A Deep Learning Approach for a Spatio-Temporal Forecasting of New Cases and New Hospitalizations of COVID-19 in the Reggio-Emilia Province, Northern Italy

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Introduction

- From February 2020, the COVID-19 epidemic rapidly spread throughout Italy.
 - First wave (~ February 2020):
 - Lombardy,
 - Veneto,
 - Emilia-Romagna
 - Second wave (~ August 2020):
 - Lombardy,
 - Emilia-Romagna,
 - Piedmont,
 - Veneto
- Some studies showed an association of environmental factors, such as PM₁₀, PM_{2.5}, NO₂, temperature, relative humidity, wind speed, solar radiation and mobility with the diffusion of the epidemic.



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Aims

- To forecast the real-time transmission of SARS-COV-2 virus at a local level with limited extension (12 km x 12 km), in terms of new COVID-19 cases and hospitalizations.
- To investigate the impact of fine-grain spatial environmental information, such as meteorological, pollution and mobility data, on the COVID-19 epidemic spread.



Material

- **Province of Reggio Emilia**, which was severely hit by the first wave of the COVID-19 epidemic
- To take into account the **spatiality**, the input and output variables were related to a **grid** that was characterized by 40 cells of size 12 km x 12 km



Data

Pollution

Data: PM₁₀, PM_{2.5}, NO₂ mean concentrations
Source: Urban Tool for Air Quality model (web application TerrAria) and from the Copernicus Atmosphere Monitoring Service (ESA).

Meteo

 Data: Air temperature, relative humidity, wind speed and solar radiations

 Source: COSMO-5M model (OpenData portal of ARPA Emilia-Romagna)

• Data: crowding index

Mobility • Sou

 Source: Very-High Resolution satellite and aerial images (Studiomapp) analyzed by an Al algorithm, to count the number of cars, busses or trucks.







Method

Deep Learning (DL): more flexible and free-from-assumptions approach (Interactions, Non-linearity,...)

Spatial DL method:

Convolutional Neural Network (CNN)

When working with *images*, the most widely used Deep Learning model is CNN.

The image is scanned by "Convolutional Layers" in which multiple filters extract the most important features.





Long-Short term Memory (LSTM)

LSTM neural networks are a type of recurrent neural network, and it is the most widely used Deep Learning model in sequence prediction problems.



Method

Spatio-Temporal DL method:



- The Convolutional-LSTM (ConvLSTM) model is an extension of the CNN and LSTM models, in which it is possible to use a multidimensional input data.
- 7-day moving average to forecast the 7th day after
- Training set: 01/08/2020 31/01/2021
 Validation set: 01/02/2021 31/04/2021
 Test set: 01/05/2021 01/09/2021

• <u>Time lags:</u>

- Mobility 7 days
- Solar radiations 21 days
- PM2.5 7 days
- Wind speed 7 days



Results

Validation set New COVID-19 cases



Results

Validation set New COVID-19 hospitalizations



Results Test New COVID-19 cases Input (Model 2): new cases, PM2.5, mobility, solar radiations Walk-forward

May, 2021 – September, 2021





Applications

Demo access: a.goffi@terraria.com

What-if scenarios for the introduction of policies

Conclusions

- ConvLSTM could achieve good performances in forecasting new SARS-COV-2 infections and new COVID-19 hospitalizations, taking advantage of a spatio-temporal representation.
- Furthermore, this approach allows accurate predictions at a local level, with a resolution of 12km x 12km, which could be of fundamental importance to help in optimizing the real-time allocation of health resources during an epidemic emergency.
- Based on our ablation studies, we can assume that mobility and environmental information are useful to improve the performance in the forecasting.
- * No early stage of epidemic (need data for training).

Space in response to COVID-19 outbreak

EPIC@19

https://www.epico19.eu/en/

A demo version of the application is available to offer an overview of the tool's potential. To gain access write to: epico19@terraria.com

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Thank you for your attention!

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