Results Presentation

Team: PandeML

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Outline

1) Chosen Approaches
    a) Parametric Curve Fitting
    b) Linear Regression
    c) SIR
    d) LSTM
2) Comparison of Models
3) Conclusion

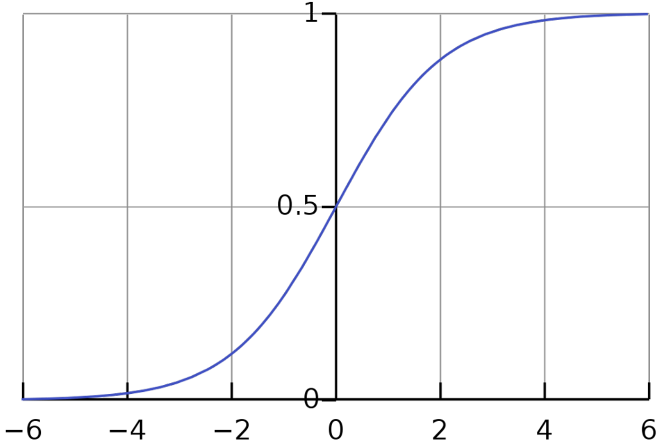
Parametric Curve Fitting

Idea: Number of infected/deceased/recovered people will follow a **Logistic Curve.**
→ Fit data to a such a curve using scipy's `optimize.curve_fit`

$$f(x) = \frac{L}{1 + e^{-k(x-x_0)}}$$

Parameters:

L :=	Maximal value
k :=	Logistic growth rate
x_0:=	Midpoint



Credit: https://en.wikipedia.org/wiki/Logistic_function

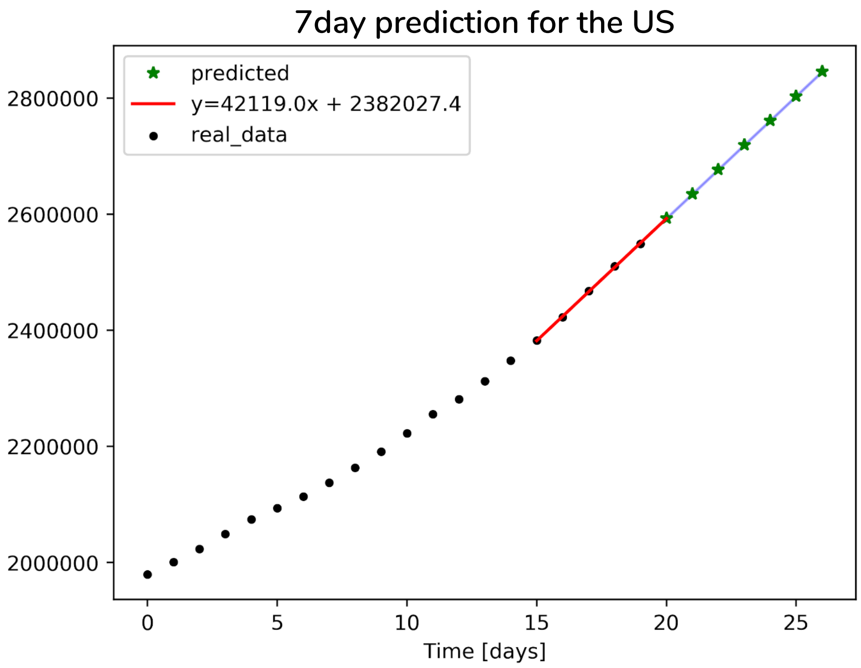
As proposed in https://medium.com/analytics-vidhya/how-to-predict-when-the-covid-19-pandemic-will-stop-in-your-country-with-python-d6fbb2425a9f

