Enhancing WSN Intrusion Detection: A Combined Deep Learning Framework with Dimensionality Reduction and Hybrid Optimization Technique

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Abstract

Wireless Sensor Networks (WSNs) are susceptible to attacks as they are limited in resources and open in nature. Class-imbalance and high-dimensional data are likely to lead to poor performance of conventional intrusion detection systems (IDS). A hybrid solution to improving IDS performance in WSNs using deep learning, feature selection, and dimensionality reduction is presented in this paper. The model uses Principal Component Analysis (PCA) and Uniform Manifold Approximation and Projection (UMAP) as dimensionality reduction techniques, Particle Swarm Optimization (PSO) and Harris Hawks Optimization (HHO) as feature selectors, and Convolutional Neural Networks (CNN) and Bidirectional Long Short-Term Memory (BiLSTM) networks as classifiers. For handling class imbalance, the Synthetic Minority Over-sampling Technique (SMOTE) is utilized on the NSL-KDD dataset for binary and multiclass labels.

The performances show that the model proposed has accuracy metrics of 99.08% and 98.71% for binary and multiclass classification, respectively, which are higher compared to other methods. This hybrid technique effectively identifies different kinds of attacks, such as low-frequency R2L and U2R attacks, indicating the strength of advanced machine learning methods in intrusion detection within WSNs.

Keywords

Wireless Sensor Networks, Intrusion Detection, UMAP, HHO-PSO, CNN- BiLSTM, Dimensionality Reduction, Feature Selection, SMOTE.