PhD Thesis Description

1. Title

DETECTION AND MITIGATION OF INTERFERENCES FOR SATELLITE SYSTEMS

2. Supervisors

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3. Description

3.1. Context

In the realm of modern technology, satellite systems stand as a pinnacle of innovation, enabling a wide spectrum of services, from global communication networks to Earth observation and navigation. These intricate constellations of orbiting satellites have become the backbone of our connected world, facilitating communication, monitoring our planet, and guiding us with pinpoint accuracy. However, among the marvel of satellite systems lies a formidable challenge, one that threatens their seamless operation and the services they provide: radiofrequency interferences (RFIs). RFIs represent a growing and pervasive concern for satellite systems. These interferences manifest in a multitude of forms, from unintentional disruptions caused by terrestrial electronic devices, to intentional jamming efforts intended to disrupt vital satellite-based systems. The repercussions of RFIs ripple across numerous sectors, jeopardizing not only the precision and reliability of satellite-based services and scientific missions but also the safety of critical applications, such as intelligent transportation, automated aircraft landing or autonomous unmanned ground/air vehicles.

As our reliance on satellite systems continues to expand, the use of countermeasures against RFIs is becoming increasingly vital; therefore, new innovative strategies for detecting and mitigating them are required. Unfortunately, the majority of interference detection techniques included in the state of the art are based on empirical experience and lack rigorous physical foundations, leading imprecise and biased solutions. On the other hand, the RFI mitigation techniques proposed in the state of the art are based on a previous knowledge of the interference structure, rendering them ineffective when faced with unknown structures or with interference that can change its characteristics. Furthermore, most methods attempt to mitigate interference indiscriminately, regardless of the specific objectives of the satellite's application. This can lead to distortions in the signal of interest, reducing the effectiveness of the service or mission.

3.2. Objective(s)

This thesis will focus on the study of new RF sample based interference detection and mitigation strategies. To achieve this, anomaly detection techniques and Bayesian inference methods will be proposed, in the spirit of a detection method proposed in a recent R&T study (R-S22/LN-0002-071-01), or a new mitigation technique based on statistical tools [1] proposed for GNSS applications. The core of the thesis will be to extend these works to a broader family of interferences that can represent a greater number of satellite technology-based system threats, allowing resilience of any satellite service. To that extent, a state of the art on the recent advances in that topic will be realized, with the aim of enhancing the best existing methods. For this purpose, the implementation of robust algorithms is planned to enable the design of architectures that can be executed online.

If time permits, the proposed detection and mitigation techniques will be validated in real-world scenarios for GNSS receivers. For this purpose, one can resort to digitizing real interferences to assess

the effectiveness of the proposed mitigation techniques. To achieve this, measurement campaigns in controlled environments (e.g., an anechoic chamber) can be conducted.

3.3. Work Plan

- State of the art
- Enhance state of the art with more rigorous approach
- Implementation of state of the art methods as well as their improvements
- Identification of scientific bottlenecks of these methods as well as their limitations
- Proposition of statistical signal processing techniques to overcome the latter
- Implementation of the new methods
- Measurements
- Test of the algorithms on real data
- Manuscript redaction
- Defense

3.4. Keywords

Signal processing, interferences, estimation, detection

3.5. References

[1] Julien Lesouple and Lorenzo Ortega. An EM Approach for GNSS Parameters of Interest Estimation Under Constant Modulus Interference. In Proc. Eur. Signal Process. Conf., Helsinki, Finland, 2023.

4. Doctoral School

EDMITT

5. Research Unit

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6. Funding

- FONISEN (confirmed, full scholarship)