FUZZY LOGIC IN PANDEMIC PREDICTION

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Problem Statement and Objective

Problem: Studying the dynamics of a pandemic to predict its spread using fuzzy based rules, fuzzy time series and comparing traditional modelling algorithms with fuzzy induced algorithms.

Objective: Developing a model to predict the effects of pandemic considering its spread in different parts of the world and to improve decision making in such situations by combining traditional and fuzzy methods. Improving runtime of algorithms.

Proposed methodology

Studying and comparing the previous related work.

Models to be studied:

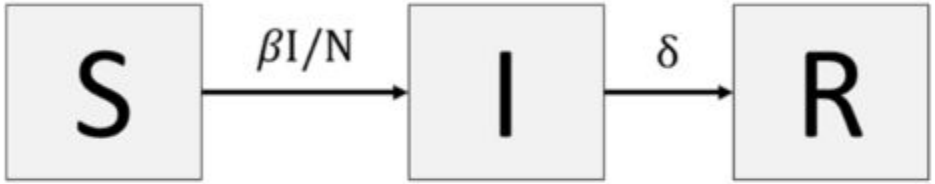
- Fuzzyfied Richards model
- SEIR Model
- fSEIR Model
- Gaussian MIxture Model
- Hybrid model(Artificial Neural Networks,fuzzy RuleBasedClassifier ,Gaussian Mixture Model)

Tools for Implementation

- Fuzzy rules based system for prediction.
- pyFTS : Fuzzy time series method
- Fuzzy logic toolbox Matlab
- Epidemics on Network EoN Library

