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A study of Covid 19 disease mathematical model via wavelets

Kumbinarasaiah, S[1] and Devaraju K S[2]
Department of Mathematics, Bangalore University, Bengaluru – 560056, Karnataka, India
Department of Biochemistry, Karnatak University, Dharwad – 580003, Karnataka, India
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Abstract. In this study, we propose an effective numerical algorithm to study the Covid-19 epidemic model that is in the form of a system of the coupled ordinary differential equation. This algorithm includes the collocation method and truncated Laguerre wavelet. Here, we reduce the system of a differential equation into a set of algebraic equations which are having unknown Laguerre wavelet coefficients. Moreover, the modeling of the spreading of a Covid-19 disease in a population is numerically solved by the present method.

Keywords: Wavelets, collocation method, mathematical model.

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1. Introduction

Since the first reports of novel pneumonia (COVID-19) in Wuhan, Hubei province, China [1], there has been considerable discussion on the origin of the causative virus, SARS-CoV-2 also referred to as HCoV-19. Infections with SARS-CoV-2 are now wide. The spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has already taken on pandemic proportions, affecting over 100 countries in a matter of weeks. A study in Italy the patients who died, 42.2% were aged 80–89 years, 32.4% were aged 70–79 years, 8.4% were aged 60–69 years, and 2.8% were aged 50–59 years, those aged >90 years made up 14.1% [2]. The potential risk factors of older age, high SOFA score Wuhan Pulmonary Hospital December 2019, Wuhan, China was carried out and found out those increasing odds of in-hospital death associated with older age [3]. Because of the COVID-19 world health emergency, various governments suggested the WHO to have an ***"Immunity Passport"*** or ***"risk-free certificate"*** to provide work or travel permits. However no evidence that people who have recovered from COVID-19 and have antibodies are protected from a second infection.

Mathematical model of severe SARS-CoV-2 to assess the potential for sustained human-to-human transmission with four datasets from within and outside of Wuhan was addressed between December 2019, and February 2020 [4]. In another stochastic transmission model, parameterized to the COVID-19 outbreak. The model used to quantify the potential effectiveness of contact tracing and isolation of cases at controlling a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)-like pathogen. This could lead to having the success of controlling outbreaks using isolation and contact tracing and quantified the weekly maximum number of cases traced to measure the feasibility of public health effort [5]. In Wuhan, China, a novel and alarmingly contagious primary atypical (viral) pneumonia broke out in December 2019. It has since been identified as a zoonotic coronavirus, similar to SARS coronavirus and MERS coronavirus and named COVID-19. As of 8 February 2020, 33 738 confirmed cases and 811 deaths have been reported in China.

A review on the basic reproduction number $\left[\frac{\beta}{\gamma} = R_0\right]$ of the COVID-19 virus. R0 is an indication of the transmissibility of a virus, representing the average number of new infections generated by an infectious person in a naïve population. For $\left[\frac{\beta}{\gamma} = R_0 > 1\right]$, the number infected is likely to increase, and for $\left[\frac{\beta}{\gamma} = R_0 < 1\right]$, the transmission is likely to die out. The basic reproduction number is a central concept in infectious disease epidemiology, indicating the risk of an infectious agent concerning epidemic spread [6].

To examine how changes in population mixing have affected outbreak progression in Wuhan, we used synthetic location-specific contact patterns in Wuhan and adapted these in the presence of school closures, extended workplace closures, and a reduction in mixing in the general community. Using these matrices and the latest estimates of the epidemiological parameters of the Wuhan outbreak, the simulated the ongoing trajectory of an outbreak in Wuhan using an age-structured susceptible-exposed-infected-removed (SEIR) model for several physical distancing measures. The latest estimates of epidemic parameters from a transmission model to data on local and internationally exported cases from Wuhan in an age-structured epidemic framework and investigated the age distribution of cases. The simulated lifting of the control measures by allowing people to return to work in a phased-in way and looked at the effects of returning to work at different stages of the underlying outbreak (at the beginning of March or April) [7].

