Two-year postdoc position in signal processing and Monte Carlo methods applied to epidemiology

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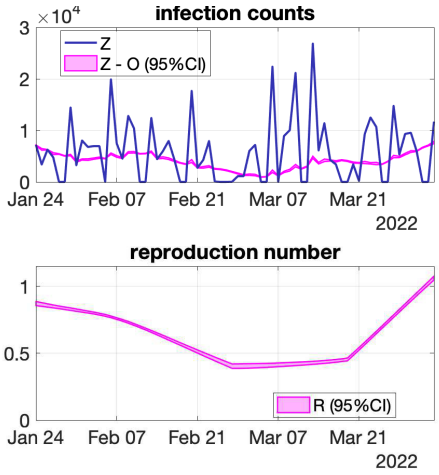
Description of work

The purpose of the project is to design **fully automated and data-driven** procedures for pointwise and/or credibility interval estimation of **epidemiological indicators**, e.g., for the reproduction number R_t of Covid19.
Elaborating on a recent epidemiological model [2], both variational estimators [6] and Monte Carlo samplers [1, 4] have been designed and implemented during the pandemic to estimate the reproduction number of the Covid19. The major bottleneck to their systematic use and generalization to other epidemics is that they require fine-tuning of hyperparameters, which until now has been done manually in conjunction with experts, inducing a prohibitive complexity.
Automated data-driven selection procedures will enable to gain objectivity and capacity to handle large amount of data from a wide range of epidemics.
The first challenge consist in refining previous models [2, 6, 4] to better account for both the epidemiological mechanisms and the possibly low quality of data reported during an epidemic. Mutliplicative models will be considered and connection with Kullback-Leibler Non-Negative Matrix Factorization will be explored [9, 5]. The second challenge is to leverage the derived statistical models to design automated data-driven procedures for the estimation of epidemiological indicators. To that aim, both Stein-based bilevel optimization [7], empirical Bayesian [8] and unsupervised deep learning [3] approaches will be considered.



Covid19 indicators in Finland

The recruited postdoc researcher will tackle both implementation challenges and theoretical questions related to statistical modeling, prior design in the Bayesian framework, convex and non convex optimization, stochastic optimization. He/she is expected to develop commented, easy to handle codes to make available the proposed methodologies to nonspecialists. He/she will work in contact with epidemiologists and will be provided real epidemiological data. An interest in interdisciplinary research will be highly appreciated.

Host institution and place of work

The recruited candidate will be hired by the Centre National de la Recherche Scientifique (CNRS) in the framework of ANR grant OptiMoCSI holded jointly by LP-IXXI in Lyon, IMT in Toulouse and LS2N in Nantes. CNRS is the largest state-funded French research institution, employing researchers in all fields from exact sciences to humanities. He/she will integrate the Laboratoire des Sciences du Numérique de Nantes (LS2N), in the Signal, Image and Sound (SIMS) team (https://www.ls2n.fr/equipe/sims/) and work on the campus of Centrale Nantes, a top-level engineering school.
"Regularly quoted in newspapers as being one of the nicest cities in France, Nantes is also renowned for being a rich, lively and innovative city. Its economic clout makes Nantes France's 3rd largest industrial city and 2nd most successful city in terms of employment growth." (https://metropole.nantes.fr/nouveaux-arrivants)

Candidate profile

Prospective applicants are expected to hold a PhD in signal processing, statistics or a related discipline, excellent programming skills (e.g., in Python or Matlab), and good communication skills in English, both written and oral. The gross monthly salary takes into account experience, e.g.,it is 4,122 euros for researchers with 2 years of professional experience after the PhD. The position comes with health insurance and other social benefits. Financial support to attend international conferences and visiting other members of the consortium in Lyon and Toulouse, as well as international collaborators in Edinburgh is included.
Candidates are requested to send a CV, a brief statement of research interests and the contact details of two referees in a single PDF file. The position is open and can start anytime from January 10, 2023 for one year renewable once. Applications will be collected until a suitable candidate is found.
Applications and informal information requests are to be emailed to barbara.pascal@cnrs.fr.

References

[1] H. Artigas, B. Pascal, G. Fort, P. Abry, and N. Pustelnik. Credibility interval design for COVID19 reproduction number from nonsmooth Langevin-type Monte Carlo sampling. In *2022 30th European Signal Processing Conference (EUSIPCO)*, Belgrade, Serbia, Aug. 29-Sept. 2 2022.

[2] A. Cori, N. M. Ferguson, C. Fraser, and S. Cauchemez. A new framework and software to estimate time-varying reproduction numbers during epidemics. *Am. J. Epidemiol.*, 2013.

[3] D. Chen, M. Davies, M. J. Ehrhardt, C.-B. Schönlieb, F. Sherry and J. Tachella. Imaging With Equivariant Deep Learning: From unrolled network design to fully unsupervised learning. *IEEE Signal Process. Mag.*, (1), 2023.

[4] G. Fort, B. Pascal, P. Abry and N. Pustelnik. Covid19 reproduction number: Credibility intervals by blockwise proximal Monte Carlo samplers. *IEEE Trans Signal Process., to appear.*, 2023.

[5] L. T. K. Hien and N. Gillis. Algorithms for nonnegative matrix factorization with the Kullback–Leibler divergence. *J. Sci. Comput.*, (3), 2021.

[6] B. Pascal, P. Abry, N. Pustelnik, S. Roux, R. Gribonval, and P. Flandrin. Nonsmooth convex optimization to estimate the Covid-19 reproduction number space-time evolution with robustness against low quality data. *IEEE Transactions on Signal Processing*, 70:2859–2868, 2022.

[7] B. Pascal, S. Vaiter, N. Pustelnik, and P. Abry. Automated data-driven selection of the hyperparameters for Total-Variation based texture segmentation. *J. Math. Imaging Vis.*, pages 1–30, 2021.

[8] A. F. Vidal, V. De Bortoli, M. Pereyra, and A. Durmus. Maximum likelihood estimation of regularization parameters in high-dimensional inverse problems: An empirical bayesian approach part I: Methodology and experiments. *SIAM J. Imaging Sciences*, (4), 2020.

[9] F. Yanez and F. Bach. Primal-dual algorithms for non-negative matrix factorization with the Kullback-Leibler divergence. In *Proc. IEEE ICASSP*, 2017.