Traditional Models

A. Classical SIR model



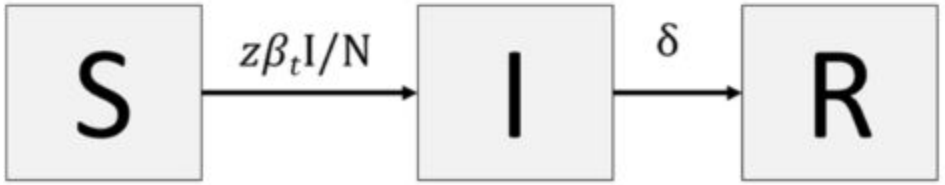
Equation

$$\frac{dS}{dt} = -\frac{\beta IS}{N}$$

$$\frac{dI}{dt} = \frac{\beta IS}{N} - \delta I$$

$$\frac{dR}{dt} = \delta I$$

B. Modified SIR model



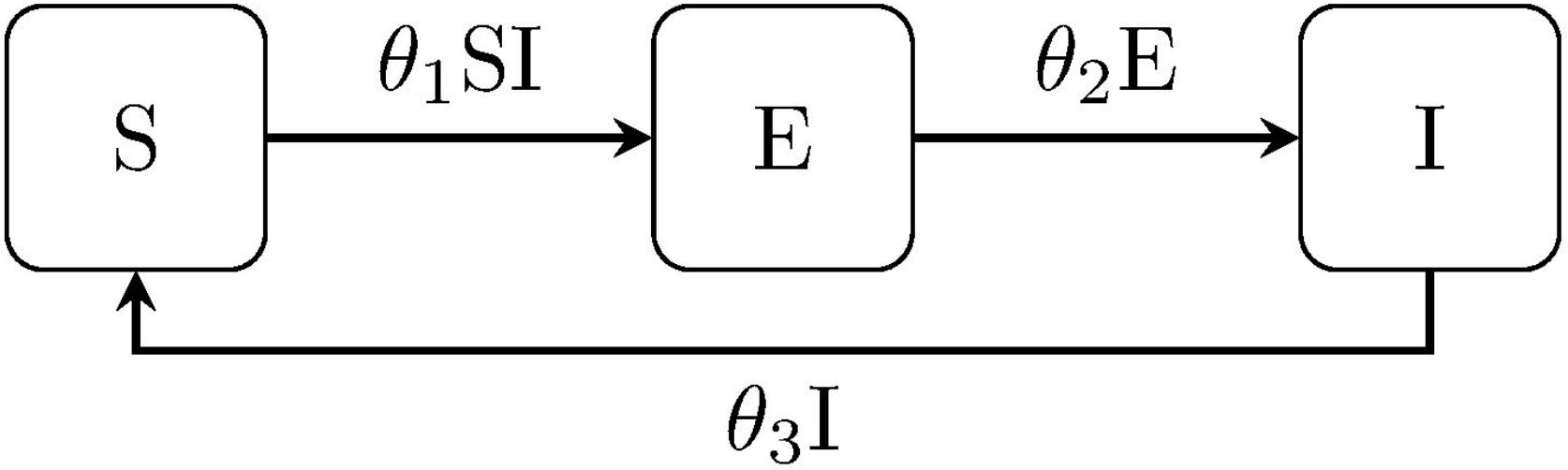
Equation

$$\frac{dS}{dt} = -\frac{z\beta_t IS}{N}$$

$$\frac{dI}{dt} = \frac{z\beta_t IS}{N} - \delta I$$

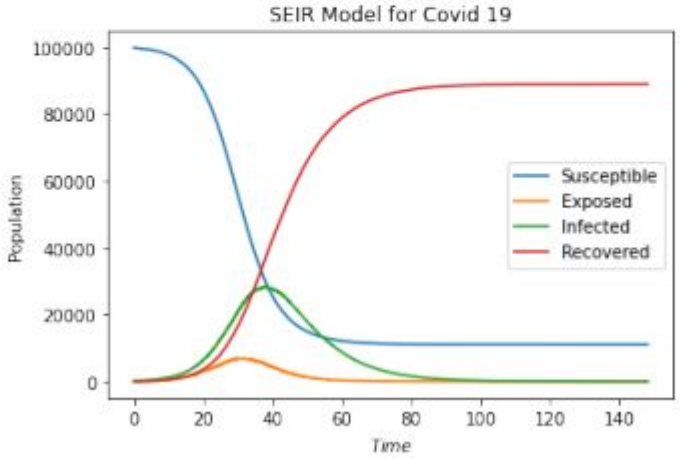
$$\frac{dR}{dt} = \delta I$$

Traditional Models



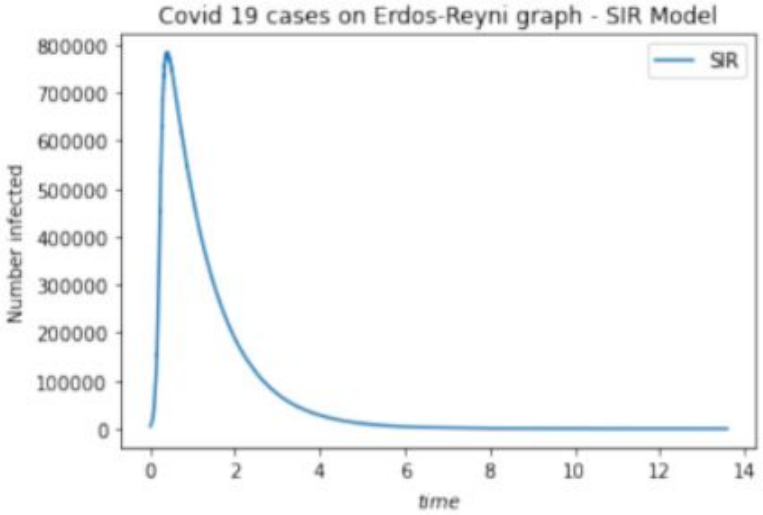
Results

- SEIR model (Susceptible-Exposed-Infectious-Removed) model is the extension of SIR model, with Exposed introduced between Susceptible and Infectious. Covid-19 can be better represented by using this model. We also introduce some random transitioning rate of people from E to I(elder people, people with low immunity). Also we introduce the randomness factor in some relationships, where some relations have higher transfer rates than the other.



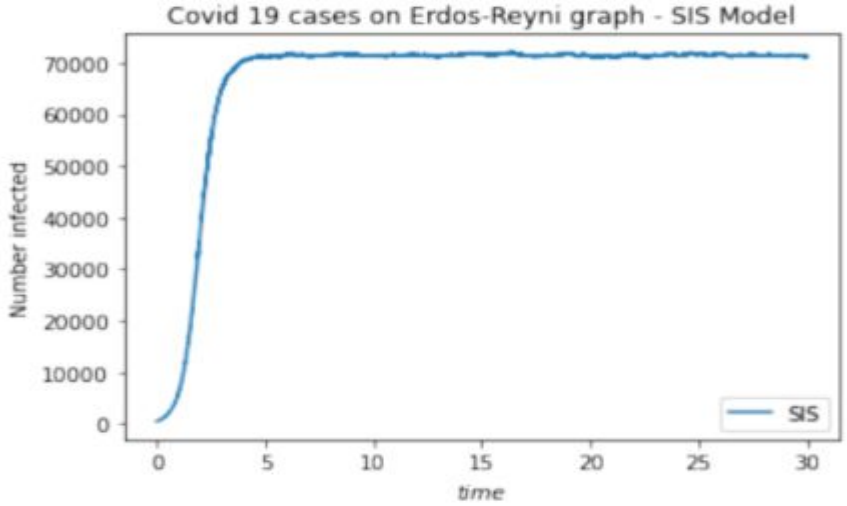
Results

- Using Erdos-Reyni graph with a million nodes, on a SIR model, with parameters, such as transmission rate (R0) = 5.7 [R020], Recovery rate has been set to 95 percent, and initial 19 cases have been set to 0.5 percent of total population, which is set to 1 million. This is the situation where people take NO PRECAUTIONS, and continue with their normal lives. We would analyze in the result section how this situation turns out.



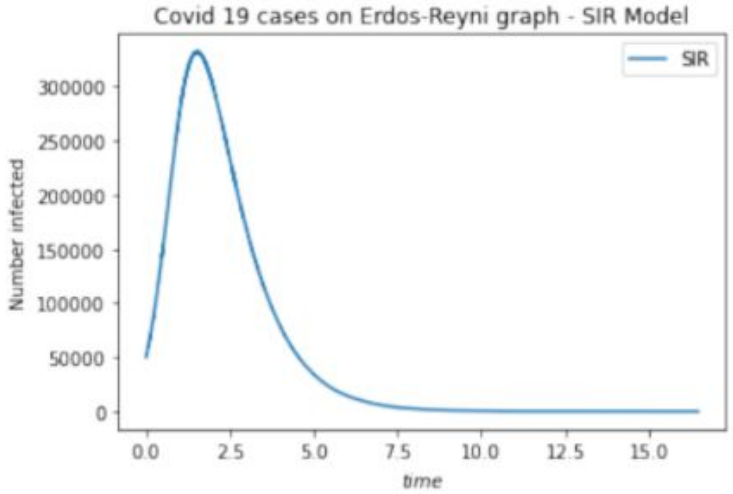
Results

- Using Erdos-Reyni graph with a lakh nodes, on a SIS model, with parameters, such as transmission rate (R0) = 5.7, Recovery rate has been set to 95 percent, and initial 19 cases have been set to 0.5 percent of total population, which is set to 1 million. This is the situation where people take NO PRECAUTIONS, and continue with their normal lives. We would analyze in the result section how this situation turns out. The difference from the above case is, we are considering to be disease which has less immunization period.



