Wind velocity field approximation from sparse data for new wind farms installation

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La Compagnie du Vent (ENGIE Group) is a French pioneer in wind energy. In order to anticipate the capabilities of wind farm deployment, this company required the help of the Laboratory of Mathematics at INSA of Rouen (LMI) in Normandy (France), where new wind facilities (offshore or onshore) are forecasted.

An exploratory project of the Labex AMIES was first dedicated to local wind field analysis: E@lien aimed at studying some wind velocity field approximation and their visualization, given sparse data.

The problem of vector field approximation from sparse data 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... Many different approaches have been introduced to solve each specific problem occurring in the above fields of investigation to fit the vector field dataset.. In this work, we use a regularized least-square problem defined on a space of potentials.

This kind of approach is related to the smoothing D^m-spline for surface approximation introduced by Arcangéli [1] (see also Duchon [2] for a general introduction or Gout [3] for convergence results). The originality of this work consists:

- in considering that the vector field derives from a potential (conservative vector field): it occurs for instance in meteorology (winds derive from temperature potentials), oceanography (currents derive from pressure potentials), image processing... For in land wind velocity field, we also take into account the topography effects, - in a rigorous study of existence-uniqueness of the solution of the problem phrased as an energy minimization, - in establishing a convergence result (while many approaches only give algorithms without mathematical study) and providing an approximation error estimate, - in taking into account the topography, - in using a specific visualization tool.

Two Master's students worked on this project: wind field approximation, wind prediction and visualization.

Keywords: PDE, spline functions, numerical analysis, wind velocity field approximation
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