Internship Report

On

COVID-19 PROPAGATION ANALYSIS

BACHELOR OF TECHNOLOGY

In

ELECTRONICS & COMMUNICATION ENGINEERING

By

YACHANA ARORA (184533)

NEHA KUMARI (184507)

Under the guidance of

Dr. Pushpender Singh

Assistant Professor
DoECE, NIT Hamirpur

Department of Electronics & communication Engineering
National Institute of Technology,Hamirpur

NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR

CERTIFICATE

This is to certify that the internship report work entitled **"Covid-19 Propagation Analysis"** submitted by **Yachana Arora & Neha Kumari** in the partial fulfillment of the requirements for the award of B.Tech degree in Electronics & Communication Engineering at National Institute of Technology, Hamirpur is an authentic work carried out under my supervision and guidance.

To the best of my knowledge, the matter embodied in this Intern report has not been submitted to another University/Institute for the award of any Degree or Diploma.

Dr. Pushpender Singh

Assistant Professor
DoECE, NIT Hamirpur

NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR

ACKNOWLEDGEMENT

We wish to express our profound gratitude and indebtedness to Dr. Pushpender Singh, Department of Electronics and Communication Engineering, National Institute of Technology, Hamirpur for introducing the present topic and for their inspiring guidance, constructive criticism and valuable suggestion throughout the internship.

Finally, I am grateful for the joint support from the National Institute of Technology, Hamirpur as a whole for the opportunity and assistance they provided me to do my training here.

Yachana Arora (184533) & Neha Kumari (184507)
DoECE
National Institute of Technology, Hamirpur-177005

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER-1

INTRODUCTION:

1.1 NON-LINEAR AND NON-STATIONARY TIME SERIES

Nonlinear time series are the one that are generated by non-linear dynamic equations. These time series cannot be analyzed by linear processes. They have variances, asymmetric cycles, higher moment, all varying nonlinearly time.

Non-stationary data are the ones that cannot be forecasted and modelled. To receive consistent, reliable results, the non-stationary data needs to be transformed into stationary data. It has a variable variance and a mean that does not remain near or returns to a long-run mean over time, the stationary process reverts around a constant long-term mean and has a constant variance independent of time.
Non-stationary behaviors can be trends, cycles, random walks, or combinations of the three.

In this study, we will explore the algorithms to analyze non-linear and non-stationary signals. By the Fourier method called FOURIER DECOMPOSITON METHOD(FDM).
FDM converts the signals into set of small number of band limited intrinsic band functions FIBFs.
Here, we will use covid-19 data as a nonlinear data to devise the methodologies to model this kind of non-stationary trend of behavior.

1.2 THE COVID-19 PANDEMIC

As the world is facing a highly contagious pandemic today, it has caused great disruptions in the life of people. The Covid-19 pandemic that started spreading around the world at the end of year 2019 reached every corner of the world in just a small span of time. More than 204 million have been infected with the virus and more than 4 million people have lost their lives to the deadly virus till date.
More than a year has passed, but the situation still remains alarming as the virus is constantly mutating.
The increasing workload and stress on health-care facilities and the resumption of economic activities can be managed more effectively by developing suitable models for understanding and predicting the spread of COVID-19.
We have made here an attempt to understand the spread of covid-19 using a few approaches.

CHAPTER-2

LITERATURE REVIEW

Table 2.1. Table consist of information of the literature reviewed and also the name of author, topic name and the finding of the literature.

S. No	Authors	Topic Name	About
1.	Amit Singhal, Pushpendra Singh, Brejesh Lall , Shiv Dutt Joshi	Modeling and prediction of COVID-19 pandemic using Gaussian mixture model	The paper proposes the methods to predict the total number of cases and end date of the pandemic.
2.	Pushpendra Singh, Shiv Dutt Joshi, Rakesh Kumar Patney and Kaushik Saha	The Fourier decomposition method for nonlinear and non-stationary time series analysis	The paper proposes the Fourier decomposition method (FDM), based on the Fourier theory to demonstrate its efficacy for the analysis of nonlinear and non-stationary time series
3.	Linhao Zhong; Lin Mu; Jing Li; Jiaying Wang; Zhe Yin; Darong Liu	Early Prediction of the 2019 Novel Coronavirus Outbreak in the Mainland China Based on Simple Mathematical Model	This work has made an early prediction of the 2019 covid outbreak in China based on a simple mathematical model and limited epidemiological data and Combing characteristics of the historical epidemic..

