

Chapter 7

Limitations and Implications of Doubling Time Approach in COVID-19 Infection Spreading Study: A Gradient Smoothing Technique

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ABSTRACT

To control the spread of COVID-19, around the world, many countries imposed lockdowns. Numerous studies were reported on COVID-19 in different disciplines with various aspects. The doubling time is a mathematical technique to estimate the current rate of spread of the disease. Researchers used the doubling technique to address the COVID-19 pandemic situation. The larger doubling period represents a low spreading rate, whereas the smaller doubling period represents a high spreading rate. In other words, high infection implies the low doubling period and low infection implies the high doubling period. So, there is an inverse relationship between doubling time and the infection rate. But the real-life data does not follow such a rule properly in various domains. The data shows that after a certain time when the infection is high, the doubling period is also high, which misleads our general concept of doubling time. This chapter addressed this issue by investigating the real-time COVID-19 data. To overcome this limitation, a gradient smoothing technique has been proposed.

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INTRODUCTION

Researchers have tried to address the epidemic diseases using mathematical modeling for a long (Britton, 2010; Kermack et al., 1927). In any epidemic disease, a fundamental question is, how fast the infection is spreading? One way to address this question is to look at how long it takes the infection count to get double the current count. This time is termed as doubling time (Patel and Patel, 2020) that is used to estimate the rate of spread of infection. This technique is used in Romania in 2006 for the avian influenza subtype H5N1 (Ward et al., 2009) and a similar study carried out for the SARS epidemic in 2003 (Galvani et al., 2003). The concept of doubling time comes from exponential growth or a particular growth model where the doubling time remains constant. For a given day, the doubling time says the number (t_d), of days passed since the number of cases was half ($n/2$) of the current number (n) or the number will be doubled ($2n$) after doubling time (t_d), in days.

The doubling time gives an interpretation of the intensity of infection spreading and it changes over days. But sometimes doubling time gives a misinterpretation especially in the boundary cases i.e. at the beginning and the end of the pandemic period. In this context, we have introduced the concept of infection spreading based on the gradient smoothing technique. Smoothing is a mathematical approach that is used for various purposes like eliminating noise and outliers from datasets, forecasting the patterns more noticeable or expose the patterns, etc. Sometimes the trend of data points is not visible but after smoothing, the patterns are exposed. There are several methods of smoothing, like random method, moving average, random walk, exponential, exponential moving average, etc.

In our cases, we have used the gradient smoothing technique. In time-series data if the gradients are calculated of each pair of points it sometimes shows the direction is ups-and-down and it depends on data. In the COVID-19 data set if gradients are calculated of each pair of points, the gradients or growths are ups-and-down shown in Figure 2. Here we have done the gradient smoothing to expose the growth pattern properly. In this smoothing technique, we have used a window of length seven to calculate the gradient. It is fixed with the window size seven by the heuristic approach i.e. it started with window size one, then two, and so on, and seeing the corresponding growth graph it is fixed with window size seven (Figure 3).

There are various smoothing techniques used in various disciplines based on the applications. According to Hitchcock et al. (2006), smoothing provides accuracy and also shows the effects on data clustering. On the other hand, Hitchcock et al. (2007), and Ghosal et al. (2014) used the smoothing technique in noise images, whereas Scott et al. (1989) used it in the curve fitting. The concepts are also used by Liu et al., (2008) in several other domains like solid mechanics, hydrodynamics by Mao et al. (2019), and so on.

The smoothing does not always offer an interpretation of the themes or patterns but sometimes it helps to recognize. In a continuous growth or continuous decline of the time series data this technique will not help much, it depends on the characteristic of the data points. In a smoothing technique, there is a chance to overlook some usable data points.

This study is an alternate approach to represent or describe the spread of a pandemic disease. It gives a better visualization of the infection spreading for a complete data set and in the case of the partial data set, it gives the trend of infection.

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