Predicting hoax spread in Indonesia using SIRS model

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Abstract. Hoax or fake news can spread easily through the internet like an epidemic. In Indonesia, hoaxes are common that it becomes a serious problem. We predicted the spread of hoaxes in Indonesia by using the Susceptible-Infected-Recovered-Susceptible (SIRS) epidemic model where the susceptible is the person who ignores the news, the infected is the person who shares the news without fact-checking it, and the recovered is the person who fact-checks the news. This paper uses data from the Indonesia Telematics Society (MASTEL) concerning the behavior of Indonesian people in 2017 and 2019 when receiving trending news. We also use data on the number of internet users in Indonesia obtained from the Indonesia Internet Service Providers Association (APJII). This model has a disease-free equilibrium which is unstable and an endemic equilibrium which is asymptotically stable. The basic reproduction number of this model, which is 5.614455426, shows that the spread of hoaxes in Indonesia will increase because the behavior of sharing the news without fact-checking it will spread in the society until it reaches endemic equilibrium.

1. Introduction

Today’s globalization has entered a new era that is the Industrial Revolution 4.0, better known as the “Technological Revolution” or “Digital Revolution”. Industrial Revolution 4.0 has a big impact on several things such as economics, politics, health, technology, and many others. Specifically, in terms of information technology, the Industrial Revolution 4.0 has had a huge impact, one of which is social media which currently the most important part of people's lives in the digital era. The impact of technological advances, especially the rapid development of social media, has good and bad impacts. The good impact of social media can be a means to express themselves, as a means for business, educational facilities and many others. In addition, social media also has many adverse effects such as the misuse of social media, criminal acts, online fraud, and distribution of fake news. In fact, social media has become main platform of hoax spread in Indonesia [1]. Through social media, hoaxes can easily spread among the people who want the ease of communication interactions. So the era of the Industrial Revolution 4.0, which prioritizes information technology in all aspects of life, made the phenomenon of the spread of hoax a major challenge.

In Indonesia, the number of hoaxes is keep increasing every month. There are 1.731 fake news recorded on the internet from August 2018 to April 2019 with a variety of issues, such as politics, government, fraud, to religion [2],[3]. The behavior of the Indonesian people to share the news is certainly something that must be considered because if the news is not checked first, then hoax will spread. This can disrupt social harmony and hamper the development of Indonesia [1].
According to [4], if people receive the same news often, they are more likely to believe the news even if it is false. This means if the fake news is widely shared and became viral, it could convince people to believe it and they could become a spreader too. From this phenomenon, the spread of hoax can be viewed as an epidemic, where the behavior of believing fake news and actively sharing it can spread to other people. Therefore, problems like this can be modeled by the epidemic models, namely the SIRS (Susceptible-Infected-Recovered-Susceptible) model. This study aims to predict the spread of hoax in Indonesia using the SIRS model.

2. Literature Review

2.1. The SIRS epidemic model
The epidemic model is used to study the spread of disease. The Kermack-McKendrick epidemic model describes the connection between someone who is susceptible, infected, and immune to the disease in a population [5]. This model successfully predicted the spread of disease similar to the epidemic cases that had occurred [6].

The Susceptible-Infected-Recovered-Susceptible (SIRS) epidemic model is a model for contagious disease that causes temporary immunity after recovery. The SIRS model has three components, namely people who are susceptible (S), infected (I), and have temporary immunity to the disease (R). An infected person can transmit the disease to the susceptible and they can recover from the disease and have temporary immunity so they can become susceptible again.

The SIRS epidemic model is expressed in the following differential equation system:

\[ \frac{dS(t)}{dt} = -\beta S(t)I(t) + \delta R(t) \] \hspace{1cm} (1)

\[ \frac{dI(t)}{dt} = \beta S(t)I(t) - \gamma I(t) \] \hspace{1cm} (2)

\[ \frac{dR(t)}{dt} = \gamma I(t) - \delta R(t) \] \hspace{1cm} (3)

\[ N = S(t) + I(t) + R(t) \]

Where the notations are:
- \( S(t) \): The number of susceptible people in a population at time \( t \)
- \( I(t) \): The number of infected people in a population at time \( t \)
- \( R(t) \): The number of recovered people in a population at time \( t \)
- \( N \): Total population
- \( \beta \): Infection rate
- \( \gamma \): Recovery rate
- \( \delta \): Rate of immunity loss

2.2. Equilibrium points of the SIRS model and stability analysis
The equilibrium points of the SIRS model is obtained by solving equations (1), (2), and (3) with \( \frac{dS(t)}{dt} = \frac{dI(t)}{dt} = \frac{dR(t)}{dt} = 0 \). The equilibrium points are:

\[ P_0 = (S^*, I^*, R^*) = (N, 0, 0) \]
\[ P^* = (S^*, I^*, R^*) = \left( \frac{N - \gamma}{\beta}, \frac{N - \gamma}{\beta}, \frac{1}{1 + \frac{\beta}{\delta}} \right) \]

\( R_0 \) is called the disease-free equilibrium and \( P^* \) is called the endemic equilibrium [7].