Linear Regression

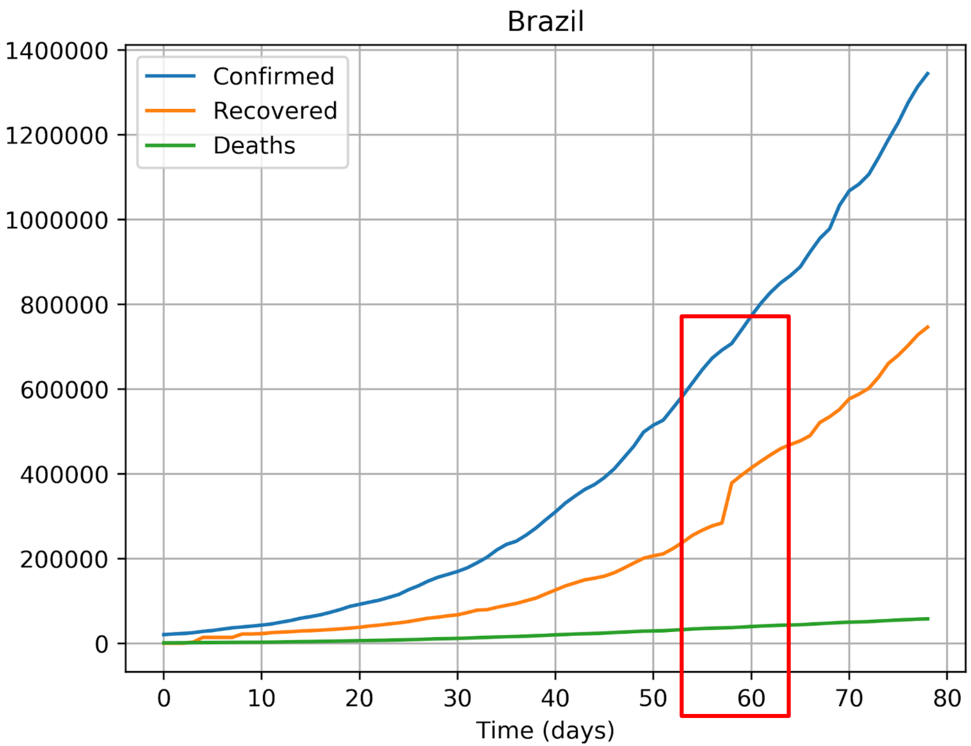
- **Motivation**: Simpler models tend to perform better for short time predictions
- **Model**: Ordinary least squares linear regression:

$$\min_{\boldsymbol{w}\in\mathbb{R}^p} ||\boldsymbol{X}\boldsymbol{w} - \boldsymbol{y}||_2^2 = \min_{\boldsymbol{w}\in\mathbb{R}^p} \sum_{i=1}^{n} (\boldsymbol{w}^\top \boldsymbol{x}^{(i)} - y_i)^2.$$

- **Parameters**: LinReg of last 5 days for both 2day and 7day prediction
- Usage of **scipy.stats.linregress**, to determine: slope, intercept and std_err
- **95%-Confidence-Interval** via: 1.96*std_err
- **Pros**: Mathematically straightforward, Transparent
- **Cons**: Not capable to predict complex relationships (in opposite e.g. SIR)

