Machine Learning Based Adaptive Cybersecurity Incident Detection

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Progress report: 40%

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Introduction

- Research Papers Review
  - Machine Learning Anomaly detection Method Review
  - Anomaly detection using Hilbert's Curve flow-to-image and CNN method review
  - MAD-GAN review
  - Paper Implementation
- Proposed Method

Anomaly detection Method Review

- Classical Machine Learning (Supervised Learning)
  - Z. K. MASEER et al. have shown the comparison in the classical machine learning model on CIC-IDS2017 dataset with multi-attack classification. (Attack type e.g. Normal, Brute Fource, XSS, SQL Injection etc.)

	Model	Accuracy	F1-Score	Precision	Recall
1	K-Nearest Neighbors (KNN)	99.52%	99.49%	99.49%	99.52%
2	Decision tree (DT)	99.49%	99.42%	99.43%	99.49%
3	Naïve Bayes (NB)	98.86%	98.85%	99.01%	98.86%

Top 3 Supervised ML models with CIC-IDS2017

Anomaly detection Method Review

- Classical Machine Learning (Unsupervised Learning)
    - Z. K. MASEER et al. have shown the comparison in the classical machine learning model on CIC-IDS2017 dataset with multi-attack classification. (Attack type e.g. Normal, Brute Fource, XSS, SQL Injection, etc.)

	Model	Accuracy	F1-Score	Precision	Recall
1	Expectation-Maximization (EM)	60.06%	74.11%	86.88%	60.06%
2	Self Organizing Maps (SOM)	59.06%	74.11%	85.88%	60.00%
3	K-means	25.59%	39.96%	97.47%	25.59%

Top 3 Unsupervised ML models with CIC-IDS2017

Anomaly detection Method Review

- Deep Learning
  - J. Jose et al. have shown the comparison in Deep neural network, Long short-term memory (LSTM) and Convolutional Neural Network (CNN) on CIC-IDS2017 and other network attacks (e.g. NSL-KDD).

	Model	Accuracy	F1-Score	Precision	Recall
1	Long short-term memory (LSTM)	97.67%	93.55%	94.96%	95.95%
2	Convolutional Neural Network (CNN)	99.61%	93.09%	97.05%	95.00%
3	Deep neural network	90.61%	84.60%	80.85%	84.60%

