Study and Analysis of Advanced Countermeasures against Interference Threats for Global Navigation Satellite Systems

Summary

With the fast evolution of modern navigation techniques based on Global Navigation Satellite Systems (GNSSs), the services relying on positioning, navigation and timing have been extensively investigated and applied in various fields. The robustness of GNSS receiver performance to grant continuous and reliable solutions has become a compelling requirement. Due to the extremely low power of GNSS signals, the presence of Radio-Frequency Interference (RFI) that are close to the GNSS bands can induce disruptive effects to the signal processing stages of GNSS receivers, leading to degraded performance or even a completely denial of the receiver services. Such interference threats can be either unintentional or intentional. The unintentional RFI is posed by the signals transmitted with carrier frequency close to the GNSS bands from the wireless communication infrastructures coexisting with GNSS. A more severe threat is the intentional RFI that are generated by the jammers with the intention to block the receiver services in a target area by broadcasting powerful signals in the GNSS bands. The research objective is to design and implement advanced techniques to counteract the anthropogenic interference to GNSS. In this thesis, the advanced countermeasures for GNSS interference threats implemented in the GNSS receivers are discussed, including interference detection, classification, estimation and mitigation. A novel interference classification and characterization method based on supervised machine learning is proposed, with the aim to provide prompt situational awareness for the jamming threats. In addition, the impact of Adaptive Notch Filter (ANF) for interference removal at the signal processing stages is assessed. Based on the proposed metrics, it is possible to quantitatively estimate the induced impairment at the acquisition and tracking stages, thus to depict a complete picture of the most influential parameters of the interference and the ANF configurations, as well as the optimal achievable performance for RFI mitigation. Scintillation is a disturbance to GNSS from the natural source. The RFI and scintillation may have similar effects in the GNSS receivers. The research topic to investigate the scintillation-like effects induced by RFI in the GNSS receivers is also addressed.