonlinear systems. Third, if there are less than three input variables, GMDH algorithm does not generate a highly versatile structure.

ANN is a computational model composed of many processing elements connected by a variable weight. The networks have layers of parallel elements, known as neurons. The concept of ANN was first introduced in 1943, when Warren McCulloch, a neurophysiologist, and a young mathematician, Walter Pitts, wrote a paper on how neurons might work; they modelled a simple neural network with electrical circuits. In recent years, ANNs have been generally used in many areas, such as control, data compression, forecasting, optimization, pattern recognition, classification, speech and vision (19-22).

The objective function of the ANN model is described by equations (4) and (5).

$$h_m = f(w_n x_n + b_j) \quad (4)$$

$$y = g(\in_n h_n + b_k) \quad (5)$$

Where $w_n$is the weight,$x_n$is the input, $b_j$and $b_k$are the bias for the input-to-hidden layer and the hidden-to-output layer, respectively, h_n is the hidden layer, and $\in_n$ is the weight of the hidden layer. f and g are the activation functions applied in between the input and hidden layers and the hidden and output layers, respectively.

The accuracy of the ANN model depends upon three parameters. The number of hidden layers, the value of the weights, and the type of activation function applied in the Input-Hidden and the Hidden-Output layers. Generally, the trial-and-error method is used to estimate these parameters. However, in recent years, search algorithms such as GA, PSO (23), etc., are applied to identify the value of the parameters for which the optimal accuracy from the ANN model can be achieved. In the next section, methodology of our study is described.

METHODOLOGY

The main objective of this present study is identifying the most significant risk factor of spread of COVID-19.

Let E (see in equation 6) denote the risk of spread of COVID-19.

$$E = f(D, W) \quad (6)$$

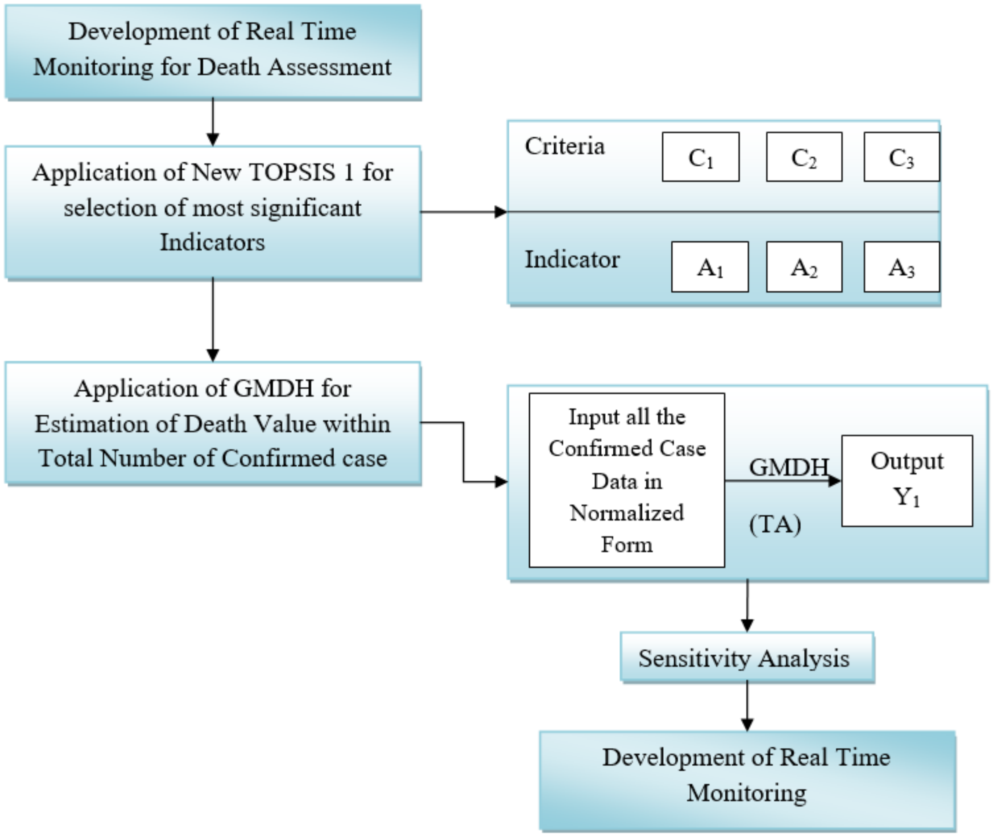

Figure 2. Schematic diagram of the methodology adopted in the present study for estimation sigma index (TA indicates training algorithm. All other abbreviation used in the figure is explained in the text of the paper)