CHAPTER-3

COVID-19 ANALYSIS METHODOLOGY

3.1 Mathematical Approach:

Since the covid-19 pandemic is an infectious disease and spread from person to person, so the rise in daily cases will upon the daily contacts of the infected person.

Following are the parameters and their definitions that will determine the case load each day:

1. **Yn**: Total number of active cases on Nth day after the disease started spreading.
2. **Nc**: total number of people coming in contact with the infected persons(on daily basis).
3. **a**: daily testing rate = people getting tested and quarantined out unidentified active cases on that day
4. **b**. Death rate = people dying in a day out of total active cases on that day.
5. $\mathbf{X_n}$: new confirmed cases on nth day.
6. $\mathbf{p_i}$ = probability of an infected person causing infection to another person, causing infection after i days after the person is infected.

So new confirmed cases on each day is given as:

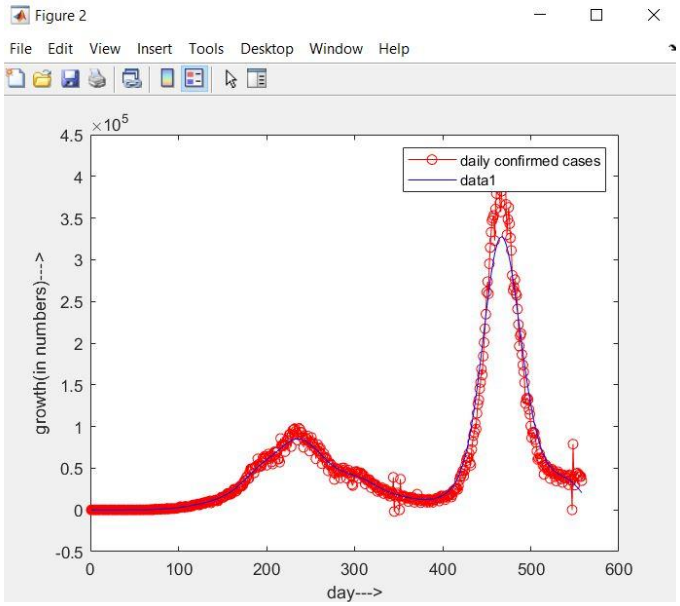
$$\mathbf{X_n : [X_{n-1}. (1-a). (1-b). p_1 + Xn_{-2}. (1-a)^2. (1-b)^2.p_2 + X_{n-3}.(1-a)^3.(1-b)^3.p_3 + \ldots + X_1. (1-a)^{n-1}. (1-b)^{n-1}. p_{(n-1)}] N_c}$$

Now the average life of virus is approx. 2 weeks.

So, in first few days virus will multiply and probability of infection to another person increases. After d days of infection, the virus will start degrading and then probability of another person being infected reduces.

So, the probability of infected person causing infection to a healthy person will follow a gaussian distribution:

$$p_i = \begin{cases} 1 & 1 <= i <= d \\ \exp[-\lambda (i - d)] & i > d \end{cases}$$



Gaussian distribution of daily confirmed cases

3.2 FOURIER DECOMPOSITION METHOD (FDM):

The Fourier decomposition method provides the approach to break a non-periodic signal into different scales of amplitudes using a set of sine and cosine functions with different frequencies. FDM decomposes any data into a small number of ‘Fourier intrinsic band functions’ (FIBFs). The FDM is a generalized Fourier expansion with variable amplitudes and variable frequencies of a time series by the Fourier method itself. (ii) The zero-phase filter bank-based MFDM algorithm, for the analysis of multivariate nonlinear and non-stationary time series, which generates a finite number of band limited multivariate FIBFs (MFIBFs). (iii) An algorithm to obtain cut-off frequencies required in MFDM for zero-phase high or low pass filtering of multivariate signals.

