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SEIR MODEL RELATED TO COVID 19 SPREAD AND FORECASTING NUMBER OF DEATH

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1. Introduction

The World Health Organization (WHO) China Country Office reported on December 31, 2019, of occurrences of pneumonia with an unknown etiology. Community infection, group infection, and widespread transmission are the three phases of COVID-19's outbreak. It has aggressively spread around the world, especially to Malaysia. Currently, Malaysia has reported 8,574 cases and 102 deaths as of July 12, 2021. Symptoms might show anywhere between two and fourteen days after being infected with the virus. In this study, we will be using the Susceptible-Exposed-Infectious-Recovered (SEIR) model as an estimation tool to develop the number of COVID-19 cases in Malaysia. The model is being used to anticipate things like how quickly a disease will spread, how many people will become affected, and what steps can be taken to slow it down. To forecast the number of COVID-19 deaths in Malaysia, we used two different methods which are Least Square Method and Holt-Winters Method to choose the best method that is more accurate. In order to determine the possible case in the future, the researchers use the SEIR model to study COVID-19 cases in Malaysia and the Least Square Method and Holt-Winters Time Series to identify the number of COVID-19 deaths in Malaysia by using data on October 2021.

2. Methodology

2.1. *SEIR Model*

The SEIR model is one of the mathematical models that is used for studying infectious diseases. The model is being used to anticipate things like how quickly a disease will spread, how many people will become affected, and what steps can be taken to slow it down (Abou-Ismail, 2020). A set of ordinary differential equations may be used to explain the evolution and dynamics of the SEIR model (Mamo and Koya, 2015). This model has been done using MATLAB with the Runge-Kutta method.

$$\frac{dS(t)}{dt} = -\beta S(t)I(t) \tag{1}$$

$$\frac{dE(t)}{dt} = \beta S(t)I(t) - \alpha E(t) \tag{2}$$

$$\frac{dI(t)}{dt} = \alpha E(t)\gamma I(t) - MI(t) \tag{3}$$

$$\frac{dR(t)}{dt} = \gamma I(t) \tag{4}$$

2.2. *Least Square Method*

In this forecast method, a polynomial function will be used as this function gives a better approximation between dependent and independent variables than the linear function (Kenton, 2021). The polynomial function in Figure 1 for the Least Square Method generated from Microsoft Excel using the data of Covid-19 death in October 2021.

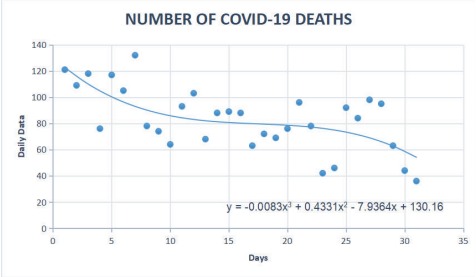

Figure 1: Number of deaths in October 2021 by using polynomial equation

The dependent variable is the number of the deaths while the number of days is set as an independent variable.The estimated trend line represented as follow:

$$Y(x) = -0.0083x^3 + 0.4331x^2 - 7.9364x + 130.16 \tag{5}$$

2.3. *Holt-Winters Method*

Holt-Winters is one of the time series forecasting methods which consists of a forecast function and three smoothing functions: seasonal smoothing S_t, level smoothing L_t and trend smoothing T_t with corresponding coefficient γ, α and β.

$$S_t = \gamma\frac{\gamma_t}{L_t} + (1-\gamma)S_{t-m} \tag{6}$$

$$L_t = \alpha\frac{\gamma_t}{S_{t-m}} + (1-\alpha)(L_{t-1} + T_{t-1}) \tag{7}$$

$$T_t = \gamma(L_t - L_{t-1}) + (1-\beta)T_{t-1} \tag{8}$$

$$F_{t+1} = (L_t + T_t)S_{t-m+1} \tag{9}$$

To forecast the fatalities of COVID-19 using Holt-Winters method, two different sets of coefficient values to determine the better values of smoothing coefficient for the problem and the equations in (6), (7), (8) and (9). Same as the Least Square Method, Microsoft Excel also will be used to generate the Holt-Winters Method.

3. Results and Discussions

3.1. *SEIR model*

The number of people in each class is depicted in Figure 2. In fewer than 20 weeks, both exposure and infection rates reach their apex. Figure 2 depicts how the pattern lasted for roughly a year, with a transmission rate of 5 and infection and recovery rates of 0.5 and 0.8, respectively. When the analysis was repeated in the presence of the vaccinated population without modifying the exposure, infection, or recovery rate, Figure 3 showed a modest change. The susceptibility population has dropped to zero, indicating that no one will be exposed to or affected by the illnesses.

