AL- Rafidain University College

PISSN: (1681-6870); EISSN: (2790-2293)

Journal of AL-Rafidain University College for Sciences

Available online at: https://www.jrucs.iq

JRUCS

Journal of AL-Rafidain University College for Sciences

Use Artificial Bee Colony to Determine the Optimal Stratigraphic Boundaries for a Threshold Geometric Stochastic Process

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Article Information

Article History:
Received: February, 18, 2024
Accepted: April, 12, 2024
Available Online: 31, December, 2024

Keywords:
Artificial Bee Colony (ABC) algorithm, Monotone Trend, Turning points, Threshold Geometric Stochastic Process, Corona virus Data (Covid-19), Optimal Stratigraphic Boundaries, Moving Window Method, Root Mean Squares Error.

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Abstract

The Artificial Bee Colony (ABC) algorithm was used in this study as a representation of a developmental artificial intelligence technique to identify the best class boundaries for modeling data on the number of daily infections with the Coronavirus (Covid-19) epidemic and for the three governorates of Iraq (Baghdad, Erbil, and Basra). The number of daily infection cases during the outbreak of a particular epidemic disease, such as the emerging acute respiratory syndrome coronavirus, frequently exhibits multiple trends: a steady increase during the epidemic's growth phase or outbreak, followed by a stable phase in the number of daily infection cases (referred to as the stabilization phase by some sources), which involves controlling the epidemic to eradicate it, and a subsequent decline, decline, or disappearance phase. In order to handle this type of data, a random stochastic model known as the geometric stochastic process model with an intelligent threshold was put forth. This model uses an intelligent technique to identify the data's turning points, or inversions.

DOI: https://doi.org/10.55562/jrucs.v56i1.32

1. Introduction

Monotone Trends is used in a wide variety of functional, engineering, and health-related applications. The Single trend data was previously modeled using the Non-Homogenous Poisson Process (NHPP) model with a Single Hazard Rate. The Cox-Lewis model and the Weibull Process Model are also used in this model. The Ordinary Geometric Stochastic Process (OGSP), which was proposed by [8], is a direct approach to modeling data with a monotonic trend. The ordinary geometric stochastic process $\left[Y_i = a^{i-1}X_i \, ; i = 1,2,\ldots\right]$ has a parameter called the ratio of geometric stochastic process; It measures the direction and the strength of this direction for geometric stochastic process [1]: it is increasing when the ratio is $(a < 1)$, and it is decreasing when the ratio is $(a > 1)$, while it is stationary when the ratio is $(a = 1)$, and then it is called Renewal Stochastic Process (RSP). [11]

During an outbreak of a specific infectious disease, for example, the number of regular infections always goes through a growth period, then a stabilization stage, and finally a decreasing stage. This statistical model aids in determining the epidemic's peak and end points, as well as assisting health-care authorities in determining the phases of the epidemic's progression and evaluating the activities and policies used in therapy to resolve and eradicate the epidemic. Furthermore, it provides them with the knowledge they need to make a decision in a rapidly changing situation. [4]

The ratio of the expected current result to the prior result, or parameter (a) for the geometric stochastic process, illustrates the progression of the trend once random noise is eliminated. Because it is connected to the Basic Reproductive Number $(R = 0)$, which represents the number of new infections brought on by each infected person as well as the virus's aggressive ability to infect new people for each infected person, the ratio geometric stochastic process (a) is significant in epidemiological modeling. If the epidemic's aggressive capacity $(R_0 > 1)$ is high, it will attack more people in each round of infection, increasing the expected number of daily infections. This indicates that the stochastic process is increasing over time, with the proportion of the geometric stochastic process defined as $(a < 1)$. Conversely, if the epidemic's hostile capacity is expressed in the form of $(R_0 < 1)$, this indicates that the epidemic's hostility diminishes over time until it disappears, and the geometric stochastic process's ratio is defined as $(a > 1)$. [9] [2]

The relationship between the value of the antagonism ratio (R_0) and the geometric stochastic process (a) is a key indicator of whether or not the epidemic is under control. [10]

2. Target

This study is the first attempt to use each of the provided models in the theoretical aspect, which is represented by modeling data on daily casualty numbers for the three governorates of Iraq (Baghdad, Erbil, and Basra), using clever approaches on epidemiological data. The inability to handle multiple monotone trend data and the shape parameter's constant behavior over all time periods without variation are two of the flaws found in the (OGSP) model. To address this flaw, several recommended methods were applied, such as the Threshold Geometric Stochastic Process (TGSP). This model's concept relies on identifying the Turning Points (TP) in order to establish the threshold. The threshold, and to find the optimal turning point (s), we recommend using the Moving Window Technique (MWT).

3. Threshold Geometric Stochastic Process (TGSP):

As one of the best techniques for processing multi-trend data (MT), we will recommend using the Threshold Geometric Stochastic Process Model (TGSP) in this part by segmenting the process into (k) sections (layers). [2]

As a result, it is imperative that this topic be addressed and used to identify epidemics that are prevalent in our everyday lives. Since its application to the epidemiological data forces us to look for a way to generalize the single-trend into multiple monotone trends, the monotone stochastic process with a single-trend has thus been studied and an attempt has been made to expand it to take account of the random nature of the data, which is multi-trend. The monotonic stochastic model is used for this. If the process is divided into (k) sections or portions as follows, then the geometric random process model with a threshold is a generalization of the geometric random process model.

$$\mathrm{GP_k} = \{\mathrm{X_i}\,;\mathrm{T_k} \le \mathrm{i} \le \mathrm{T_{k+1}}\} \qquad \mathrm{k} = 1,2,\dots,\mathrm{K} \tag{1}$$

