

The Elephant in the Room:

Towards A Reliable Time-series Anomaly
Detection Benchmark

Qinghua Liu

John Paparrizos

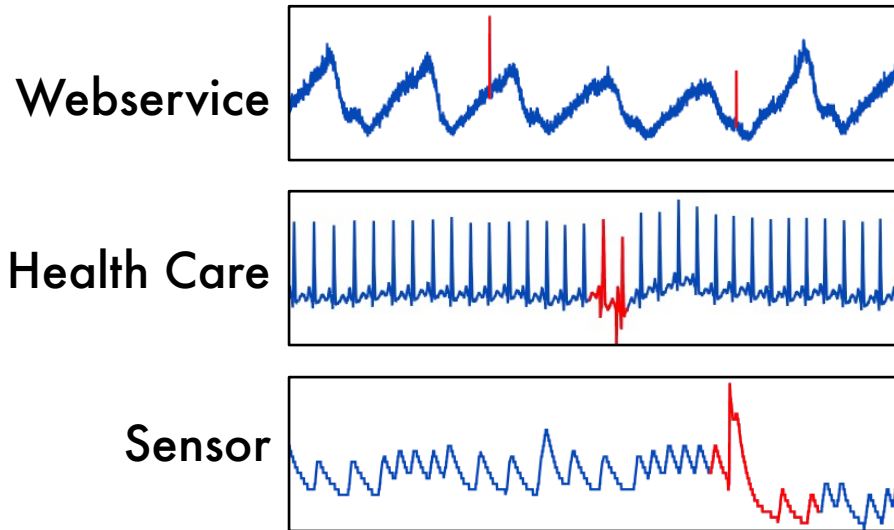


THE OHIO STATE
UNIVERSITY



Background and Overview

Rising Demand for Time-Series Anomaly Detection

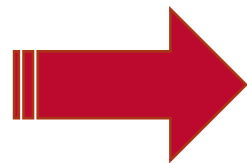


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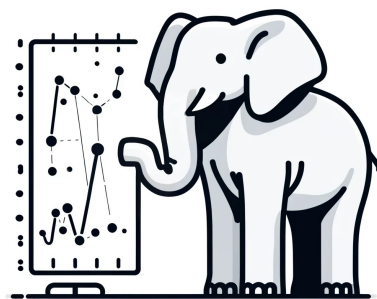
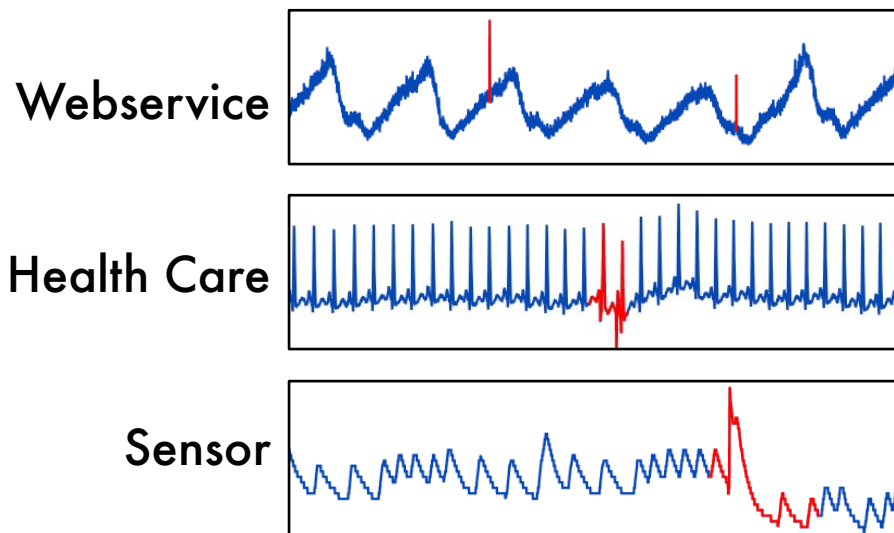
[1] Qinghua Liu, Paul Boniol, Themis Palpanas, and John Paparrizos.
Time-Series Anomaly Detection: Overview and New Trends. VLDB 2024.

