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GNSS Spoofing and Jammin in London

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Abstract

This research provides a thorough examination of GNSS interference, with a focus on multipath effects and interference events. Field trials in London, a global analysis of interference incidents, and a specific exploration of the Chinese context were conducted to gather a diverse dataset. The research aims to enhance our understanding of GNSS interference complexity and its implications. Four main objectives include proficiency in interference measurement devices, rigorous field trials, a global assessment of interference events, and an examination of jamming and spoofing incidents in China. The CTL3510 GNSS Interference Detector was utilized in field trials, capturing interference signals and facilitating real-time monitoring. The study, conducted in high-traffic zones in London, collected data on signal strength, coordinates, and time stamps. The collected data was analyzed to uncover interference patterns, providing valuable insights into the multifaceted nature of GNSS interference and suggesting recommendations for global GNSS navigation system resilience and security.

Keywords

GNSS Interference, GNSS Spoofing and Jamming, Field Trials, London, CTL3510 GNSS Interference Detector.

1. Introduction

1.1. Global Navigation Satellite Systems (GNSS)

The utilization of Global Navigation Satellite Systems (GNSS) has made substantial advancements across various global domains. These advancements are particularly evident in areas such as operational efficiency, productivity enhancement, and ecological sustainability (Radočaj, Plaščak et al. 2023). Four primary technology platforms—GPS, GLONASS, Galileo, and BeiDou—constitute the foundation of GNSS, globally adopted and integral to various industrial sectors and applications (Kumar, P. et al. 2021).

Figure 1 provides an overview of the four main global satellite navigation systems:.

GPS (Global Positioning System): Operated by the United States, GPS stands as a pioneering system that has played a pivotal role since achieving full operational capacity in 1995. Its origins can be traced back to the military landscape of the 1970s (Radočaj, Plaščak et al. 2023).

GLONASS (Global Navigation Satellite System): Originating from Russia and emerging from military necessities in the 1970s, GLONASS reached operational maturity in 1995, following the same trajectory as the Global Positioning System (Sokolova, Morrison et al. 2022).

BeiDou (BeiDou Navigation Satellite System): Spearheaded by China, the BeiDou system commenced its journey with regional services in 2000 and subsequently achieved global coverage by 2020 (VOIGT 2021).

Galileo (Galileo Navigation Satellite System): An ambitious endeavor driven by the European Union, Galileo realized its operational capabilities in 2016. It represents a sovereign global navigation constellation primarily tailored for civil applications (Psiaki and Humphreys 2016).

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Figure 1. Overview of Global Navigation Satellite System (MOBATIME 2023)

1.2. GNSS Interference: Jamming and Spoofing

Global Navigation Satellite System (GNSS) interference includes jamming and spoofing, both involving stronger radio signals overriding weak GNSS signals on the same frequency. Jamming, often caused by nearby electronic devices or external sources, impacts GNSS signal quality and accuracy. Spoofing is a more sophisticated form, where intentional transmission of altered GNSS signals leads to inaccurate navigation outcomes. The rising number of jamming and spoofing incidents poses significant concerns for GNSS users, affecting signal quality and navigation accuracy.

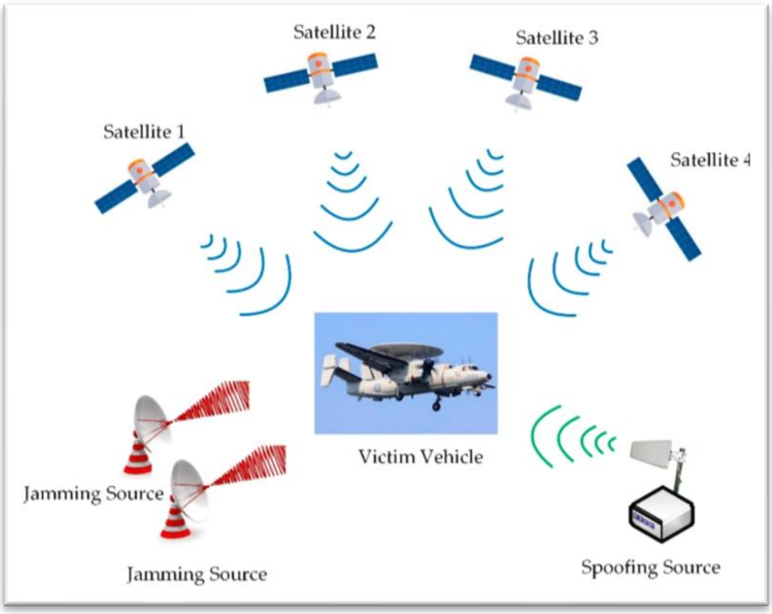

Figure 2. Overview of GNSS Jamming and Spoofing (Zhang, Cui et al. 2019)