To each $(\mathrm{n_k})$ observational pattern that starts with a turning point $(\mathrm{T_k})$ where:

$$\mathrm{T_k} = 1 + \sum_{\mathrm{j}=1}^{\mathrm{k}-1} \mathrm{n_j} \qquad \{\mathrm{k} = ,2,\dots,\mathrm{K}\} \tag{2}$$

$$T_{k+1} = n + 1 \quad ; \quad \sum_{k=1}^{K} n_k = n \quad ; \quad T_1 = 1 \tag{3}$$

The renewal stochastic process may therefore be used to represent the model as follows:

$$RP_k = \left\{a_k^{i-T_k} X_i \, ; T_k \le i \le T_{k+1}\right\} \quad \{k = 1,2, \dots, K\} \tag{4}$$

where ($a_k > 0$) is known as the ratio of the (k^{th}) geometric stochastic process, and it quantifies the process's trend and strength. The threshold geometric stochastic process's expected value and variance are as follows:

$$\mathbb{E}\left(X_{T_k+t}\right) = \frac{\mu_k}{a_k^t} \quad \& \quad \mathrm{Var}\left(X_{T_k+t}\right) = \frac{\sigma_k^2}{a_k^{2t}} \quad t = 0,1, \dots, n_k - 1 \tag{5}$$

Therefore, in the (k^{th}) geometric stochastic process, $\left\{a_k , \mu_k \,\&\, \sigma_k^2\right\}$ are crucial threshold geometric stochastic process parameters that completely influence the mean and variance of $\left(X_{T_k+t}\right)$

In this research, we propose to estimate the turning points $\{T_k \, ; k = 1,2, \dots, K \}$, which reflect the time when the trend changes its direction, using the Artificial Bee Colony (ABC) algorithm with the moving window technique. A subset of data of fixed length (L) is subjected to the threshold geometric stochastic process models one after the other, beginning at time $\{s = 1; s = 2\}$ and continuing until $\{s = n - L\}$. It is possible to detect turning points (T_s) by observing a change in (a_s) from "less than 1" to "greater than 1" and vice versa, which occurs at $(s = T_s)$; $[k = 1,2, \dots, K]$. This is because the ratio ($a_s > 0$) of a (GSP) will change with each (s) as the window advances. Then the (GSP) model are given by:

$$GP_k = \{X_i \, ; T_k \le i \le T_{k+1}\} \quad k = 1,2, \dots, K \tag{6}$$

As a result, we can identify several turning points, depending on the type of data. The ratio parameter (a_s) seems to oscillate around one in several studies, which leads to brief patterns and erratic parameter estimations. The number of observations in each point must not be less than seven $\{h = 7\}$ in order to prevent "noisy" movements. Short trends are blended with subsequent trends and given constraints to make them less brief and unpredictable. Furthermore, each point's change in the geometric stochastic process ratio (a) value surpasses the value of (0.005), indicating that: [2]

$$\left|a_{(T_k)} - a_{(T_{k-1})}\right| > d = 0.05 \text{ or } 0.005 \tag{7}$$

Furthermore, various values of {h,d} will be experimented with until high accuracy and satisfactory results are achieved. Since different window widths (L) provide distinct sets of turning points (T_i), the window widths (L) play a crucial role in determining the correctness of the results. In contrast, a shorter window width (L) results in a more precise measurement of the change. In the meanwhile, the noise might potentially be recorded in several variations. However, if the window width (L) is extremely large or wide, a bias will result in a very large average change, which will lead to a loss of information and changes in trends because an increase at one period may be offset by a decrease at another. Error in the outcomes. There is only one trend that can be determined, one threshold, and no turning points (T_s) if the window length is equal to the whole sample size (n). Different values were assumed for the fundamental parameters in order to analyze the data set. For example, the length or width of the window (L) was selected within a range of values (20–30), and there are a set of related trends for each window.

4. Artificial Bee Colony (ABC) Optimization Algorithm:

Karaboga invented the Artificial Bee Colony (ABC) algorithm in 2005 [Karaboga, 2005] as a swarm-based meta-heuristic algorithm for the optimization of numerical problems. It came from the inventive foraging practices of honey bees. The approach is mostly based on the foraging behavior model for honey bee colonies. The (ABC) method classifies bees into three groups: scout bees, employed bees, and observer bees. Near the food source, the employed bees use their memory to hunt for food; in the meantime, they inform the onlooker bees about these food sources. Good food sources are typically selected by onlooker bees from those found by paid bees. Higher quality (fitness) food supplies will choose onlooker bees more frequently than lower rate ones. A tiny percentage of employed bees that leave their food sources in search of new ones give rise to the scout bees [13].

In (ABC) (excellent solutions for a given problem), a colony of artificial forager bees (agents) searches for rich artificial food sources. The optimization problem at hand is first converted into the problem of finding the ideal parameter vector that minimizes an objective function by the apply (ABC) technique. The artificial bees then randomly select a population of initial solution vectors and use the methods to iteratively improve them, moving away from subpar solutions and toward better ones using a neighbor search mechanism.

4.1. Foraging Behavior of Honey Bees

Food sources, employed foragers, and unemployed foragers make up the minimal model of forage selection that results in the emergence of the collective intelligence of honey bee swarms. The model also defines two leading modes of behavior: the recruitment to a rich nectar source and the abandonment of a poor source.[12]

- Food Sources: A food source's worth is determined by a number of criteria, including how close it is to the nest, how concentrated or rich its energy is, and how simple it is to take it. A single quantity can be used to describe the "profitability" of a food source in the interest of simplicity.
- Employed foragers: These individuals are linked to a certain food supply that they presently utilize, or are "employed" by. They bring knowledge of this particular source to the hive. Information like as the direction and distance from the nest, the original's profitability, and the likelihood of sharing this information can all be included. Unemployed foragers: They are continually on the lookout for a food source to exploit.

Approximately $(5-10)\%$ of other bees comprise the mean number of scouts on average throughout conditions [12].