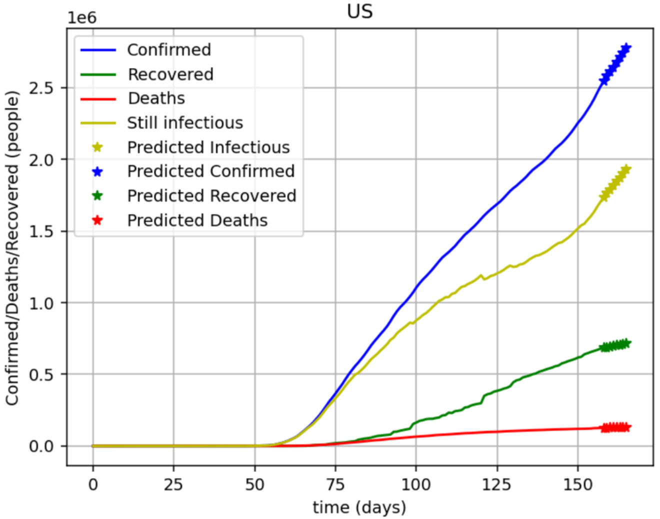


Linear Regression



SIRD

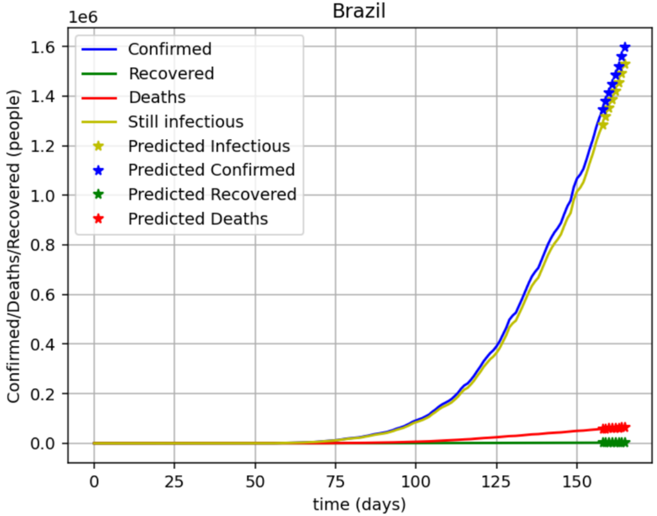
$$\frac{dS}{dt} = -\beta \cdot I \cdot \frac{S}{N}$$
$$\frac{dI}{dt} = -(1-\alpha) \cdot \gamma \cdot I - \alpha \cdot \rho \cdot I$$
$$\frac{dR}{dt} = (1-\alpha) \cdot \gamma \cdot I$$
$$\frac{dD}{dt} = \alpha \cdot \rho \cdot I$$



➢ β = number of persons an infected person infects per day

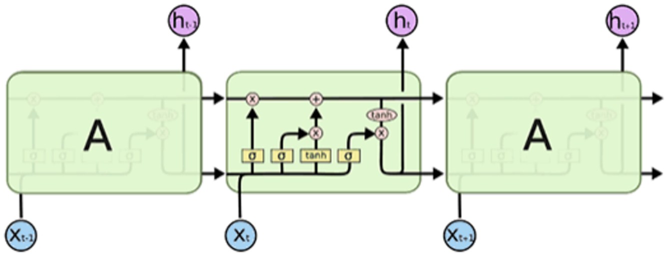
➢ days = number of days an infected person is infectious

➢ R = beta × days = total number of persons an infected person infects



Problem:

- SIR-model tries to describe "real" epidemic outbreak, but prediction is made for incomplete data (mainly missing recovered data) → parameters need to be calculated from given data → leads to unreal parameters
- Example:
  - Calculated parameters for prediction in US:
    R = 7.13, β = 0.018, days = 396.8



LSTM-Recursive NN

LongShortTermMemory

<u>Idea</u>: Use COVID19 data from all countries world wide to learn the behavior
(11000 training Samples, 2000 Samples for validation)

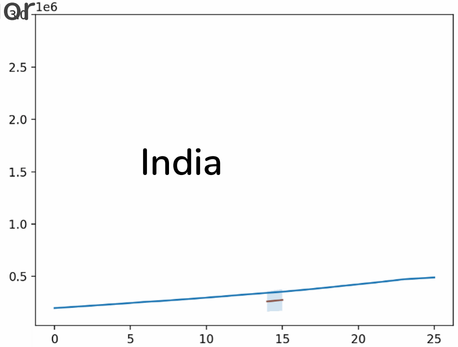
<u>Strategy</u>: *Multiple Parallel Input and Multi-Step Output* for 100 epochs

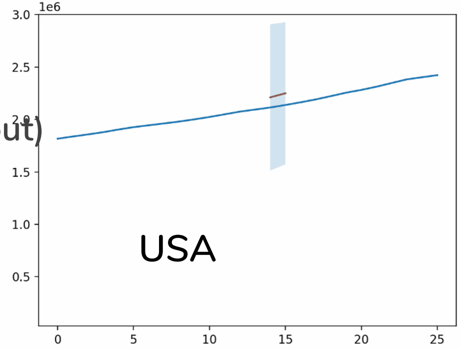
<u>Input</u>: 7 Days of data (Cases, Deaths, Recovered)

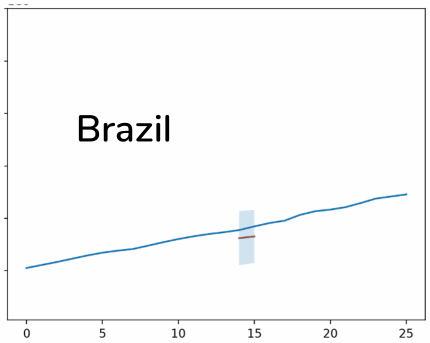
<u>Output</u>: 2 or 7 Days of Data (Cases, Deaths, Recovered)

