Internship Description

1. Title: **DETECTION AND MITIGATION OF INTERFERNCES FOR GLOBAL NAVIGATION SATELLITE SYSTEMS**

2. Supervisors:

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3. Description

3.1. Context

Global Navigation Satellite Systems (GNSS) are free and easily available information sources for outdoor positioning on Earth. These systems are based on trilateration: a receiver estimates the ranges between itself and several satellites, and knowing the positions of each of these satellites, it can reverse the equations and therefore give an estimation of its position. However, the signal received from the satellites have such low power that they are easily jammed [1].

When going from the satellite to the receiver, the signal is subjected to an attenuation, due mainly to free space losses, and a propagation delay. This propagation delay will result in a shift of the emitted signal as well as a shift in the phase of the signal. Moreover, the relative movement between the satellite and the receiver will result into a frequency shift due to the Doppler effect. All these parameters (attenuation, phase offset, propagation delay and Doppler shift) are estimated by the receiver and will be used to find the PVT (position, velocity, and time) of the receiver.

To that purpose, the receiver owns an RF front-end allowing to catch, amplify, filter, and sample the incoming signal, leading at the output of the Hilbert filter to the so-called baseband signal where the estimation process of the various parameters can begin. Hence, it is of utmost importance to describe the evolution of the incoming signal, especially in the presence of an interference, after all these steps, represented in Figure 1, to have a good model allowing the estimation process to be efficient.

Recent works [2, 3] have proposed an Expectation-Maximization (EM) algorithm [4] to tackle one interference with constant modulus. These methods performed well in presence of a single interference; however, they cannot generalize to a sum of interferences. An interesting approach, called the Space Alternating Generalized EM (SAGE) [5], which generalizes the previous EM, has already been proved to perform well in presence of a mixtures of signals.

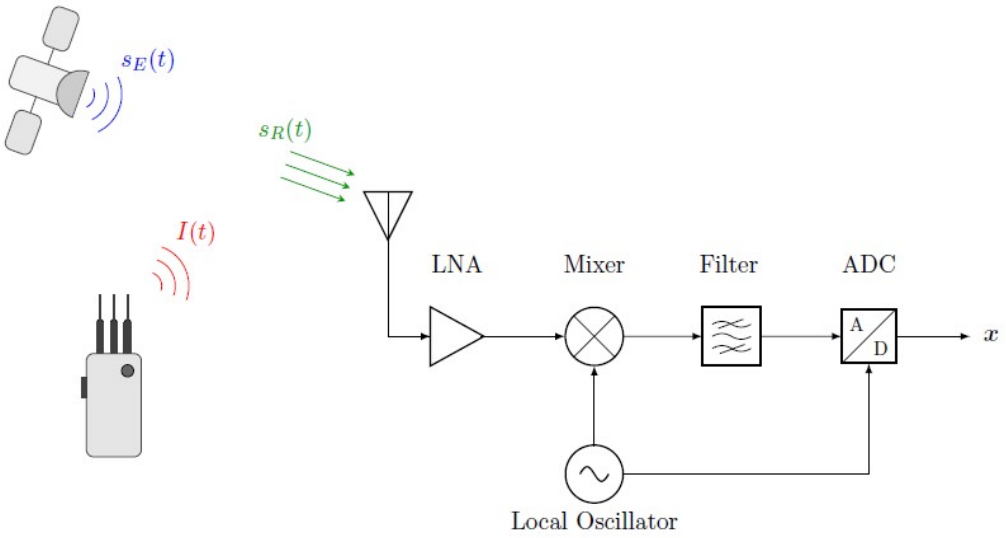

Figure 1: GNSS signal + interference reception chain until sampling. $s_E(t)$ is the signal emitted by a GNSS satellite, $I(t)$ is a potential interference, $s_R(t)$ is the received signal and x is the sampled signal at the output of the Hilbert filter.

3.2. Objectives

The main objective of this internship is to apply the SAGE algorithm to a mixture of interferences to improve the estimation of the GNSS parameters of interest. Moreover, an identification of existing interference mitigation methods will be done to compare them to the proposed method.

3.3. Work plan

The proposed planning of this internship is as follows

1) state of the art on interference mitigation and SAGE based methods
2) model definition
3) implementation of the proposed model and state of the art methods
4) proposition of an innovative solution to the problem
5) implementation of the proposed solution and comparison with other methods
6) report redaction
7) defense preparation

If time allows, performance estimation bounds can be studied, and if the proposed solution is innovative enough it can be submitted to a conference or a journal.

3.4. References

[1] https://www.connexionfrance.com/article/French-news/Forgotten-GPS-jammer-costs-motorist-2-000

[2] J. Lesouple and L. Ortega, “An EM Approach for GNSS Parameters of Interest Estimation Under Constant Modulus Interference,” in Proc. EURASIP Eur. Signal Process. Conf. (EUSIPCO), Helsinki, Finland, 9 2023.

[3] ——, “Bayesian EM Approach for GNSS Parameters of Interest Estimation Under Constant Modulus Interference,” EURASIP Journal on Advances in Signal Processing, submitted 2023.

[4] A. Dempster, N. Laird, and D. Rubin, “Maximum Likelihood from Incomplete Data via the EM Algorithm,” J. R. Stat. Soc. Series B, vol. 39, no. 1, pp. 1–38, 1977.

[5] J. Fessler and A. Hero, “Space-Alternating Generalized Expectation-Maximization Algorithm,” IEEE Trans. Signal Process., vol. 42, no. 10, pp. 2664–2677, 1994.

4. Remarks

This work is a continuation of a collaboration with IPSA Toulouse and TéSA. Be aware that a PhD thesis is to start right after this internship and therefore this internship can constitute a good introduction to the thesis and be a plus if you consider applying to this thesis.

5. Period

- Starting date: 1st March 2024 (flexible)
- Duration: 6 Months (flexible)

6. Department

SINA/TELECOM/SIGNAV

The internship is proposed by the SIGNAV (SIGnals for NAVigation) research group. SIGNAV is one of three research groups of the TELECOM team in the SINA (Sciences et Ingenierie de la Navigation Aerienne) department at ENAC (Ecole Nationale de l'Aviation Civile).

7. Location

The internship will take place at main campus of ENAC in Toulouse, France. Adress: 7, avenue Edouard Belin BP 31055 Toulouse Cedex 4, building F.

8. Candidate's profile

Master/Engineering student with knowledge in statistical signal processing (knowledge of GNSS is a plus but not mandatory). Good coding skills in Matlab and/or Python.