Where D represents the set of collection of all factors of E and W denote the set of priority value of corresponding each factors of D.

$$D = \{m: m = all\ selected\ factors\}$$

and $W = \{w: w = weights\ all\ selected\ factors\}$

Where m and w represents the selected parameter and its priority value (PV) respectively.

In this present study methodology divided into five pats namely selection of criteria, selection of alternatives, application of TOPSIS 1 method, Application of GMDH and sensitivity analysis, all this subsection discuss according as in the sub-sections "Selection of Criteria", "Selection of Alternatives", "Application of TOPSIS 1 Method", "Application of GMDH" and "Sensitivity Analysis." **Figure 2** shows the Schematic diagram of the methodology

Selection of Criteria

In this present study criteria are selected Literature review, Expert Survey and Media Survey. We studied nearly 40 papers for select the all the risk factors of spread of Coronavirus. In literature it is clearly indicate that why each selected factors are responsible for spread of Coronavirus. So, in this study we select Literature review as important criteria for select the alternatives.

Since our objective is medical issue so in this study experts takes an important role. In this study expert are selects some assistant professor, associate professor and professor of some reputed medical college as well as we take opinion some doctors who are engaged with hospital. Approximately we take nearly 12 experts' opinions for select the risk factors of COVID-19.

Media survey is another important criterion to select the factors because they always trying to collect the information about Coronavirus. In this study we use the report of 5 reputed Media for selecting the risk factors.

Let m is a parameter which is select using equation (7) and (8)

$$m = select, if\ n(m) > \left[\frac{p}{2}\right] \quad (7)$$

$$m = not\ select, if\ n(m) \leq \left[\frac{p}{2}\right] \quad (8)$$

Where $n(m)$ represents the number of literature and p represents the total number of sources. And $[x]$ represents the greatest integer less than equals to x.

Selection of Alternatives

At the second phase of the current procedure, the alternatives selected as indicators that spread Coronavirus. These factors selected by the review of relevant literature followed by selection by a group of experts and Media survey. According to the survey we get Verbal contamination, Contamination due to eatables and contamination due to contact with the infected person are three risk factors of this virus. In this study all these indicators are selected by literature review, expert survey and Media survey. So, in this present study literature review, expert survey and relative of peasant opinions are consider as criteria and denoted by C_1, C_2 and C_3 respectively. In **Table 2** describe all the risk factors of Coronavirus. **Figure 3** shows decision hierarchy Structure of our decision problem.

Table 2. Description of Selected Factors

Name of Factors	Description	Reference
Verbal contamination (A_1)	When two people are talking, or if someone sneezes, there are chances that the virus may spread. And thus, comes the idea of wearing a mask. The infected / suspected person is specifically asked to keep on the mask.	(2,24)
Contamination due to eatables (A_2)	It is said the cold food items, beverages, or ice-cream is to be avoided as the colder temperature allows the virus to work. With a warmer condition, the virus is unable to do affect much.	(2,24)
Contamination due to contact with the infected person (A_3)	With contact with the infected person there is a high chance of spreading of the virus. That's why people are asked to keep safe distances, wash hand often and, for the best, to stay at home.	(2,25,26)

