Postdoctoral fellowship (2 years) in Signal Processing and Machine Learning for Ocean Remote Sensing

Context

IMT-Atlantique is looking for a postdoctoral fellow for 2 years starting as soon as possible starting from January 2019. The position is based on the Brest campus of the school. The fellow will join the Signal and Communications department, working within the TOMS team of Lab-STICC (Traitement, Observations et Méthodes Statistiques – Statistical signal processing), whose research activities include signal and image processing in remote sensing for spatial oceanography.

Altimetry data and other geophysical measurements allow an improved understanding of ocean dynamics thanks to the various types of data acquired on the surface of the ocean by different in situ sensors and satellite missions. A large number of different sensors exist (Fig. 1), ranging from buoys in the sea to along track satellite altimetry data, or even imaging techniques (e.g. future SWOT and SKIM altimetry missions). However, none of these sensors have a high resolution both in space and time, whereas we know local phenomena are crucial to understand global effects.

Because of the sampling schemes in space and time of satellites, combined with the sensitivity to atmospheric conditions (rain, cloud cover,...), the data in ocean remote sensing are noisy and incomplete. Interpolation and reconstruction algorithms have to be carried out to obtain spatio-temporally gridded data for further analysis. This problem has been extensively studied using “model-based” approaches, such as data assimilation (e.g. Kalman filtering), combining observations to a numerical model to estimate parameters of interest or interpolate the data.

Recently, “data-driven” methods have been investigated to perform interpolation of incomplete data without a priori knowledge of a dynamical model [1] [2], but rather using the large amounts of data acquired over the years by the different sensors and altimetry missions [3]. Among these methods, analog methods [4] and deep learning techniques [5] are of particular interest to learn the dynamics from the data and carry out the assimilation. Specific classes of residual neural networks have been shown to be capable to learn the operator governing the dynamics of data and to mimick the behavior of numerical ODE/PDE integration schemes (Euler and Runge-Kutta methods) [6].

In this context, the objective of this postdoctoral fellowship is to develop new machine learning (e.g. deep learning) models to learn and propagate ocean dynamics, with an emphasis on:

- Handling incomplete and noisy data
- A probabilistic formulation of the problem, i.e. not just learning a mean value over space and time of the parameters of interest, but also to propagate uncertainties in these parameters over space in time (ideally, a full probability density function).
- Guaranteeing properties of the targeted dynamics (smoothness, topological properties, invertibility [7], long term predictions...) through the definition of new architectures and cost functions

Candidate

The candidate should hold a PhD in signal or image processing, machine learning or related fields. We are looking for strong candidates with the following skills:

- Machine learning, signal and image processing, applied mathematics (required)
Figure 1: Different modalities to acquire Sea Surface Height (SSH) and Sea Surface Temperature (SST) data with different space and time resolutions: buoys (top left), along track SSH data (top right), incomplete SST data (bottom left), and future SKIM and SWOT imaging sensors (bottom right).

- Programming in Python (required)
- Dynamical systems and data assimilation techniques
- Experience or interest in deep learning and the associated Python libraries (Keras, Tensorflow, Pytorch)
- Remote Sensing applications

Contact
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References