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Applications of ML/DL for Predicting Epidemic Outbreaks

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Abstract

Officials around the world are using many COVID-19 outbreak prediction models to make intelligent conclusions and implement applicable precautions. Easy epidemiological and statistical models are among the typical prototypes for COVID-19 worldwide pandemic forecasting. Authorities have paid more attention to them, and they are well known in the media. Thus, a high-level mathematical framework has low deep predictive performance due to speculation and insufficient data. Existing models are not generally sufficient in addressing the problem; they ought to be developed further and their accuracy and generality increased. In this article, two deep learning techniques, referred are contrasted with a previous soft method in order to evaluate their performance in predicting a new technology, the "co-variate" and sensitive effect" and "imputed residual incident rate" versions. Out of the multi-level perception models (MLP) and the numerous models researched, only two (complex neural and adaptive particle swarm optimization) highlights the potential. Based on the findings presented here, because of the COVID-19 outbreak's highly dynamic existence and wide range of actions. This study indicates that machine learning can be used to model the outbreak from country to country. This paper serves as an initial benchmarking exercise to show how machine learning can be used in future research. The paper also suggests that by combining machine learning and SEIR models, true novelty in outbreak prediction can be realised.

Introduction

In the last decade, diseases caused by previously unknown threats have emerged, as well as the unexpected introduction of established diseases in new environments. Therefore, for the moment, people must proceed to pay thousands of dollars and risk their lives with contagious diseases [1]. Prohibiting the transmission of contagious diseases is especially becoming even more important during the early stages of an outbreak [2]. It has been argued that computerized monitoring systems, that identify infectious diseases on the efficient manner, are one way to quickly address security maladies. Some outbreaks of disease and risks can be detected using a number of different approaches in surveillance. Even when applied to different types of data or to which situation, the effectiveness of algorithms has not been thoroughly examined [3]. This scientific proof could improve the overall health officials in determining the optimal security algorithms and settings. For example, the occurrence of the pandemic, attributes (for example, the week's average and variance), such as with reference to emission strength, should be taken into consideration in developing anomaly detection [4]. The problem is that there is no streamlined method for determining outbreak severity, and also the different factors that impact on identification are difficult to take into account [5][6][7]. The goal of this research is to create and evaluate a quantifiable and subjectively interpreting prediction models [8][9]. The study made a binary logistic forecasting, which presumes that significantly higher in power in multiples of each other. While this framework was precise, it was unable to simultaneously model [10] interdependence of techniques with multiple evaluation criteria. This limitation originated from using a linear, non-exponential regression, in part. The downside is that it also offers an interpretation of the differences between individual connections between epidemic features and method results [11][12].

Materials and Methods

Data for 5 countries were obtained from https://www.worldometers. info/coronavirus/country [13] in total cases over 30 days: Italy, Germany, Iran, the United States, and China. At the moment, To control the epidemic, governments have taken a range of steps to minimize transmission. by impeding public's schedules and social interactions Nonetheless [14], data on variations in community distancing is required for modelling in order to advance epidemiology models. There is no need to make any assumptions. In the early weeks of the epidemic, China's growth rate was higher than that of Italy, Iran, Germany, and the United States [15].

Table 1.Mathematical forecasting models

Description of the model	Name of the model
R=X/(1+exp(((4*µ)*(M-y)/X)+2))	Logistic
R=Xc-Y	Sequential
R=X+ Ylog(c)	Algorithmic
$R=X+Yc+Zc^2$	Quadratic
$R=X+Yc+Zc^2+Wx^3$	Cubic
$R=XY^y$	Compound
$R=Xc^y$	Power
R=XEXP(Yc)	Exponential

The above-mentioned functions are described by the parameters A, B, C, µ and L, which are constants [16]. To create a reliable estimation model, these constants must be calculated. The study's aim was to use the logistic microbial growth model to model time-series data[17][18]. As an example, in order to estimate and forecast the prevalence, the modified equation of regression

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was used. Disease as a function of time. To estimate the parameters improver, evolutionary algorithms and genetic algorithms were used. The following sections go into these algorithms in detail [19].

Evolutionary Algorithms

Computational development is a significant tool for solving problems of intelligence. To discover all potential alternatives, the algorithms frequently follow the patterns of nature. You have to customize your answers when you're in the creative mode [20]. In this assessment, bio gene algorithm, meta heuristic optimization, and ant colony optimization (ACOs), the most commonly utilized techniques for estimation of parameters [21].