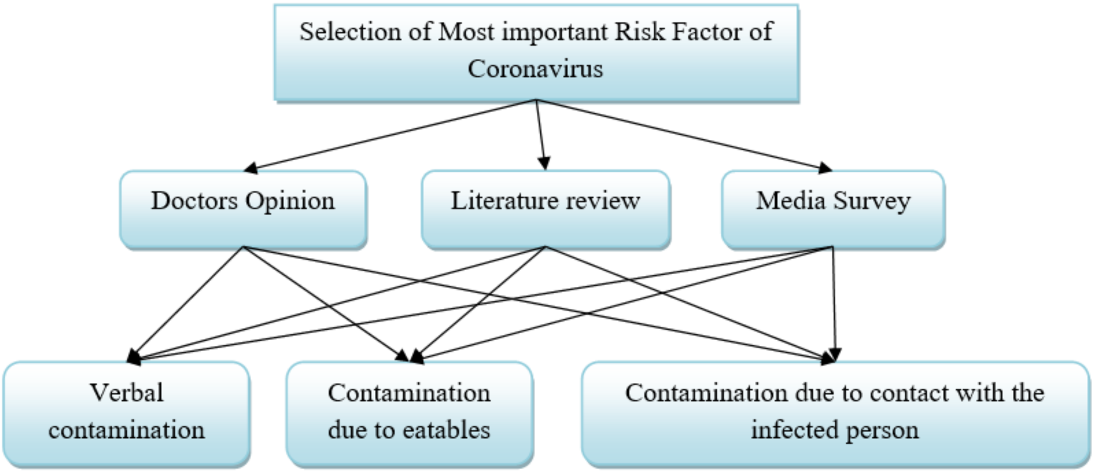

Figure 3. Decision hierarchy Structure

Table 3. 5-point scale

Name	Score
Low (L)	1
Below Average (BA)	2
Average (A)	3
Good (G)	4
Excellent (E)	5

Table 4. Score table of alternatives with respect to criteria

Alternatives	Criteria		
	C_1	C_2	C_3
A_1	G	E	G
A_2	BA	A	L
A_3	E	G	G

Application of TOPSIS 1 Method

In TOPSIS 1 method first find the priority value (PV) of each criterion by any MCDM method. In this study we use Fuzzy AHP MCDM for find the PV of each criteria. Then use TOPSIS 3 MCDM techniques. In this study 5-point scales used for giving relative score. **Table 3** represents 5-point scale. In this study relative score of each parameter with respect to each criterion is selected by literature review, expert survey and Media survey. **Table 4** represents the relative score with the help of 5-point scale.

Table 5. Score table of alternatives with the help of 5-point scale

Alternatives	Criteria		
	C_1	C_2	C_3
A_1	x_{11} =4	x_{12} =5	x_{13} =4
A_2	x_{21} =2	x_{22} =3	x_{23} =1
A_3	x_{31} =5	x_{32} =4	x_{33} =4
$\sqrt{\sum_{i=1}^{3} x_{ij}^2}$	6.708203932	7.071067812	5.744563

Using 5-point scale **Table 4** convert as a score and score table represented by **Table 5**.

All this column vectors of **Table 5** represented by the formula (9). After calculating we get the normalized decision matrix represent in **Table 6**. In **Table 6** column two represents the PV of each criteria, determined by AHP method.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{4} x_{ij}^2}}, \forall\ i = 1,2,3, j = 1,2,3 \quad (9)$$

Using the formula 9 calculate weighted normalized decision matrix from **Table 6**. **Table 7** represents the weighted normalized decision matrix. Determine the ideal A^+ and negative-ideal A^- solution using the formula according as (11) and (12). Last two column of **Table 5** represents the A^+ and A^- value.

Table 6. Normalized Decision Matrix

	Priority value of each Criteria		
	$w_1 = 0.561185468$	$w_2 = 0.2900234737$	$w_3 = 0.1487910579$
Alternatives	C_1	C_2	C_3
A_1	$r_{11} = 0.59628479$	$r_{12} = 0.70710678$	$r_{13} = 0.69631062$
A_2	$r_{21} = 0.2981424$	$r_{22} = 0.42426407$	$r_{23} = 0.17407766$
A_3	$r_{31} = 0.74535599$	$r_{32} = 0.56568542$	$r_{33} = 0.69631062$