Background and Overview

Rising Demand for Time-Series Anomaly Detection



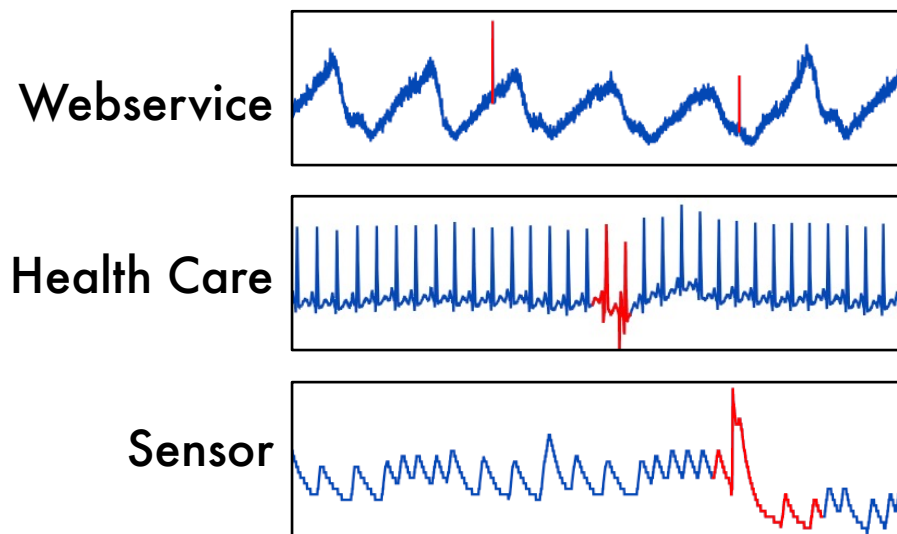
The Elephant in the Room



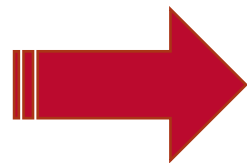
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Background and Overview

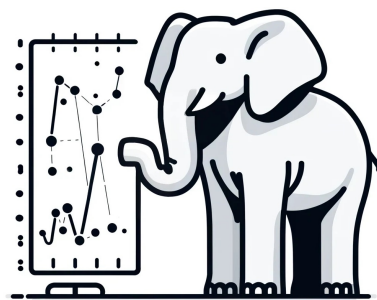
Rising Demand for Time-Series Anomaly Detection



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The Elephant in the Room



Flaws in Dataset

Problematic Evaluation Measures

Inconsistent Benchmarking Practice

[1] Qinghua Liu, Paul Boniol, Themis Palpanas, and John Paparrizos.
Time-Series Anomaly Detection: Overview and New Trends. VLDB 2024.