<u>Architechture:</u>

200 Node LSTM
150 Node LSTM
100 Node LSTM
50 Node LSTM
3 Node Dense (output)







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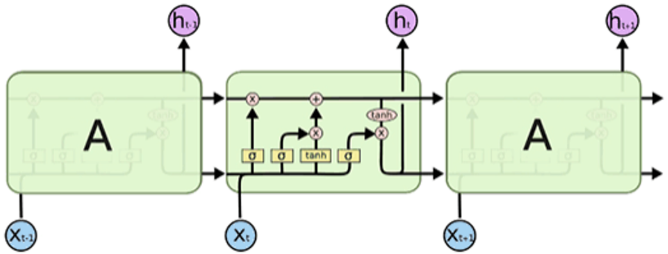

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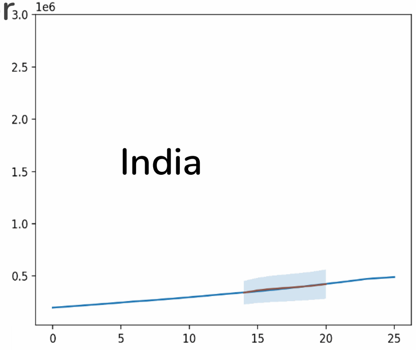
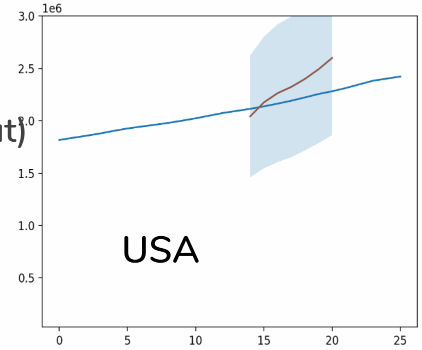
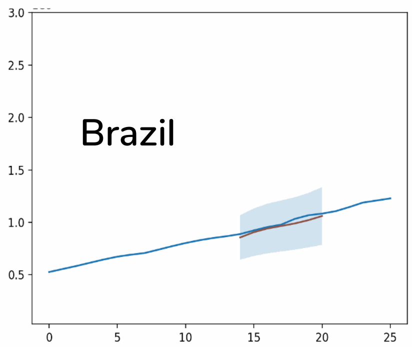
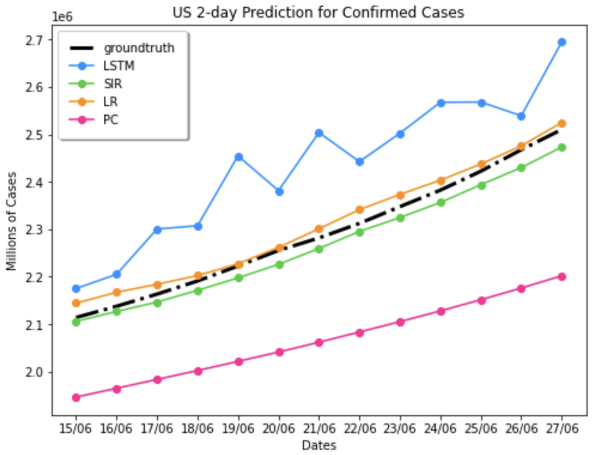
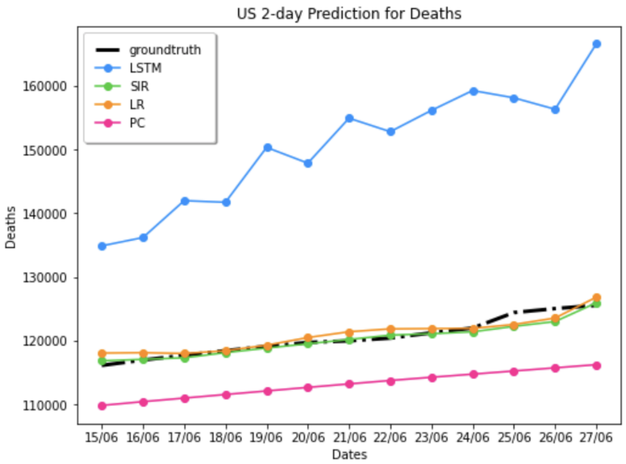


