Sequential Models for COVID Peak Prediction

Introduction

Problem Statement

To predict by Corona Virus Peak in a Country by Machine Learning Methods

1) **LSTM**
2) **Generalized Linear Mixed Models (Next Experiment)**

Materials and Methods

Data

We dynamically take daily data from Our World in Data repository
`https://covid.ourworldindata.org/data/owid-covid-data.csv`

The important usable features in the data per location are as follows
population, population_density, median_age, aged_65_older, aged_70_older, gdp_per_capita, extreme_poverty, cvd_death_rate, diabetes_prevalence, female_smokers, male_smokers, handwashing_facilities, hospital_beds_per_thousand

The following data is non-sparse and important

- **`Location`**
- **`Date`**
- **`Total_cases`**
- **`New_cases`**
- **`Total_cases_per_million`**
- **`New_cases_per_million`**
- **`Gdp_per_capita`**
- **`Population`**
- **`Population_density`**
- **`Median_age`**

The following features are important sequential data by date for each location

- **`Total_cases`**
- **`New_cases`**
- **`Total_cases_per_million`**
- **`New_cases_per_million`**

We filter data for each Location

- **With Population > 1,00,000**
- **Staring from Total_cases_per_million > 1**
- **And had No of weeks since above > 10**

All data is aligned with day 0 as the day when Total_cases_per_million crosses 1 for the country
Orignal data has 209 Countries, after filtering 163 Countries are left
Total of **151 Countries** are found among which **101 Countries have peaked and 50 Countries including India have yet to peak** one week before

Further, we generate 2 features, as **moving average with a rolling window of 7 days**

- **`moving_average(new_cases)`**
- **`moving_average(new_cases_per_million)`**

Further, to predict if the peak is n weeks after this week

Further, we find the peak of each country and take the last (n+1)*7 to (n)7 days previous to peak as sequential features (of length 7, other lengths can also be used) for the LSTM model with the following six features:

- **`Total_cases`**
- **`New_cases`**
- **`Total_cases_per_million`**
- **`New_cases_per_million`**
- **`moving_average(new_cases)`**
- **`moving_average(new_cases_per_million)`**

So as to form,

n_countries*7*6 features for training

For n = 1 week

Total of **151 Countries** are found among which **101 Countries have peaked and 50 Countries including India have yet to peak**

For n = 3 week

Total of **127 Countries** are found among which **74 Countries have peaked and 49 Countries including India have yet to peak**

For n = 6 week

A total of **80 Countries** are found among which **31 Countries have peaked and 49 Countries including India have yet to peak.**
Data is so less it's completely upon chance, experimentally verified.

Model - LSTM

LSTM based Sequential model

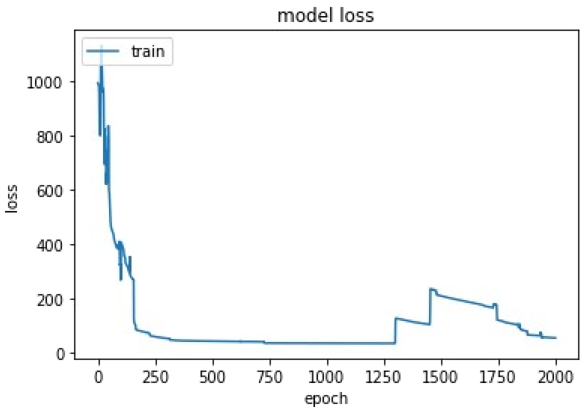
```
LSTM with cell units= 28, activation layers='relu'
FC Dense Layer 1, activation='sigmoid'
loss='binary_crossentropy', optimizer= stochastic gradient descent
Learning rate=1e-10, decay=1e-6, momentum=0.9
```

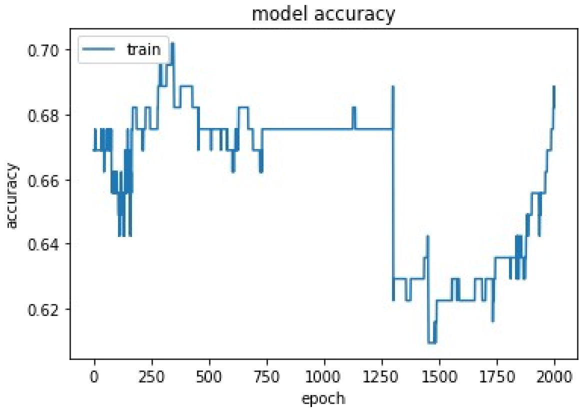
Results

LSTM Model Metrics

For n = 1 week

There is no train-test split as to preserve data (which is not ideal), i.e. test set = train set
N = 151