Deep Learning models with CIC-IDS2017 dataset

Anomaly detection Method Review

- P. S. Muhuri et al. have shown the performace of the LSTM on NSL-KDD

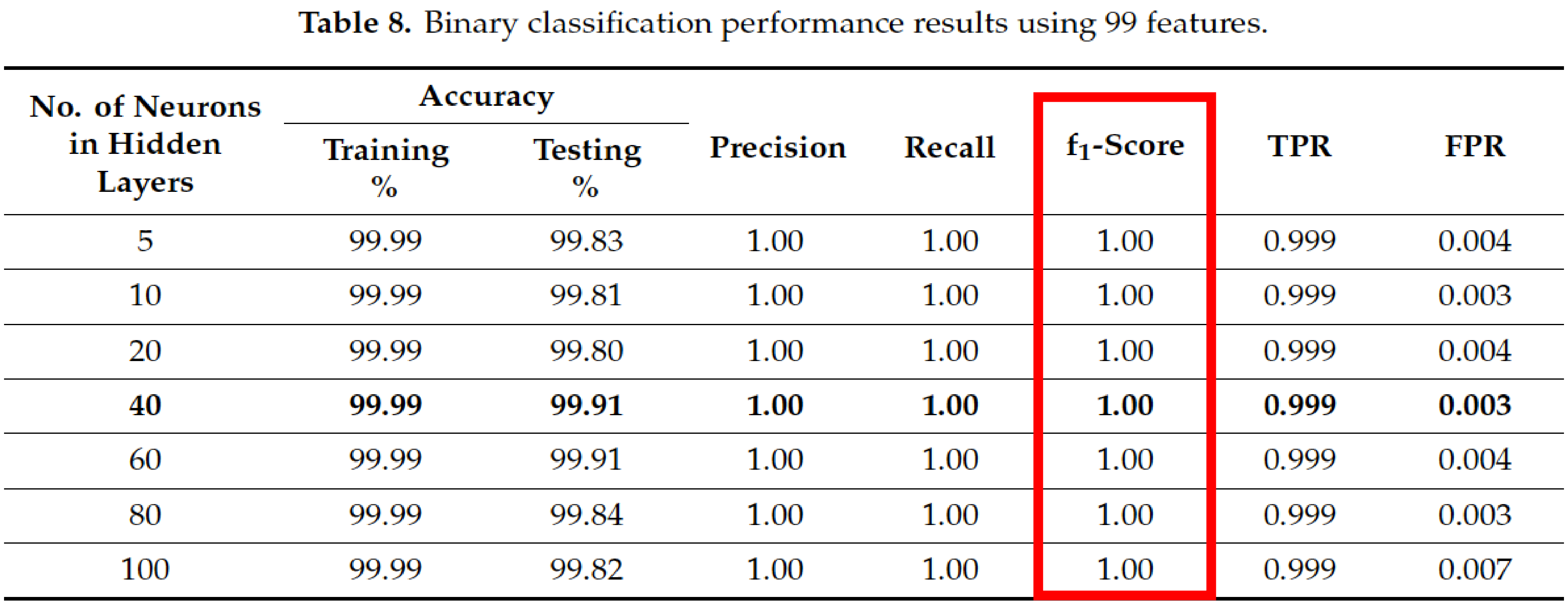
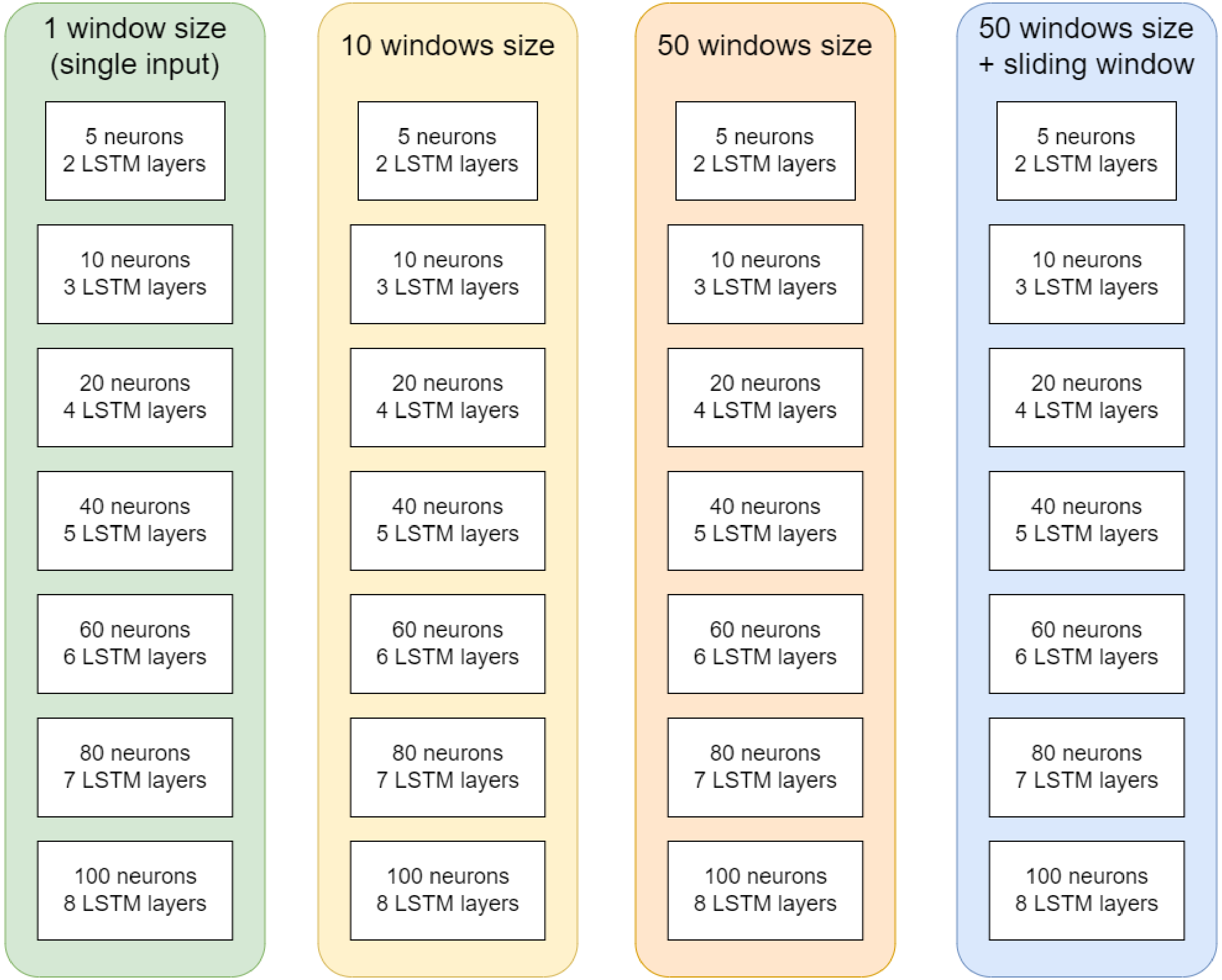


