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Using the Lagrange Interpolation Polynomial Method to Calculate the Prevalence of Coronavirus Disease 2019 (COVID-19) in Turkey*

Mahmut MODANLI and Sadeq Taha Abdulazeez

ABSTRACT: The goal of this paper is to look into a numerical approximation for the spread of the coronavirus disease 2019 (COVID-19) in Turkey. From March 11th to November 30th, all data is examined one by one for this purpose. Under Turkey's influence, Covid-19 displayed a widespread, as did the rest of the world shortly after. The information revealed daily about the disease must be formulated mathematically. The time-dependent variation of every piece of data has a significant place in Lagrange interpolation. Using this technique, data were obtained as polynomials. These polynomials were used to draw the simulation of the spread and death rate in turkey by the virus and to track the increase and decrease over the months. The Lagrange interpolation method does not require evenly spaced x values. On the other hand, usually preferable to find the closest value in the table and then use the lowest-order interpolation that is consistent with the data's functional form. A function for monthly and overall data on the number of COVID-19 disease deaths and cases infected with the disease can be obtained using this technique. Simulations for month-by-month and general data are obtained using Lagrange interpolation polynomial. The rate of spread of disease and death numbers is obtained by taking the first derivative of this function. An analysis table for the given data is presented depending on the average speed of death and spread of disease monthly. The information in these simulations is used to determine the disease's peak point and different change values. The rates of death and disease spread by month are compared using these simulations. As a result of this comparison, it can be seen in which months the rate of spread of disease and death increases and decreases. Monthly increase and decrease values can be seen in Figure 3 and Figure 6. For example, a relative decrease can be observed in April and May. Finally, it can be concluded that the Lagrange interpolation polynomial method offered a mathematical framework for data analysis.

Key Words: COVID-19, Lagrange interpolation, simulation, numerical approximation, average speed of propagation rate of death and disease.

Contents

1. Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease that first appeared in China in December 2019 and has since spread to many other countries. On 9 February 2020, some group developed a preliminary mathematical model of the outbreak (see [1]), based on the Be-CoDiS model (see [2]) and our group's background in epidemic mathematical modeling (see https://www.ucm.es/momat/epidemics). They calibrated the model with the available data reported by authorities by 8 February 2020 and reported a forecast. It fitted the data well for 3 weeks (see [3]), even with a sudden unexpected increase of official reported cases on 17 February 2020 due to a change in the World Health Organization guidelines to count cases (see Figure 3). On 21 February 2020 COVID-19 started spreading locally around Italy (see [4]). This country became the epicenter of COVID-19, which spread worldwide. To the best of our knowledge this fact was not forecasted for any scientific paper or report in early February 2020. The main reason is the previously mentioned poor quality of official reported data, which is due in part to the fact that COVID-19 is a disease caused by a new virus known as SARS-CoV-2, which has created

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a completely unprecedented new global emergency situation. The World Health Organization declared COVID-19 a pandemic on March 11, 2020 [5]. On the same day, the first case was discovered in Turkey. Numerous scientists and researchers used a variety of precise computational and numerical techniques to address a variety of mathematical models, including the modified (G'/G)-expansion method [6], the Kudryashov method and the sine-Gordon method [7], finite difference method [8], generalized auxiliary equation technique [9], fractional iteration algorithm-I [10], VIA-I with an auxiliary parameter [11], Elzaki homotopy perturbation method [12], meshless method [13], [14], Riccati transformation method [15], Variational iteration algorithm-II [16], [17], and the optimal control power series technique [18], have been applied to solve different mathematical problems. The purpose of this research is to develop a mathematical model based on real Covid-19 data from Turkey using the interpolation polynomial method. With simulations, this model is used to show the monthly variation of disease spread and mortality rate. The increase and decrease in disease spread and death rate for the monthly and overall condition of the Covid-19 virus were compared using these simulations obtained with the Matlab program. The graph of the polynomial can be viewed as filling in the curve to account for data between known points, which contributes to the robustness of the Lagrange interpolation polynomial method. This technique, called polynomial interpolation, frequently yields results that are more precise than those of linear interpolation. Utilizing existing knowledge from a case with a substantial impact on the world, the Lagrange polynomial interpolation method provided a mathematical model that can be used to investigate data. This study is distinctive because it uses a mathematical formulation based on this approach for the data collections.

