INTERNSHIP OPENING

Blind synchronization techniques for Faster-than-Nyquist signals

ISAE SUPAERO
Institut Supérieur de l'Aéronautique et de l'Espace

Context and expected outcomes

In a race for spectral efficiency, the idea of overriding the Nyquist criterion has been proposed in [Maz75] leading to "faster-than-Nyquist" (FTN) systems. Consequently, interpulse interference cannot be avoided at the output of any linear receiver. Several authors proposed efficient techniques to mitigate such interference and yield spectacular spectral efficiency gains (above 60 % over Nyquist systems in some cases) [PA12; Mar+17].

However, synchronization techniques (mainly timing, but also phase and frequency) should be studied in the case of FTN signals. In the case of non-data-aided (*i.e.*, blind) synchronization, it should be noted that usual algorithms based on second order cyclostationarity cannot be used within FTN signals. However, higher-order statistics may be used to perform such an optimization [IN96; ARF17].

In this internship, we will study and compare various estimation techniques split into two categories: structured approaches (deterministic or bayesian) and non-structured approaches (neural networks) [Mac03; Kri07].

Fields of application of this work includes primarily satellite and aeronautical communications (*i.e.*, non-selective and linear channel model with synchronization impairments). Several challenges such as cybersecurity and very-high data rate services are at stake !

A scientific communication is targeted at the end of the internship. **A PhD thesis is planned as a continuation of this work (co-funded by DGA)**[1].

Host institution and place of work

Located in Toulouse (France), ISAE-SUPAERO is a public higher education and research institute focused on aerospace applications. More particularly, the department of electronics, optronics and signal processing (DEOS) has an extensive expertise in electrical engineering applied to aerospace systems. Activities in the field of telecommunications are focused on secured high throughput transmission techniques for satellite and aeronautical systems. To this extent, commonly used tools are related to information theory, estimation and detection, optimization, time-frequency analysis and much more signal processing building blocks.

Candidate profile and application

Applicants should be last-year master (or engineer) students. A strong background in signal processing and statistics is required since the internship is focused on estimation theory. Good communication skills in English are necessary (written and oral), as well as good development skills (Matlab, Python...). Applications from candidates familiar with digital communications and estimation/detection techniques are particularly encouraged.

Applications (CV, motivation letter and grade report) and informal inquiries are to be emailed to {damien.roque, meryem.benammar} @isae-supaero.fr.

[1] A funding from DGA requires the students to hold UE citizenship.

Useful information...

- Accommodation and food service are available on the campus.
- Dates and duration: between January and September 2018 (5 to 6 months).
- **Application deadline: 8-Dec-2018**.

References

[ARF17] A. Abello, D. Roque, and J.M. Freixe. "Blind Symbol Rate Estimation of Faster-than-Nyquist Signals Based on Higher-Order Statistics". In: *Cognitive Radio Oriented Wireless Networks*. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering. In press. Springer International Publishing, Sept. 2017.

[IN96] L. Izzo and A. Napolitano. "Higher-Order Cyclostationarity Properties of Sampled Time-Series". In: *Signal Processing* 54.3 (1996), pp. 303 –307. ISSN: 0165-1684.

[Kri07] D. Kriesel. *A Brief Introduction on Neural Networks*. 2007.

[Mac03] D. MacKay. *Information Theory, Inference and Learning Algorithms*. Cambridge university press, 2003.

[Mar+17] A. Marquet et al. "FTN Multicarrier Transmission Based on Tight Gabor Frames". In: *EURASIP Journal on Wireless Communications and Networking* 2017.1 (May 2017).

[Maz75] J. E. Mazo. "Faster Than Nyquist Signaling". In: *Bell System Technical Journal* 54 (1975), pp. 1451–1462.

[PA12] A. Prlja and J. Anderson. "Reduced-Complexity Receivers for Strongly Narrowband Intersymbol Interference Introduced by Faster-than-Nyquist Signaling". In: *Communications, IEEE Transactions on* 60.9 (2012), pp. 2591–2601. ISSN: 0090-6778.