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2. Literature Review

The field of GNSS spoofing and jamming has attracted considerable attention due to its potential to disrupt navigation systems and critical infrastructure. This section provides a comprehensive review of existing literature, aiming to gain insights into the diverse techniques devised for the detection and mitigation of GNSS spoofing and jamming events. Additionally, it delves into the current status of GNSS interference on a global scale, with a specific focus on the situation in both the worldwide context and within China.

2.1. Detection and Mitigation Techniques

Detecting GNSS interference signals is crucial for maintaining navigation system integrity. Various techniques have been developed for this purpose, including signal quality monitoring, real-time monitoring, and the use of portable jammer detection devices like the Chronos GPS jammer detector CTL3510. Literature reviews highlight cost-effective and portable devices employing statistical and time-frequency methods for interference detection and localization. Spectrum analysis, examining frequency spectra for deviations from established GNSS patterns, adds sophistication to the process, identifying intentional jamming and unintentional sources of electromagnetic noise that could disrupt GNSS reception. These methods contribute to the ongoing research focus on effective interference detection and mitigation in GNSS.

2.2. Global Landscape of GNSS Interference

GNSS interference is a global concern with widespread implications for a variety of applications. In this section, we delve deeper into the global distribution of GNSS interference incidents, setting the stage for a comprehensive analysis of specific cases. Understanding the regulation and distribution of GNSS interference incidents is crucial for developing effective mitigation strategies. In order to collect these data, a systematic approach was adopted that fully utilized primary and secondary sources. A wide range of literature reviews, academic papers, industry reports, and government documents serve as valuable repositories of information. Keyword-driven searches across search engines and academic databases facilitated comprehensive data collection. Additionally, government publications offer authoritative insights into GNSS interference.

3. Data and Methods

In this section, This research outline the approach taken to achieve the research objectives and aims set forth in the previous sections. The methodology provides a detailed description of the steps and procedures used to gather data, analyze information, and help to draw meaningful conclusions on the last part.

This dissertation focuses on GNSS jamming in London, using the GPS jammer detector CTL3510 to assess interference in the urban area. GNSS jamming, often caused by deliberate use of jamming devices, can disrupt services within a few kilometers of the jamming source. The CTL3510, developed by Chronos, is a handheld device designed for real-time detection of disruptions in critical GNSS bands. While effective, its performance in dense urban areas may be impacted by obstacles. Nevertheless, using the CTL3510 alongside an inexpensive GNSS receiver allows for observations and detection attempts in densely trafficked areas of London, contributing to understanding contemporary GNSS interference.

This research combines the utilization of Evernote and jammer detector to record the interference signals. Considering that the obvious correlation between higher interference signals and high traffic density areas, specific locations characterized by substantial vehicular activity have been strategically selected for data collection. Notably, areas such as University of

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East London, Bow Road and King's Cross Station because of their heightened vehicular presence, as shown in figure 7.

3.1. Data Collection and Analysis

4.2.1 Data Collection

Field trials involve rigorous experiments to evaluate the Chronos CTL3510 GPS Jammer Detector's capabilities in various real-world conditions. Deployed at selected test locations, the detector is compared with a standard GPS receiver, operated simultaneously for direct performance comparison. Meticulous planning, including optimal time window selection during the afternoon peak hours (6:00 pm to 7:00 pm on weekdays), ensures robust and representative data collection. This approach enables a comprehensive investigation of GNSS interference, particularly in high-traffic areas, providing valuable insights into the detector's effectiveness and reliability.

4.2.2 Data Analysis

After data collection, it is necessary to conduct a analysis of the collected data and discuss the limitations encountered during the data collection process. As previously mentioned, the research focused on gathering data during the time frame from 6:00 pm to 7:00 pm on weekdays due to the expected heightened traffic congestion in the selected locations. However, it is crucial to acknowledge the constraints that led to a relatively limited dataset, as reflected in Table 1.