Bio Algorithm

GAs will use theory of transformation as a mathematical computation. Its derivative predictions include: Instead, these "chromo-like" algorithms rely on "solution", “Potential", "usable hypotheses," or "plausible theories" for a given issue [22]. "Hybridization Operators" is defined as data frameworks that mimic chromosomes, and thus saves essential information that was previously part of these optimization techniques. Many GA techniques are also referred to as "function enhancers," or those that improve the performance of optimization problem. Obviously [23], the GA's designed to be employed for a myriad of issues. Figure 2 depicts the primary GA technique.

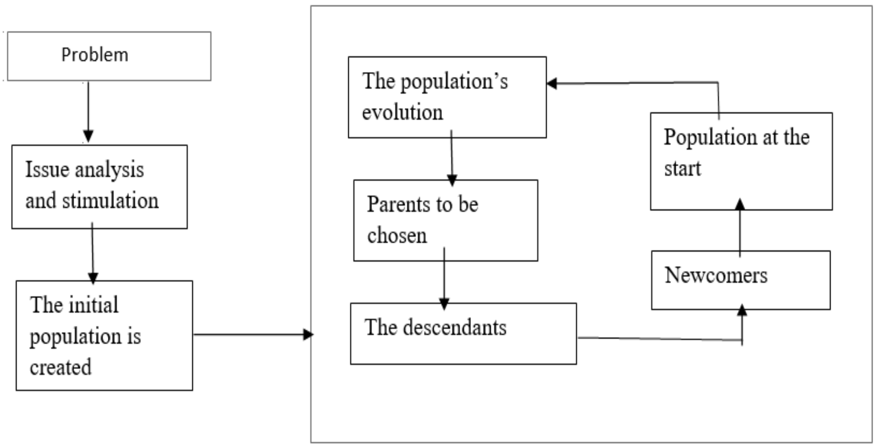

Figure 1.GA algorithm

The parameters were estimated using GA [57] in the current study. To minimize the cost function value, the number of people was fixed at 300, and the highest number of iterations was set to 500 using various trial and error processes [24]. According to Eq. 14, calculation assumed that the functional form was the mode of the squared error of the destination and the predicted value [25].

MSE = $\sqrt{[(EsT)^2]/N}$, - 1

where Es denotes approximate values, T denotes target values, and N denotes the number of data points [26].

Particle Swarm Optimization (PSO)

The PSO was proposed first in 1995 as a vague method for tuning [27]; it is currently an obvious candidate for such a search. The urbanization of the birds in order to find their preferred food inspired the algorithm. Totally inadvertent, a bunch of birds happened to investigate the vacuum cleaner [28]. There can be only one morsel of food throughout the debris field. Each Optimization approach is a bird in the flock, which matches a molecule in the flocking algorithm.

- Every particle also has a number.
- This algorithm contains particles of Creative Quality
- There is no central controller in the universe.
- Wherever the point that a particle is, so is its associated wavelength.
- Every particle is situated in the optimum place

The particles communicate with each other to discover the locations they're looking for information [29]. Everything is connected to everything else. It is assumed that every particle knows exactly where every other particle is located. As far as anyone knows, all particles are equal. The principal population is defined and evaluated in the design process, development, and acquisition stages of the PSO procedure. What individuals and groups have shared experiences shape the greatest collective and individual memories. Throughout the third phase [30], both the velocity and location have been adjusted. If the circumstances for slowing down are not met, the circuit will keep going. The primary community is described and evaluated in the design process, development, and acquisition stages of the PSO process. What individuals and groups have shared experiences shape the finest personal and group memories [31]. In the fourth stage, both the velocity and location have been adjusted. If the expectations are not fulfilled, the process will proceed to the stage 2. Using PSO, the variables of the ongoing investigation were estimated. Numerous basic type of sampling methods was designed to reduce the demographic worth to 1000. The project's definition of expense was derived from the estimates values [32].

Grey Wolf Optimizer (GWO)

GWO, like the majority of intellectual algorithms, is motivated by nature. The grey wolf algorithm's main concept is focused on wolf groups' leadership hierarchy and how they hunt. In general, the herd of grey wolves is divided into four categories: alpha, beta, delta, and omega [33].

GWO was used to estimate the parameters in the current study. The inhabitants number was set at 600, and the amount of iterations was set at 1000. To minimize the cost function value, various trial and error methods were used [34]. The role of cost according to equation, the expected value and the calculated value.

