Wind velocity field and oceanic surface currents approximation and visualization from sparse data

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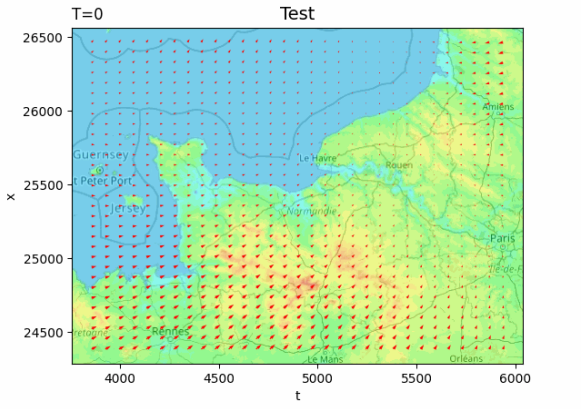
In this work, we study the problem of vector field approximation from sparse data. The modelling is linked to the Dm spline approximation (see Gout et al. [1]). Such problem emerges in a wide range of fields such as : motion control, computer vision, geometrical analysis, geometrical design, analysis of acoustic or electromagnetic waves, as well as in geophysics, medical imaging, fluid mechanics and so on... In [2], the authors initially introduced a regularized least-square problem defined on a space of potentials (real-valued functions) to fit a vector field dataset. For any $\epsilon > 0$, we introduce the functional $\mathcal{J}_\epsilon$ defined as follows :

$$\mathcal{J}_\epsilon : \begin{cases} H^{m+1}(\Omega, R) \to R \\ v \mapsto \langle \rho(\nabla v) - w \rangle_N^2 + \epsilon |v|_{m+1,\Omega,R}^2, \end{cases} \tag{1}$$

where $w = (w_1, \cdots, w_N)^T \in (R^n)^N$ is the vector field dataset and $|\cdot|_{m+1,\Omega,R}$, the semi-norm on $H^{m+1}(\Omega, R)$. We will give the corresponding variational problem, discretized using the finite elements method. Then, numerical results are given and the approximated vector field is visualized using the library Matplotlib ([3]) :



The originality of this work consists :
- the fact that (like in [2]) the vector field derives from a potential : in meteorology (winds derive from temperature potentials), in oceanography (currents derive from pression potentials) for instance,
- in establishing a convergence result and providing an approximation error estimate,
- in using a specific visualization tool using the library MATPLOTLIB.

Références

[1] C. Gout, Z. Lambert and D. Apprato, Data approximation : mathematical modelling and numerical simulations, 166 p., ISBN 9978-2-7598-2367-3, EDP Sciences, 2019.

[2] C. Le Guyader, D. Apprato, C. Gout, Spline approximation of gradient fields : applications to wind velocity fields, Mathematics and Computers in Simulation 97 : 260-279, 2014.

[3] URL : https ://matplotlib.org/

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