The FDM can be practically implemented using (a) Fourier representations such as discrete Fourier transform, discrete sine transform, and discrete cosine transform (DCT); (b) Finite impulse response and infinite impulse response based zero-phase filtering. In this study, we have used the DCT based implementation of the FDM. Let c[n] be a time-series of a length N. The DCT type-2 of c[n] is defined as

$$C[k] = \sqrt{\frac{2}{N}}\sigma_k \sum_{n=0}^{N-1} c[n] \cos\left(\frac{\pi k(2n+1)}{2N}\right), \qquad 0 \le k \le N-1,$$

where $\sigma_k = 1$ for $k \neq 0$ and $\sigma_k = 1/\sqrt{2}$ for $k = 0$. The original time-series c[n] is recovered using the inverse DCT (IDCT) as

$$c[n] = \sqrt{\frac{2}{N}} \sum_{k=0}^{N-1} \sigma_k C[k] \cos\left(\frac{\pi k(2n+1)}{2N}\right), \qquad 0 \le n \le N-1.$$

The DCT basis functions cos (πk(2n+1)/N) are a class of discrete polynomials which form an orthogonal set. The time-series c[n] can be written as superposition of M FIBFs

$$c[n] = \sqrt{\frac{2}{N}} \sum_{k=0}^{N-1} \sigma_k C[k] \cos\left(\frac{\pi k(2n+1)}{2N}\right) = c_0 + \sum_{i=1}^{M} c_i[n],$$

Where M<<N, $c_0 = \sqrt{\frac{2}{N}}\sigma_0 C[0]$, $c_1[n] = \sqrt{\frac{2}{N}} \sum_{k=1}^{K_1} \sigma_k C[k] \cos\left(\frac{\pi k(2n+1)}{2N}\right)$, ………,

$$c_M[n] = \sqrt{\frac{2}{N}} \sum_{k=(K_{M-1}+1)}^{N-1} \sigma_k C[k] \cos\left(\frac{\pi k(2n+1)}{2N}\right),$$

and the values of K1, K2, ..., KM−1 are selected as per the application requirements. The trend τ [n] and variability v[n] can be computed from the time-series c[n] as

$$c[n] = \tau[n] + v[n],$$

where $\tau[n] = c_0 + \sum_{i=1}^{P} c_i[n]$ and $v[n] = \sum_{i=P+1}^{M} c_i[n]$ are uncorrelated.

The DCT based FDM can be efficiently implemented using the fast Fourier transform algorithm.

3.3 GUASSIAN MIXTURE MODEL:

A Gaussian mixture model is a probabilistic model that assumes all the data points are generated from a mixture of a finite number of Gaussian distributions with unknown parameters. One can think of mixture models as generalizing k-means clustering to incorporate information about the covariance structure of the data as well as the centers of the latent Gaussians.
Gaussian Mixture Models to group the data points belonging to a single distribution together.

The Gaussian Distribution

It has a bell-shaped curve, with the data points symmetrically distributed around the mean value.In a one dimensional space, the probability density function of a Gaussian distribution is given by:

$$f(x \mid \mu, \sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

where μ is the mean and σ^2 is the variance.

CHAPTER-4
SIMULATION & RESULTS

We have tried to model the database of covid 19 cases of **INDIA** in MATLAB to study the rise in cases on daily basis.

- **Source of Database for COVID-19 numbers:**
  COVID-19 dashboard by the center for system science and engineering (CSSE) at Johns Hopkins University (JHU)

Following are the simulation results: India reported its first case on Jan 27,2020