The dance area is the most crucial section of the hive for information exchange. In the dance area, bees communicate about the quality of their food supplies. We refer to this dance as a waggle dance. Given that an observer on the dance floor has access to knowledge about every current rich source, it is likely that she will watch a number of dances before choosing to work for the most lucrative source. Since more information about the better sources is shared, there is a higher chance that observers will select the better sources. As a result, hiring is correlated with the food source's profitability [Li et al., 2012]. With regard to the foraging habits of honey bees.

Reexamining the honey bees' previously described foraging behavior reveals that [Millonas 1993]'s established principles are fully met.

4.2. Algorithmic Structure of (ABC):

The artificial bee colony in (ABC) has three groups of bees, similar to the minimal model of forage selection of natural honey bees: Employed Bees linked to particular food sources, Onlooker Bees observing the dance of Employed Bees within the hive to choose a food source, and Scout Bees randomly searching for food sources. Unemployed Bees are another term for observers and scouts alike. Scout bees initially found every location of the food source. Following that, worker bees and observer bees begin to plunder the nectar of food sources, and this ongoing plundering will eventually wear them out. After that, the worker bee transforms into a scout bee, employing the depleted food supply to find new food sources. Stated differently, the worker bee that has used up all of its food supplies turns into a scout bee. In ABC, a food source's location denotes a potential fix for the issue, and the food source's nectar content indicates the caliber (fitness) of the related response. Since each hired bee is connected to a single food source, the number of employed bees is equal to the number of food sources (solutions) in its simplest form. Artificial scout bees are used to initialize the population of food sources (solutions) and set control settings during the Initialization Phase.

Artificial employed bees look for new food sources with more nectar nearby the food source that they remember during the Employed Bees Phase. After locating a nearby food supply, they assess its fitness. The new food source is produced, and then its fitness is determined. It is selected greedily in comparison to its parent. Subsequently, working bees use the dancing area to alert other bees waiting inside the hive about their food supply.[12]

Artificial onlooker bees use information from hired bees to probabilistically select their food sources during the Onlooker Bees Phase. A fitness-based selection approach, like the roulette wheel selection method, can be applied for this purpose. A neighborhood source is identified and its fitness value is calculated once a food source for an onlooker bee has been probabilistically selected. There is a greedy selection between the two sources, much like in the employed bees phase.[14]. These three steps are repeated until a termination criterion is satisfied, for example, a maximum cycle number or a maximum (CPU) time.

Recently, an optimization technique called the artificial bee colony (ABC) algorithm was devised to mimic the intelligent foraging behavior of honey bees. A swarm of honey bees is a group of bees that work together to complete tasks.

The hired bees make up the first half of the swarm in the (ABC) algorithm, while the observer bees make up the second half. The number of solutions in the swarm is equal to the number of working bees or observer bees [Karaboga & Basturk, 2008]. A randomly distributed starting population of (SN) solutions (food sources) is produced by the (ABC), where (SN) stands for Swarm Size. The (i^{th}) solution in the swarm is represented as $X_i = \{x_{i,1}, x_{i,2}, \dots, x_{i,D}\}$, where ($D$) is the dimension size. In the vicinity of its current position, each employed bee (X_i) produces a new candidate solution (V_i) in the manner described below:

$$v_{i,j} = x_{i,j} + \phi_{i,j}\left(x_{i,j} - x_{kj}\right) \tag{8}$$

where (j) is a random dimension index chosen from the set {1,2,...,D}, (X_k) is a randomly chosen candidate solution $(i \neq k)$, and $\left(\phi_{i,j}\right)$ is a random value inside $[-1,1]$. A greedy selection method is applied after the new candidate solution (V_i) is produced. Update (X_i) with (V_i) if (V_i) 's fitness value is higher than that of its parent (X_i); if not, leave (X_i) unchanged.

Waggle dances are used by all worker bees to alert observer bees about their food sources once they have finished their hunt. An observer bee selects a food source based on a likelihood associated with its nectar content after assessing the nectar data collected from every working bee. This roulette wheel selection process, which uses probabilistic selection, is explained as follows:

$$P_i = \frac{fit_i}{\sum_{j=1}^{SN} fit_j} \tag{9}$$

where (fit_i) is the (i^{th}) solution's fitness value in the swarm. As can be observed, the likelihood that the (i^{th}) food source will be chosen increases with the quality of the solution (i). Assume that a position cannot be improved beyond a certain number of cycles, also referred to as the limit. The food supply is thereafter given up on. Let's say that (X_i) is the abandoned source. The scout bee finds a new food source to replace (X_i) in the manner described below:[10]

$$x_{i,j} = lb_j + rand(0,1) * \left(ub_j - lb_j\right) \tag{10}$$

where (lb), (ub) are the lower and upper limits of the (j^{th}) dimension, respectively, and rand(0,1) is a random number inside [0,1] based on a normal distribution.

The hired bees make up the first half of the swarm in the (ABC) algorithm, while the observer bees make up the second half. The number of solutions in the swarm is equal to the number of working bees or observer bees [12].

5. Using (ABC) Algorithm to Find (ITGSP) :

The Artificial Bee Colony Optimization (ABC) algorithm is made up of a number of straightforward processes that are coupled to each other. Without following each of these phases, the algorithm loses its value and ability to find or improve the answer, making it unusable for any situation. The following is the suggested (ABC) algorithm for choosing the optimal stratigraphic boundaries for a threshold geometric stochastic process:

1. The first set of parameters for the (ABC) algorithm is as follows: The four basic parameters of the (ABC) method will be covered.
2. Initial Data: This is a reading of the data values related to the issue that is being researched.
3. Initialization of data: The moving window technology, which operates by taking a set of data of a certain size (30 observations, for example) which represents displaying that window and finding the parameters for that group, is applied after the sudden fluctuations in the data are eliminated using the moving average of the random series. This procedure was previously used in the Artificial Bee Colony algorithm.
4. Locate Inversion Points: Locating inflection points in the data and classifying the points as rising, decreasing, or stable based on the geometric stochastic process parameter ratio (a) constitute one of the most crucial tasks in the suggested technique.
5. Individual Representation: In the stratification issue, the individual's structure and form are separated into two sections. The first section depicts the data's division points, which are the inflection points selected in stage (3). The parameters of the geometric stochastic process that have been assessed for the different stratifications are defined in the second section.
6. Creation of the Initial Population: The algorithm's output and the caliber of the outcomes are mostly dependent on the size of the population (the total number of particles) and the technique used to create the initial population. ((L-1) + L * 2) is the number of sites that each individual must have, where (L) is the number of classes that the population is to be centered on. An ideal group should, in general, guarantee the greatest potential diversity of persons (solutions) inside the search space.
7. Objective Function: In this step, we compute the objective function for the problem as well as for every particle in the community. The stratification problem's objective function is a Root Mean Square Error (RMSE) criterion, which is thought to be One of the most crucial factors to consider when comparing the models that are employed and evaluating the accuracy of the model that is being used is the threshold between the data, which can be determined using the following formula and is applied to both one-way and multiple trend data.

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \hat{\mu}_k \hat{a}_K{}^{-(i-T_K)}\right)^2} \quad \text{for } T_k \le i \le T_{k+1} \tag{11}$$

8. Using the Artificial Bee Colony Algorithm Procedures:

The (ABC) optimization algorithm's procedures will be implemented in accordance with the equations displayed on (8) to (10), following the establishment of an elementary community with a size of (N_{pop}) Individuals.

6. Application Side

6.1. Covid-19 Data

The global spread of the virus commenced on December 31, 2019, when the first case was recorded in Wuhan, China. A sample from an Iranian religious student was analyzed in the city of Najaf on February 24, 2020. The results indicated that the student had contracted the Corona virus disease, which is associated with severe acute respiratory syndrome type II (SARS-CoV-2). In Iraq, this was the first infection. Additional reports of the Corona outbreak in several regions of Iraq have surfaced. till the 31st of December. There have been more reports of the Corona outbreak in different parts of Iraq. Up to December (31^{st}). There were (5,95,291) confirmed cases in Iraq overall, however there were (12,813) total deaths there.

We analyze modeling data for the three governorates (Baghdad, Erbil, and Basra) as well as the daily infection statistics for the COVID-19 pandemic in Iraq. Figure 1 shows the number of corona virus cases that occur in Iraq and the Baghdad Governorate on a daily basis. being increasing at one point in time (the epidemic's outbreak period), stable at another (the time the necessary controls are implemented), and dropping at other points in time (the epidemic's recessionary periods preceding its fading away).

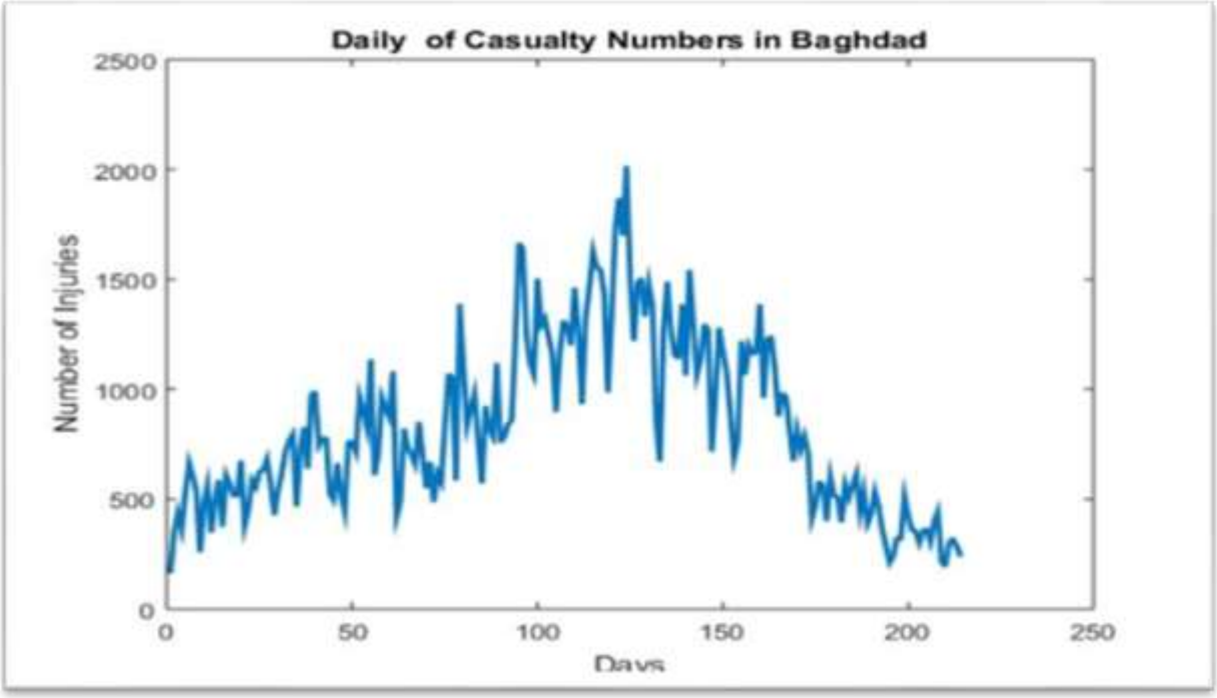

Figure (1): The number of daily infected in Baghdad governorate.