Table 8. Binary classification performance results using 99 features.

No. of Neurons in Hidden Layers	Accuracy		Precision	Recall	f_1-Score	TPR	FPR
	Training %	Testing %					
5	99.99	99.83	1.00	1.00	1.00	0.999	0.004
10	99.99	99.81	1.00	1.00	1.00	0.999	0.003
20	99.99	99.80	1.00	1.00	1.00	0.999	0.004
40	**99.99**	**99.91**	**1.00**	**1.00**	**1.00**	**0.999**	**0.003**
60	99.99	99.91	1.00	1.00	1.00	0.999	0.004
80	99.99	99.84	1.00	1.00	1.00	0.999	0.003
100	99.99	99.82	1.00	1.00	1.00	0.999	0.007

Reference : Using a long short-term memory recurrent neural network (LSTM-RNN) to classify network attacks (PS. Muhuri et al., 2020)

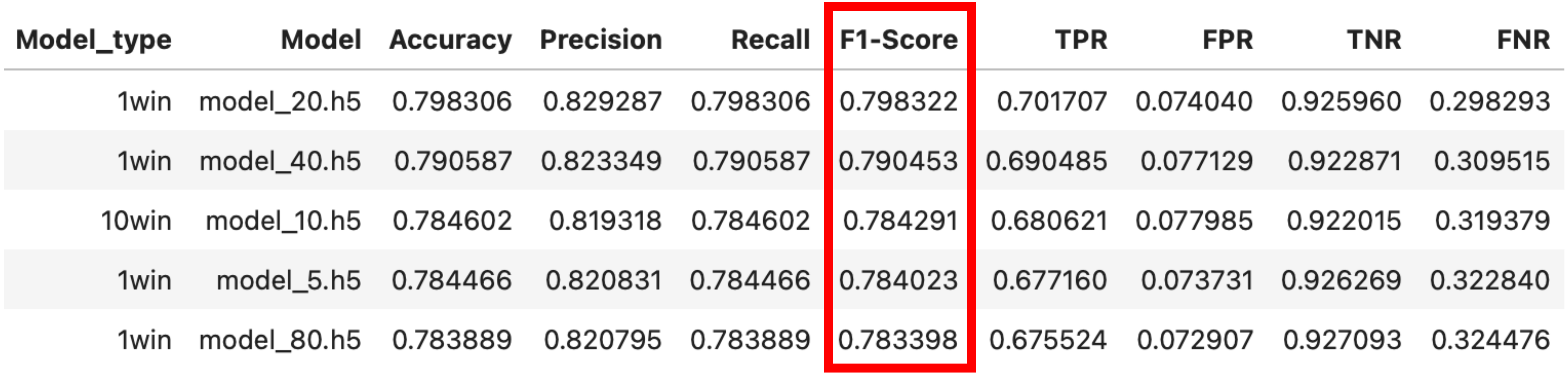


1 window size (single input)	10 windows size	50 windows size	50 windows size + sliding window
5 neurons 2 LSTM layers	5 neurons 2 LSTM layers	5 neurons 2 LSTM layers	5 neurons 2 LSTM layers
10 neurons 3 LSTM layers	10 neurons 3 LSTM layers	10 neurons 3 LSTM layers	10 neurons 3 LSTM layers
20 neurons 4 LSTM layers	20 neurons 4 LSTM layers	20 neurons 4 LSTM layers	20 neurons 4 LSTM layers
40 neurons 5 LSTM layers	40 neurons 5 LSTM layers	40 neurons 5 LSTM layers	40 neurons 5 LSTM layers
60 neurons 6 LSTM layers	60 neurons 6 LSTM layers	60 neurons 6 LSTM layers	60 neurons 6 LSTM layers
80 neurons 7 LSTM layers	80 neurons 7 LSTM layers	80 neurons 7 LSTM layers	80 neurons 7 LSTM layers
100 neurons 8 LSTM layers	100 neurons 8 LSTM layers	100 neurons 8 LSTM layers	100 neurons 8 LSTM layers

