IRIMAS UNIVERSITÉ HAUTE-ALSACE
Institut de Recherche en Informatique, Mathématiques, Automatique et Signal

ISL

Study of artificial intelligence methods for Navigation of a loitering munition in GNSS-denied environment

Supervisors:

Jonathan Weber (UHA/IRIMAS EA 7499)

Jean-Philippe Lauffenburger (UHA/IRIMAS EA 7499)

Miche Basset (UHA/IRIMAS EA 7499)

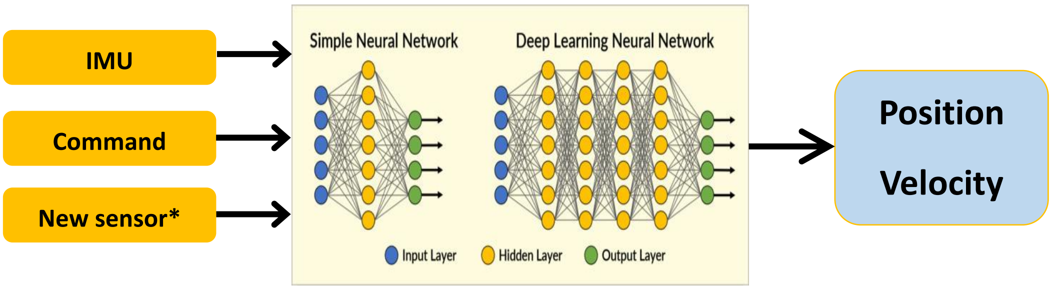
Sébastien Changey (ISL)

Context and Objective:

The recent conflicts have highlighted the vulnerability of geolocation using Global Navigation Satellite Systems (GNSS). The ease with which GNSS signals can be jammed makes it critical to have alternative navigation solutions. During a recent PhD study, we demonstrated that it is possible to localize a projectile using inertial sensors, magnetometers, and artificial intelligence (AI). In this PhD research, Long Short-Term Memory (LSTM) networks were trained with projectile trajectory data, which are highly predictable.

In this new subject area, we propose to extend the application of this technology to all types of flying vehicles. To make the AI model more generic, we need to feed it with additional inputs, such as control signals sent to the actuators and potentially other types of sensors.

As shown in the diagram below, the objective of this subject is to develop and train an AI model capable of localizing a flying vehicle.



New sensor can be optical flow or others, to be determined during the PhD*

Content of the study and expected results

Simulated data based on well-known dynamic systems will be produced to enable the learning of deep neural networks. The proposed approach should be flexible enough to be adapted to other types of flying vehicles. Then, some experiments will be done, to validate the results.

Academic contribution

This project will benefit from the experience gained in time series classification through deep learning [3, 4], state observation and navigation approaches [1, 2] at IRIMAS. It will be based on knowledge, simulation/experimentation results and hardware provided by ISL [5, 6, 7, 8].

Agenda

The thesis will be carried out 50% of the time at ISL and 50% of the time at the university. The periods of time at the ISL and at the University will be decided case-by-case, according to the needs of the thesis and the availability of the supervisors.

Références

[1] Thomas Brunner. Contribution to dead reckoning: multiple inertial navigation systems integrating absolute magnetic data state observers. Thèse de doctorat, Université de Haute-Alsace, March 2016.

[2] Thomas Brunner, Jean-Philippe Lauffenburger, Sébastien Changey, and Michel Basset. Magnetometer-augmented imu simulator: In-depth elaboration. Sensors, 15(3):5293–5310, Mar 2015.

[3] Hassan Ismail Fawaz, Germain Forestier, Jonathan Weber, Lhassane Idoumghar, and Pierre-Alain Muller. Accurate and interpretable evaluation of surgical skills from kinematic data using fully convolutional neural networks. International Journal of Computer Assisted Radiology and Surgery, Jul 2019.

[4] Hassan Ismail Fawaz, Germain Forestier, Jonathan Weber, Lhassane Idoumghar, and Pierre-Alain Muller. Deep learning for time series classification: a Review, Data Mining and Knowledge Discovery, vol. 33, Issue 4, Jul 2019.

[5] Alicia Roux, Sébastien Changey, Jonathan Weber, and Jean-Philippe Lauffenburger. “CNN-based Invariant Extended Kalman Filter for projectile trajectory estimation using IMU only”. 2021 International Conference on Control, Automation and Diagnosis (ICCAD), pages 1–6, 2021.

[6] Alicia Roux, Sébastien Changey, Jonathan Weber, and Jean-Philippe Lauffenburger. “Projectile trajectory estimation: performance analysis of an Extended Kalman Filter and an Imperfect Invariant Extended Kalman Filter”. 2021 9th International Conference on Systems and Control (ICSC), pages 274–281, 2021

[7] Alicia Roux, Sébastien Changey, Jonathan Weber, and Jean-Philippe Lauffenburger. “Estimation de la trajectoire d’un projectile ajustée dynamiquement par un réseau de neurones”. GRETSI'22 XXVIIIème Colloque Francophone de Traitement du Signal et des Images, Nancy, 06 – 09 Septembre 2022

[8] Alicia Roux, Sébastien Changey, JonathanWeber, and Jean-Philippe Lauffenburger. “Projectile trajectory estimation: an LSTMapproach”. CAID 2022: Conference on Artificial Intelligence for Defense, 16–17 November 2022