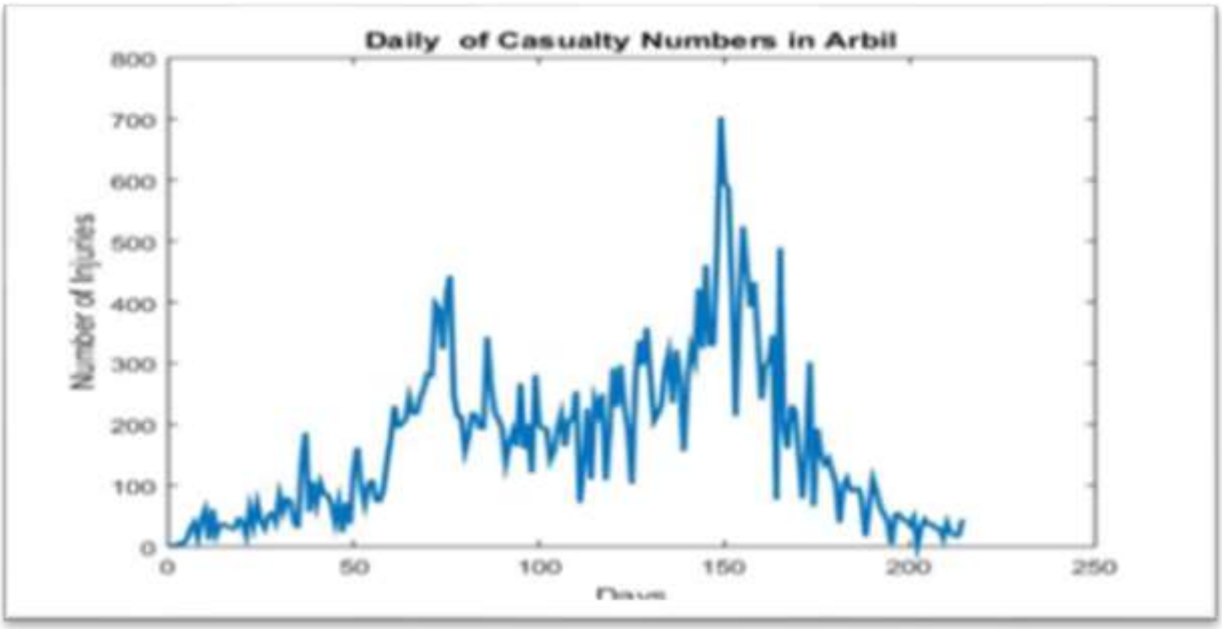

Figure (2): the number of daily infected in Erbil Governorate.

While Figure (2): shows the number of daily cases of the Corona virus epidemic in Iraq and Erbil Governorate.it is also evident by drawing the randomness of the data during the different periods and the passage of registration cases in cycles, each of which represents a change in the aggressiveness of the epidemic and its strength in infecting the largest possible number of people.

Figure No. (3) shows the number of daily cases the Corona virus epidemic in Iraq and Basra Governorate. As it is noticed through the figure as well as the passage of cases of Infected registration in the governorate in three stages, which is the increase, followed by stability, and then decreasing numbers of the data under study.

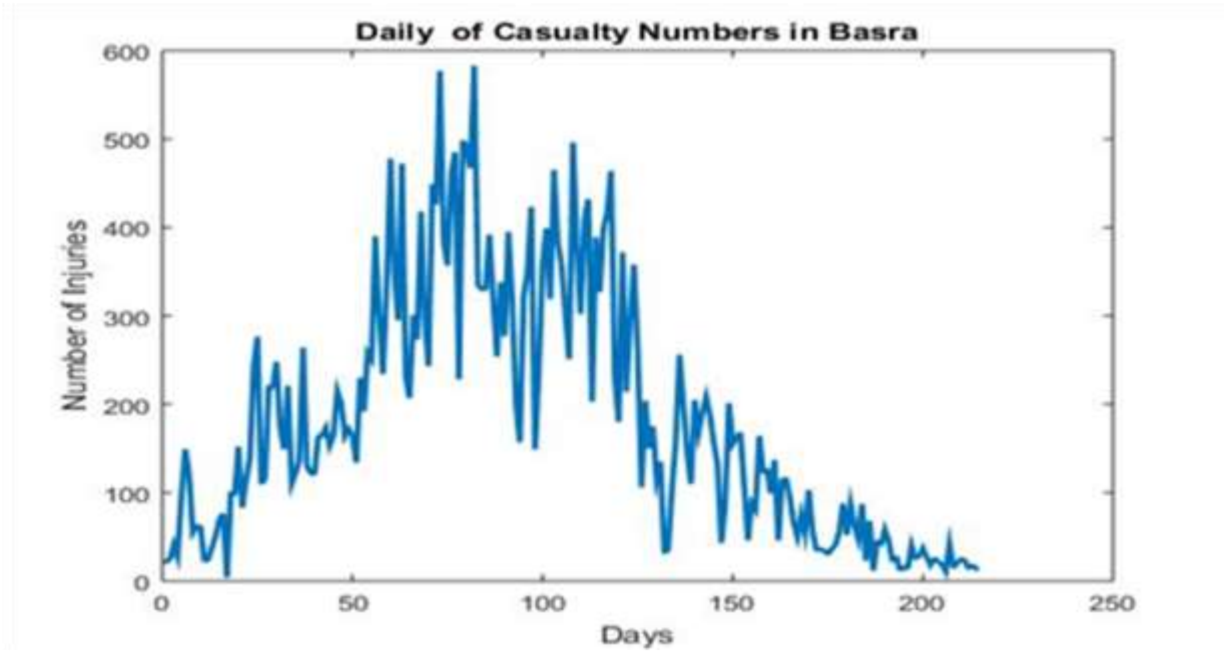

Figure (3): the number of daily injuries in Basra Governorate.

In order to provide additional context for the basic summary of the data under stud, which represents the number of infections per day, Table 1 provides the fundamental data for data preparation of infections per day in the COVID19 epidemic in Iraq, covering the three provinces (Baghdad, Erbil, and Basra) for the period from (15 \ 3 \ 2020) to (31 \ 12 \ 2020). The first few months after the injury was recorded were disregarded because of data unpredictability and a lack of equipment required for laboratory testing procedures.