Results

- Using Erdos-Reyni graph with a million nodes, on a SIR model, with parameters, such as transmission rate (R0) = 0.8, Recovery rate has been set to 95 percent, and initial 19 cases have been set to 5 percent(considering cases of USA when Vaccine is developed and distributed) of total population, which is set to 1 million. This is the situation where people take PRECAUTIONS, and continue with their lives taking care of hygiene, and social distance. We would analyze in the result section how this situation turns out.



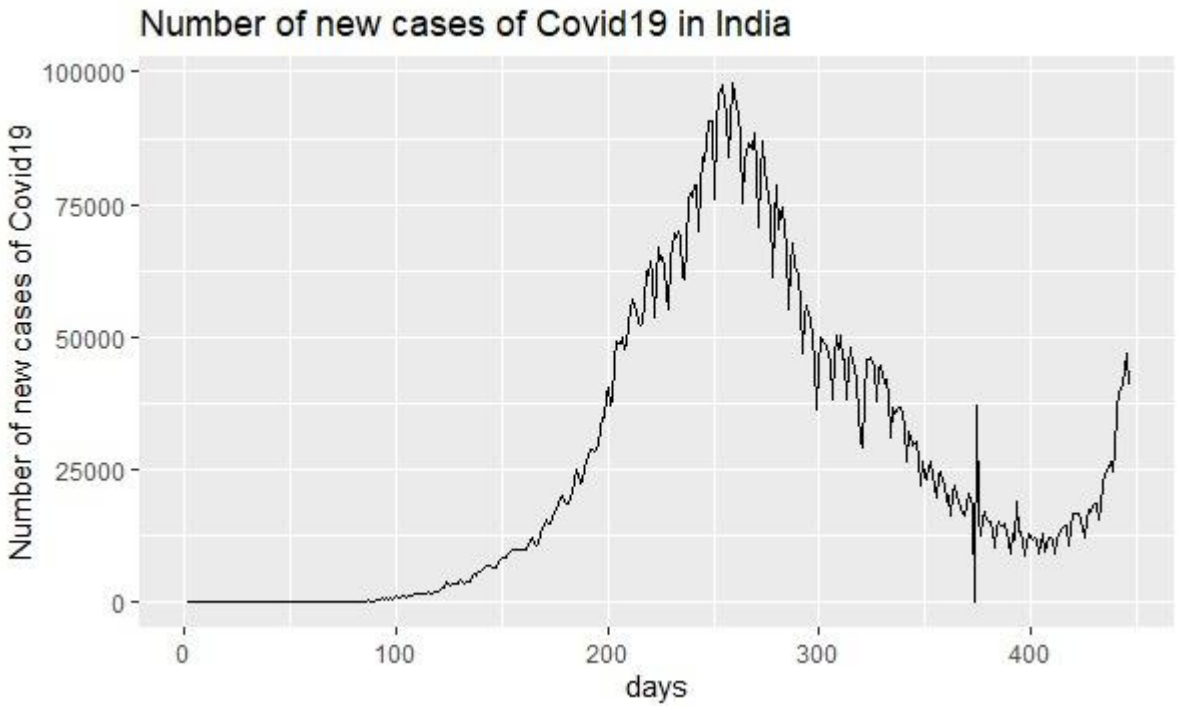
Time Series prediction using HW Model:

Data Set: The data considered for time series prediction is from January 2020 to April 12th 2021, having a date wise data of countries , confirmed, recovered and death cases.

We use Holts Winter model with default seasonality value (additive).

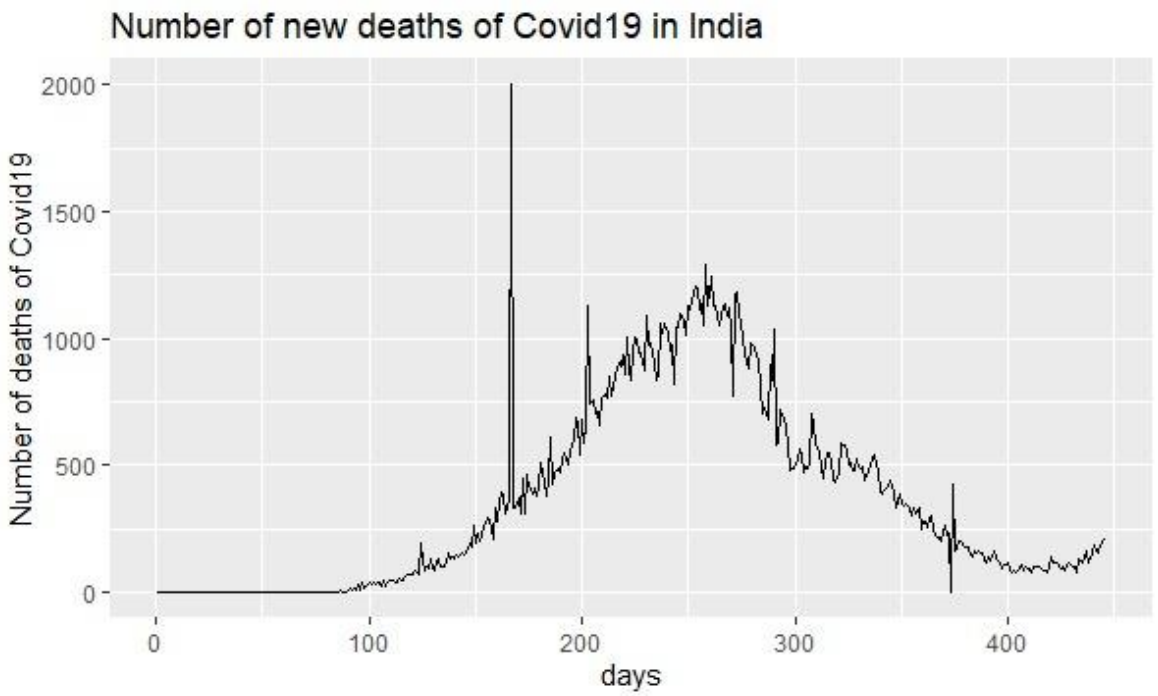
Result:

