4th URSI AT-RASC, Gran Canaria, 19 – 24 May 2024

Data-driven algorithm for the decomposition and analysis of non-stationary spherical data sets

Giovanni Barbarino[(1)], Roberto Cavassi*[(2)], and Antonio Cicone[(2)(3)(4)]
(1) Aalto University, Finland
(2) DISIM, University of l'Aquila, Italy
(3) Istituto di Astrofisica e Planetologia Spaziali, INAF, Rome, Italy
(4) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy

Researchers have to handle spherical data sets in many research areas, like geophysical and astrophysical fields. We can think, for instance, of a planet's gravity maps, or our universe's cosmic microwave background. Since these data sets are non-stationary, it is better to study them through non-stationary techniques, and 'Fast Iterative Filtering' has proven to be an interesting and useful method to achieve this goal, in 1D or 2D cases [3]. However, some problems arise when we want to extend this method to handle spherical data, i.e. non-Euclidean settings, since FIF relies on convolutions that cannot be directly generalized from $\mathbb{R}^n$ to the sphere.

In this presentation, after introducing a continuous operator to filter signals defined on the sphere we analysed its discretisation through the Generalised Locally Toeplitz (GLT) sequences of matrices [2]. Using some properties from the GLT theory we show that it is possible to guarantee the convergence of FIF extended to the sphere [1].

In the second part of our presentation, we show a few examples of applications of this newly developed method to real-life geophysical signals and compare them with the ones produced using the classical spherical harmonics.

References

[1] G. Barbarino, R. Cavassi, and A. Cicone, "Extension and convergence analysis of Iterative Filtering to spherical data," arXiv (Cornell University), Nov. 2023, doi: https://doi.org/10.48550/arxiv.2311.18657.

[2] C. Garoni and Stefano Serra-Capizzano, Generalized Locally Toeplitz Sequences: Theory and Applications. 2017. doi: https://doi.org/10.1007/978-3-319-53679-8.

[3] A. Cicone and H. Zhou, "Multidimensional Iterative Filtering Method for the Decomposition of High–Dimensional Non–Stationary Signals," Numerical Mathematics: Theory, Methods and Applications, vol. 10, no. 2, pp. 278–298, May 2017, doi: https://doi.org/10.4208/nmtma.2017.s05.