Table 1: Basic information of covid-19 data for the three regions.

City	Basra city	Erbil city	Baghdad city
Start	2020\3\15	2020\3\15	2020\3\15
End	2020\12\31	2020\12\31	2020\12\31
n = number of sample	214	214	214
Number of cases in total (Sn)	38980	35987	177628
Number of cases per	182.149	168.163	830.037

6.2. The procedures used to test stochastic processes of geometric form:

When applying the geometric shape stochastic process in a set of real data, the researcher faces several problems, the most important of which is measuring the appropriateness of data for these stochastic process. To solve this problem, the following procedures used to test the geometric shape stochastic process are applied by the following steps:

- ✓ **First: Test monotony trend in the data set :**

This test is the first process in analyzing monotone-trend data, and in order to test the monotonic trend in the data set, the graphical technique (GT) was used as follows:

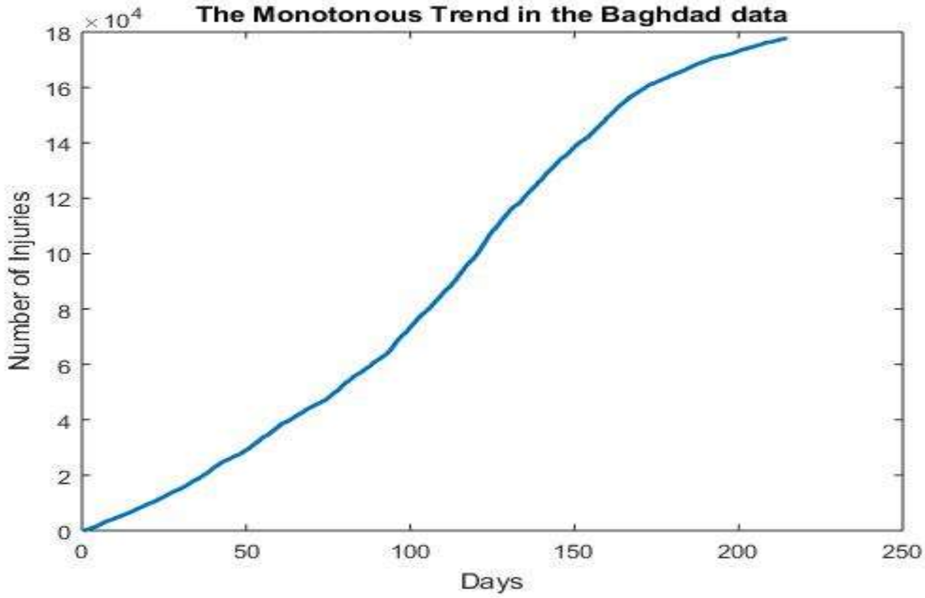

Figure (4):Monotonic trend in daily infected figures data in Baghdad.

From Figure (4), it is noticed that there is a monotonic trend in the data on the numbers of daily Coronavirus infections in Baghdad Governorate. Figure (5) shows the existence of a monotonic trend in the data on the numbers of daily Corona virus infections in Erbil Governorate.

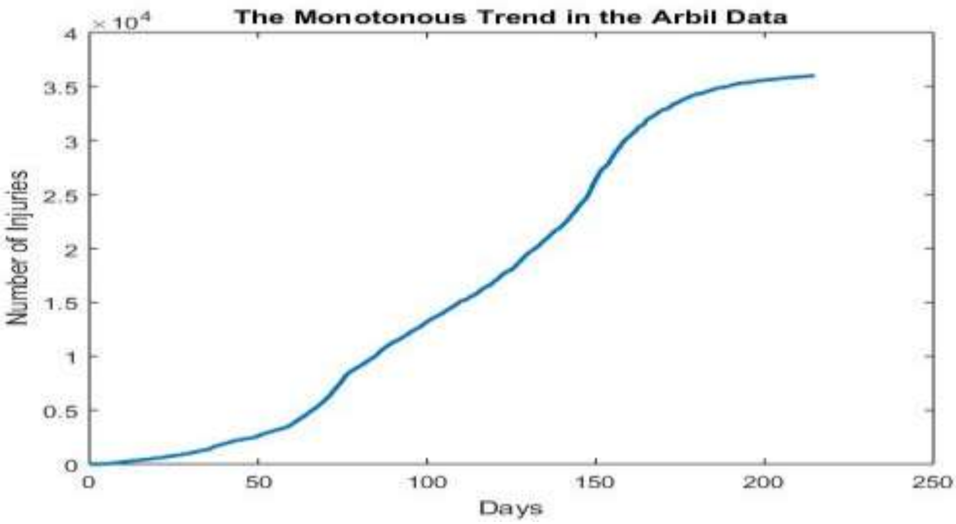

Figure (5): Monotonic trend in daily infected figures data in Erbil.

While Figure (6) shows the existence of a monotonous trend in the data on the numbers of daily Corona virus infections in Basra Governorate.

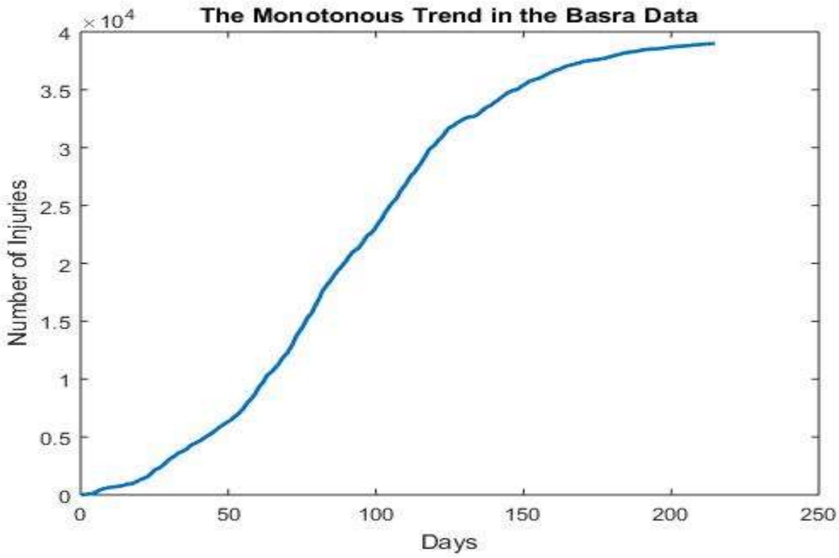

Figure (6): Monotonic trend in daily casualty figures data in Basra..