Table 7. Weighted Normalized Decision Matrix

Alternatives	Criteria		
	C_1(B)	C_2(B)	C_3(B)
A_1	v_{11} =0.33462636	v_{12} =0.20507756	v_{13} =0.10360479
A_2	v_{21} =0.16731318	v_{22} =0.12304654	v_{23} =0.0259012
A_3	v_{31} =0.41828295	v_{32} =0.16406205	v_{33} =0.10360479
A^+	v_1^+ = 0.41828295	v_2^+ = 0.20507756	v_3^+ = 0.10360479
A^-	v_1^- = 0.16731318	v_2^- = 0.12304654	v_3^- = 0.0259012

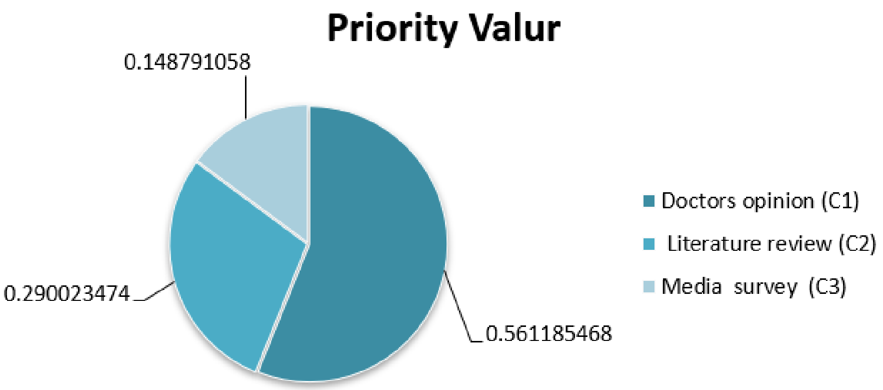

Figure 4. Result of Criteria from Fuzzy AHP

$$v_{ij} = w_j r_{ij}, \forall\ i = 1,2,3, j = 1,2,3. \quad (10)$$

$$A^+ = \{v_1^+, v_2^+, v_3^+, \dots, v_m^+\} = \{(\max_i v_{ij} | j \in C_b)\} \quad (11)$$

$$A^- = \{v_1^-, v_2^-, v_3^-, \dots, v_m^-\} = \{(\min_i v_{ij} | j \in C_b)\} \quad (12)$$

Application of GMDH

GMDH model has been widely used to elevate the short comings of the conventional algorithms to deal with complex problems. A GMDH model is based on input and corresponding output data information. The model is developed to predict the death assessment which is proved to be helpful in the continuous monitoring of coronavirus affected peoples' death. By the use of some newly formed equations new set of independent observations are generated which will be successively very helpful.

Sensitivity Analysis

A sensitivity analysis is a mathematical formula that is used in financial modeling to calculate whether a target variable is influenced by other variables, called input variables. This study used sensitivity analysis to validate its model. The sensitivity analysis was performed with the help of a multiple input, one output, tornado method that was developed by SensIt Limited. The ranges for the input variables varied between 0 and 1. The impact of each input was then obtained on the outputs observed, and the results were compared with the weights of the variables found from the new MCDM approach. In the next section, results are discussed.

RESULT AND DISCUSSION

In this section we discuss about our findings. These section divide into three sub-section namely result from TOPSIS 1, result from TOPSIS, result from GMDH and result from sensitivity analysis and all this sub-section described in the section "Result from Fuzzy AHP and Fuzzy ANP", "Result from TOPSIS", "Result from GMDH" and "Result from Sensitivity Analysis" respectively. In the section "Result from Fuzzy AHP and Fuzzy ANP" discuss about the result of most significant risk factor by TOPSIS 1. Next compare the result of TOPSIS 1 with TOPSIS (in section "Result from TOPSIS"). An optimal network is found in section "Result from GMDH" using GMDH by which we predict spread of Coronavirus. In the last section "Result from Sensitivity Analysis" tests the sensitive parameter of three considers parameters for validate our result.

