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COVID-19 Reproduction Number Estimation: Spatial and Temporal in Convex Optimization to Promote Piecewise Smoothness

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Among the different indicators that quantify the spread of an epidemic such as the on-going COVID-19, stands first the reproduction number which measures how many people can be contaminated by an infected person. In order to permit the monitoring of the evolution of this number, a new estimation procedure is proposed here, assuming a well-accepted model for current incidence data, based on past observations [1]. The novelty of the proposed approach [2] is twofold: 1) the estimation of the reproduction number is achieved by convex optimization within a proximal-based inverse problem formulation, with constraints aimed at promoting piecewise smoothness; 2) the approach is developed in a multivariate setting, allowing for the simultaneous handling of multiple time series attached to different geographical regions, together with a spatial (graph-based) regularization of their evolutions in time. The effectiveness of the approach is first supported by simulations, and two main applications to real COVID-19 data are then discussed. The first one refers to the comparative evolution of the reproduction number for a number of countries, while the second one focuses on French departments and their joint analysis, leading to dynamic maps revealing the temporal co-evolution of their reproduction numbers. Additionally, we will report new work showing how to deal, in this framework, with outliers coming from errors in data reporting or other events.

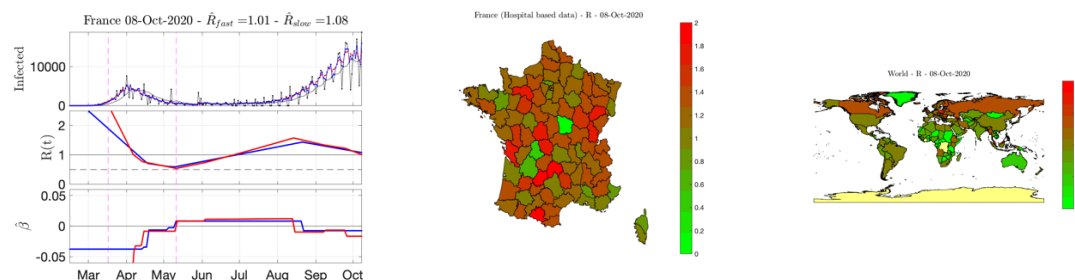


Figure 1: Current estimate of the Reproduction number in France (left), at the level of departments in France using the graph-based regularization (center) and for the world (right).

Maps update daily at <https://perso.ens-lyon.fr/patrice.abry/>, and interactive maps:

<http://barthes.enssib.fr/coronavirus/cartes/R-Covid-19-today-World.svg>

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References

- [1] Cori A, Ferguson NM, Fraser C, Cauchemez S. A new framework and software to estimate time-varying reproduction numbers during epidemics. *American Journal of Epidemiology*. 2013; 178(9):1505–1512. <https://doi.org/10.1093/aje/kwt133> PMID: 24043437
- [2] Abry P, Pustelnik N, Roux S, Jensen P, Flandrin P, Gribonval R, et al. (2020) Spatial and temporal regularization to estimate COVID-19 reproduction number $R(t)$: Promoting piecewise smoothness via convex optimization. *PLoS ONE*, 15(8): e0237901. <https://doi.org/10.1371/journal.pone.0237901>.