Next section, we will construct Lagrange interpolation polynomial for the morbidity and mortality data result from COVI-19 in Turkey.

2. Lagrange Interpolation Polynomial Method

In mathematics, the fact that a function is continuous and differentiable provides a very important tool for studying the behavior of that function.Most "real" implementations struggle with this because functions are used to model correlation between quantities, but our only knowledge of these functions is that they construct a set of discrete data points from which measurements are extracted. As a result, we must obtain continuous functions that rely on discrete data. Data fitting is the problem of implementing such a continuous function.

We will build a special occasion of data fitting known as interpolation in this paper. The goal is to find a linear combination of n defined functions that will fit a dataset with n constraints, ensuring only one solution that fits the data exactly, not numerically. Instead of "data points," the broader term "limitations" is used because they may include additional information such as a description of the input, rates of change, or the requirement that the fitting function have a fixed number of continuous derivatives Working with polynomials is especially easy when studying calculus-based functions. As a result, in this study, we will concentrate on the problem of constructing a polynomial that, in some ways, fits the obtained input.First, we obtain some algorithms for computing the unique polynomial $p_n(x)$, of degree n, which yields $p_n(x) = y_i), i = 0, 1, \ldots n$, where the points (x_i, y_i) are presented. The interpolation points $(x_0, x_1, \ldots, x_n)$ are well-known. The polynomial $p_n(x)$ is the interpolating polynomial of the input $(x_0, y_0), (x_1, y_1), \ldots, (x_n, y_n)$ [19].

In Lagrange interpolation, we will try to obtain a formula that can be easily obtained if the points are given evenly. Suppose that the function values are known at $(n + 1)$ evenly spaced point. Let the dependent variable Y assumes the values $y_0, y_1, \ldots y_n$, corresponding to the independent variable X values

$$x_0, x_1, \ldots x_n,$$

The authors in [20] describes Lagrange's interpolation formula for finding the value of y that corresponds to a value of x between any x_0 and x_n, by

$$f(x) = \frac{((x - x_1)(x - x_2)\ldots(x - x_n))}{((x_0 - x_1)(x_0 - x_2)\ldots(x_0 - x_n))} \times y_0 + \cdots + \frac{((x - x_1)(x - x_2)\ldots(x - x_{(n-1)}))}{((x_n - x_1)(x_n - x_2)\ldots(x_n - x_{(n-1)}))} \times y_n, \quad (2.1)$$

In this context, the biggest disadvantage of Lagrange Interpolation is not being able to apply a job that has been done before, that is, not being able to benefit from it while evaluating. Calculations must be repeated with the addition of each new data point. The Newton Interpolation polynomial overcomes this disadvantage. The Lagrange interpolation polynomial method has the advantage over other existing methods in that Lagrange's form is more effective when you need to interpolate multiple data sets using the same data points.

3. Results of Lagrange Interpolation Polynomial for all Data in Turkey

In this section, we will get a separate polynomial for each month for all data in Turkey. For this, we relied on data from the Ministry of Health in Turkey. Then we will find a general Lagrange polynomial interpolation using all the data in Turkey (see: [21]). The rate of spread of death and disease in Covid-19 will be calculated for each month and for all times by taking the derivative of these polynomials with respect to time.

Using the formula (2.1) and Matlab programming for the death data of the March month, we get

$$D(t) = AT, \tag{3.1}$$

where

$$A = [0.0000 - 0.0000 - 0.0000 - 0.0000 - 0.0000 - 0.0000 - 0.0000 - 0.0000 - 0.0000 - 0.0001 - 0.0011 \\ - 0.0072 - 0.0387 - 0.1613 - 0.5132 - 1.2128 - 2.0410 - 2.2846 - 1.5015 - 0.4294 - 0]_{(1\times 21)},$$

and

$$T(t) = [1tt^2 \dots .t^{20}]^T_{(1\times 21)}.$$

Taking derivative the formula (3.1), we get

$$\frac{\partial D(t)}{\partial t} = A\frac{\partial T(t)}{\partial t}. \tag{3.2}$$

Using the formula (3.2), it is seen that the average spread rate of death for March is

$$v = 8.2205 \times 10^{(-13)} m/s,$$

for $t = 1$. Where t is taken as one second, and v is the rate of propagation in one second. If the data in [7] is used and the same procedure is continued, the average speed of propagation of the covid-19 disease in Turkey calculated as

$$v = 1.1574 \times 10^(- 5) m/s.$$

From March until November using the Lagrange interpolation polynomial method, the average speed of propagation rate of death and disease in Turkey is given in the following table. These results were obtained using the Matlab program.