DATASET INTEGRITY

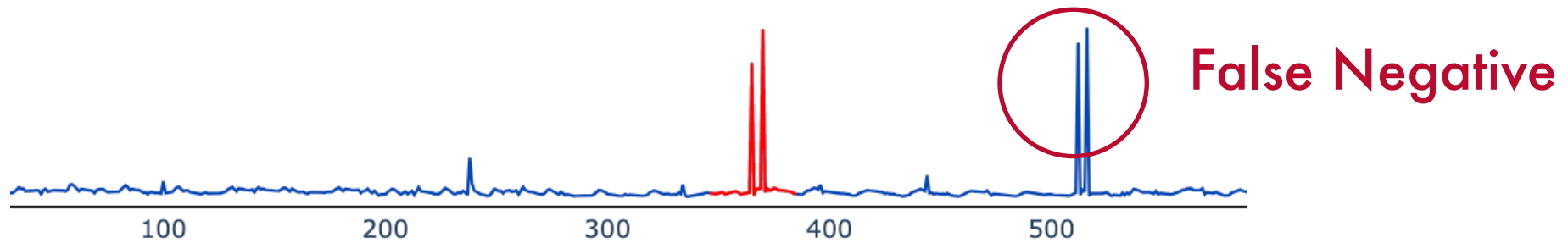


Common Flaws in Dataset

Mislabeling

Bias

Feasibility

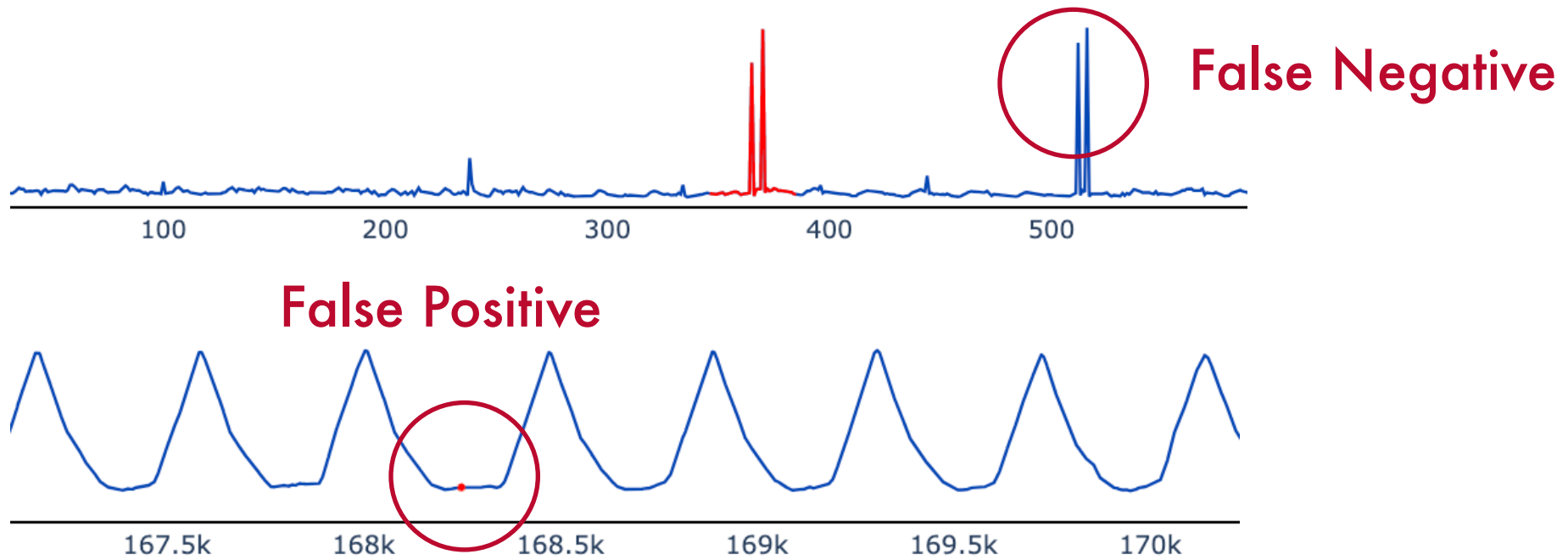


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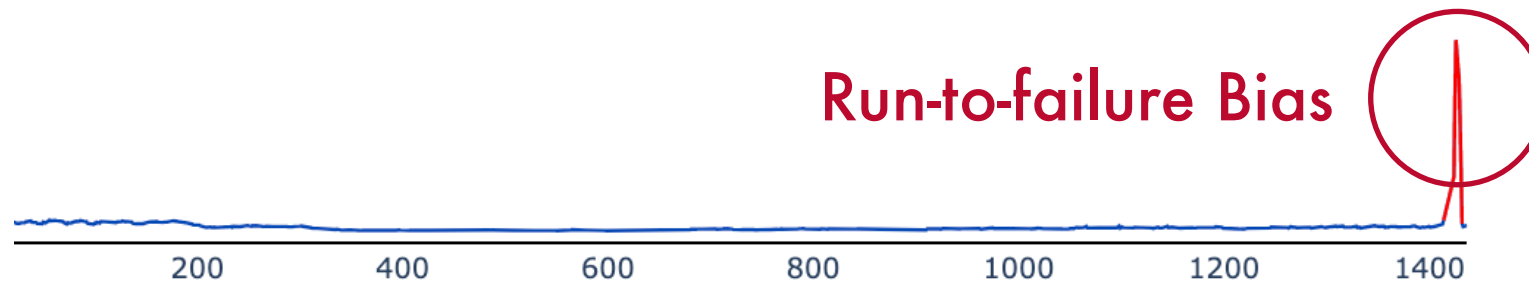