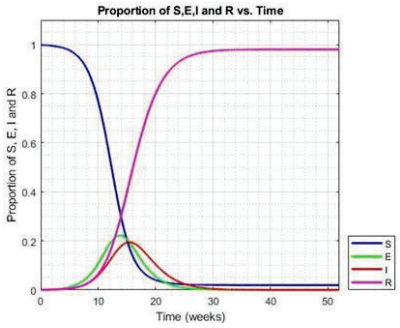

Figure 2: SEIR model

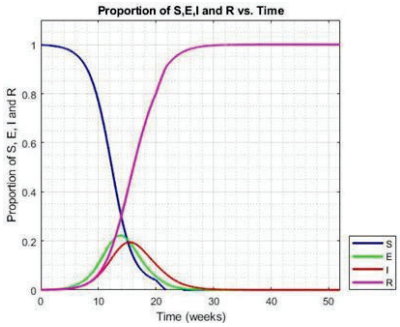

Figure 3: SEIR model with Vaccination

3.2. *The Least Square method*

The error value of the Least Square Method in Figure 4 to forecast the number of deaths is 17.9627 for COVID-19 deaths in a month. This value shows that the method gives a small number of errors.

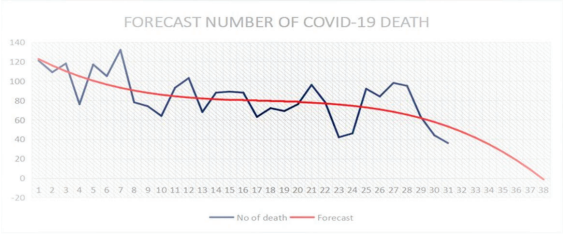

Figure 4: Forecast COVID-19 Deaths by Least Square Method

3.3. *The Holt-Winters method*

The Figure 5 shows the forecast until 7th November 2021, the RMSE for Holt-Winters Method is calculated. RMSE for Figure 5 is calculated as follow

$$\begin{aligned} RMSE &= \sqrt{\frac{18244.0253}{2}} \\ &= 28.1641 \end{aligned}$$

Same as in Figure 5, Figure 6 also forecasted fatalities until 7th November 2021.

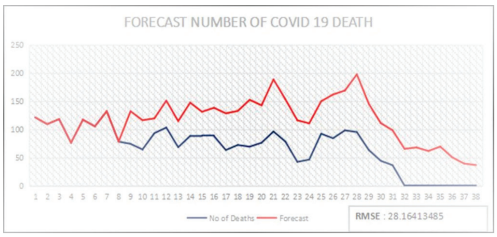

Figure 5: Forecast COVID-19 Deaths by Holt-Winters Exponential Smoothing using $\alpha = 0.2$, $\beta = \gamma = 0.3$

The RMSE for Holt-Winters Method in Figure 6 is calculated as below

$$\begin{aligned} RMSE &= \sqrt{\frac{13680.7227}{23}} \\ &= 24.3888096 \end{aligned}$$

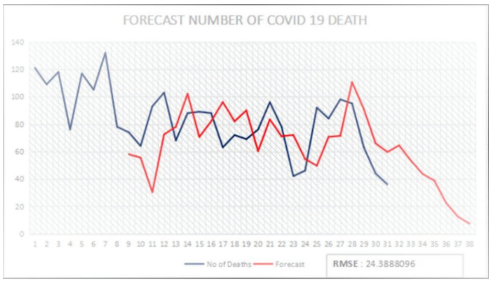

Figure 6: Forecast COVID-19 Deaths by Holt-Winters Exponential Smoothing using $\alpha = 0.3$, $\beta = \gamma = 0.5$

4. Conclusion

This study concludes the following main contributions: 1. The number of cases using the SEIR model. It has become important to understand the disease trends in order to mitigate its effects; 2. Forecasting number of COVID-19 death using the Least Square Method and Holt-Winter Method. The number of COVID-19 fatalities in Malaysia is identified using the Least Square Method and Holt-Winters Method, which compare polynomial function and time series forecasting. By comparing performance metrics RMSE, Holt-Winters Method has higher value of RMSE for COVID-19 deaths. Because of the lower number of errors compared to the Holt-Winters, the value indicates by the Least Square method that the approach provides more accurate estimation than Holt-Winters method.

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