Table 1: Gives death and disease spread rate by months

Months	Average spread speed of death (m/s)	Average spread speed of disease (m/s)
March	$8.2205 \times 10^{(-13)}$	$1.1023 \times 10^{(-5)}$
April	0.0031	0.1754
May	0.0365	1.3709
June	0.0511	1.8435
July	0.0577	2.2524
Agust	0.0640	2.5971
September	0.0718	3.0399
October	0.0895	3.4655
Novamber	0.1155	4.2233
General for total time	0.4892	2.1076

Remark 3.1. *From this table, average speed of propagation of the disease spreading in Turkey is given as 2.1076 and the death rate is given as 0.4892. Other data in the table also show monthly mortality and disease spread rate, respectively.*

Remark 3.2. *Using real death and illness data found Lagrange polynomial interpolation. With the help of this polynomial function, the following simulations were drawn using the Matlab program for monthly mortality and disease spread values.*

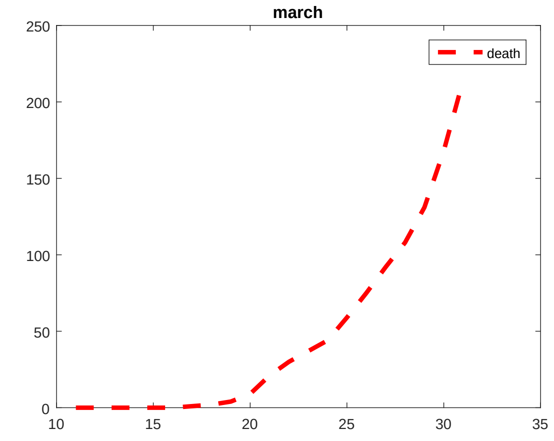

Figure 1: Death numbers for March month

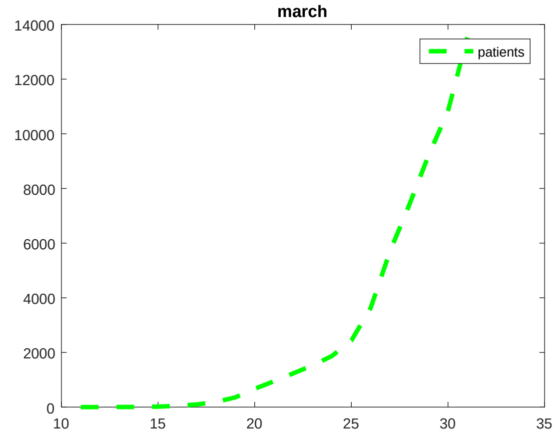

Figure 2: Patient numbers for March month

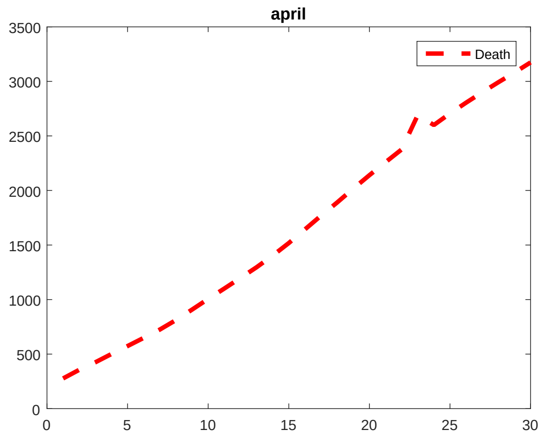

Figure 3: Death numbers for April month

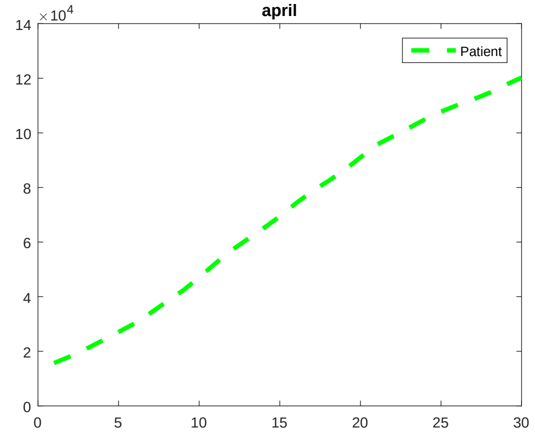

Figure 4: Patient numbers for April month

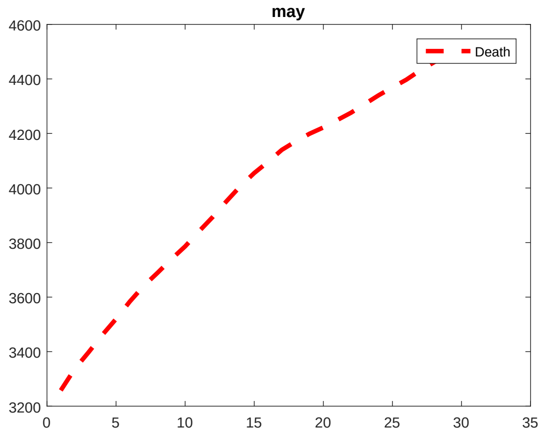

Figure 5: Death numbers for May month

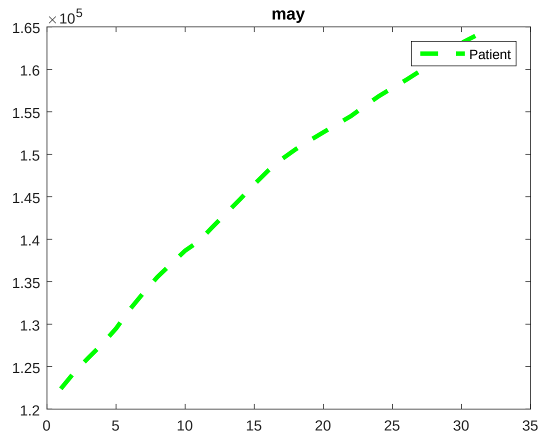

Figure 6: Patient numbers for May month

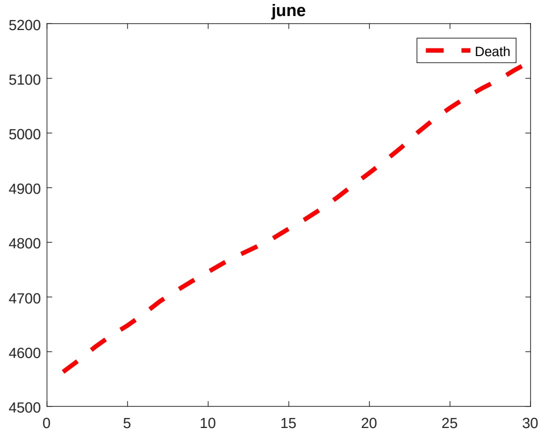

Figure 7: Death numbers for June month

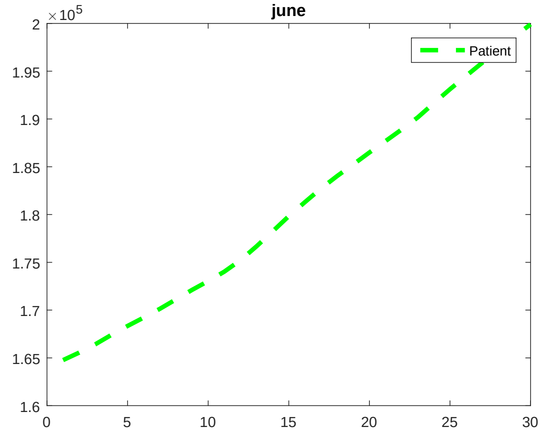

Figure 8: Patient numbers for June month

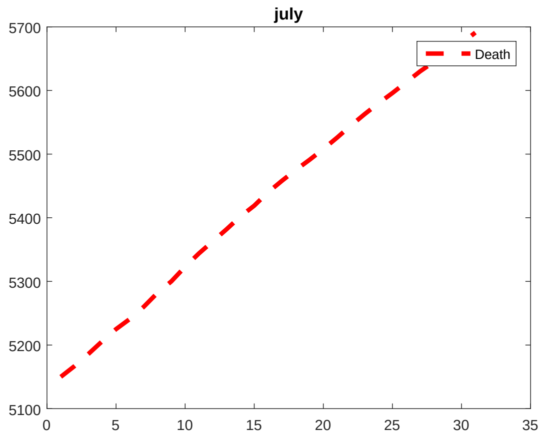

Figure 9: Death numbers for July month

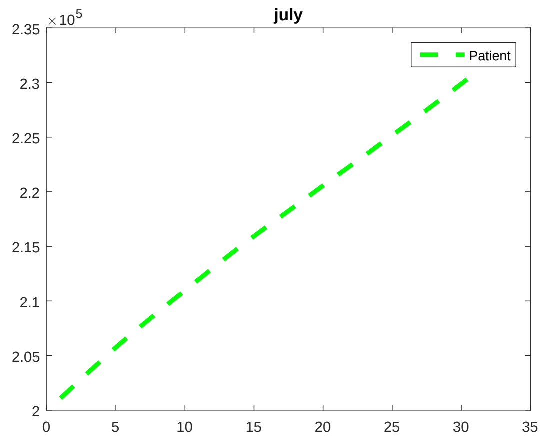

Figure 10: Patient numbers for July month

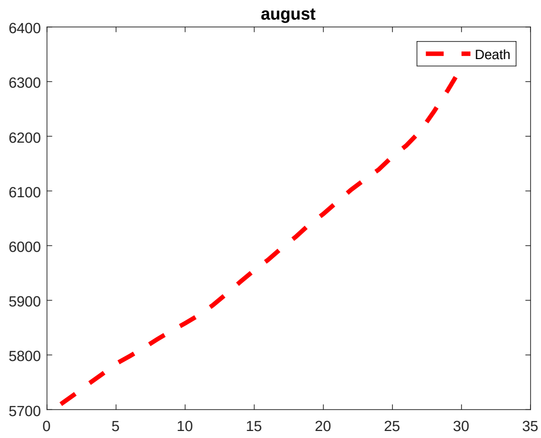