In real-time, estimates of the case fatality ratio (CFR) and infection fatality ratio (IFR) can be biased upwards by under-reporting of cases and downwards by failure to account for the delay from confirmation to death. Collecting detailed epidemiological information from a closed population such as the quarantined Diamond Princess Cruise ship in Japan can produce a more comprehensive description of asymptomatic and symptomatic cases and their subsequent outcomes. We aimed to estimate the IFR and CFR of coronavirus disease (COVID-19) in China, using data from passengers of the Diamond Princess while correcting for delays between confirmation and death and for the age structure of the population [8].

The novel 2019 coronavirus, SARS-CoV-2 (COVID-19), emerged towards the end of 2019 in the city of Wuhan in the province of Hubei in the People's Republic of China, and it has spread to the entire world very fast and in a very short time. This study aimed to investigate the course of the pandemic by mathematical modeling based on the information that the time-dependent change (spreading) rate of the H number of individuals who have caught a contagious disease is proportional to the multiplication of the numbers of those who have caught the disease and those who have not. According to the results of the mathematical modeling in our study, in the case that sufficient precautions are not taken, or precautions are reduced, the course of the pandemic may show a very fast change in the negative direction. For this reason, every precaution, individual or social, will be significant in terms of the course of the COVID-19 pandemic [9].

The outbreak of novel coronavirus-caused pneumonia (COVID-19) in Wuhan has attracted worldwide attention. Here, we propose a generalized SEIR model to analyze this epidemic. Based on the public data of the National Health Commission of China from Jan. 20th to Feb. 9th, 2020, we reliably estimate key epidemic parameters and make predictions on the inflection point and possible ending time for 5 different regions. According to optimistic estimation, the epidemics in Beijing and Shanghai will end soon within two weeks, while for most of China, including the majority of cities in Hubei province, the success of anti-epidemic will be no later than the middle of March. The situation in Wuhan is still very severe, at least based on public data until Feb. 15th. We expect it will end up at the beginning of April. Moreover, by inverse inference, we find the outbreak of COVID-19 in Mainland, Hubei province and Wuhan all can be dated back to the end of December 2019, and the doubling time is around two days at the early stage.

Wavelets are special functions in a limited domain that is, a wave function instead of oscillating forever it drops to zero. Recently, we have facing different kinds of wavelets which are depending on two parameters such as, n is dilation parameter and k is the translation parameter [10]. The theory and application of wavelets is a comparatively young branch in signal processing and mathematical field. It has been applied in engineering disciplines, such as signal analysis, time-frequency analysis, and engineering mathematics [11-17].

In this study, we proposed a new algorithm to obtain numerical solutions for the system of ordinary differential equations with different constraints. it is very important to obtain numerical solutions for the system of nonlinear ordinary differential equations in many different fields of science and engineering such as chemical physics, fluid mechanics, solid-state physics, plasma physics, and plasma waves. Most realistic systems of ordinary differential equations do not have exact solutions, therefore, we need numerical techniques [18]. Consider the system of an ordinary differential equation is of the form [16]:

$$y_{p_1}^{d}(x) = f(x, y_1^{n_1}, y_2^{n_2}, \dots, y_p^{n_p}) \tag{1.1}$$

Where, $d \geq n_i \in \{0\}UN, p_1\ and\ i = 1, \dots, p, p$ is any natural number, d and n_i represents the order of the derivatives. Corresponding initial conditions are as follows,

$$y_{p_1}^{d_1}(a_1) = b_j,\ \ j, d_1 = 0,1, \dots, d-1, \tag{1.2}$$

Or boundary conditions (only for a system having second-order differential equations) are of the form,

$$y_{p_1}(a_2) = b_j,\ \ y_{p_1}(a_3) = c_j \tag{1.3}$$

Where b_j and c_j are constant. Many mathematicians already contributed some methods towards the solution of the system of ordinary differential equations they are as follows, Adomian decomposition method [19], operational matrix method with Chebyshev polynomials [20], Modification of Adomian Decomposition