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XXXIII Cycle

Interference detection and mitigation methods on GNSS signals

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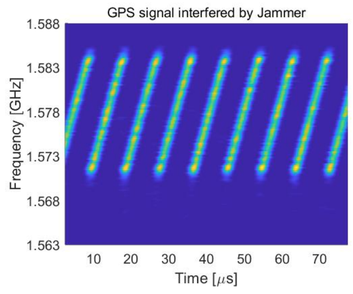
Research context and motivation

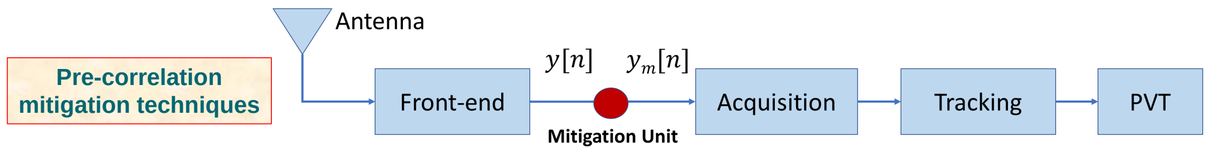
The presence of spurious signals in the GNSS bandwidth, or close to it, is source of errors for the signal processing stages of the GNSS receivers.

BIASES AND NOISE ON THE POSITIONING

TREASURE
TRAINING RESEARCH AND APPLICATIONS NETWORK TO SUPPORT THE ULTIMATE REAL TIME HIGH ACCURACY EGNSS SOLUTION



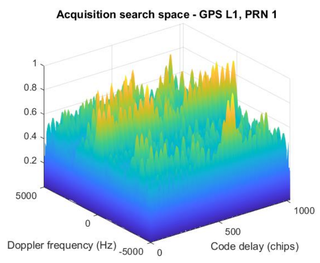
The research addresses the design and implementation of **advanced signal processing techniques for detection/classification and mitigation** of Radio Frequency Interference (RFI) on GNSS signals.



Addressed research questions/problems

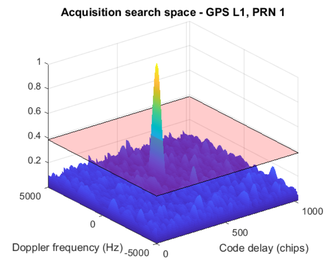
Among existing solutions, **Adaptive Notch Filter (ANF)** is particularly appealing.

The **ANF parameters** should be customized for different jamming signals and be capable of not only **mitigating the interference** but also **preserving useful GNSS signal**.



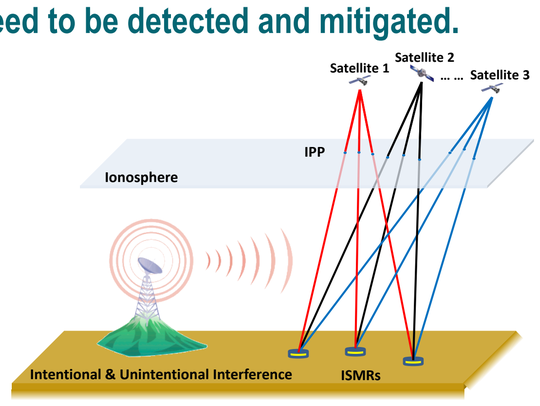
1. Pole contraction factor k_α
2. Algorithm step δ
3. Threshold T
…

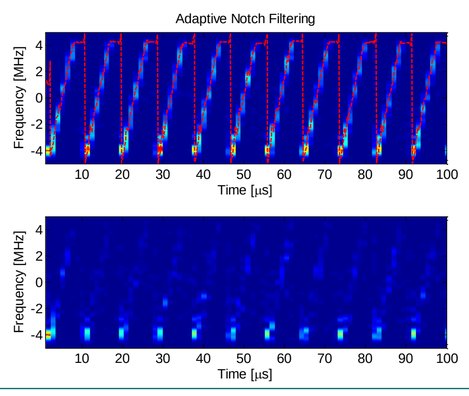
Parameters Optimization Technique



Scintillation monitoring could be operated in scenarios where **communication systems or even jammers are present**.

Such sources can provide **scintillation-like performance** in signal processing stages and **need to be detected and mitigated.**