Figure 11: Death numbers for August month

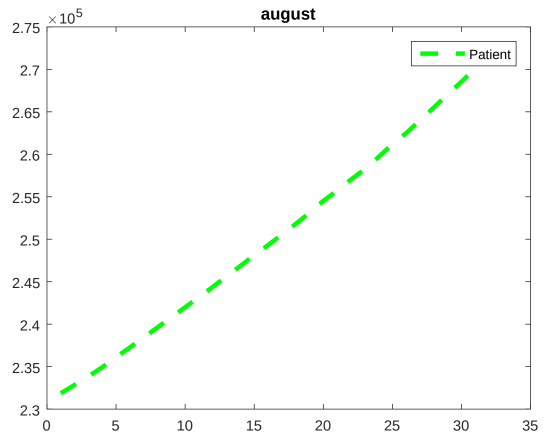

Figure 12: Patient numbers for August month

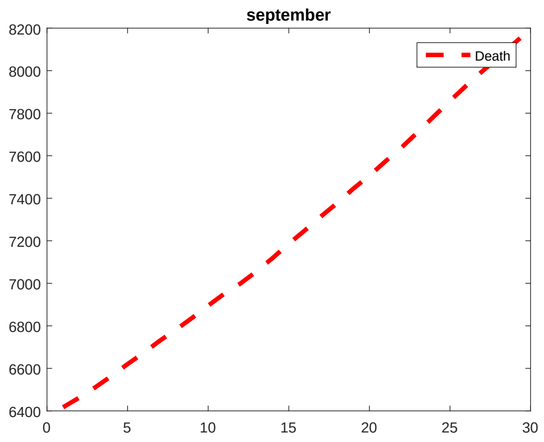

Figure 13: Death numbers for September month

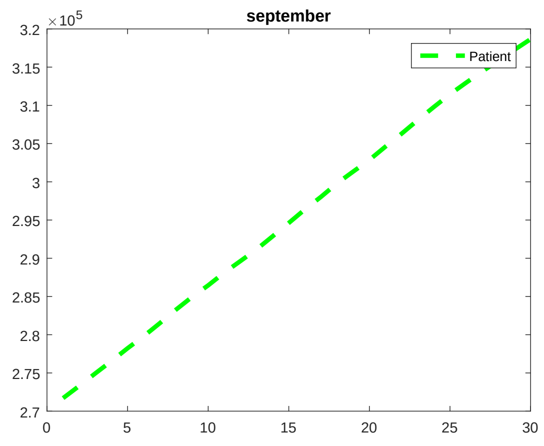

Figure 14: Patient numbers for September month

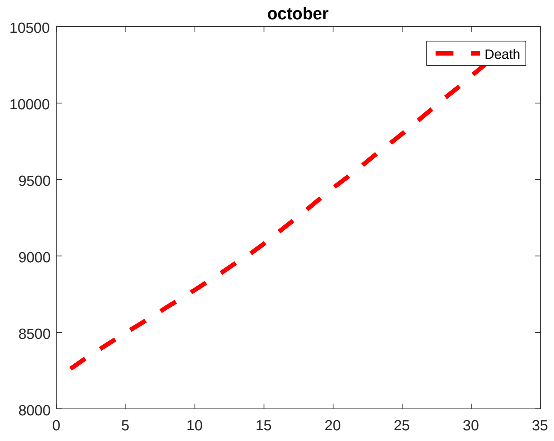

Figure 15: Death numbers for October month

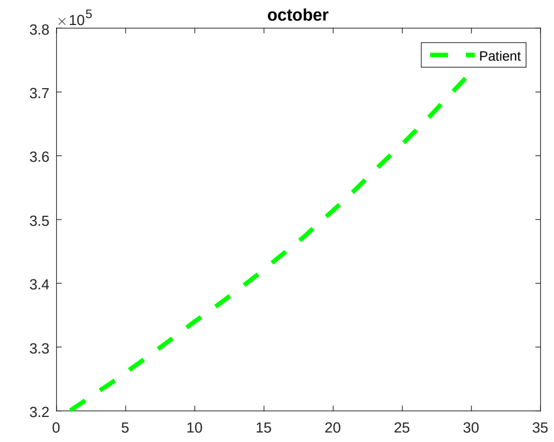

Figure 16: Patient numbers for October month

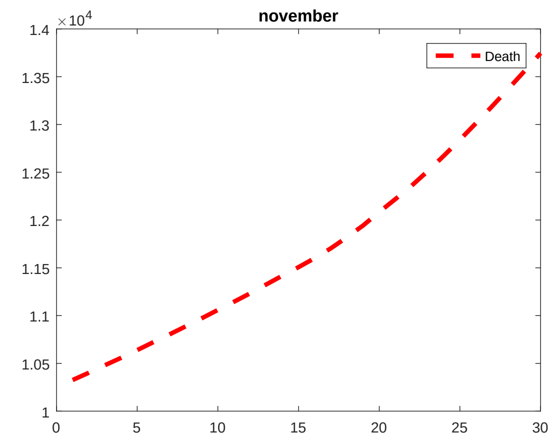

Figure 17: Death numbers for November month

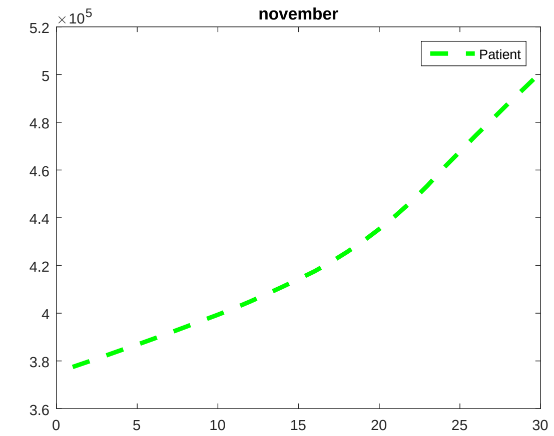

Figure 18: Patient numbers for November month

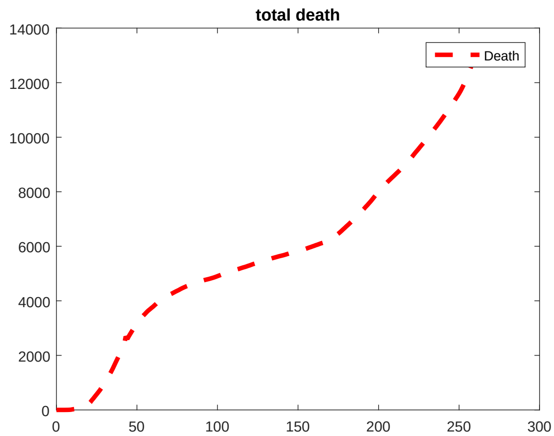

Figure 19: Total Patient numbers

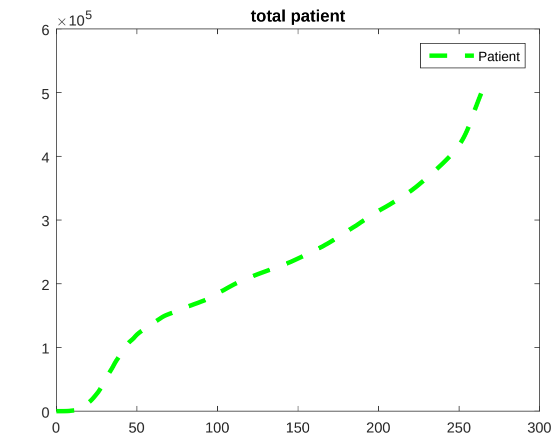

Figure 20: Total Death numbers

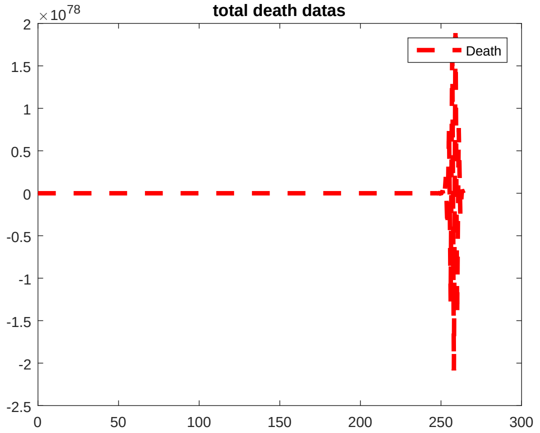

Figure 21: Interpolation polynomial and time for total Deaths