On this basis, this study relied on employing the advantages of evolutionary algorithms represented by the Artificial Bee Colony optimization algorithm in stratified random sampling and specifically in finding the optimal stratified limits depending on the method of the moving window to determine the threshold limit, as the stratigraphic boundaries were found for the data of the daily numbers of infections of the Corona epidemic (Covid-19) in Iraq for the three governorates (Baghdad, Erbil, Basra) using the Colony Bee Swarm Optimization (ABC) algorithm.

✓ **Second : Estimate and Determine The Optimal Boundaries**

In this section of the study, the ordinary geometric stochastic process (OGSP) model—if one is also proposed—will be compared to the proposed model, which is represented by the geometric stochastic process with an intelligent threshold and based on the artificial bee colony optimization algorithm to determine the stratigraphic boundaries in order to determine which model best represents the data under investigation. The usual geometric stochastic process model's parameters are estimated through the use of the artificial bee colony optimization technique.

Table No. (2) shows the best stratification based on the optimal window width (h), which depends on the Root mean Squares Error (RMSE) criterion for the model, as well as the estimates of the intelligent threshold geometric stochastic process model parameters using the artificial bee colony optimization algorithm.

Table (2): shows the parameter estimates for the proposed model using ABC optimization algorithm.

Cities	Baghdad city	Erbil city	Basra city
Number of layers (L)	3	3	3
width of Window (h)	30	25	25
Class boundarie	165,174	16,59	141,185
$\hat{a}$	[0.987,0.986,1.050]	[0.916,1.049,1.0038]	[0.9954,1.002,1.068]
$\widehat{\mu}$	[603.68,405.71, 146.16]	[147.44,361.66,197.31]	[225.85,106.46,620.36]
RMSE	377.80	161.40	114.55

In contrast, Table (3) shows the parameter estimates for the ordinary geometric stochastic process (OGSP) using the ABC algorithm. It also calculates the root mean squares error criterion for the model as a whole, compares the two models, and determines which model best represents the data under investigation.

Table (3): shows the parameters estimates for the geometric stochastic process using the ABC optimization algorithm.

City	Baghdad city	Erbil city	Basra city
$(\hat{a})$	0.9975	0.9783	1.0128
$(\widehat{\mu})$	819.7047	139.4178	244.4222
RMSE	389.0115	130.2086	134.7642

The degree to which the suggested models match the actual data is depicted in the accompanying images, which also provide insight into which model is preferred.