For data between 24.03.2021 and 30.03.2021:



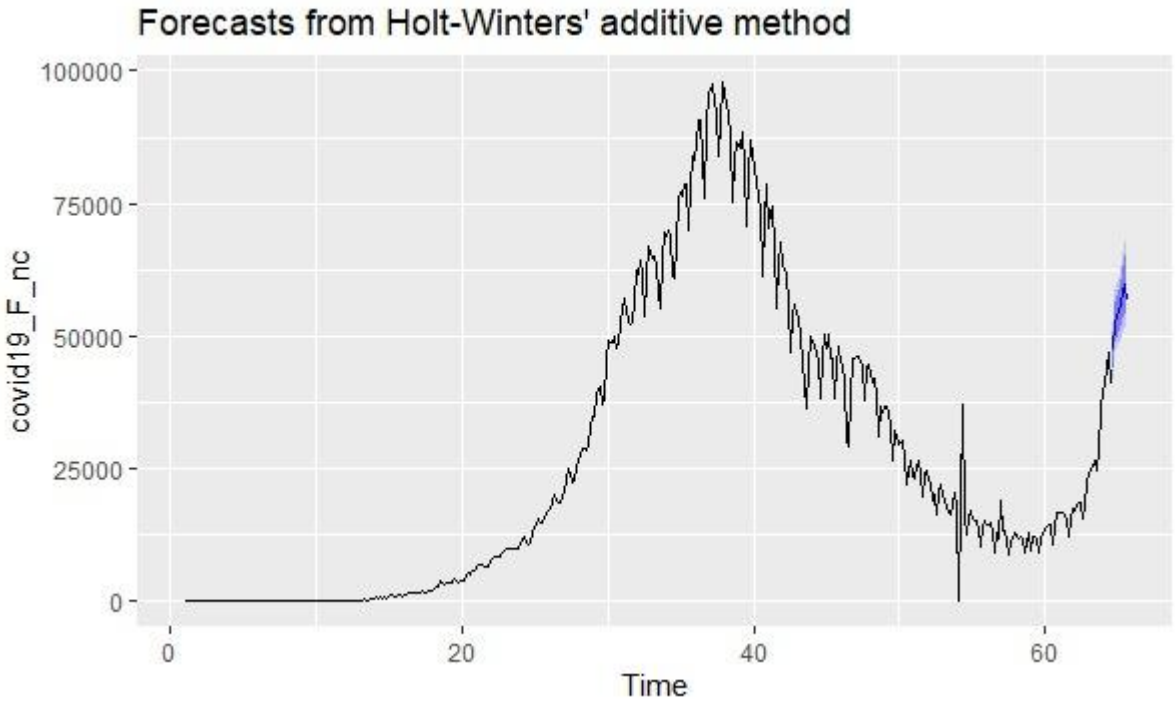
Result:

The two graphs try to find out patterns in the data, for example: what is the effect of number of days on number of cases and number of deaths.



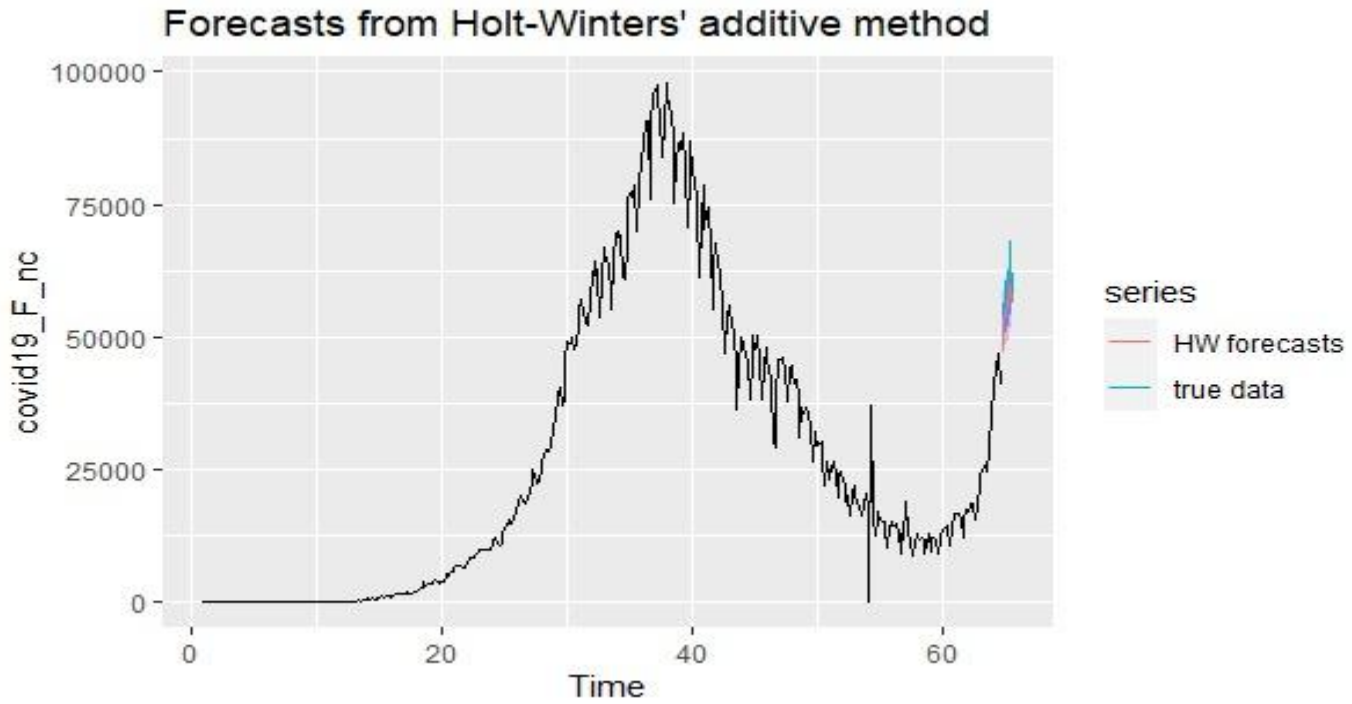
Result:

Forecast using HW model for number of cases:



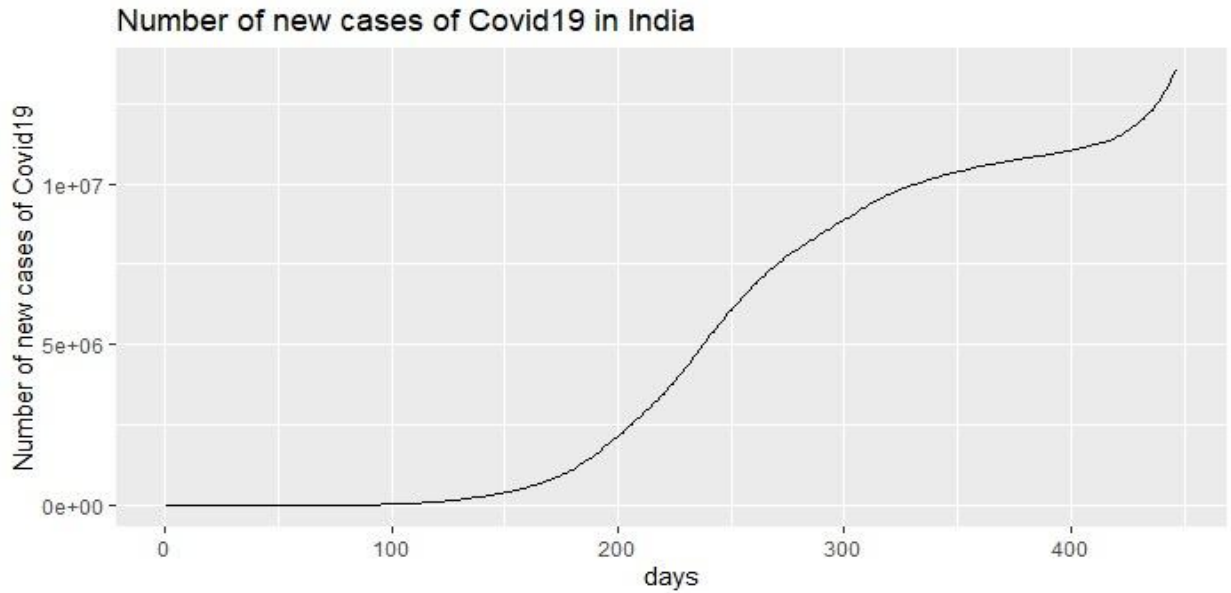
Result:

Forecast using HW model for Number of Deaths:



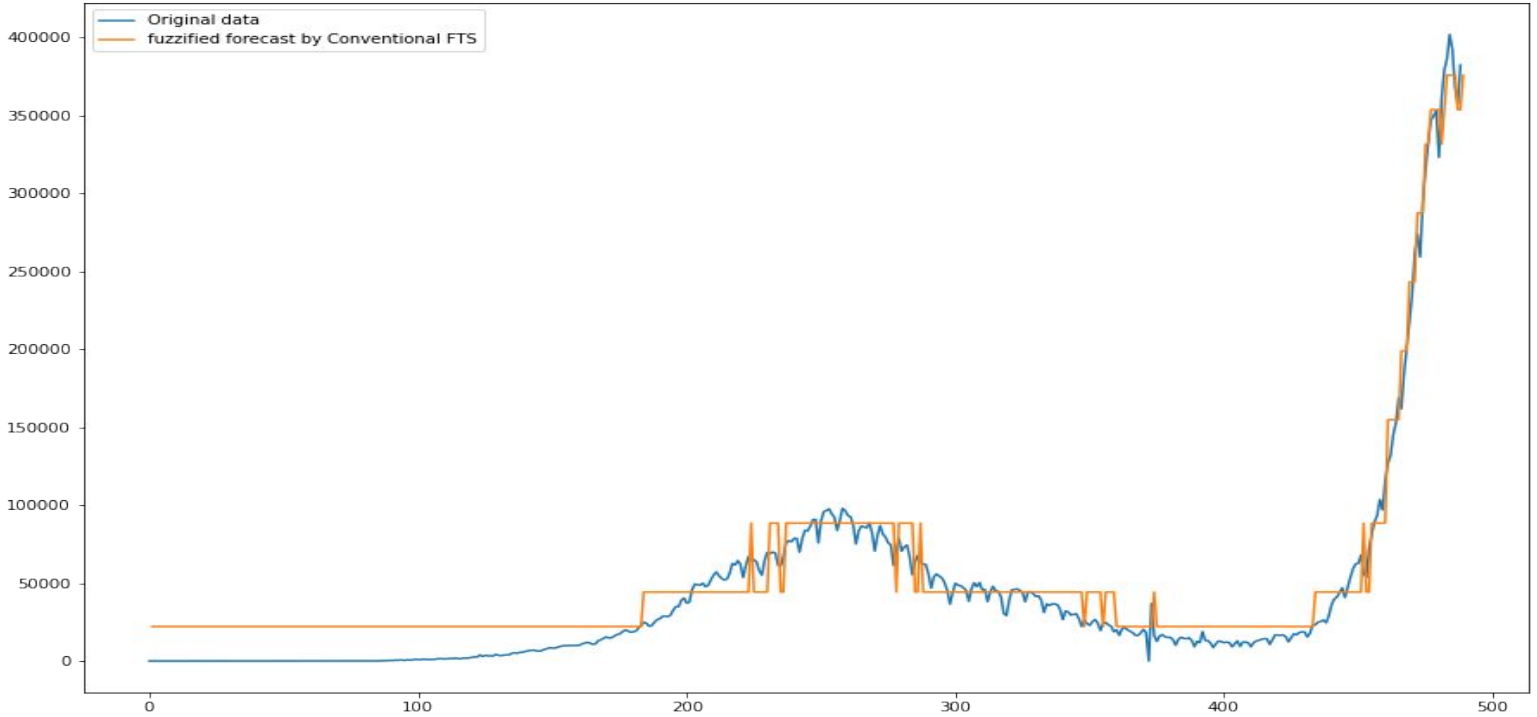
Result:

Prediction for Number of Cases on the basis of data from 5.04.2021 to 12.04.2021:

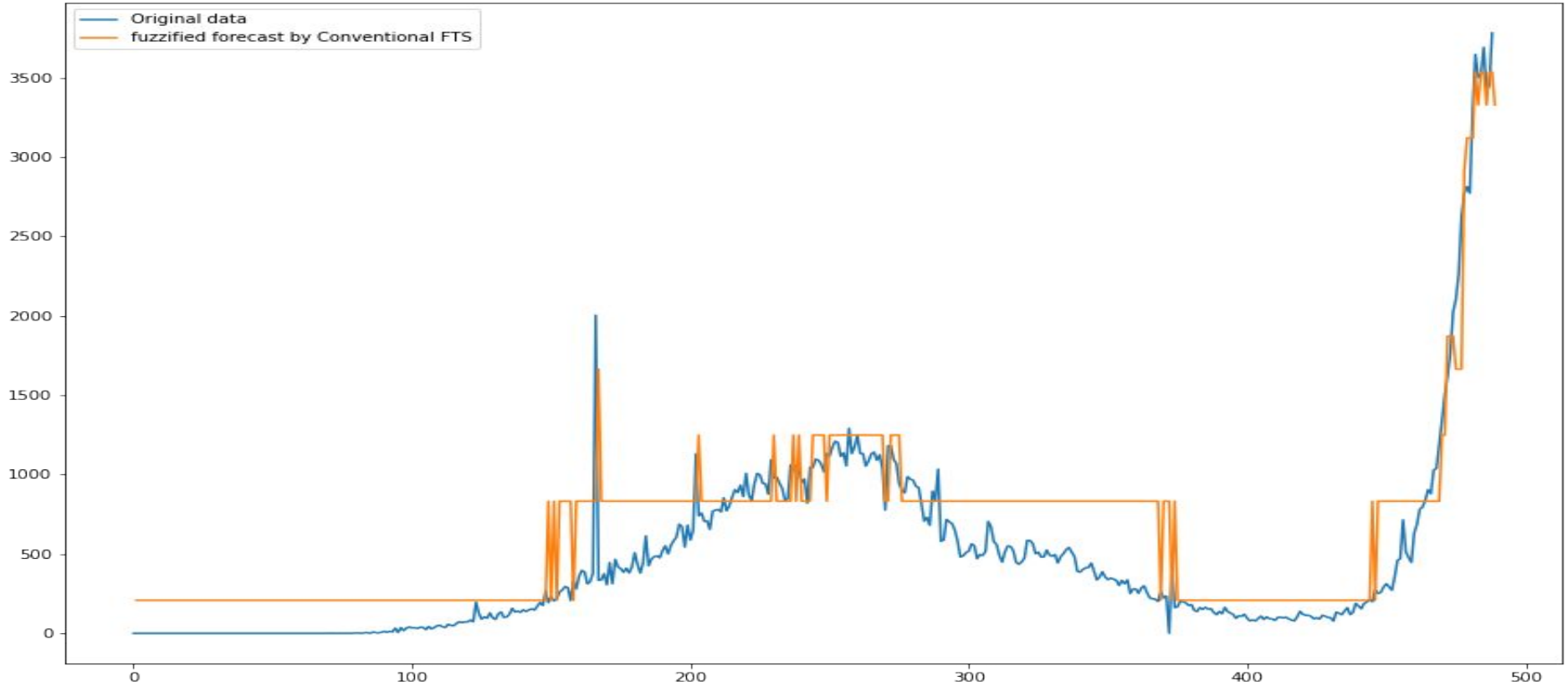


