TALLINN UNIVERSITY OF TECHNOLOGY
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Applying Machine Learning for Enhanced Satellite Navigation Defence Mechanisms in Military Context

Master's thesis

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Masinõppe rakendamine satelliitnavigatsiooni süsteemide tõhustamiseks militaaroperatsioonide kontekstis

Magistritöö

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Abstract

The recent conflicts in Ukraine and Syria have demonstrated the growing reliance on dual-use technologies such as drones and networked military platforms for enhanced situational awareness. These systems depend on Global Navigation Satellite Systems (GNSS) for navigation and precision timing. However, GNSS remains susceptible to jamming attacks enabled by adversarial electronic warfare (EW). This thesis explores the integration of machine learning (ML) into GNSS security frameworks to improve resilience against such threats. Specifically, it addresses the research question: How can ML algorithms be systematically integrated into GNSS security frameworks to enable automated, adaptive anomaly detection?

The study applies Long Short-Term Memory (LSTM) autoencoders to model GNSS signal behaviour in an unsupervised temporal framework. A real-world dataset is used to train and evaluate the system, enabling the construction of clean-signal baselines and implementation of adaptive, per-satellite thresholding techniques. Ensemble-based classification is employed to detect and categorise jamming-related anomalies. The results demonstrate improved detection accuracy compared to earlier rule-based approaches. The findings contribute to the academic and practical understanding of GNSS anomaly detection and outline a viable path towards scalable, embedded ML-based defence systems.

The thesis is written in English.