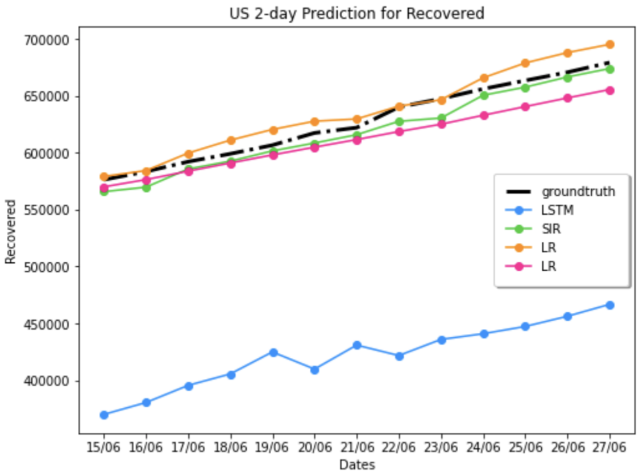




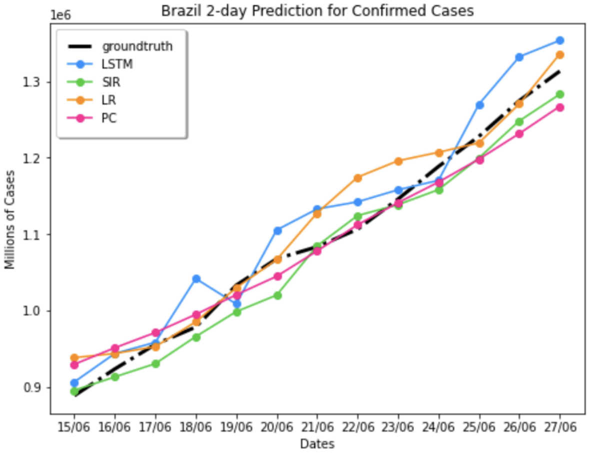
2-day Predictions: US

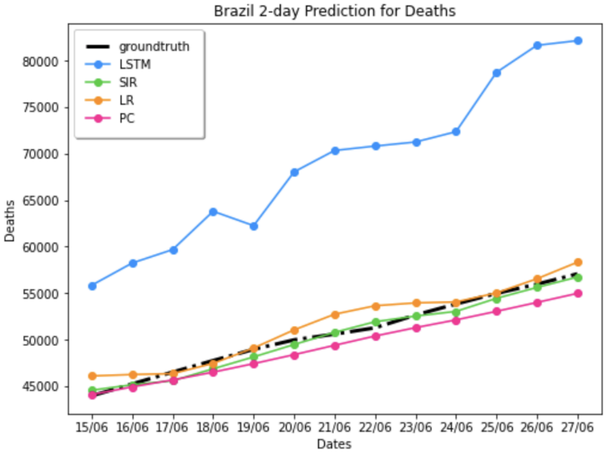


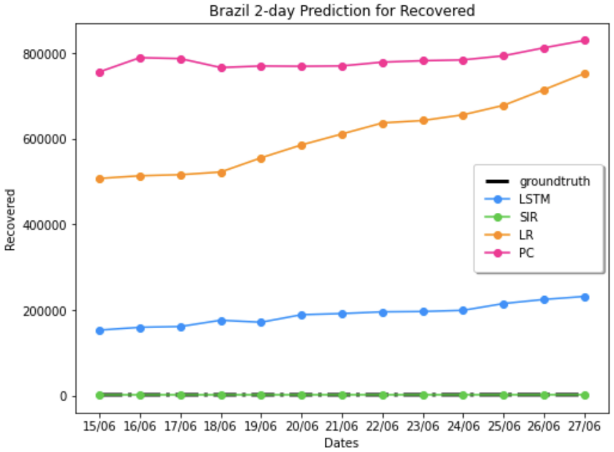




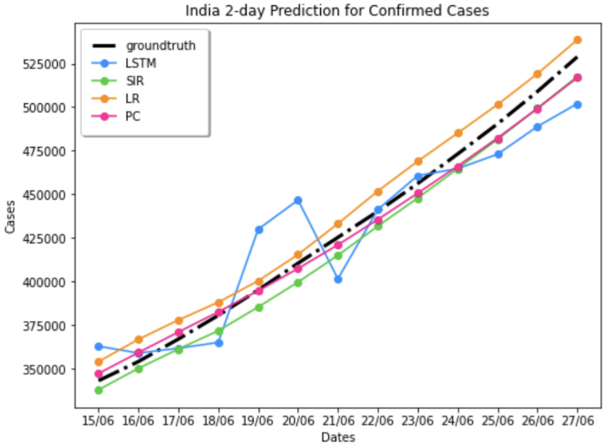