pyFTS: Fuzzy Time series model

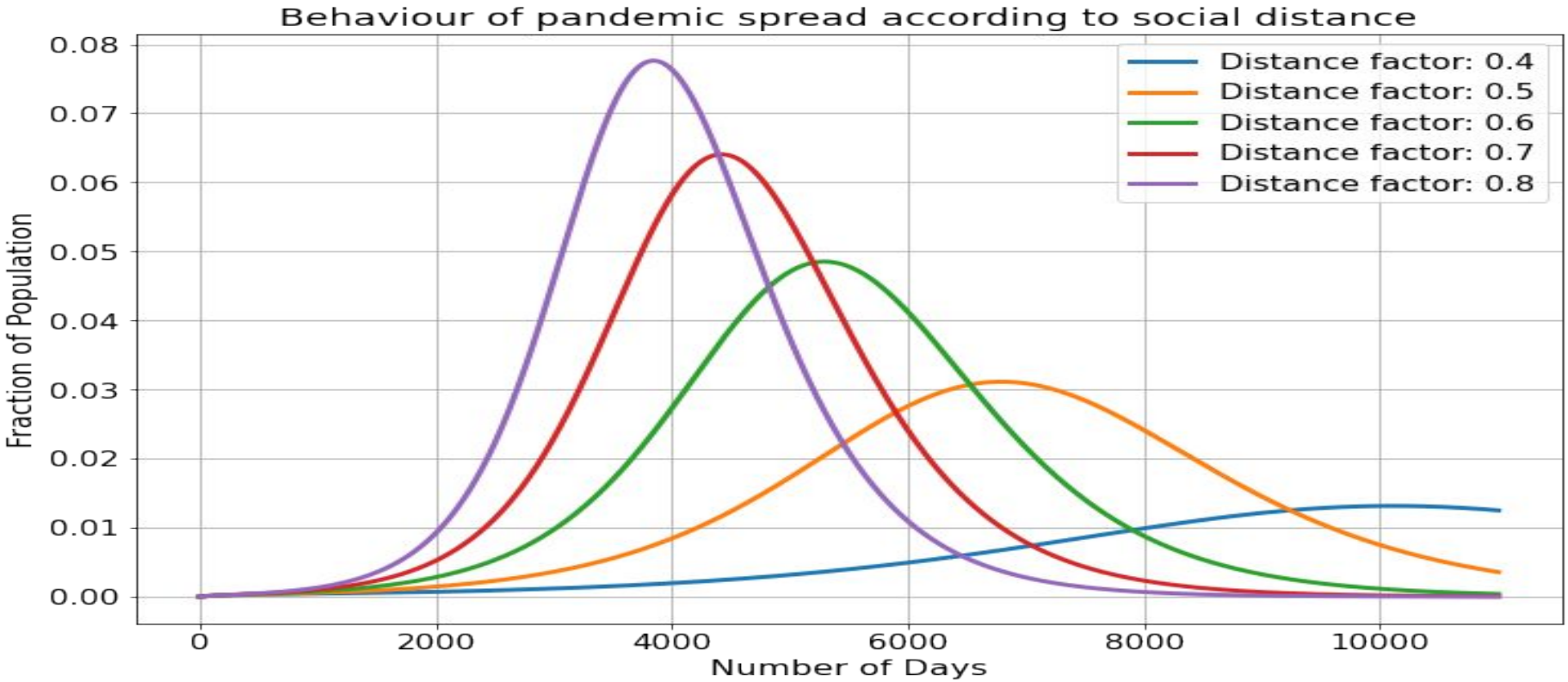
Number of Cases:



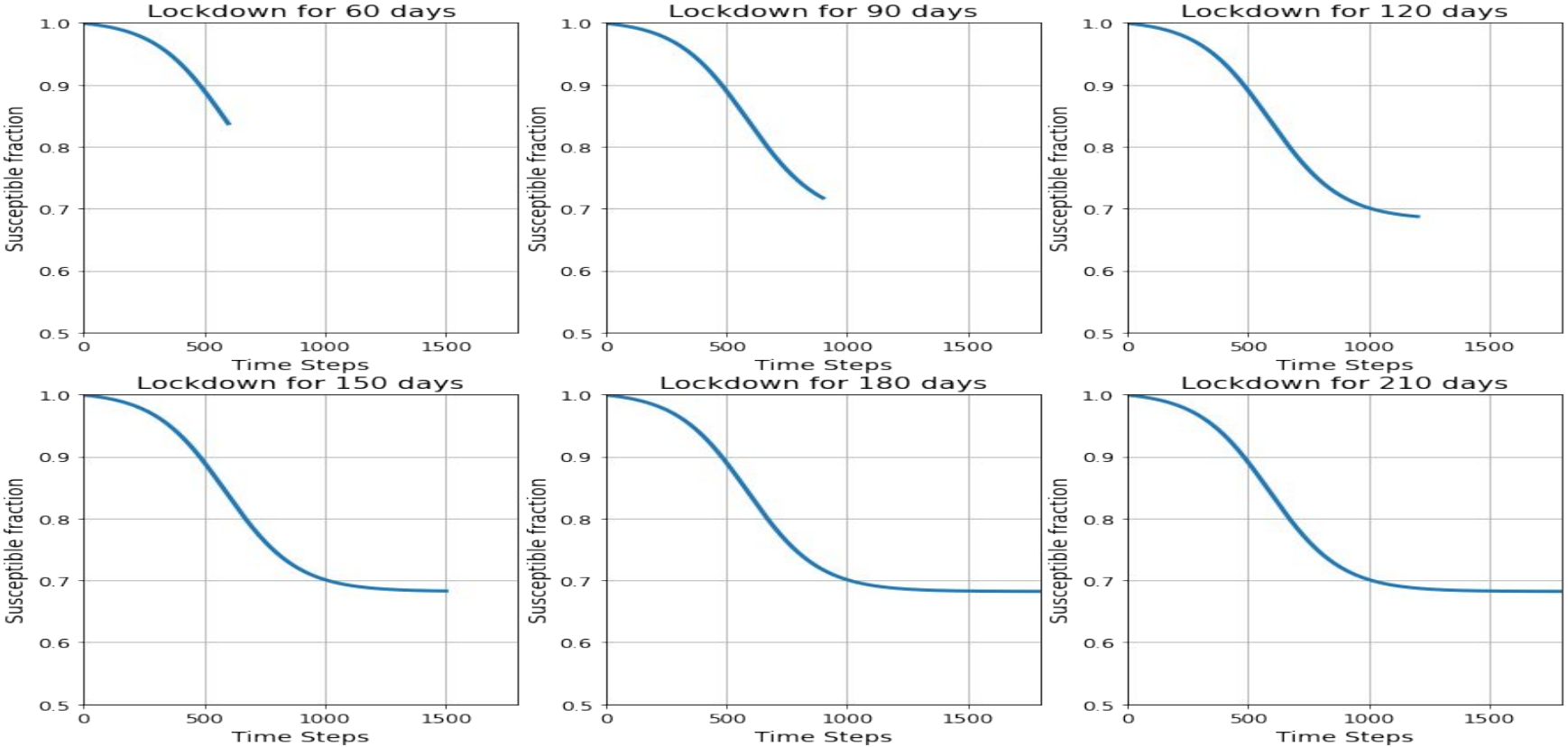
Number of Deaths:



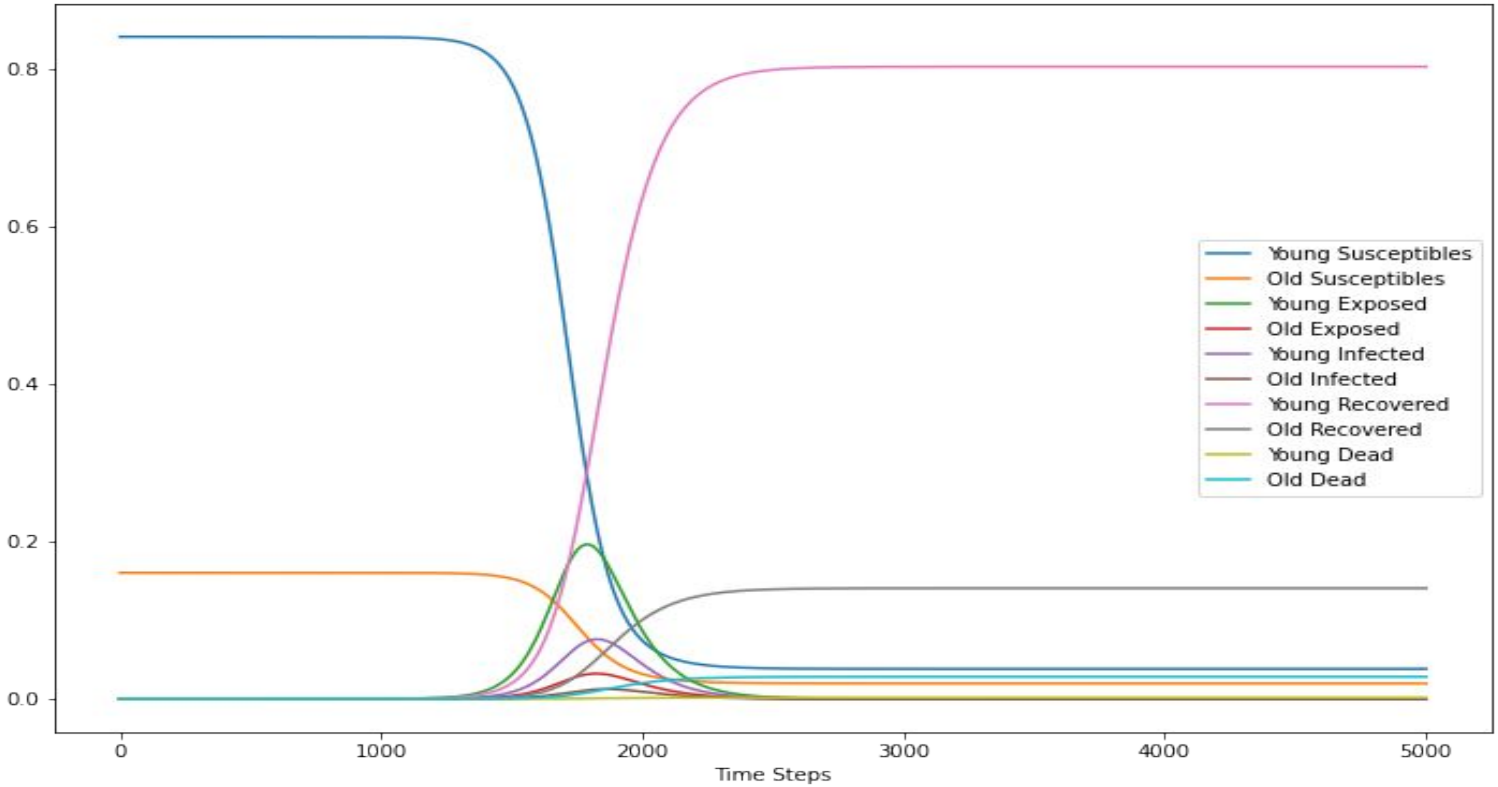
SEIR Analysis: Social Distancing



LockDown


Lockdown for 60 days
Lockdown for 90 days
Lockdown for 120 days
Lockdown for 150 days
Lockdown for 180 days
Lockdown for 210 days
Susceptible fraction
Time Steps
1.0
0.9
0.8
0.7
0.6
0.5
0
500
1000
1500

Effect of Social Distancing on Various age groups



Future Work:

- Performing a similar kind of analysis on FTS model.
- Performing the analysis to understand the effect of mitigation strategies like social distancing and lockdown on economy.
- Studying other models and trying to integrate the best features in fuzzy induced model.