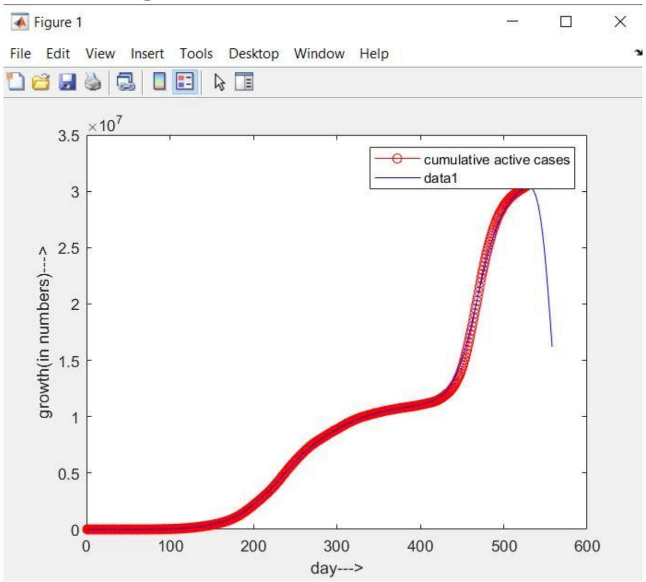


Fig. 4.1 cumulative active cases

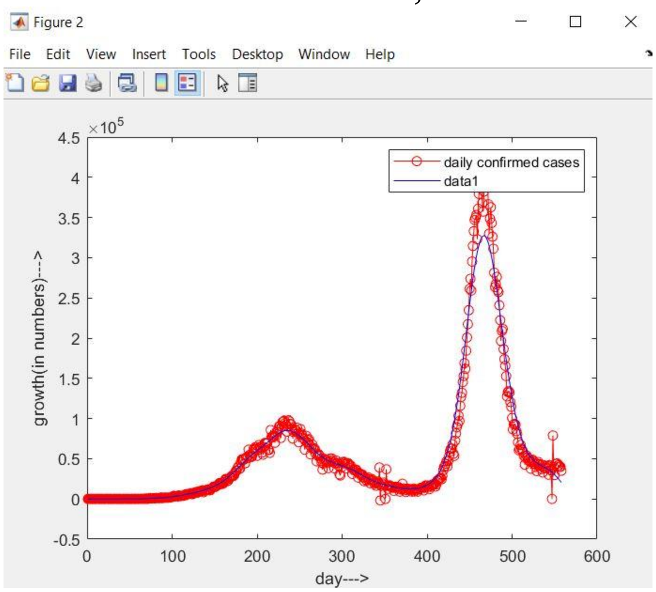


Fig. 4.2 Daily rise in confirmed cases

Observation from fig4.1 and fig 4.2(approx.):

1. No. of infections started to increase invariably from 150th day to 300th day i.e. JUNE,2020 to October,2020 with maximum each day rise found to be approximated 1 lac**. [1st peak]**

2. Also, from 400th to 500th days, there has been a dramatic rise in covid cases with maximum each day rise of more than 4 lacs cases in the month of MAY,2021. **[2nd peak]**