Overall detail with the implemented models

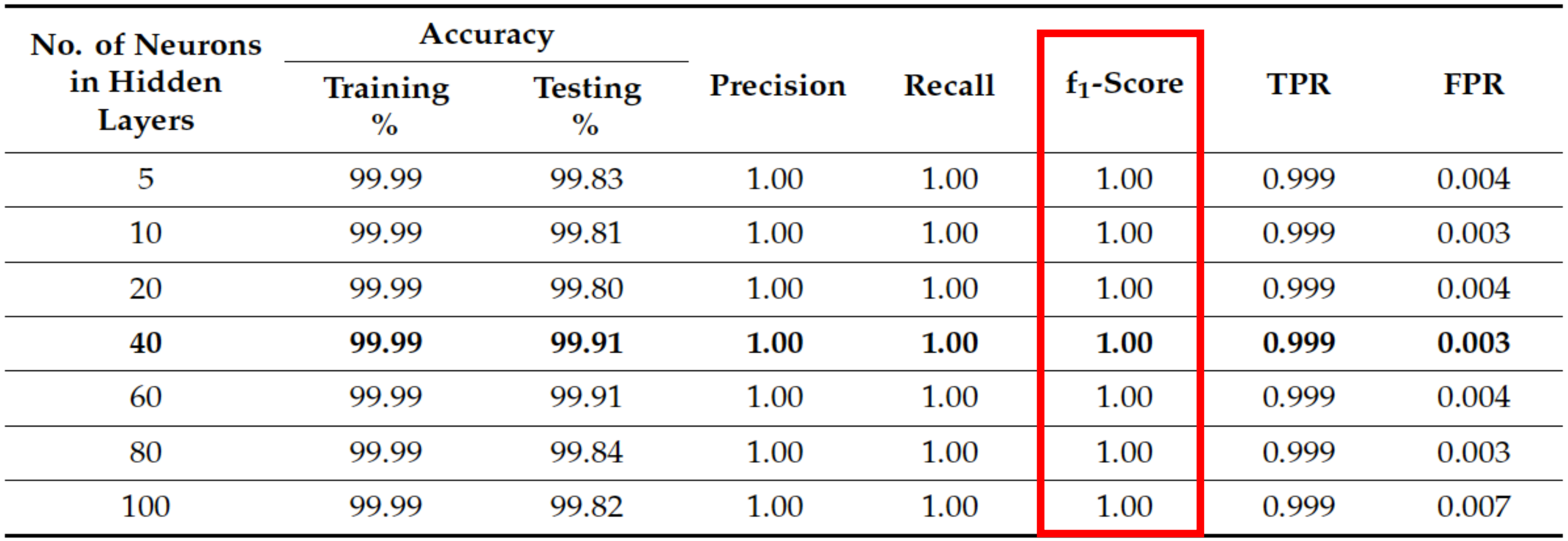
Paper Implementation- Result

- Top 5 models that have the best F1-Score
- F1-Score is the harmonic mean between Precision and Recall



Model_type	Model	Accuracy	Precision	Recall	F1-Score	TPR	FPR	TNR	FNR
1win	model_20.h5	0.798306	0.829287	0.798306	0.798322	0.701707	0.074040	0.925960	0.298293
1win	model_40.h5	0.790587	0.823349	0.790587	0.790453	0.690485	0.077129	0.922871	0.309515
10win	model_10.h5	0.784602	0.819318	0.784602	0.784291	0.680621	0.077985	0.922015	0.319379
1win	model_5.h5	0.784466	0.820831	0.784466	0.784023	0.677160	0.073731	0.926269	0.322840
1win	model_80.h5	0.783889	0.820795	0.783889	0.783398	0.675524	0.072907	0.927093	0.324476

The evaluation from the paper.