Table 1. The comprehensive overview of Data Collection

Day	Date	Time	Location	Traffic condition	Number of signal
Wednesday	19-Jul-23	18:00--19:00	King's Cross Station	Heavy	0
Thursday	20-Jul-23	18:00--19:00	King's Cross Station	Heavy	0
Friday	21-Jul-23	18:00--19:00	King's Cross Station	Heavy	2
Wednesday	26-Jul-23	18:00--19:00	King's Cross Station	Heavy	0
Thursday	27-Jul-23	18:00--19:00	University of East London	Light	0
Friday	28-Jul-23	18:00--19:00	University of East London	Heavy	1
Monday	31-Jul-23	18:00--19:00	University of East London	Heavy	1
Tuesday	01-Aug-23	18:00--19:00	Bow Road	Heavy	0
Thursday	03-Aug-23	18:00--19:00	Bow Road	Heavy	0
Friday	04-Aug-23	18:00--19:00	Bow Road	Heavy	0
Monday	07-Aug-23	18:00--19:00	Bow Road	Heavy	1
Tuesday	08-Aug-23	18:00--19:00	Bow Road	Heavy	0

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The results of this investigation indicated that although peak time offers abundant data collection possibilities, the amount of data collected is so weak. This result can likely be attributed to the limitations of the employed equipment, which might be not able to capture more data. Additionally, it is possible that the scarcity of available signals on the streets of London contribute to this phenomenon.

Nevertheless, a dataset is compiled that included five interference signals. The dataset is detailed in the table below and contains various attributes including date, day, time, geographic coordinates, qualitative observations, and data collection methods as shown in Table 2.

Table 2. The information of Data Collection by Jammer Detector

Day	Date	Time	Location	Comment	Detector
Friday	21-Jul-23	18,34,35	(51.5271695, -0.1308610)	Consistent with passing vehicle for 10 seconds	On foot
Friday	21-Jul-23	18,42,55	(51.5287996, -0.1265979)	Brief	On foot
Monday	28-Jul-23	18,13,38	(51.5434341, 0.0090511)	Passing vehicle	On foot
Thursday	31-Jul-23	18,38,50	(51.5425490, 0.0090170)	Brief with Passing vehicle	On foot
Monday	07-Aug-23	18,53,27	(51.5296758, -0.0138362)	Brief with Passing vehicle	On foot

These data reflect different interference conditions, including consistent with passing vehicle for 10 seconds and brief with passing vehicle. This dataset epitomizes the interference situation in areas with frequent vehicle traffic. It provides the basis for this study to gain insight into the dynamics of GNSS signal interference and its interaction with urban traffic patterns. However, the current dataset includes only five interference events, which may be considered to have limited interpretive power and perhaps lack robustness. In order to address these limitations and enhance the robustness of the analysis, a sensible approach would be to contextualize the acquired data within a broader framework. This entails incorporating insights from existing literature and relevant case studies that delve into GNSS signal interference. By synthesizing multiple sources (including academic discourse and empirical examples), a more comprehensive understanding of the phenomenon can be achieved.

Through field experiment, this study demonstrates the effective performance of the GNSS interference detector in various conditions, providing robust assurance for the reliability of GNSS systems, particularly in high-interference environments like urban areas. Further research is required to comprehensively understand the impact of interference on GPS receivers and optimize interference detectors, making this study a valuable reference for future GNSS interference research.

4. Discussion and conclusion

4.1. Conclusion

This research has embarked on an extensive exploration of GNSS interference and jamming events on a global scale, with a primary focus on understanding their impacts and formulating strategies for detection and mitigation. The overarching research question that guided this study was how to optimize the efficacy of GNSS interference detection and mitigation methods to enhance the resilience of navigation systems in response to evolving interference threats.

The four research objectives set forth at the outset of this study were rigorously pursued and have been effectively achieved:

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The acquisition of Chronos CTL3510 GPS Jammer Detector for assessing interference signals, coupled with an in-depth understanding of its operational intricacies, enabled the seamless execution of field trials and data collection.

Comprehensive field trials conducted across diverse locations with the utilization of the measurement device and obtain interference data successfully. Meticulous data collection methodologies were employed, which ensures the precision and reliability of the results.

An exhaustive analysis of worldwide jamming and spoofing incidents was executed, leading to the construction of a dynamic geographical representation that illuminates global event hots spots. Temporal analysis techniques were adeptly utilized to uncover patterns of event occurrence, thereby providing deeper insights into the temporal dynamics of interference phenomena.

A methodical exploration of Chinese literature sources, spanning news reports, scholarly publications, and anecdotal content from digital platforms, furnished unique insights within the distinctive context of China's GNSS interference landscape.

By meticulously examining real-world incidents and assessing their consequences, this study not only deepens our understanding of the multifaceted challenges posed by GNSS interference but also contributes to the development of informed strategies aimed at mitigating its impact.

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