SIR modelling of COVID-19 with cumulative cases, deaths, recovered and active cases in India

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Abstract

COVID-19 which has spread internationally very rapidly and has become a pandemic. In this research paper, we set forward a statistical model called SIR-Poisson   helps us to determine the spread of infectious disease of COVID-19 in India. The proposed SIR-Poisson model is able to predict the range of the infected cases in a future period. It is also used to detect the transmission of the COVID-19. Using the SIR-Poisson model and based on daily reported we attempted to predict the future disease period over 104 days.

1. Introduction

The need for epidemiological models in today's times is self-explanatory and field of epidemiological modelling is huge as well. In the wake of Corona Virus hitting the entire globe at an unimaginative rate, the need for such model is dire. This study shows a very popular epidemiological model SIR model to explain the situation of the pandemic. The SIR model is a hybrid model using Stochastic process, more accurately Markov's simulation with Poisson distribution. The air of such a model is to describe the entire process of the disease. SIR model stands for Susceptible, Infected and Removed, that is, subjects who are susceptible to cation the infectious disease then infected subjects who already have the disease and are potential carriers of the disease and finally the removed who are subjects that have recovered or died. Upon studying the entire process, we can find similarities with Poisson distribution where the variable is coming into the process waiting for some time in the process and then is leaving the process. SIR model is a very popular model for this reason

that it explains the entire behaviour of the spread of infectious disease and provides us with a with information on three major categories of the subject. This study shows implementation of SIR-Poisson hybrid model on data collected from COVID India database from 16-09-2020 to 31-12-2020 explaining the spread of COVID-19.

Keywords: Poisson Distribution, Epidemiology, Covid-19.

2. Material and Methods

❖ Statistical Modelling

To accomplish our objective, a hybrid model combining a Poisson Markov process with a SIR model is introduced, called SIR-Poisson model. Through various simulations, this model manages to predict the infected and death number so as to mitigate the infection risk under various different scenarios. To compare the SIR model, we will also show a linear regression and a GLM with exponential distribution.

❖ The SIR Model

The simple SIR (Susceptible–Infectious–Removed) model describes different states of a population. The model SIR describes three human states which are Susceptible, Infectious, and Removed. A person moves from one state to another at different rates. The model assumes that the recovered humans receive immunity against the disease. The people interact homogenously, and finally, the birth rates and natural death rates are constant.

S= susceptible to becoming infected

I= Infected through contact with someone already infected

R= Recovered, no longer sick or infected

Through time a person may move from being susceptible to infected to recovered, so the number of people in each condition changes, but the total of S+I+R is constant. S+I+R=N where N represents the entire population.

To run this model, we need to know the following

Initial population, S (initial number of people who are susceptible),

l (initial number of infected people),

B (infection rate, the rate that susceptible people become infected),

Y (recovery rate, the rate that infected people recover)

T (time increment, time interval or steps during the change occur. T is usually set at one day because its value is 1, is often ignored. For rapidly spreading outbreaks T might be one hour or some other short interval

❖ **Equations**

With these parameters, the number of people at any time who are Susceptible, infected, or Recovered can be calculated with these equations:

$$S_n = S_{n-1} - (\left(\frac{S_{n-1}}{S}\right) * \beta(\beta * I_{n-1}))$$

$$I_n = I_{n-1} + \left(\frac{S_{n-1}}{S}\right) * (\beta * I_{n-1}) - (I_{n-1} * \gamma)$$

$$R_n = R_{n-1} + (I_{n-1} * \gamma)$$

❖ **Data Collection**

In order to analyse and model the evolution of the infectious disease of COVID-19 the evolution comprises of the total cumulative confirmed cases, total cumulative deaths, cumulated recovered, and demographic population density of infected.