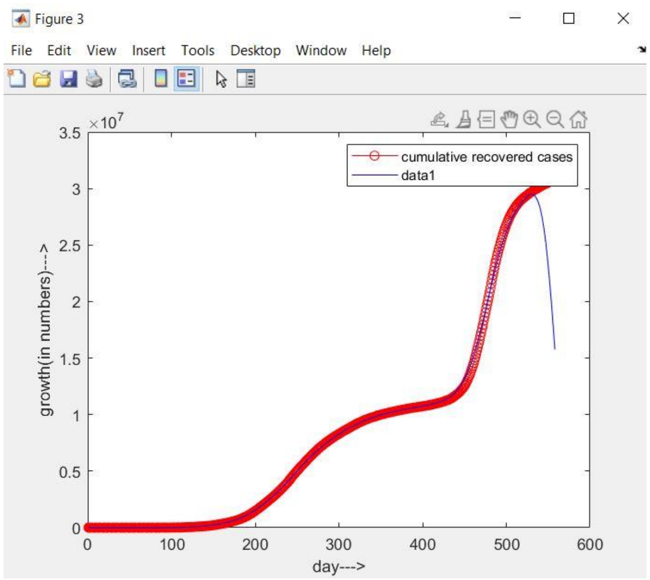


Fig. 4.3 Cumulative recovered cases

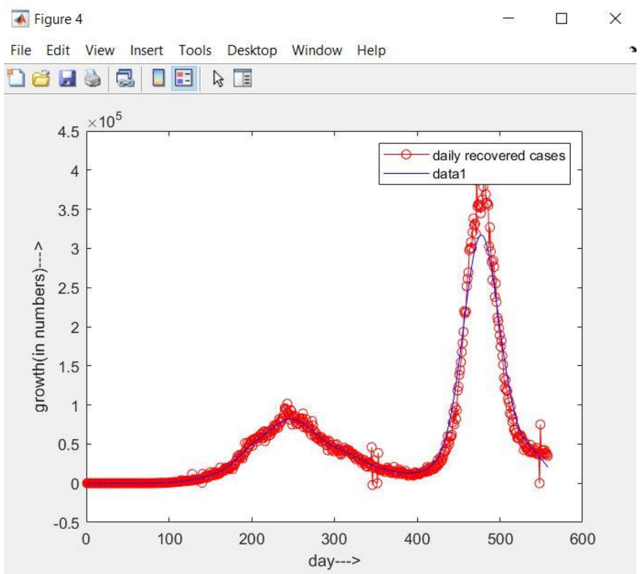


Fig. 4.4 Daily recovered cases

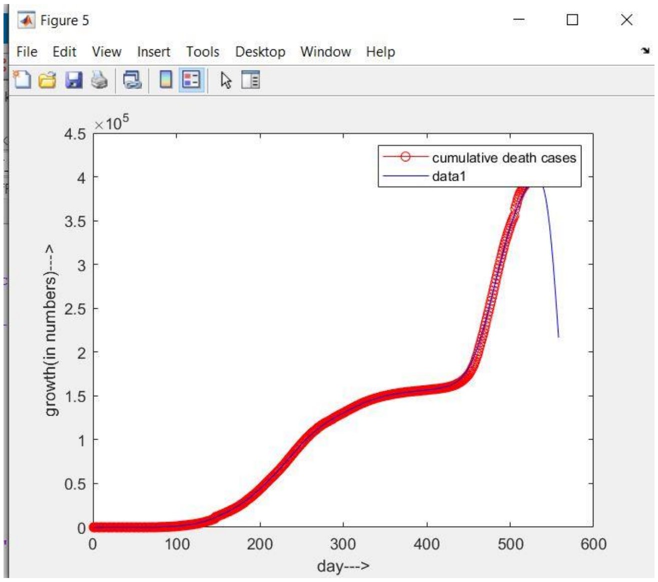


Fig. 4.5 Cumulative deaths

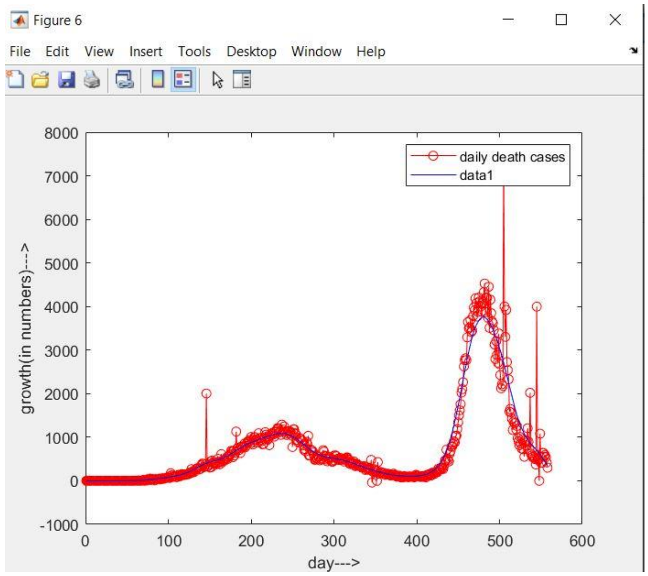


Fig. 4.6 Daily deaths

Observation from fig4.1 and fig 4.2(approx.):

1. India saw a maximum of 1500 deaths(approx.) per day during its first wave and more than 4000 daily deaths in the second wave.
2. India saw more than 4 lac deaths in total from the start of pandemic till date.

REFERENCES

[1] https://royalsocietypublishing.org/doi/full/10.1098/rspa.2016.0871#d3e10844
[2]https://www.researchgate.net/publication/274570245_Matlab_Code_Of_The_Fourier_Decomposition_Method_FDM
[3]https://data.humdata.org/dataset/novel-coronavirus-2019-ncov-cases
[4]https://www.sciencedirect.com/science/article/pii/S2468042720300087
[5]https://ieeexplore.ieee.org/document/9028194
[6]https://covid19.who.int/