Result from Fuzzy AHP and Fuzzy ANP

In the present we consider three factors as criteria namely Doctors opinion (C_1), Literature review (C_2) and Media survey (C_3). Verbal contamination, Contamination due to eatables and contamination due to contact with the infected person are consider as alternatives and denoted by A_1, A_2 and A_3 respectively. After selection of factors then we select the most important risk factor using Fuzzy AHP for find the PV of criteria. According to the result it is clear that PV of doctors opinion (see in **Figure 4**) is greater than remaining two criteria. Using Fuzzy AHP result in TOPSIS 1 for selecting the most significant risk factor of spread of COVID-19. In TOPSIS 1 method S_i^+ and S_i^- are calculated supremum distance from **Table 5** using the formula according as (13) and (14). Final aggregation is calculating from RC_i^* using formula (15). **Table 8** showing all the results of S_i^+, S_i^- and RC_i^*. According to the results it was found that contamination due to contact with the infected person is the significant risk factor of spread of COVID-19.

$$S_i^+ = max\{|v_{ij} - v_j^+| : j = 1,2,3\}, \forall\ i = 1,2,3,4 \quad (13)$$

$$S_i^- = \sqrt{\sum_{j=1}^{3} (v_{ij} - v_j^-)^2}, \forall\ i = 1,2,3,4 \quad (14)$$

$$RC_i^* = \frac{S_i^-}{S_i^- + S_i^+}, \forall\ i = 1,2,3,4 \quad (15)$$

Table 8. RC* value for TOPSIS 1

	S_i^+	S_i^-	RC_i^*
A_1	0.08365659	0.16731318	0.66667
A_2	0.25096977	0	0
A_3	0.04101551	0.25096977	0.85953

Table 9. RC* value for TOPSIS

	S_i^+	S_i^-	RC_i^*
A1	0.08365659	0.20189264	0.70703269
A2	0.2752322	0	0
A3	0.04101551	0.2659059	0.86636477

Result from TOPSIS

In the TOPSIS method S_i^+ and S_i^- are calculated Euclidean distance from **Table 7**. Final aggregation is calculated (i.e., RC* value) using formula (14). According to the result it is found that TOPSIS and TOPSIS 1 give same raking of each indicator. **Table 9** represents all the results of S_i^+, S_i^- and RC_i^* Also **Table 10** represents the RC* value error between TOPSIS and TOPSIS 1. To find this error TOPSIS RC* value consider truth value or exact value because TOPSIS method already exist but TOPSIS 1 method is totally new approach so RC* value of TOPSIS 1 consider as approximate value. In this study we calculate absolute and relative error.

Table 10. Error estimation between RC* value between TOSIS and TOPSIS 1

Alternative	Absolute Error	Relative error
A1	0.040366023	0.057092159
A2	0	Does not Exist
A3	0.006835937	0.007890368

Result from GMDH

The GMDH model was deliberately used to minimize the error and to maximize the performance. Moreover, now a day the Neuro genetic models play a greater role in the field of research and study because of their simplicity. Here we have used the very basic equation (15) got from the artificial neural network. **Figure 5** shows the comparison between observed and predicted output, **Figure 6** depicts Residual, **Figure 7** depicts autocorrelation and **Figure 8** shows number of