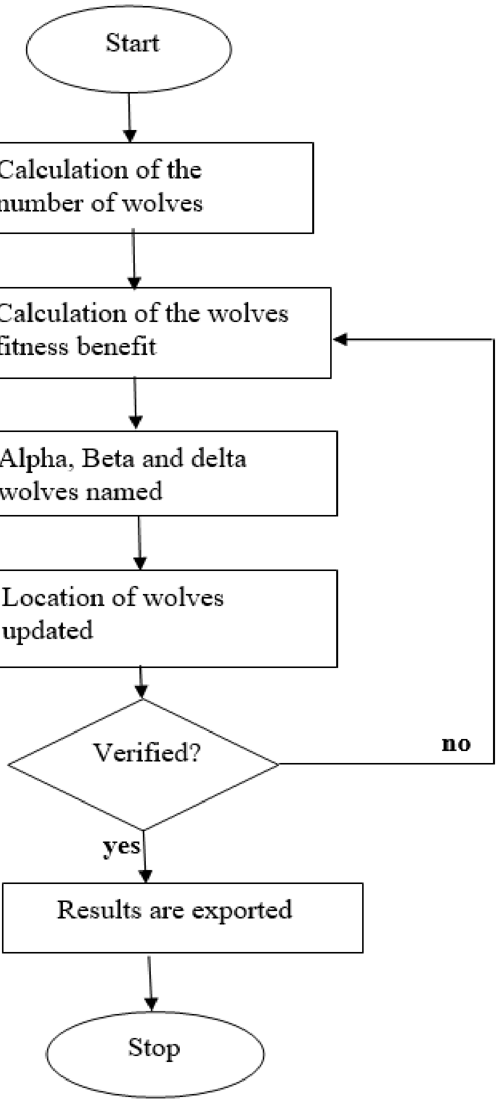

Figure 2.GWO Algorithm

Machine Learning (Ml)

Algorithmic can be defined as a form of artificial intelligence. The operating system for personal computers without being told to do so using regularities or prior knowledge using methodologies such as artificial intelligence by exposure to "scenarios" [35]. According to this author, techniques and designs are observational analyses used by devices and applications are referred to as artificial intelligence. Time analysis sequences of values used during input to neural networksthe transformation of a concept over time [36].

Table 2.Input and Output methods for using ML method

	Contributions	Contributionquantity	Productions
Model I	$Y_{r-1}, y_{r-5}, y_{r-8}$ and y_{r-15}	6	Y_r(epidemic)
Model II	$x_{t-5}, x_{t-6}, x_{t-7}$ and x_{t-8}	8	y_r(epidemic)

Using information from the existing 3 weeks (model I), the epidemic on day r will occur, and information from the 5 days (model II) predicts it [37], the epidemic, if it occurs, will occur within five days. Artificial intelligence methods such as these were employed in both of these instances. The two main deep learning methods used in this research are Artificial Neural Networks (ANN) and Decision Trees (DT). Approximately eight methodologies used include a multi-node (MN) and an evolutionary platform inference scheme. There is a way to foresee the spread of disease that has been devised for the five countries: an ANIS [38].

Adaptive Neuro Fuzzy Inference System (ANFIS)

Deep neural networks, as a type of ANN, use the Takagi-Sugeno evolutionary framework. It was in the mid-nineties that this technique was introduced. Since it integrates the interpretations, it can function as a genetic algorithm that is connected to the rules, it can also be described as a probabilistic reasoning network. With the wide availability of hybrid artificial intelligence, this is perhaps the most broadly applicable and dependable methodology [39]. Fuzzy mathematical rules make for estimating differential equations make sense. A result of these events, the creation of ANFIS was spawned. On the basis of common knowledge, the common wisdom, it was suggested. Fuzzy systems also incorporate a soft partitioning of the decision boundary.

- The linguistic variables generate a f-face cube with respect to the I input
- Creating a variation-al inversion is hard, but not insurmountable.
- This model has a multifaceted and spatial range of capabilities.
- ANFIS employs artificial neural networks to increase the system's overall performance Soft standards, rules of acceptability [40].

Neural networks, often known as neurons systems, are built on fuzzification. This management model takes a divide and conquer approach. This network is not only containing a single node, but a multitude of nodes for almost all of information input and output channels [41]. Each class gets its own layer. It is possible that ANFIS will be used in response to these two situations listed in the second table above. Using Triangular, Rectangular, and Gaussian models, each input had two MFs of the two types. Instead of using a mixed finite/continuous optimization method, outcome was selected to be a predictable was utilized with a fusion optimizer [42].