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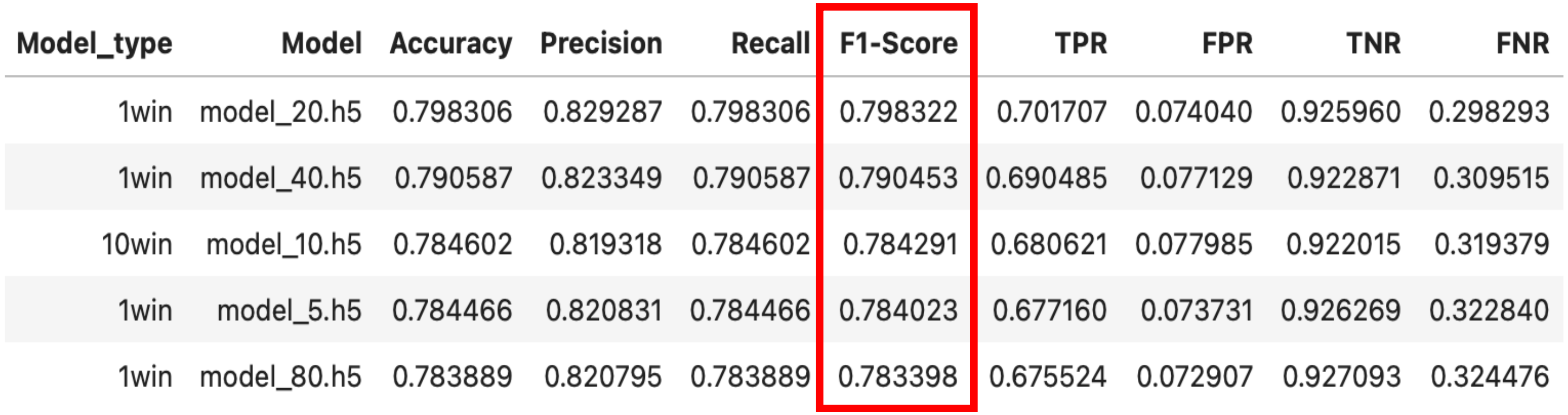
100	99.99	99.82	1.00	1.00	1.00	0.999	0.007

The evaluation by implementation.



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1win	model_80.h5	0.783889	0.820795	0.783889	0.783398	0.675524	0.072907	0.927093	0.324476

Anomaly detection using Hilbert Curve technique and Convolutional Neural Network (CNN) method review

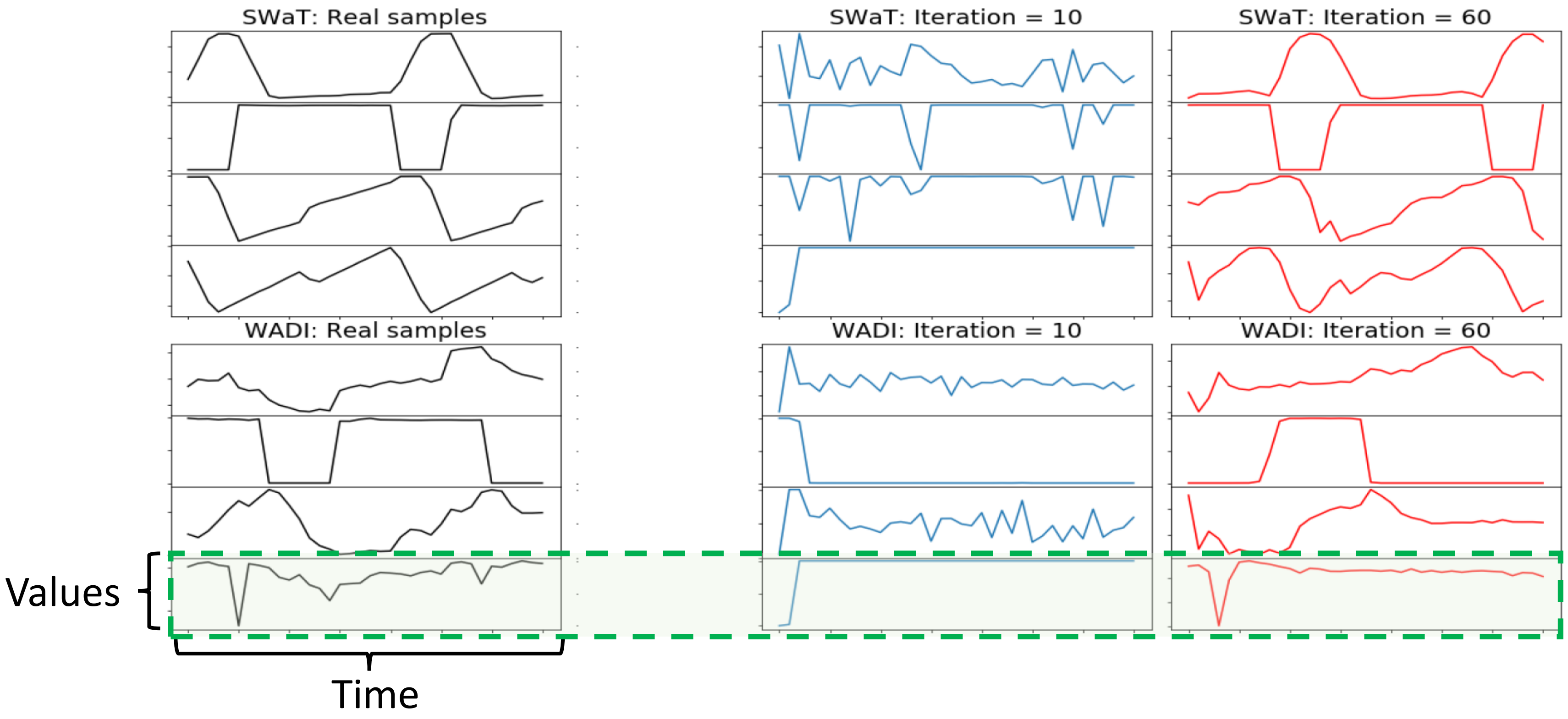
- P. Jaroensiripong has shown the potential of CNN, the image classification model to detect intrusion from image of network flow which training on 2 dataset

