A New Histogram-based Visualization Tool for Analyzing Anomaly Detection Algorithm Performance

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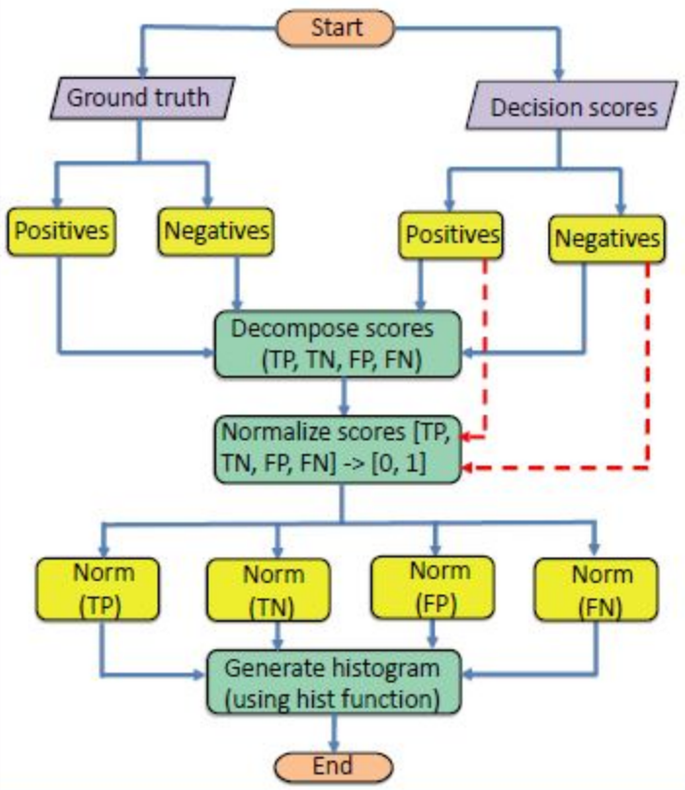
1. INTRODUCTION

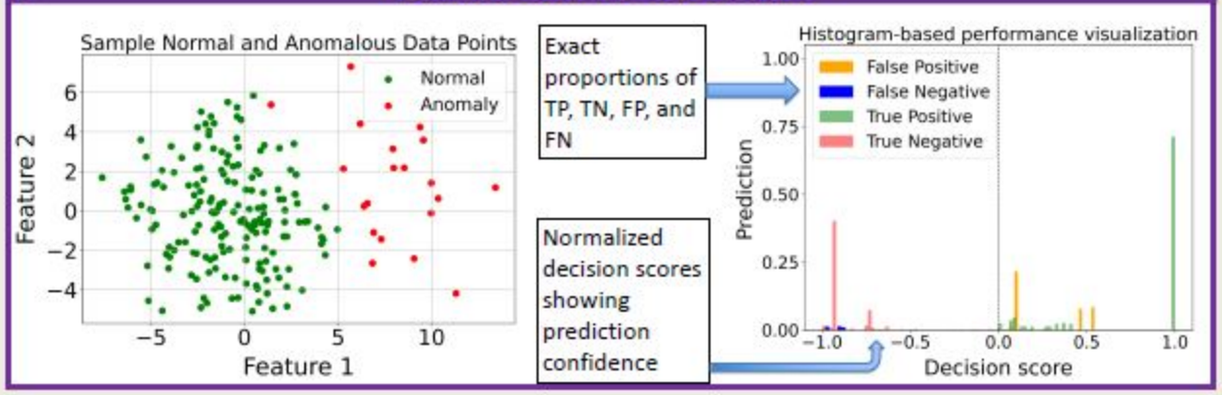
- Performance visualization of anomaly detection algorithms enables researchers to highlight trends and outliers in anomaly detection models results to gain intuitive understanding of detection models.
- Generally, anomaly detection algorithms produce negative and positive decision scores, representing normal and anomalous data points.
- Previous work relies on using histograms based on positive and negative scores for visualizing anomaly detection algorithms' performance [1].
- This work proposes a new histogram-based visualization approach that provides a better understanding of detection algorithms' performance by revealing the exact proportions of true positives (TP), true negatives (TN), false positives (FP), and false negatives (FN) values.
- The proposed method also reveals the detection confidence of detection algorithms.