3. Results and Discussions

❖ **Summary of the Data**

Total Confirmed Cases

Country	Totals	Global Percentage	Last day Change	t-2	t-3	t-7	t-14
India	10244852	12.5	20549	16432	20021	24712	24010

Total Death Cases

Country	Totals	Percentage	Last Day Change	t-2	t-3	t-7	t-14	t-30
India	148439	1.45	286	252	279	312	355	482

Total Recovered Cases

Country	Totals	Percentage	Last Day Change	t-2	t-3	t-7	t-14	t-30
India	9834141	95.99	26572	24900	21131	29791	33291	41985

State-wise Data for confirmed, death, recovered and active cases

| S.no	Location	Confirmed	Deaths	Recovered	Active
1	Maharashtra	1925066	49373	1820021	55672
2	Karnataka	917571	12074	893617	11880
3	Andhra Pradesh	583925	5041	486531	2353
4	Tamil Nadu	324036	4604	252097	92353
5	Kerala	114033	4660	82341	31226
6	Delhi	225796	4806	191202	29787
7	Uttar Pradesh	324036	4604	252097	67335
8	West Bengal	209146	4062	181142	23942

AGGREGATED Data -- ORDERED BY CONFIRMED Cases -- Data dated: 2020-09-16 :: 2020-12-31 03:08:36
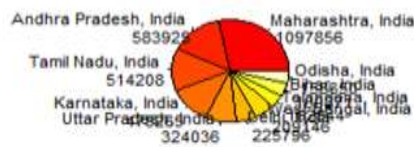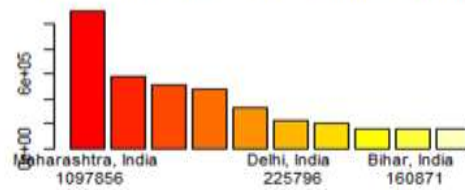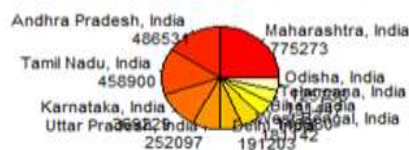

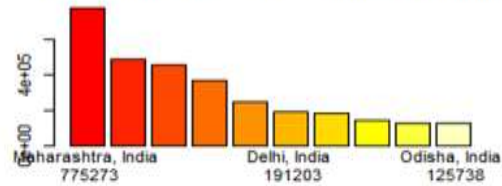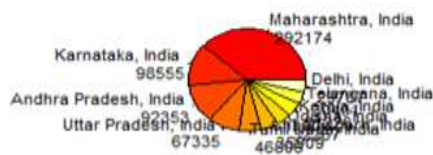AGGREGATED Data -- ORDERED BY DEATHS Cases -- Data dated: 2020-09-16 :: 2020-12-31 03:08:36
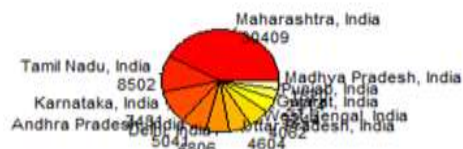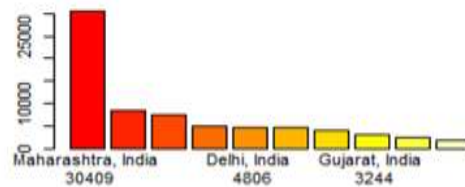
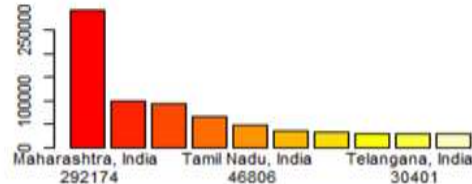AGGREGATED Data -- ORDERED BY RECOVERED Cases -- Data dated: 2020-09-16 :: 2020-12-31 03:08:36

AGGREGATED Data -- ORDERED BY ACTIVE Cases -- Data dated: 2020-09-16 :: 2020-12-31 03:08:36

❖ **Statistical Models**

❖ **Linear Regression (using a log scale)**

Summary:

Min	1Q	Median	3Q	Max
-1590.2	-666.8	-461.4	373.1	1012.8

Coefficients:

	Estimate	Std.Error	Z value	Pr(>|z|)
Intercept	1.136e+01	1.452e-04	78251	<2e-16***
X var	1.527e-02	5.071e-07	30119	<2e-16***

Residual standard error: 2.125 on 341 degrees of freedom

Multiple R-squared: 0.8232,   Adjusted R-squared: 0.8227

F-statistic: 1588 on 1 and 341 DF, p-value: < 2.2e-16

❖ **GLM [generalised Linear Model] (using Poisson Family)**

Summary:

Min	1Q	Median	3Q	Max
-1590.2	-666.8	-461.4	373.1	1012.8

Coefficients:

	Estimate	Sd.Error	Z value	Pr(>|z|)
Intercept	1.136e+01	1.452e-04	78251	<2e-16***
X Var	1.527 e-02	5.071e-07	30119	<2e-16***

Null deviance: 1616561810 on 342 degrees of freedom
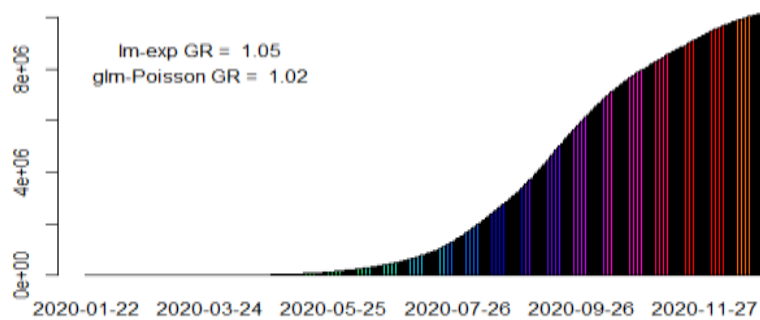
Residual deviance: 149884894 on 341 degrees of freedom