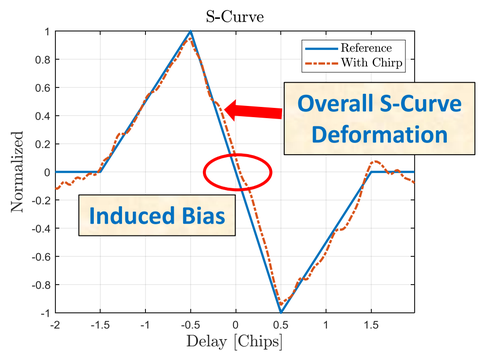


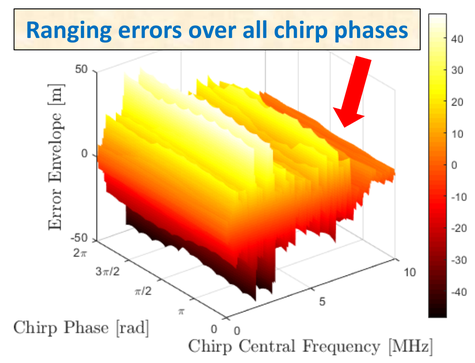
Submitted and published works

- W. Qin, F. Dovis, "Effects of Interference Mitigation Methods on Scintillation Detection," *2018 9th ESA Workshop on Satellite Navigation Technologies and European Workshop on GNSS Signals and Signal Processing (NAVITEC)*, Noordwijk, 2018.
- W. Qin, F. Dovis, M. Troglia Gamba, and E. Falletti, "A Comparison of Optimized Mitigation Techniques for Swept-frequency Jammers," *Proceedings of the 2019 International Technical Meeting of The Institute of Navigation*, Reston, Virginia, January 2019.
- W. Qin, M. Troglia Gamba, E. Falletti, and F. Dovis, "Effects of Optimized Mitigation Techniques for Swept-frequency Jammers on Tracking Loops," *Proceedings of the 32nd International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS+ 2019)*, Miami, Florida, September 2019.
- W Qin, N. Gogoi, A. Rustamov, and F. Dovis, "Assessment of Anthropogenic Disturbances on GNSS-based Navigation," submitted to UPINLBS 2019, Beijing.
- W. Qin, M. Troglia Gamba, E. Falletti, and F. Dovis, "An Assessment of Impact of Adaptive Notch Filters for Interference Removal on the Signal Processing Stages of a GNSS Receiver," submitted to IEEE Trans on Aerospace and Electronic systems.

Novel contributions

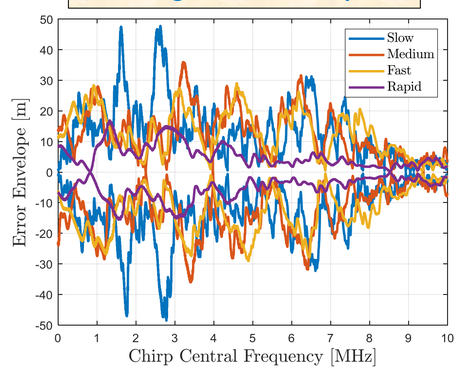
Two key metrics, namely **Interference Error Envelope (IEE)** and **code jitter**, are used to observe the **bias** and the **overall shape deformation** of the S-Curve induced by chirps and ANF.



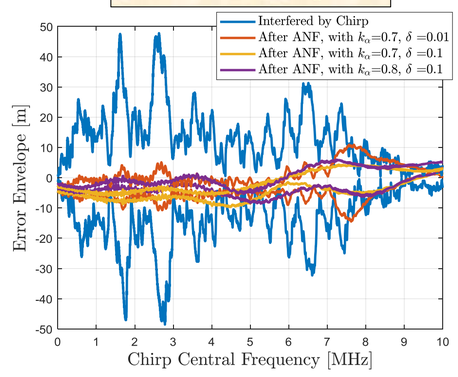


The different characteristics of chirps and ANF parameters exhibit **very different error envelopes**. The code jitter is a measure of the ANF efficiency and can be used for **ANF parameters optimization**.

IEE changes due to sweep rate



IEE after ANF mitigation



Adopted methodologies

The ANF distortion analysis at the tracking stage is based on the **output of the DLL discrimination function**.

- **Open Loop Analysis**: interference error envelope.
- **Closed Loop Analysis**: code jitter.

Software simulation: signal processing is implemented by using the software receiver developed by the NavSAS team in **MATLAB® Simulation Environment**.

Future work

- **RFI detection**: proper techniques to be identified considering the different possible classes of interfering signals.
- **RFI mitigation**: advanced techniques working at signal processing level will be analyzed, considering impacts on performance of code and carrier based positioning techniques.
- **RFI classification**: the focus will be in the feature extraction (bandwidth, power and time domain behavior) needed to activate proper countermeasures.
- Implementation of the **anti-jamming detector and mitigator** in a GNSS receiver.
- Artificial interference mitigation for **scintillation detection**.

List of attended classes

- 03LPXBG – Satellite navigation systems (10/2017, 8 CFU)
- 01RGWGN – Carrier phase positioning (03/2018, 4 CFU)
- 04JURGN – Time scale and timing in GPS and Galileo (03/2018, 3 CFU)
- 02LWHRV – Communication (09/2018, 1 CFU)
- 01QRPRV – Satellite navigation signal exploitation for atmospheric and environmental monitoring (07/2018, 3 CFU)
- – ESA/JRC Summer School on GNSS 2018 – Loipersdorf, Austria
- 01TEVRV – Deep learning (06/2019, 6 CFU)
- 01SYBRV – Research integrity (05/2019, 1 CFU)
- 01SHMRV – Entrepreneurial Finance (05/2019, 1 CFU)

POLITECNICO DI TORINO

PhD program in
Electrical, Electronics and Communications Engineering