PARAMETER ESTIMATION IN COVID-19 MODEL USING LONG SHORT-TERM MEMORY

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ABSTRACT

The COVID-19 pandemic has significantly impacted global health and economies. Estimating the parameters of epidemic models is crucial for forecasting disease trends and guiding public health policies. This research investigates the use of Long Short-Term Memory (LSTM) neural networks to estimate the parameters of a COVID-19 epidemic model using historical infection data. The objective is to determine whether LSTM can learn and estimate the model parameters. The results are compared with the input data to validate the accuracy of the parameter estimation.

INTRODUCTION

The COVID-19 pandemic has significantly affected global public health and the economy, emphasizing the need for accurate models to analyze and predict disease spread. The SEIR (Susceptible-Exposed-Infected-Recovered) model is a widely used mathematical framework for epidemic dynamics. However, its accuracy depends on estimating parameters such as the transmission rate (β), recovery rate (γ), and transition rate from exposed to infected (σ), which vary with real-world conditions.

This study investigates parameter estimation for the SEIR model using a Long Short-Term Memory (LSTM) neural network. Prior research highlights LSTM's effectiveness in analyzing epidemic data due to its ability to learn complex patterns. Here, LSTM estimates SEIR parameters using COVID-19 wave 4 data (01/01/2022–31/12/2022) from the Department of Disease Control. The study evaluates LSTM's accuracy by comparing estimated parameters with real-world data, improving the SEIR model's predictive performance.

OBJECTIVE

- To study LSTM for estimating SEIR model parameters for COVID-19.
- To use data from the COVID-19 Wave 4 Situation to train and test the model and compare estimated parameters with real data.

METHODOLOGY

Step 1: Data Collection and Preprocessing
- Collected Data from the Department of Disease Control (01/01/2022 - 31/12/2022)
- Handled Missing Values using linear interpolation
- Applied Min-Max Normalization to scale data between [0,1]

Step 2: Feature Splitting
- Divided into Two Parts:
1. Raw Data (Unnormalized) Used to calculate SEIR parameters
2. Normalized Data Used as input to train LSTM

Mathematical Formula for SEIR Parameters:
Transmission Rate (β)   Recovery Rate (γ)

$$\beta = \frac{\text{new infected}}{S \cdot I/N} \qquad \gamma = \frac{\text{new recovered}}{I}$$

Exposure Rate (σ) is set to a fixed value of 1/5

Step 3: LSTM Training
- Trained LSTM with Normalized Input Data
- Target (Y) = SEIR Parameters (β, γ, σ)

Step 4: Performance Evaluation

Used MAE (Mean Absolute Error) & RMSE (Root Mean Squared Error) to measure accuracy

$$MAE = \frac{1}{n}\sum_{j=1}^{n}|y_j - \hat{y}_j| \qquad RMSE = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(y_j - \hat{y}_j)^2}$$

RESULTS

Graph 1 : Comparison of True and Predicted SEIR Parameters
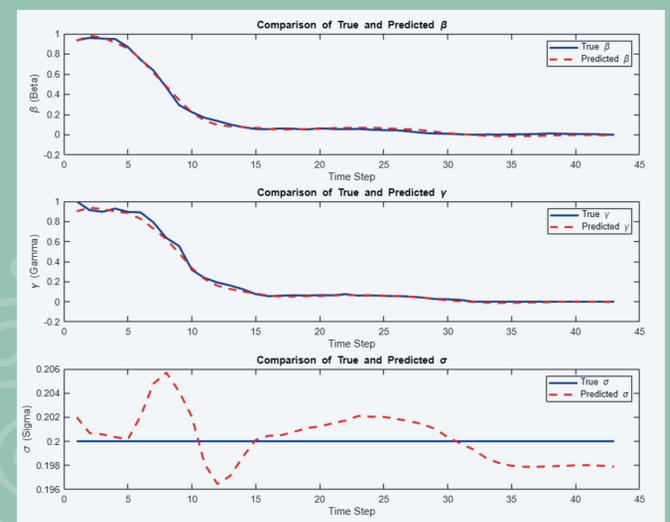

Table 1 : Performance Evaluation of LSTM Predictions Using MAE and RMSE

Parameter	Mean Absolute Error (MAE)	Root Mean Squared Error (RMSE)
β	0.01454	0.01773
γ	0.01573	0.01773
σ	0.00174	0.00209

CONCLUSION

The study found that LSTM effectively predicted β and γ with low MAE and RMSE, accurately capturing infection and recovery trends. However, σ showed higher errors due to its fixed incubation period assumption. While LSTM learns parameters from real data, results may vary due to weight initialization and external factors like lockdowns and vaccination, which were not considered.

REFERENCES

Department of Disease Control. (2022). COVID-19 Wave 4 Situation Report. Ministry of Public Health.https:// covid19.ddc.moph.go.th
Cintra, P. H. P., Citeli, M. F., & Fontinele, F. N. (2020). Mathematical Models for Describing and Predicting the COVID-19 Pandemic Crisis. arXiv preprint arXiv:2006.02507.