A dense network model of traffic classification based on autoencoder and attention mechanism

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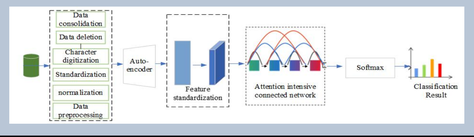
Abstract

This paper proposes a DenseNet-based network traffic classification model that combines autoencoder and attention mechanism to address the issues of insufficient feature extraction, gradient vanishing, and inaccurate dimensionality reduction of high-dimensional data in existing models.

The model uses an autoencoder for dimensionality reduction, an attention mechanism to focus on key features, and DenseNet to reuse features, significantly improving the performance of traffic classification.



Introduction

As network traffic increases, traditional classification models struggle with processing large-scale data and complex traffic patterns.
This paper adopts a combination of autoencoder for dimensionality reduction, DenseNet for feature reuse, and attention mechanism to reduce feature redundancy and enhance gradient transmission efficiency ,thus improving classification performance.

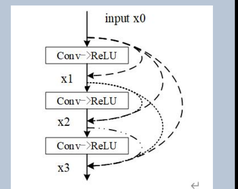
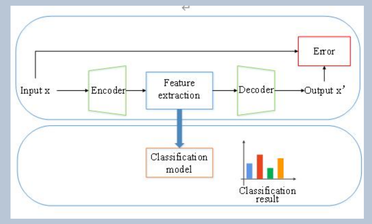


Figure. 2. Structure of the dense block

Methods

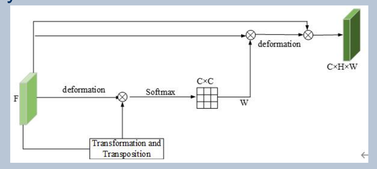
▪ A. Autoencoder for Dimensionality Reduction

The autoencoder plays a critical role in dimensionality reduction and feature extraction, reducing high-dimensional data redundancy through encoding, extracting feature and decoding layers.



▪ B. Attention Mechanism

The attention mechanism assigns greater weight to key features, using the Softmax function to compute the distribution of relevance, improving classification accuracy.



▪ C. DenseNet Structure

DenseNet improves gradient transmission efficiency through feature reuse and short connections, addressing the issue of vanishing gradients and ensuring more stable deep network training.

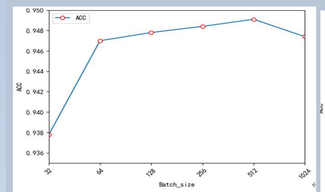
Results

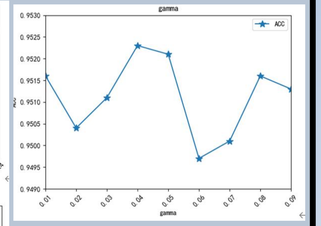
▪ A. Classification Accuracy of Training Set

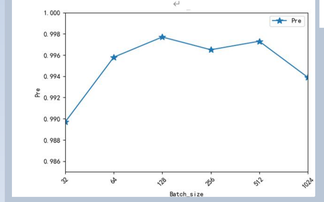
The experimental results show that adjusting the batch size and gamma parameters effectively improves model classification performance.

TABLE III. PERFORMANCE COMPARISON OF BINARYCLASSIFICATION

Algorithms/metrics	ACC	PRE	TPR	FPR	F1-Score
LSTM	77.43	85.23	77.05	**21.93**	79.47
CNN	94.41	98.97	91.64	1.47	95.16
Resnet	94.78	99.54	91.75	0.66	95.49
Desnet	94.98	99.61	92.11	0.54	95.65
Proposed model	**95.23**	**99.77**	**92.39**	0.33	**95.94**







▪ B. Ablation Study

To verify the importance of the DenseNet connections and attention mechanism, an ablation study is conducted by removing specific components. Results show that DenseNet connections have a greater impact on model performance.

TABLE V. ABLATION COMPARISON

Algorithms/metrics	Benign	Bot	Bruteforce	Dos	Infiltration
S1	99.66	100.00	100.00	100.00	22.46
S2	94.35	98.13	99.10	98.39	20.12
Proposed model	**99.77**	100.00	100.00	100.00	**24.66**

Conclusions

This paper successfully addresses the challenges of dimensionality reduction, feature extraction, and gradient vanishing in high-dimensional data classification by combining autoencoder, attention mechanism, and DenseNet.

The experimental results demonstrate that the proposed model outperforms existing models in all classification tasks, especially in handling complex attacks such as Infiltration.

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