Dataset	Accuracy	F1-Score	Precision	Recall
NSL-KDD	77.87%	77.82%	90.63%	68.18%
CIC-IDS2017	91.52%	92.01%	93.73%	90.36%

Result of the CNN image classification model by Hilbert curve network flow to image technique

Multivariate Anomaly Detection for Time Series Data with Generative Adversarial Networks review

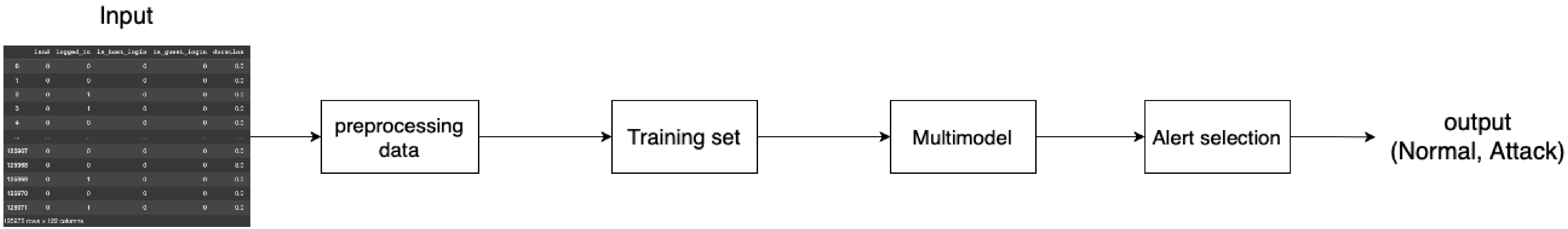
- To generate data samples and to detect anomalies in Cyber-Physical Systems (CPSs) with Generative Adversarial Networks (GANs) based on LSTM-RNN using multivariate time series data generated by the systems.



