Postdoc Proposal: Detection of abnormal ship trajectories by machine learning

Context

This postdoctoral position is integrated within the activities of the company Hensoldt Nexeya France (located in Toulouse) devoted to maritime surveillance. These activities consist of proposing new algorithms fusing data resulting from different sensors (radar, automatic identification systems (AIS) …) in order to control the activities of ships in seas/oceans for several applications including safety, protection of environment, fishery surveillance and detection of illicit traffic on the seas and oceans.

Objectives of the postdoctoral project

The objectives of this postdoctoral project are to propose new anomaly detection methods allowing abnormal ship trajectories to be detected in an unsupervised context. Many anomaly or novelty detection methods have been proposed in the literature to detect abnormal time series belonging to a training database. The idea is to extract appropriate features from these time series that are introduced to a machine learning algorithm such as local outlier probabilities (LoOP) [1], one-class SVM [2] [3] or isolation forests [4]. However, these methods need to be adapted to take into account the information contained in multiple time series such radar and AIS trajectories.

The objectives of this postdoctoral project are precisely to adapt existing anomaly detection strategies to the detection of abnormal ship trajectories. Some research tracks that have already been identified are summarized below

- How can we define local outlier probabilities for multiple time series such as radar and AIS trajectories?
- How can we define kernels in the one-class SVM method taking into account the complementary information contained in radar and AIS data?
- How can we generalize the isolation forest algorithms to handle multiple times series?

Another important research area is “active learning”, which allows the feedback of the user to be integrated within an existing anomaly detection method. This problem will be considered in the second part of the postdoctoral project. The research team involved in the supervision of this postdoc position has been active in this field (see for instance [5], [6]).

[1] H. P. Kriegel, P. Kröger, E. Schubert and A. Zimek, "LoOP: Local outlier probabilities," in Proc. Conf. Inf. Knowledge Management (CIKM’2009), Hong-Kong, China, pp. 1649-1652, Nov. 2009.

[2] [Schölkopf, 2001] B. Schölkopf, J. C. Platt, J. S. Taylor, A. J. Smola and R. C. Williamson, “Estimating the support of a high-dimensional distribution,” Neural Comput., vol. 13, no. 7, pp. 1443-1471, 2001.

[3] [Tax, 2004] D. M. J. Tax and R. P. W. Duin, “Support Vector Data Description,” Machine Learning., vol. 54, pp. 45-66, 2004.

[4] [Liu, 2012] F. T. Liu, K. M. Ting and Z.-H. Zhou, "Isolation-based anomaly detection," in Proc. ACM Trans. Knowl. Discov. Data, vol. 6, no. 1, pp. 1-39, Mar. 2012.

[5] J. Lesouple, C. Baudoin, M. Spigai and J.-Y. Tourneret, “How to introduce expert feedback in one-class support vector machines for anomaly detection?,” Signal Processing, vol. 188, Article 108197, Nov. 2021.

[6] J. Lesouple, C. Baudoin, M. Spigai and J.-Y. Tourneret, “Generalized isolation forest for anomaly detection,” Pattern Recognition Letters, vol. 149, pp. 109-119, 2021.

Contacts

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Postdoc conditions

Duration: There is funding for 18months, starting in 2023 and finishing in 2024.
Location: The postdoc candidate will be hosted by Laboratory TeSA, 7 bd de la gare, 31500 Toulouse. Some interactions with Hensoldt France Nexeya will also be required.
Funding: about 2700 euros per month before taxes.

Required skills

Statistical signal processing, data science, Machine learning
MatLab, Python
Motivations for research