Considering the value of \( R_0 = \frac{N \beta}{\gamma} \), based on [7], there are two possibilities:

- If \( R_0 < 1 \), then the equilibrium point is \( P_0 \) and is asymptotically stable.
- If \( R_0 > 1 \), then the equilibrium points are \( P_0 \) and \( P^* \) where \( P_0 \) is unstable and \( P^* \) is asymptotically stable.

\( R_0 \) is also called the basic reproduction number which shows the average number of the susceptible (\( S \)) contaminated by one infected individual (\( I \)).

3. Research Methodology

This paper uses secondary data obtained from the Indonesia Telematics Society (MASTEL) concerning the behavior of Indonesian people in 2017 and 2019 when receiving trending news. Besides that, we also use data on the number of internet users in Indonesia in 2018 obtained from the Indonesia Internet Service Provider Association (APJII). Using this data, we predict the spread of hoaxes in Indonesia using the SIRS model with the following steps:

- Determine the parameters of the SIRS model
- Determine the equilibrium points of the SIRS model and its stability
- Numerical simulation of the SIRS model using Maple software

4. Results and Discussion

Based on the latest data from [8], the number of internet users in Indonesia is 171.17 million people with the percentage of people who ignored the trending news is 15.9% in 2017 and 20.1% in 2019, the percentage of people who immediately shared the trending news is 0.9% in 2017 and 1% in 2019, and the percentage of people who fact-checked the trending news in 2017 and 2019 are 83.2% and 78.9% respectively [1],[9]. By defining the variable \( S \) as the number of ignorant people, \( I \) as the number of the spreaders, \( R \) as the number of the fact-checkers, and \( N \) as the total population, the behavior of Indonesian people when receiving trending news is represented in the following table:

| Year | \( S \)     | \( I \)     | \( R \)     | \( N \)     |
|------|------------|------------|------------|------------|
| 2017 | 27,216,030 | 1,540,530  | 142,413,440| 171,170,000|
| 2019 | 34,405,170 | 1,711,700  | 135,053,130| 171,170,000|

4.1. SIRS model parameters determination

The parameters are estimated by trial and error method so the graph of the SIRS model fit the actual data. With an estimated recovery rate \( \gamma = 0.7 \) and rate of immunity loss \( \delta = 0.032 \), the infection rate \( \beta \) can be sought from equation (1) with \( \frac{dS(t)}{dt} \approx \frac{S(2019) - S(2017)}{t} = 3594570 \) so that \( \beta = 0.02296032478 \).

4.2. Equilibrium points of the SIRS model and its stability

The basic reproduction number of this model is:
$R_0 = 5.614455426$

Since $R_0 > 1$, the equilibrium points are:

$P_0 = (S^*, I^*, R^*) = (171170000, 0, 0)$ and
$P^* = (S^*, I^*, R^*) = (30487374, 6150060, 134532566)$

The disease-free equilibrium $P_0$ is unstable and the endemic equilibrium $P^*$ is asymptotically stable. That means the behavior of sharing the news without fact-checking it is going to spread in the population with $S, I,$ and $R$ will converge to 30,487,374, 6,150,060, and 134,532,566 people over time. The basic reproduction number $R_0$ also shows that one person who has this behavior can infect five to six ignorant people.

4.3. Numerical simulation of the SIRS model

We predict the spread of hoaxes in Indonesia through numerical simulation of the SIRS model using these parameters:

**Table 2. The parameters of the SIRS model.**

| Parameters | Values          |
|------------|-----------------|
| $\beta$    | 0.02296032478  |
| $\gamma$   | 0.7             |
| $\delta$   | 0.032           |

The numerical simulation of the SIRS model is shown by the following plot using Maple software with initial conditions: $S(0) = 27216030, I(0) = 1540530,$ and $R(0) = 142413440$.

**Figure 1. Numerical simulation of SIRS model using Maple software.**

Figure 1 shows that the number of fact-checkers ($R$) keeps decreasing in the first 8 years followed by the increasing number of ignorant people ($S$) and the spreaders ($I$). The number of the spreaders ($I$) is estimated to reach its peak in the 12th year which is 9,902,970 people. After that, each component
continues to oscillate around the endemic equilibrium until it reaches stability approximately in the 50th year where $S = 30,487,374, I = 6,150,060,$ and $R = 134,532,566$.

5. Conclusion
The prediction of hoax distribution in Indonesia is produced using the SIRS model using the following parameters:

$\beta = 0.02296032478$
$\gamma = 0.7$
$\delta = 0.032$

With 171.17 million people of internet users in Indonesia, this model has a disease-free equilibrium $P_0 = (S^*, I^*, R^*) = (171170000, 0, 0)$ which is unstable and endemic equilibrium $P^* = (S^*, I^*, R^*) = (30487374, 6150060, 134532566)$ which is asymptotically stable. The basic reproduction number of this model is $R_0 = 5.614455426$. This means that the behavior of sharing the news without fact-checking it will spread in the population until it reaches the endemic equilibrium. This causes an increase of hoax spread in Indonesia, in line with the number of people who have this behavior.

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