Comparison between generated samples at different training stages

Proposed Anomaly detection Method

- Idea came from ensemble machine learning method
- Each model will be trained by different type of cyber attack
- Integrate every trained model to predict one result

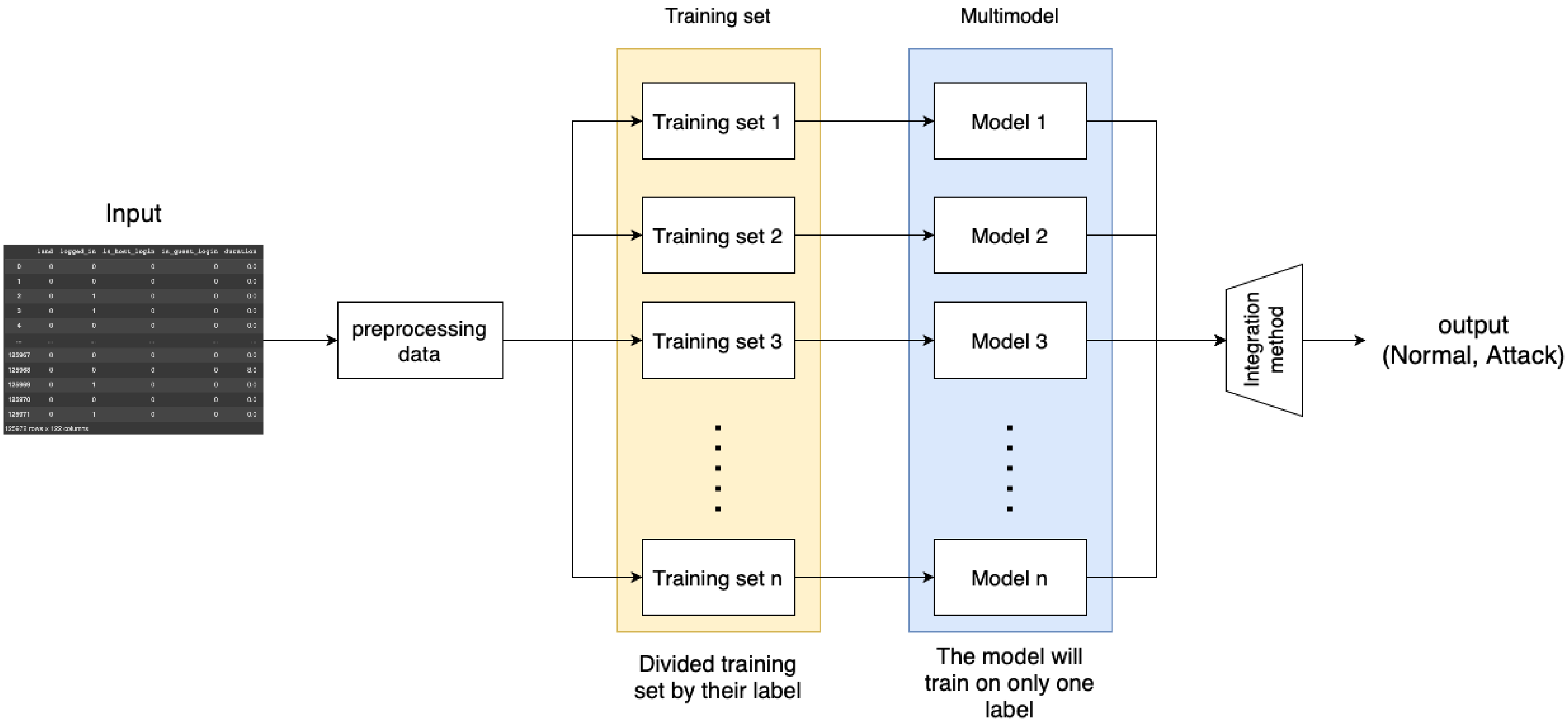


	land	logged_in	is_host_login	is_guest_login	duration
0	0	0	0	0	0.0
1	0	0	0	0	0.0
2	0	1	0	0	0.0
3	0	1	0	0	0.0
4	0	0	0	0	0.0
...	...	...	...	...	...
125967	0	0	0	0	0.0
125968	0	0	0	0	0.0
125969	0	1	0	0	0.0
125970	0	0	0	0	0.0
125971	0	1	0	0	0.0

125973 rows × 122 columns

Model training methodology

Overall Model



	land	logged_in	is_host_login	is_guest_login	duration
0	0	0	0	0	0.0
1	0	0	0	0	0.0
2	0	1	0	0	0.0
3	0	1	0	0	0.0
4	0	0	0	0	0.0
...	...	...	...	...	...
125967	0	0	0	0	0.0
125968	0	0	0	0	0.0
125969	0	1	0	0	0.0
125970	0	0	0	0	0.0
125971	0	1	0	0	0.0

125972 rows × 122 columns

Divided training set by their label

The model will train on only one label

Thank You