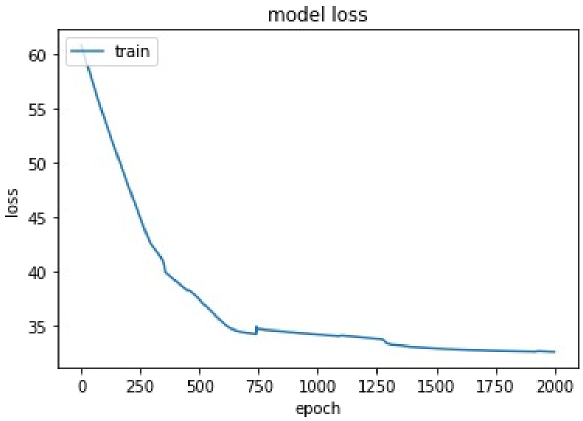
True Positive	83
True Negative	20
False Positive	30
False Negative	18
Accuracy	0.68

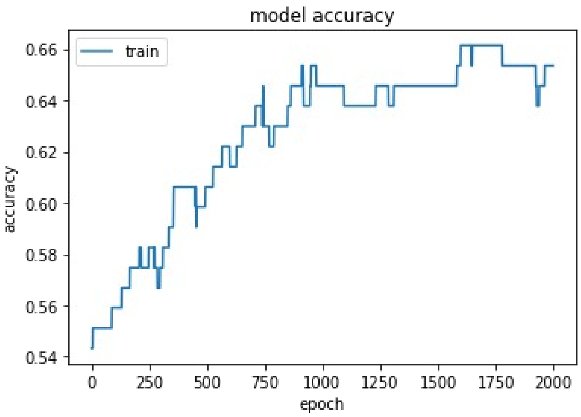
The probability that next week is the peak of new cases for India is 1.1e-11.
Therefore certainly next week is not the peak of new cases for India

```
Confusion Matrix
[[20 30]
 [18 83]]
Classification Report
             precision    recall  f1-score   support

          0       0.53      0.40      0.45        50
          1       0.73      0.82      0.78       101

   accuracy                           0.68       151
  macro avg       0.63      0.61      0.62       151
weighted avg       0.67      0.68      0.67       151
```

For n = 3 week

There is no train-test split as to preserve data (which is not ideal), i.e. test set = train set
N = 127





True Positive	41
True Negative	42
False Positive	8
False Negative	36
Accuracy	0.65

```
Confusion Matrix
[[42  8]
 [36 41]]
Classification Report
             precision    recall  f1-score   support

          0       0.54      0.84      0.66        50
          1       0.84      0.53      0.65        77

   accuracy                           0.65       127
  macro avg       0.69      0.69      0.65       127
weighted avg       0.72      0.65      0.65       127
```

The probability that next week is the peak of new cases for India is 0.00010963.
Therefore three weeks after today has a very low probability of being the peak of new cases for India

For n = 6 week

There is no train-test split as to preserve data (which is not ideal), i.e. test set = train set,
N = 80

```
Confusion Matrix
[[48  1]
 [30  1]]
Classification Report
              precision    recall  f1-score   support

           0       0.62      0.98      0.76        49
           1       0.50      0.03      0.06        31

    accuracy                           0.61        80
   macro avg       0.56      0.51      0.41        80
weighted avg       0.57      0.61      0.49        80
```

Rough Conclusion

- We can roughly predict if the COVID new cases peak is exactly after 1 week with 68% accuracy, and after 3 weeks with 65% accuracy.
- At 6 weeks the data and learning are so insufficient that the prediction is almost completely chance and thus of not much use.
- With the majority of the difficulty in predicting given COVID peak is not in x weeks accurately predicting that it is not.
- It is not a fairly accurate prediction.

Further Directions

1. Add features such as **`Gdp_per_capita`**, **`Population`**, **`Population_density`**, **`Median_age`** as covariates in the LSTM model possible as a logistic model.
2. Try out **Generalized Linear Mixed Models (Next Experiment)** with said data.
3. Try Further experimentation with LSTM based model.