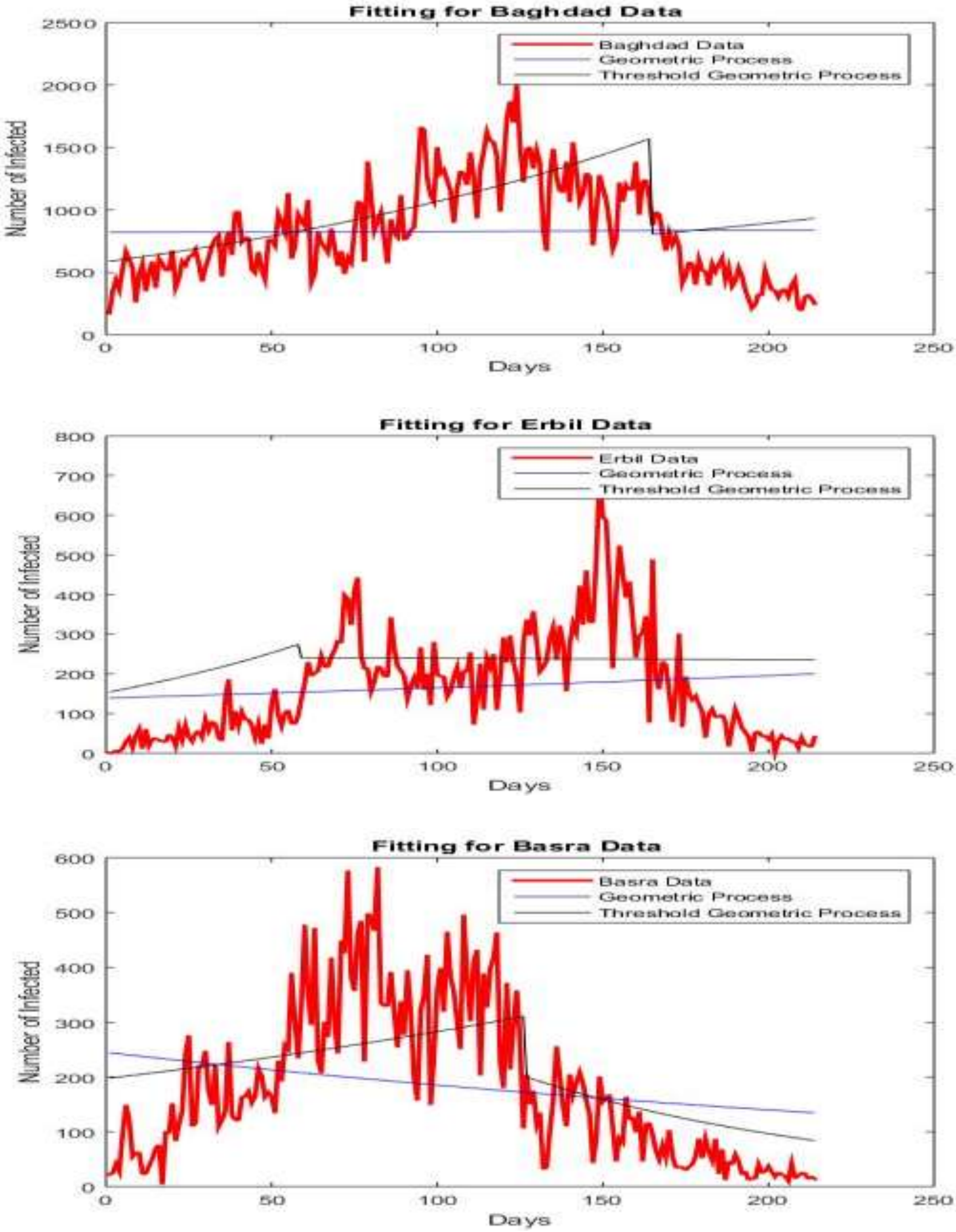

Figure (7): shows how much of the three governorates' fitting data there is for the two stochastic models.

7. Discussion

Using the parameters estimation for the intelligent threshold geometric stochastic process displayed in Table (2). The findings demonstrate that the data was separated into three layers, each of which represents the behavior of an epidemic in terms of spread at the start of the period. The value of ($a < 1$) indicates that the process is increasing, and the second layer denotes the process's stability (that is, the beginning of controlling the epidemic), Thus, we see that the Renewal Process (RP) is the most appropriate model for this time period since the parameter value ($a \cong 1$), at last, allows us to see that the data behavior starts to decline and fade, as shown by the value of the ratio geometric stochastic parameter ($a > 1$).

Therefore, the proposed model can be used in Multi Trend data, while the ordinary geometric stochastic process model is used for single trend data only.

8. Conclusion

The theoretical conclusions are considered an introduction to the interpretation of the researcher's perceptual framework, in addition to being a guide in strengthening the theoretical principle of the research and an extension of his theoretical assumptions, and in this way the most important conclusions (practical and theoretical) are presented as follows:

The study revealed that the primary reason of the coronavirus outbreak is the community's dissemination of sick individuals, since it is the direct cause of numerous cluster infections in hospitals and nearby towns in Baghdad, Erbil, and Basra.

The findings suggest that a range of environmental elements, including temperature and humidity, as well as other external factors, such changing preventive efforts, may have an impact on the disease's spread.

Based on the theoretical superiority of the proposed model in both parameter estimation and fitting, we can observe that the proposed model outperformed the excellent epidemic data for the province of Baghdad by (22.42%), while the provinces of Basra and Erbil had superior epidemic data with rates of (24.13%) and (24.56%), respectively. This suggests that the theoretical postulates that have been discussed are valid.

9. Recommendations

The completion of the approved conclusions in building the content of the recommendations with the following:

- Use other stochastic models for modeling data of the numbers of daily infections in the Corona virus epidemic. Among these models, the stochastic alpha-series process model and the (HPP) or (NHPP) after dividing the community into several layers and treating each layer separately according to the best model Represented.
- Use another intelligent algorithms to determine the optimal class boundaries of the threshold geometric shape stochastic process model. These intelligent algorithms include(ant optimization algorithm, and the blue whale optimization algorithm).

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مجلة كلية الرافدين الجامعة للعلوم (2024)؛ العدد 56؛ 359 -372

AL- Rafidain University College

PISSN: (1681-6870); EISSN: (2790-2293)

مجلة كلية الرافدين الجامعة للعلوم

Available online at: https://www.jrucs.iq

JRUCS

Journal of AL-Rafidain University College for Sciences

استخدام مستعمرة النحل الاصطناعية لتحديد الحدود الطبقية المثلى لعملية العتبة الهندسية العشوائية

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المستخلص

تم استخدام خوارزمية مستعمرة النحل الاصطناعي Artificial Bee Colony (ABC) في هذه الدراسة كتمثيل لتقنية الذكاء الاصطناعي لتحديد أفضل الحدود الطبقية لنمذجة البيانات حول عدد الإصابات اليومية بوباء فيروس كورونا (Covid-19) وللثلاثة المحافظات العراقية (بغداد وأربيل والبصرة). يُظهر عدد حالات الإصابة اليومية أثناء تفشي مرض وبائي معين، مثل فيروس كورونا المسبب للمتلازمة التنفسية الحادة الناشئة، في كثير من الأحيان اتجاهات متعددة: زيادة مطردة خلال مرحلة نمو الوباء أو تفشيه، تليها مرحلة مستقرة في عدد حالات الإصابة اليومية حالات الإصابة (التي يشار إليها في بعض المصادر بمرحلة الاستقرار)، والتي تتضمن السيطرة على الوباء للقضاء عليه، ومرحلة لاحقة من التراجع أو الانحسار أو الاختفاء. ومن أجل التعامل مع هذا النوع من البيانات تم طرح النموذج العشوائي المعروف بنموذج العملية العشوائية الهندسية ذو العتبة الذكية. يستخدم هذا النموذج تقنية ذكية لتحديد نقاط تحول البيانات، أو الانقلابات.

معلومات البحث

تواريخ البحث:

تاريخ تقديم البحث:18/2/2024
تاريخ قبول البحث:12/4/2024
تاريخ رفع البحث على الموقع: 31/12/2024

الكلمات المفتاحية:

خوارزمية مستعمرة النحل الاصطناعية (ABC)، الاتجاه الرتيب، نقاط التحول، عتبة العملية العشوائية الهندسية، بيانات فيروس كورونا (كوفيد-19)، الحدود الطبقية المثلى، طريقة النافذة المتحركة، متوسط مربعات الخطأ

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DOI: https://doi.org/10.55562/jrucs.v56i1.32