Evaluation Criteria

The root mean square error (RMSE) and correlation coefficient were used to determine the effects. These statistics compute a score as an index for the goal and performance values by comparing them. The developed methods' efficiency and accuracy [43]. The assessment criteria are mentioned in Table 3the usage of equations [44].

Where, m is the quantity value, $\mathbf{O_p}$ is the expected outcome and $\mathbf{O_a}$ is the actual outcome respectively [45] [46].

Global Journal on Innovation, Opportunities and Challenges in AAI and Machine Learning
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Table 3.Performance Analysis

Correlation coefficient = $\frac{[m\Sigma(O_pO_a) - \Sigma(O_a)\,\Sigma(O_p)]}{\sqrt{[m\Sigma O_a^{2-}(\Sigma O_a^2)][m\Sigma\, O_p^2-(\Sigma O_pO_a)^2]}}$
RMSE = $\sqrt{[1/m\Sigma(O_a-O_p)^2]}$

Results

The accuracy statistics for the creates a variety, vector, lognormal, Cartesian coordinates, cubic, composite, rule, and exponential formulas are given in Tables 4–8. The three ML optimizing compilers, GA, PSO, and GWO [47] [48] [49], computed the coefficients of each equation. The table gives the description of the nations, along with their capital. Name of a model, growth rate, iterations, processing time, RMSE, and correlation coefficient [50] [51].

Table 4.Framework for China

Structure	**Explanation**	**Root**	**Squaring**
Linear model	It = 4147. 5y y - 24618. 75	6148. 56	0. 876
Logarithmic model	It = -44859. 26+ 38236. 81y log(y)	53828. 75	0. 717
Quadratic model	It = -6191. 77+ 2566. 87 y^2 + 50. 98 y y^2	3710. 17	0. 97
Cubic model	R = 4895. 84 -28813 y^2 +41963 y s^2 - 4. 42 y y^3	2429. 46	0. 98
Compound model	It = 2712. 14 y 2. 27 y	24,987. 35	0. 802
Power model	It = 26227 x IA	4078. 98	0. 97
Exponential model	It = 1601. 03 x EXP(0. 15 x^2)	24,987. 35	0. 802
Logistic model	It = n011. 297/(1 + EXP(((4 x 4483. 304) • (9. 423 - x)/85011. 297) + 2))	3384. 68	0. 993

Table 5.Framework for Italy

Structure	**Explanation**	**Root**	**Squaring**
Linear model	It = 554. 82 y y- 6568. 36	4753. 55	0. 712
Logarithmic model	It = -8778. 84 + 6274. 94 y log(y)	8385. 47	0. 401
Quadratic model	It= 388872 - 826. 84 y y + 49. 15y y^2	12722	0. 964
Cubic model	It r- -978. 55 + 506. 05 x 82 - 61. 95x x^2+ 2. 42x x^3	324. 34	0. 996
Compound model	R = 2. 78 x 1. 406x	12,585. 78	0. 903
Power model	It = 0. 096 x x^{106}	3450. 97	0. 985
Exponential model	It = 2. 786 x EXP(0. 341 x x)	13878. 78	0. 903
Logistic model	It = 81842. 195/(1 + exp(((3y 3967-88) x (31. 99 - y)/ 81842. 195) + 2))	217. 16	0. 998

Global Journal on Innovation, Opportunities and Challenges in AAI and Machine Learning
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Table 6.Framework for Iran

Structure	Explanation	Root	Squaring
Linear model	R = 747. 075 yy - 5638. 75	1875. 34	0. 890
Logarithmic model	R = -8634. 21 + 6113. 565 y log(y)	7884. 51	0. 573
Quadratic model	R = 295. 67 - 369yy + 2926 yy2	310. 026	0. 996
Cubic model	R = 9(12. 33 - 463. 02x x + 46. 07 x x2 - 0. 36 x x3	250. 203	0. 997
Compound model	12 = 13. 26 x 1. 33x	13,635. 013	0. 747
Power model	12 = 0. 51 x x3. 09	1031. 606	0. 981
Exponential model	It = 13. 26 x EXP(028 x x)	13,635. 013	0. 747
Logistic model	12 = 21936. 052/(1 + EXP(((4 • 1255. 36) x (13. 87 - y)/32567. 134) + 1))	467. 87	0. 997

