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Dynamic flood hazard maps based on traffic flow forecasts using mobile phone data

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Maps of flooding risk and exposure generally assume people and vehicles density constant over time, although this is not the case in the real world, as crowding is a highly dynamic process in urban areas. Monitoring and forecasting people mobility is a relevant aspect for metropolitan areas subjected to high risk of flooding. Information and communication technologies (ICT) along with big data are massively used, e.g., to support the optimization of traffic flows and the study of urban systems. In particular, mobile phone network data suits with the aim of producing dynamic information on people's movements that can be used to develop dynamic exposure to flood risk maps for areas with hydrogeological criticality, as done by Balistrocchi et al. (2020).

In this work we aim at proposing a time series modelling strategy to obtain “real time” traffic flows prediction. To do so we use mobile phone origin-destination signals on the flow of Telecom Italia Mobile (TIM) users among different census areas (ACE of ISTAT, the Italian National Statistical Institute), and for the MoSoRe Project 2020-2022 and recorded at hourly basis from September 2020 to August 2021.

An Harmonic Dynamic Regression (HDR) model (Hyndman, Athanasopoulos, 2021) as it follows:

$$\text{Flow} = \alpha + \text{Fourier.day}(K_d) + \text{Fourier.week}(K_w) + \text{Month} + \varepsilon\_(\text{ARIMA}(p,d,q)) \quad (1)$$

is proposed, where multiple seasonal periods are modelled with a properly selected number of Fourier basis, month is a dummy variable to account for different levels of flows by months and the error component is structured as an ARIMA.

HDR model suits for our purposes due to the strong daily and weekly patterns in traffic flows, as also confirmed by preliminar results on the accuracy of prediction based on a cross-validation strategy.

In future developments, the model in equation 1 may be improved by adding proper features as explanatory variables to increase the prediction accuracy, such as, e.g., the presence of people in the census area of origin and in the census area of destination of the flow, or precipitation data.

People's and vehicles' exposure obtained from mobile phone data and processed with the above stochastic model are then combined to flooding hazard maps estimated for different storm return period in a urbanized area close to Brescia to estimate dynamic flood risk maps.

References

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