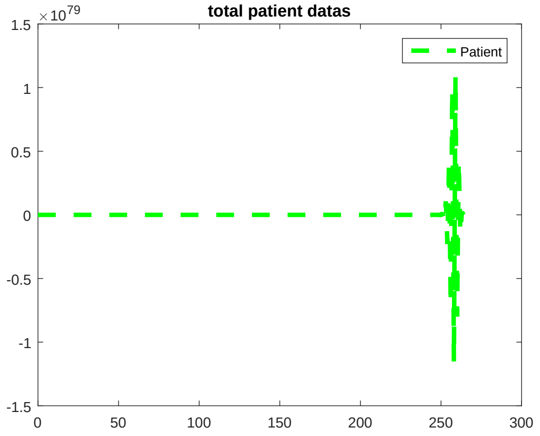

Figure 22: Interpolation polynomial and time for total Patients

4. Conclusion and Discussion

In this paper, the Lagrange interpolation polynomial method was given for all real coronavirus-19 data in Turkey. Applied the existing data from an event with a substantial impact on the world, the proposed method provided a mathematical model that could be used to analyze data. All simulations for mortality and disease data were obtained using this method (see Figure 1 - Figure 18). Monthly increase and decrease values can be seen from these graphs. For example, a relative decrease can be observed in April and May (see Figure 3 - Figure 6). The most important reason for this is that the number of quarantine days applied in these months is more than in the following months. By taking the first derivative of the interpolation polynomial, the rate of spread of disease and death was obtained. From here, a monthly propagation rate table was created. It is clearly seen from the figures and the speed table that there was a visible increase from June to November and that the increase was faster in November. Again, as can be seen from the total data figures (see figures 19 and 20) and speed table, it can be said that the peak point has not been reached. From Figures 21 and 22, it is clear that the greatest intensity is at the end of November.

Acknowledgments

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Mahmut MODANLI
Department of Mathematics,
Faculty of Art and Science,
Harran University,
Sanliurfa, Turkey.
E-mail address: mmodanli@harran.edu.tr

and

Sadeq Taha Abdulazeez
Department of Mathematics,
College of Basic Education,
University of Duhok,
Duhok, Iraq.
E-mail address: sadiq.taha@uod.ac