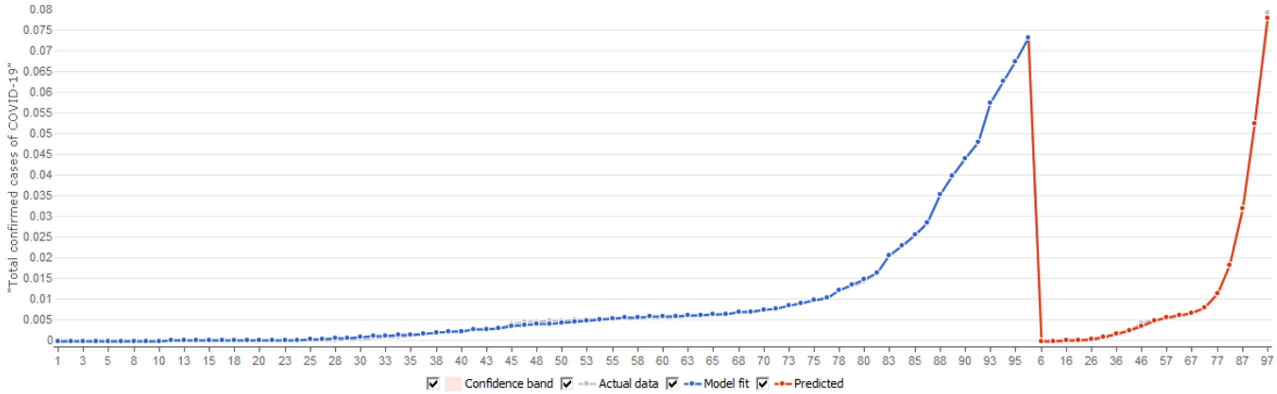

Figure 5. The comparison between observed and predicted output for model

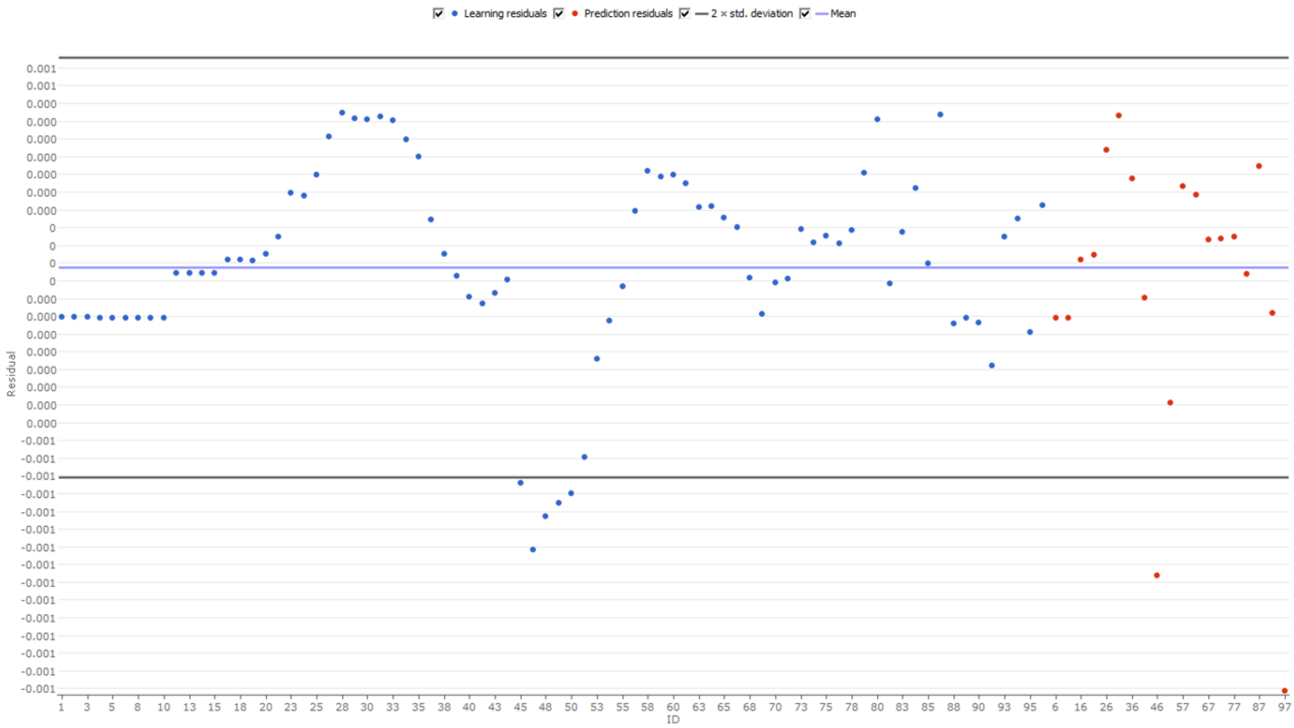

Figure 6. Residual of the proposed model

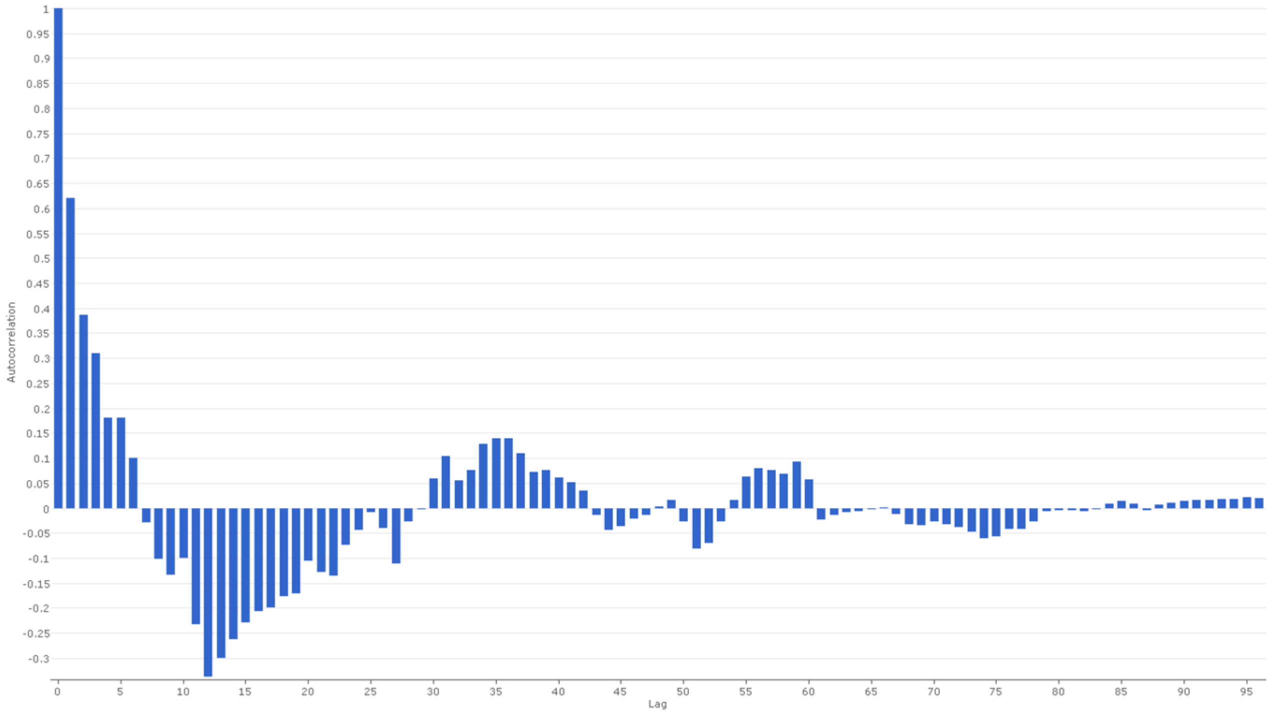

Figure 7. Autocorrelation of the proposed model

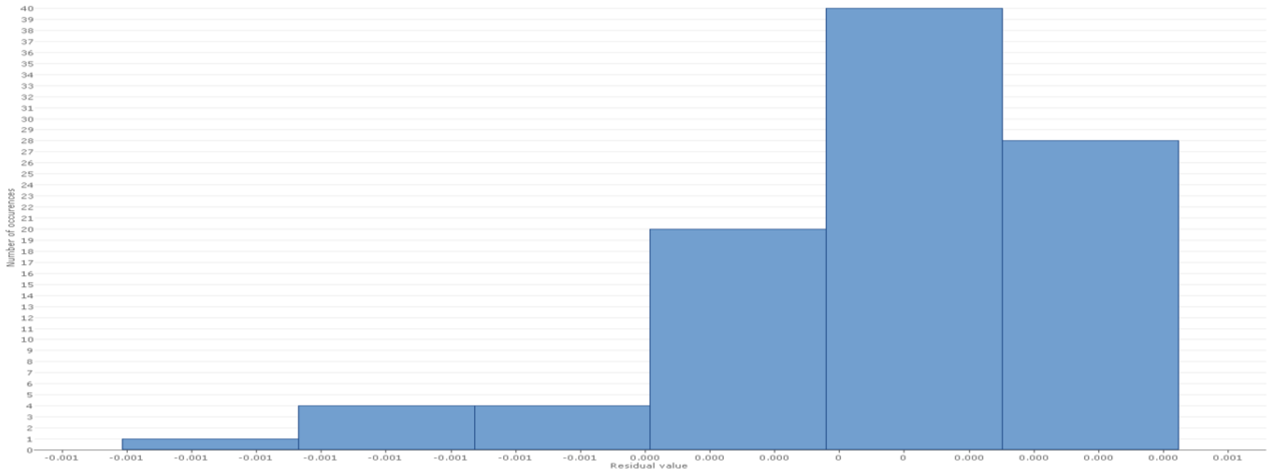

Figure 8. Number of Occurrence of the proposed model

Table 11. Absolutely Error Measure

Postprocessed result	Model fit	Predictions
Number of observations	46	11
Max. Negative error	– 0.00206202	– 0.00161798
Max. Positive error	0.00337702	0.00123025
Mean absolute error (MAE)	0.000860548	0.000864668
Root mean square error (RMSE)	0.00115513	0.00101318
Residual sum	2.68882E-16	– 0.00466756
Standard deviation residuals	0.00115513	0.000920044
Coefficient of determination (R^2)	0.993606	0.996731
Correlation	0.996798	0.998899

occurence of the proposed model. **Table 11** shows absolutely Error Measurement of developed model.

$$Y1 = -5.34102e - 15 + N4 * 0.510204 + N3 * 0.489796 \quad (15)$$

Where, N3 = -1.03536e-14 + N4*1

N4=-0.000699931 + x1*7.74316 - x1*"x1,cubert"*14.2998 + x1^2*24.9147 + "x1,cubert"*0.0586169 - "x1,cubert"^2*1.12926

Here x_1 denote the data of confirmed affected case in coronavirus.