AIC: 149889498

Number of Fisher Scoring iterations: 5

exp.model coefs: -3.701 - 0.046
GLM-Poisson model coefs: 11.362 - 0.015

INDIA

lm-exp GR = 1.05
glm-Poisson GR = 1.02
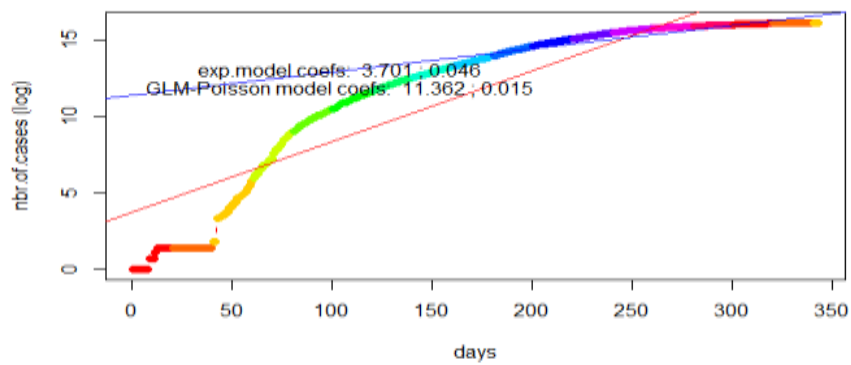
❖ **Growth Rate**
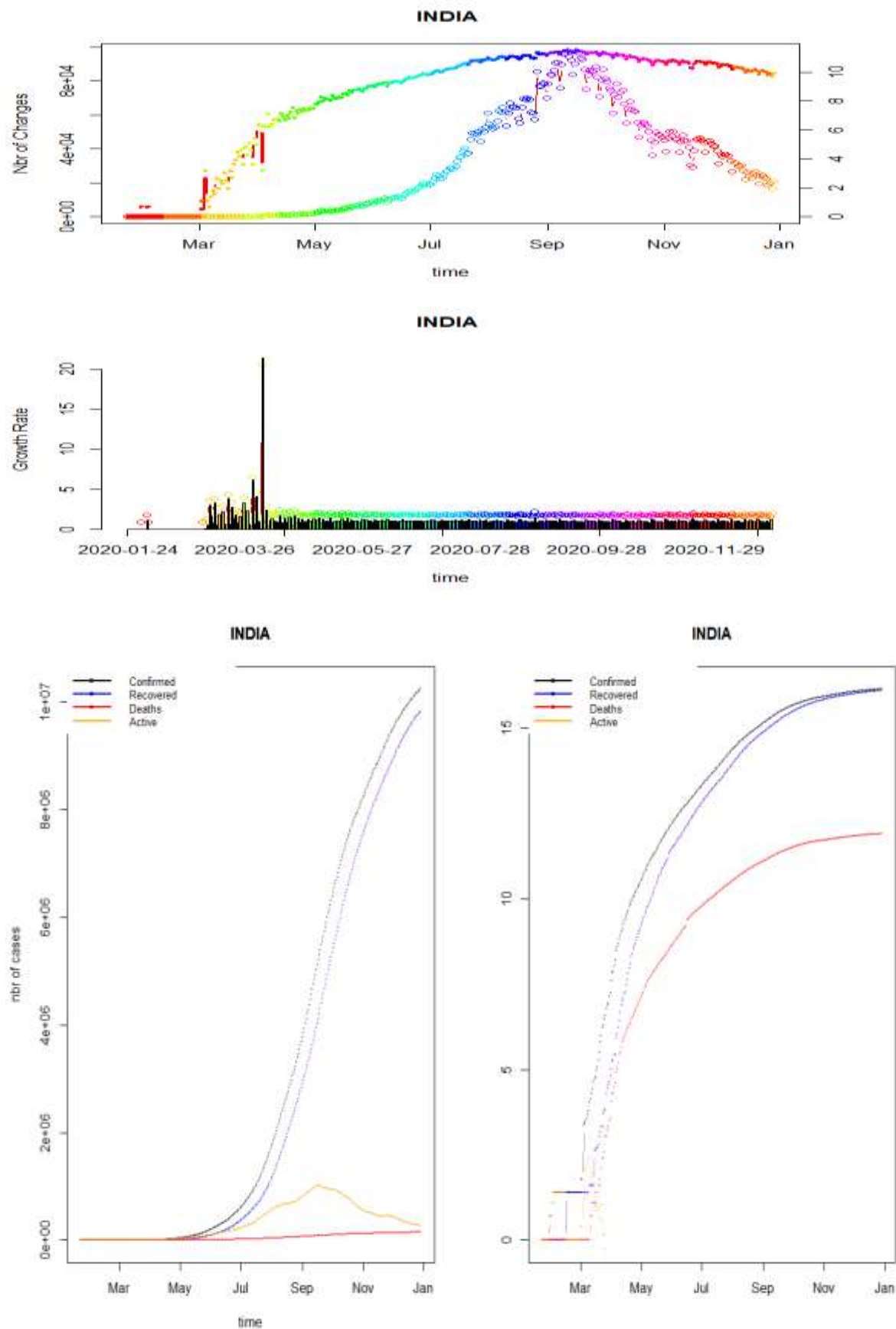
❖ **SIR model**

