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PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **PHY-DEMR-2024-15**
(à rappeler dans toute correspondance)

Lieu : Toulouse

Département/Dir./Serv. : DEMR

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DESCRIPTION DU STAGE

Thématique(s) : Deep learning, convolutive and recurrent neural networks

Type de stage : ☒ Fin d'études bac+5 ☒ Master 2 ☐ Bac+2 à bac+4 ☐ Autres

Intitulé : Joint use of recurrent and convolutional networks to predict physico-statistical variables

Sujet :

The current boom in deep learning is affecting a wide range of application fields, having already proved its worth in the original fields of text, image and video processing. Predictive models, based for example on recurrent (GRU or LSTM type) or convolutional networks, are beginning to be used in new fields where prediction was originally only possible using physical or statistical simulation models. However, certain specific characteristics make it difficult to exploit or adapt directly these predictive models to certain complex physical variables. Indeed, the evolution of these variables of interest is correlated to various heterogeneous factors (TEC content of the ionosphere, water vapor in the troposphere, evaporation conduits over the sea...) whose evolution can sometimes be characterized with variable spatial or temporal granularity (using weather radar maps for example, solar imagery...). So a predictive model based solely on the observed signal, and whose prediction is sought for a given time horizon, may be doomed to fail, since information not included in the signal is essential to the prediction. The predictive model must therefore be able to take heterogeneous data as input, including the signal observed at each instant, but also external information and in particular series of 2D maps corresponding to physical observations of the complementary variables needed to predict the signal of interest. ONERA is interested, for example, in the following three concrete applications:

- Prediction of the attenuation of a SatCom-type signal (whose carrier frequency can vary between 20GHz and 80GHz depending on the system under consideration) as it crosses the troposphere: this attenuation is mainly due to water in all its forms in the troposphere (water vapor, clouds, rain, etc.). Predicting the attenuation of a signal measured at a ground base station can be based on external information, such as weather radar maps.

- Prediction of scintillation in the ionosphere: the TEC content of the ionosphere can vary and will impact the amplitude, phase and propagation speed of signals passing through the ionosphere, particularly in low bands such as L-band GNSS signals, leading to difficulties in estimating the position of receivers. This variation in TEC is linked, among other things, to solar activity (flares, day-night cycles...) and the evolution of ionospheric scintillation indicator maps can also be based on information linked to solar activity.

- Predicting attenuation in closed (indoor) environments: when people move around a building, their internal communication systems can be disrupted by the building's furnishings and structures. For certain scenarios (e.g. rescue forces), it may be essential to be able to predict the areas where the performance of communication systems will be degraded, and the extent of this degradation. Using heterogeneous information (signal-to-noise ratios of each receiver, partially or totally known building map, nature of materials used...), this type of prediction could be carried out more accurately than using only the received signal or elementary statistical models.

Objectives:

Drawing inspiration from various hybrid approaches such as [Zheng2020], ONERA has developed a first processing chain to exploit multidimensional signals (1D and 2D maps in particular) on canonical problems. The objectives of the internship are as follows:

- Get to grips with the tool developed and available at ONERA, and situate it in the context of the state of the art of the problem (prediction from heterogeneous data). If necessary, propose developments, improvements or even complementary approaches to achieve the same objective.

- Valorization within at least one of the three application frameworks mentioned. The choice of application framework will be made jointly by the internship supervisor and the intern, taking into account various factors, notably the availability of sufficient data to enable learning and inference to be performed on real data, and the adaptability of the method to the constraints of the problem under consideration.

- In an R&D context, propose and test any interesting improvements, whether they concern theoretical or physical aspects (improvement of the BDD, modification of the type of inputs, exploitation of new data, modified mathematical formalization, etc.) or computer science (analysis of possible convergence problems or choice of network hyperparameters, modified neural architectures, etc.).

[Zheng2020] Zheng, Haifeng & Lin, Feng & Feng, Xinxin & Chen, Youjia. (2020). A Hybrid Deep Learning Model with Attention-Based Conv-LSTM Networks for Short-Term Traffic Flow Prediction. IEEE Transactions on Intelligent Transportation Systems. PP. 1-11. 10.1109/TITS.2020.2997352.

Est-il possible d'envisager un travail en binôme ? **Non**

Méthodes à mettre en oeuvre :

- ☐ Recherche théorique
- ☒ Recherche appliquée
- ☐ Recherche expérimentale
- ☐ Travail de synthèse
- ☐ Travail de documentation
- ☐ Participation à une réalisation

Possibilité de prolongation en thèse : **Oui**

Durée du stage : Minimum : 4 Maximum : 6

Période souhaitée : 2nd - 3rd trimester

PROFIL DU STAGIAIRE

Connaissances et niveau requis :	Ecoles ou établissements souhaités :
Computer science and programming Python (P1) or matlab (P2), deep learning, experience of classic AI libraries (tensorflow, keras...) would be a plus	Final-year engineering or M2 internships