Result from Sensitivity Analysis

The sensitivity analysis was conveyed to access the sensitivity of the model with respectto its input indicators. If the priority value of the indicators be coherent with the sensitivity of the indicators used as the input to the model in the present study, then the validation of the results will be established. According to the results, the contamination due to contact with the infected person was found to have a Swing^2 value of 43.7% whereas Contamination due to eatables was found to have a Swing^2 value of 18.4%. Thus, the contamination due to contact with the infected person was rated the most sensitive parameter and Contamination due to eatables the second most sensitive parameter.

Figure 9. Result of Sensitivity Analysis

The two parameters found out to be most sensitive were also found to be the two most significant parameters having the highest PV values. This indicates that these two parameters have similar sensitivity and PV which supports the selection of alternatives. It can also be concluded that from the MCDM technique, the most sensitive indicator and the least sensitive indicator has highest and lowest PV values. **Figure 9** depicts the result of sensitivity analysis.

CONCLUSION

The present investigation has attempted to develop a new model for evaluation of the risk assessment of Coronavirus with the help of TOPSIS 1 and GMDH methods. The advantage of this new model will be it can objectively and cognitively analyze the spread of Coronavirus. By Doctors opinion, Literature review and Media Survey we select three risk factors of Coronavirus namely Verbal contamination, contamination through eatables, and contamination due to contact with the infected person. After collection of all factors we apply Fuzzy AHP for finding the PV of criteria. Using the PV of criteria apply TOPSIS 1 for find the best alternative. Result of TOPSIS 1 indicate that contamination due to contact with the infected person is the most significant alternative of spread of Coronavirus. Some literatures and reports also support our findings (2,25,26). Next, we find an optimal network by which continuously monitoring the death from Coronavirus of infected person. In feature this TOPSIS 1 apply in energy study, manage problem and several decision-making problem. Also, these new methods apply in fuzzy environment.

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