Table 7.Framework for Germany

Structure	Explanation	Root	Squaring
Linear model	It = 237. 532 y y -1130. 294	862. 545	0. 681
Logarithmic model	12 = -2678. 142+868. 852 y log(y)	1936. 724	0. 45
Quadratic model	R = 822. 345 - 369. 451 x x + 12347x x2	472623	0. 894
Cubic model	R= -47&087 + 243. 097 x x - 27. 118 x x2 + 0. 848 x	196. 808	0. 980
Compound model	12 = 3. 821 x 1. 263•	431. 974	0. 995
Power model	It = 0. 937x2221	1341. 910	0. 767
Exponential model	12 = 3. 821 x EXP(0233 x x)	547. 974	0. 997
Logistic model	R = 662847. 778/(1 + exp(03 y4127. 361) x (28. 69 - y)/66127. 548) + 2))	66. 879	0. 987

The logistic equation, supplemented by the quadratic and cubic equations, generated the smallest RMSE [52] and the largest r-square values for the forecast of COVID-19 bursts, which can be seen in Tables 4-7.

Comparing the Fitted Models

This segment compares the precision and efficiency of the designated models for predicting the outbreak in 30 days [53]. The variance from the objective values for the nominated models is shown in Figures 17 to 21.

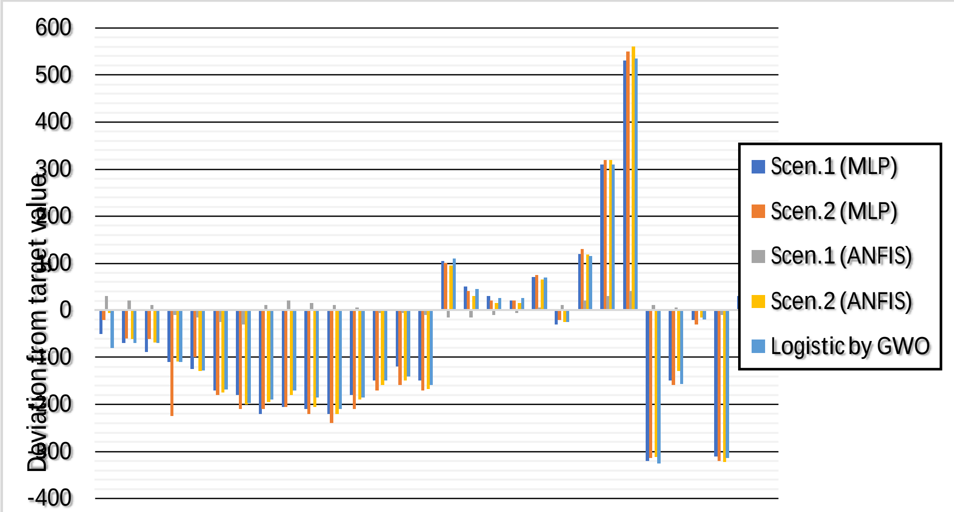

Figure 3.Actual vs predicted for Italy

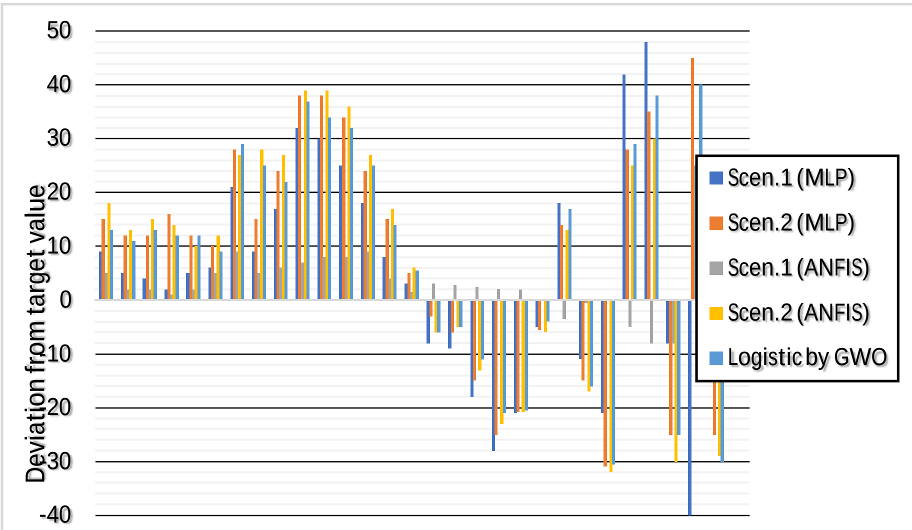

Figure 4.Actual vs predicted for China

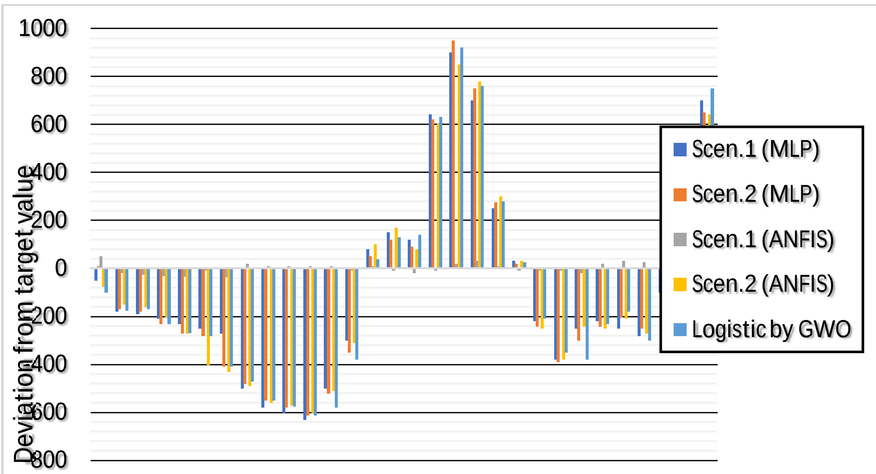

Figure 5.Actual vs predicted for Iran

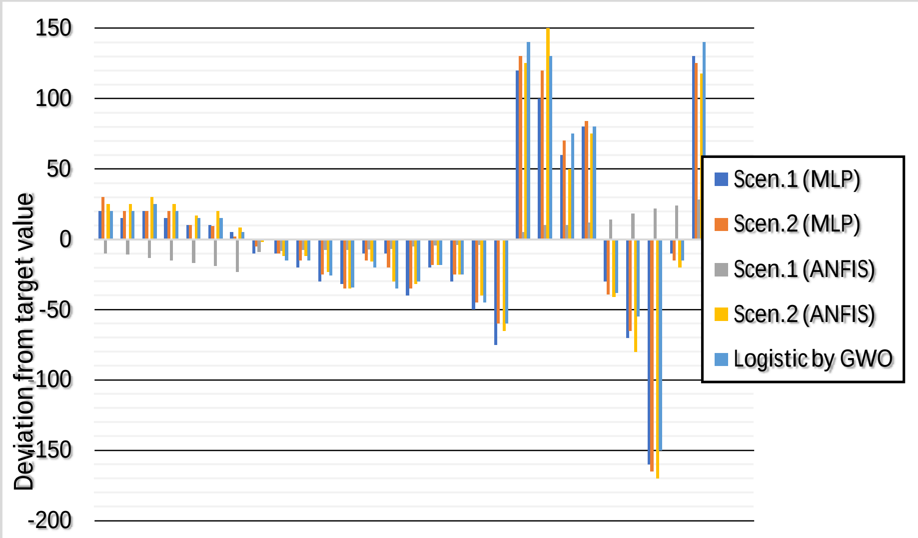

Figure 6.Actual vs predicted for Germany

Figures 3 to 6 show that the intelligent learning for scenario 1 has the minimumeccentricity from the object values, tailed by intelligent learning for scenario 2 [54] [55]. This means that the intelligent learning approach has the best results in terms of outbreak prediction [56].

Conclusion

Researchers looked at the output from future governmental wellness epidemic detection systems that accounts for these three main variables: size, outbreak attributes, and predictive algorithm variables. We used simulation and hardware data in order to compare the capabilities of 7 distinct algorithms and created Bayesian networks in a controlled experiment in order to define all of these methods, evaluating and training each of them on eighteen times in a total. We can also extend our method to include new optimization techniques and data. Our current approach lets us evaluate new computation efficiency in except H t, E s, and Integrated Poisson modes. To our model's specifications, any nonstandard detection approaches could be viewed as different, and if they produce better results, they would be allowed in. If more follow-up research is done, this investigation could be quite effective. since we employed outbreaks in our modelling, the simulation's outcomes had an influence. We can use multiple approaches that include identification, structured data that span time, space, and use, as well as spatial and time - varying data.

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