2. FLOWCHART OF PROPOSED METHOD

Input 1 ← {Decision scores} ∈ R
Input 2 ← {Ground truth} ∈ $[-1,1]$



3. BENEFITS OF PROPOSED METHOD

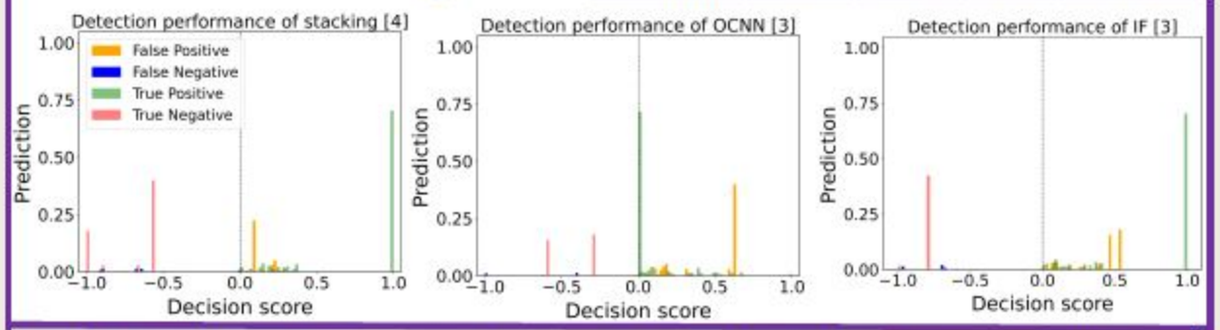


4. RESULTS

- Previous work such as [2] relies on table 1 for detection algorithms performance evaluation and comparison.
- How do we know the true performance of the models in table 1? **New Histogram-based approach**

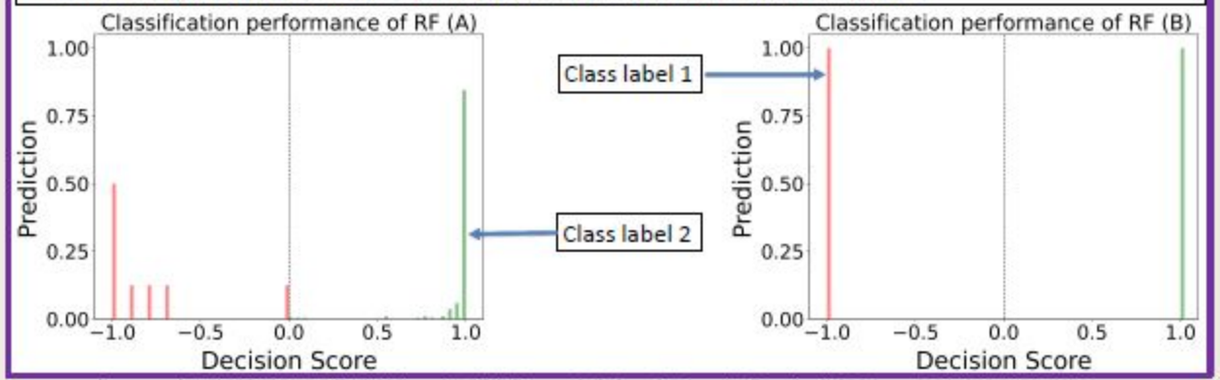
Table 1: Performance comparison of anomaly detection models using dataset in [3]

Method	Accuracy	Precision	Recall	F1-score
OCNN [3]	0.91	0.90	0.91	0.91
IF [3]	0.91	0.91	0.90	0.91
Stacking [4]	0.92	0.92	0.92	0.92



Extension of the visualization approach to supervised machine learning involving binary classification

- Random Forest (RF) classifier A is plotted using the histogram-based approach in this work, whereas RF (B) is plotted using the visualization approach in [1]. RF (A) and RF (B) have perfect accuracies.



5. INSTALLATION/USAGE

- The histogram-based visualization software is open-source and can be installed by:

```
$ pip install hist-plot
```

- Usage:

```
from hist_plot import AnomalyScoreHist
fig = AnomalyScoreHist(dec_score, g_truth)
fig.plot_hist(fig_name)
```

Where:
- dec_score: decision score output of anomaly detection model
- g_truth: ground truth label
- fig_name: optional name for the plot

6. CONCLUSION

- This work has introduced a better way of visualizing and analyzing anomaly detection algorithm performance using a histogram-based approach.
- Results show that the proposed method provides a better meaning of detection algorithm performance as compared to previous work.
- The proposed method can be applied to the performance visualization of supervised machine learning models involving binary classification.

7. REFERENCES

[1] R. Chalapathy, et. al, "Anomaly detection using one-class neural networks." *arXiv preprint arXiv*:1802.06360 (2018)
[2] E. Aboah Boateng, "Anomaly Detection for Industrial Control Systems Based on Neural Networks with One-Class Objective Function." *Proc. of Student Research and Creativity Inquiry Day* 5 (2021).
[3] E. Aboah Boateng, and J.W. Bruce. "Unsupervised Machine Learning Techniques for Detecting PLC Process Control Anomalies." *Journal of Cybersecurity and Privacy* 2.2 (2022): 220-244..
[4] E. Aboah Boateng, and J.W. Bruce. "Unsupervised Ensemble Methods for Anomaly Detection in PLC-based Process Control." IEE Transactions (under review).

8. ACKNOWLEDGEMENTS

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