Parameters

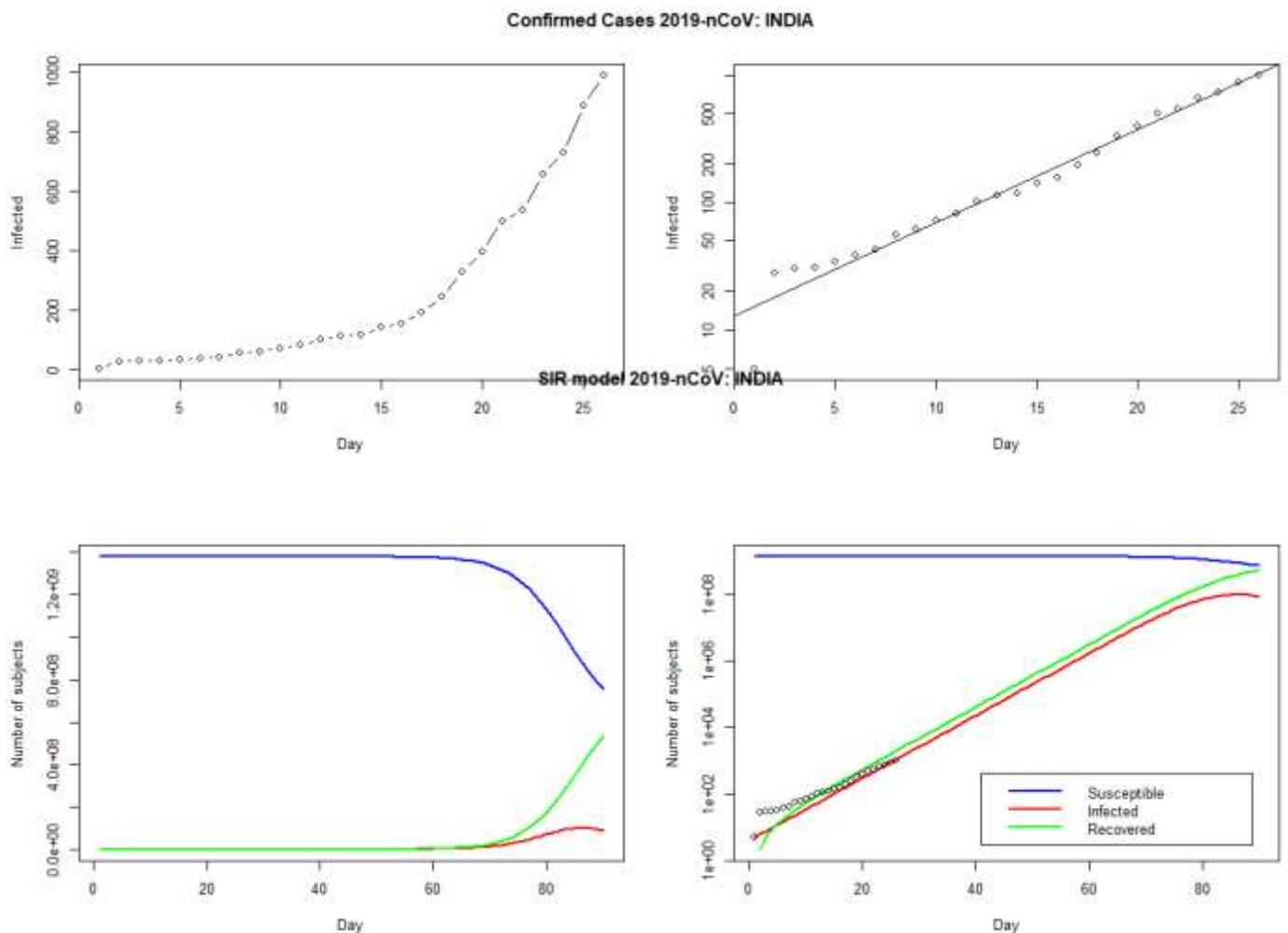| Beta	Gamma	Ro
0.6081878	0.3918122	1.55224341892099

Max number of infected: 100045491.6 (7.25 %)

Max number of casualties, assuming 2% fatality rate: 2000909.83

Max reached at day: 86 ==> 2020-05-29

Confirmed Cases 2019-nCoV: INDIA

SIR model 2019-nCoV: INDIA

4. Conclusion

This study investigates the impact of COVID-19 evolution (deaths and infected numbers of cases) for the future. A new SIR-Poisson model is developed by combining the Poisson Markovian and the SIR models. his model is able to generate the evolution of transmission which predicts the range of the infected cases in a future period with different values, which help government to analyse more precisely.

5. References

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