2-day Predictions: Brazil

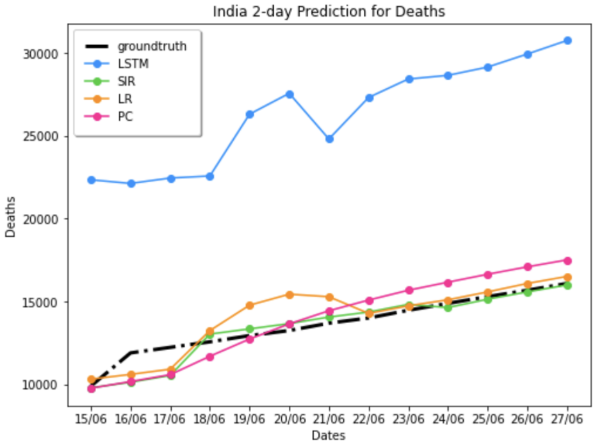


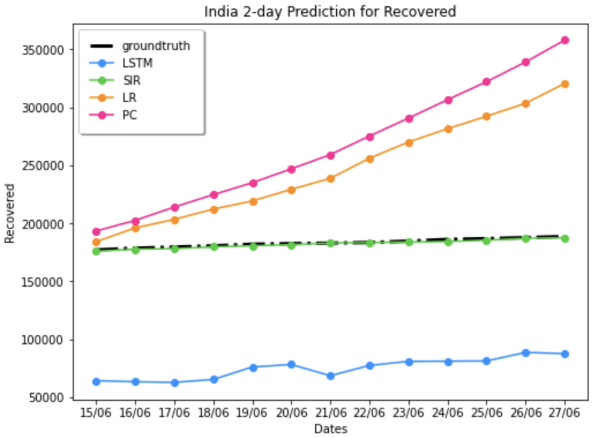




2-day Predictions: India



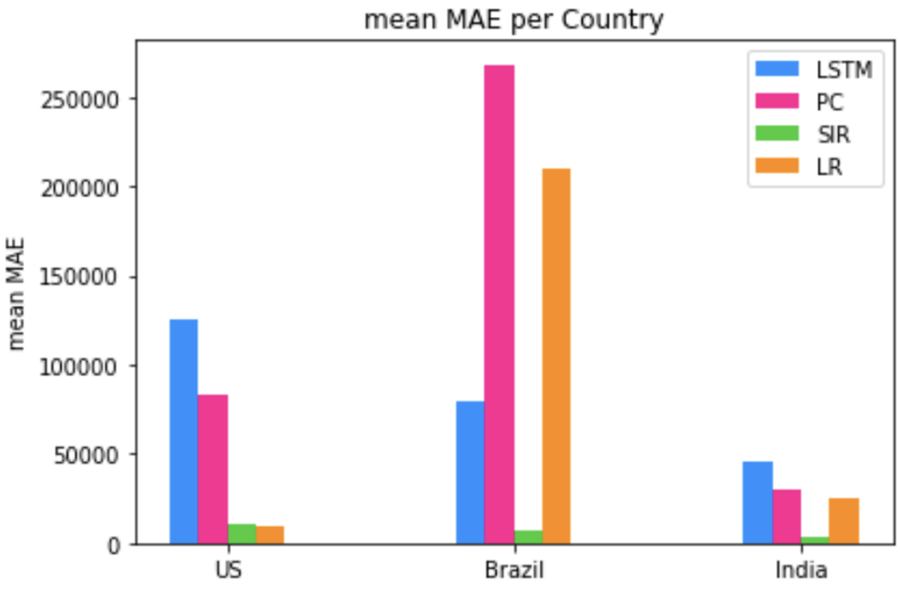


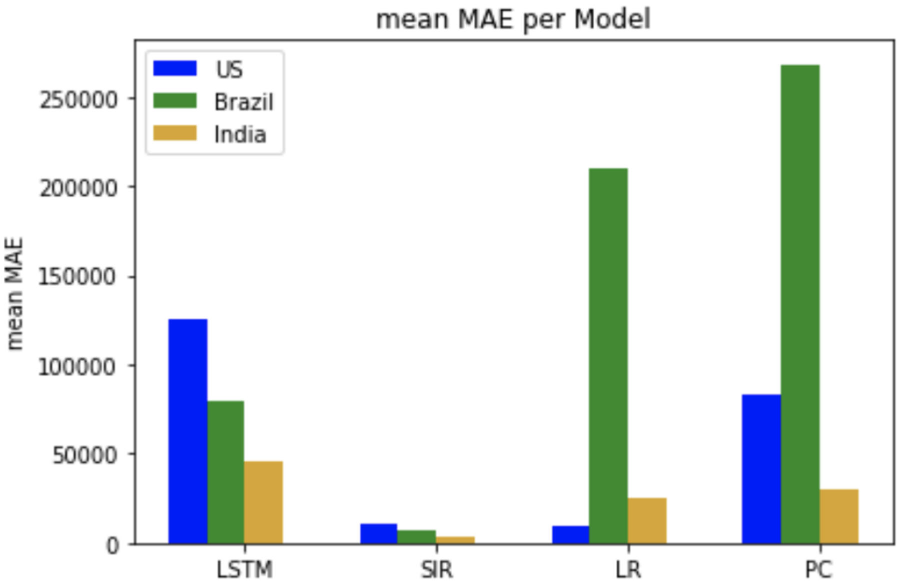


2-day Predictions: Evaluation

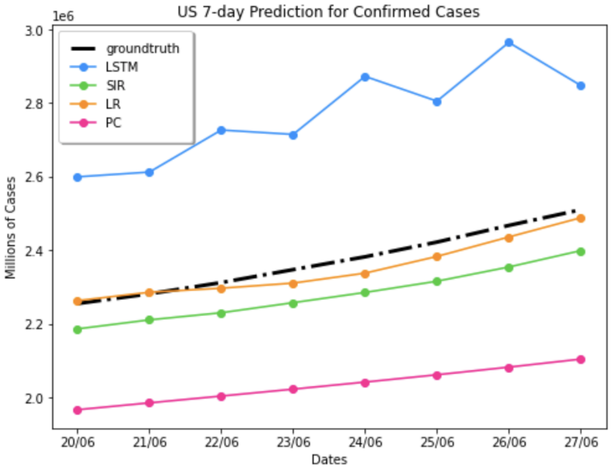
Mean Absolute Error:

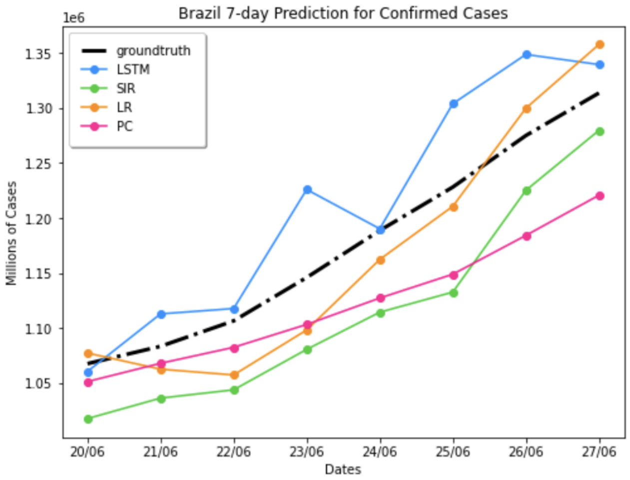
0.33 *
(abs(# predicted cases - # actual cases)
+
abs(# predicted deaths - # actual deaths)
+
abs(# predicted recovered - # actual recovered))

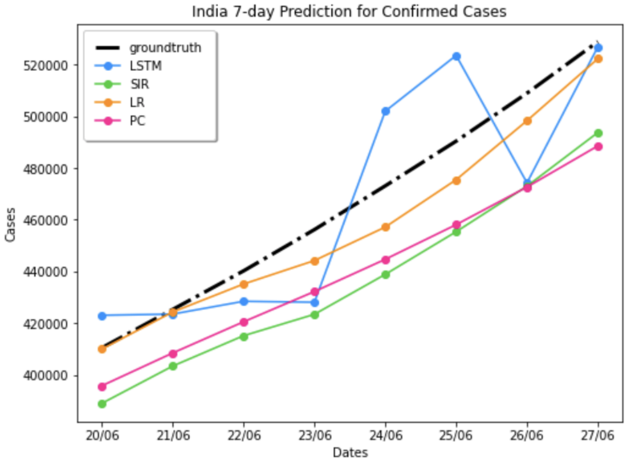




7-day Predictions







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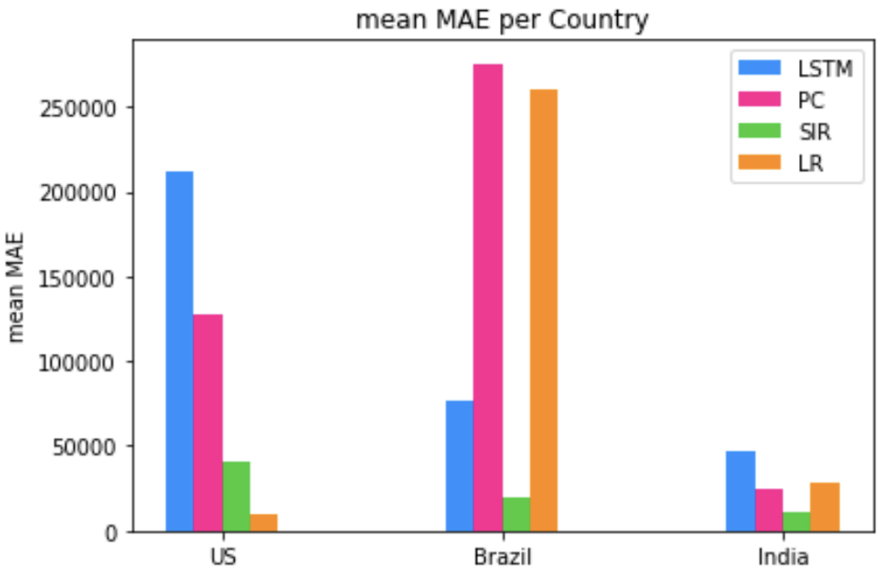

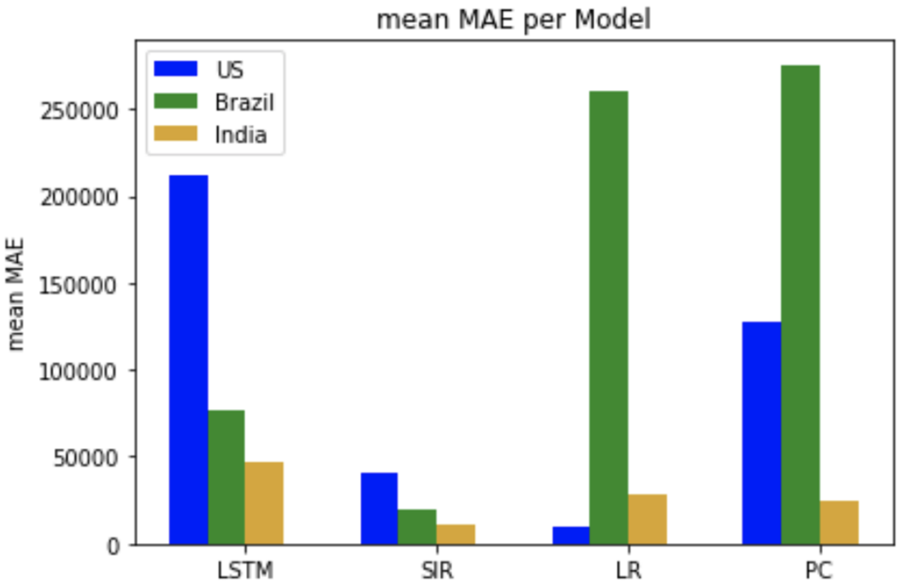

Conclusion

Learnings:

- SIRD-model best estimate covid-19 BUT may lose interpretability
- LSTM with multiple outputs need well prepared training data
- Some 7day models may be more accurate for 2day predictions
- Complex models have a lot more effort to get robust results.

Work available at: https://gitlab.ethz.ch/olemuell/pandeml