Common Flaws in Dataset

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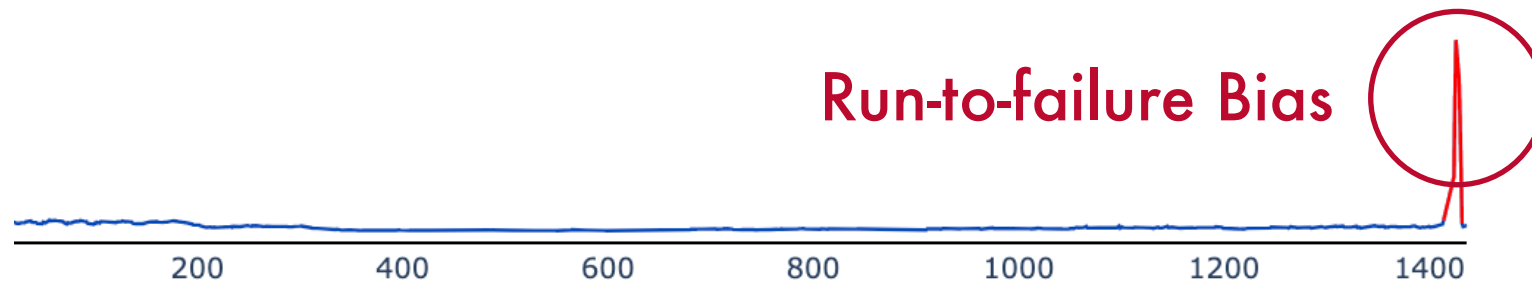
Common Flaws in Dataset

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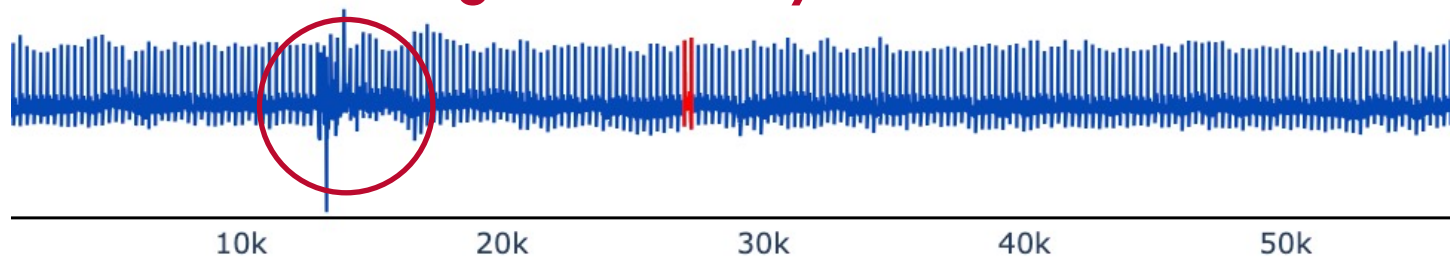
Bias

Feasibility

Run-to-failure Bias



Single Anomaly Bias



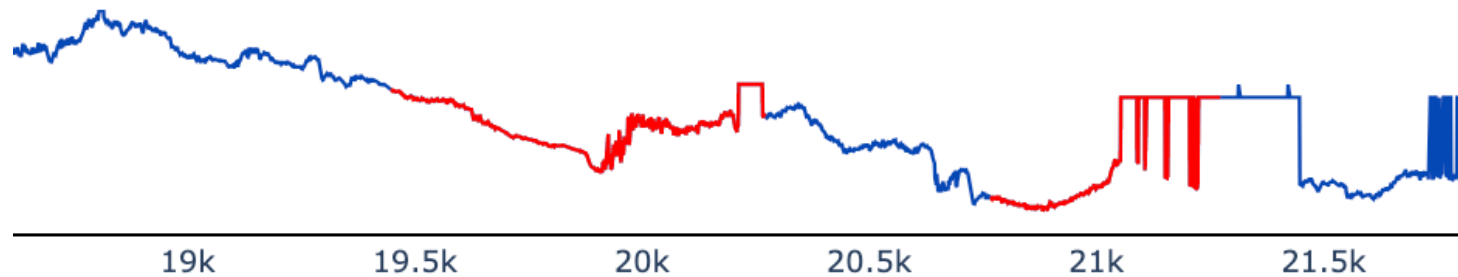
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Lack of In-context Data



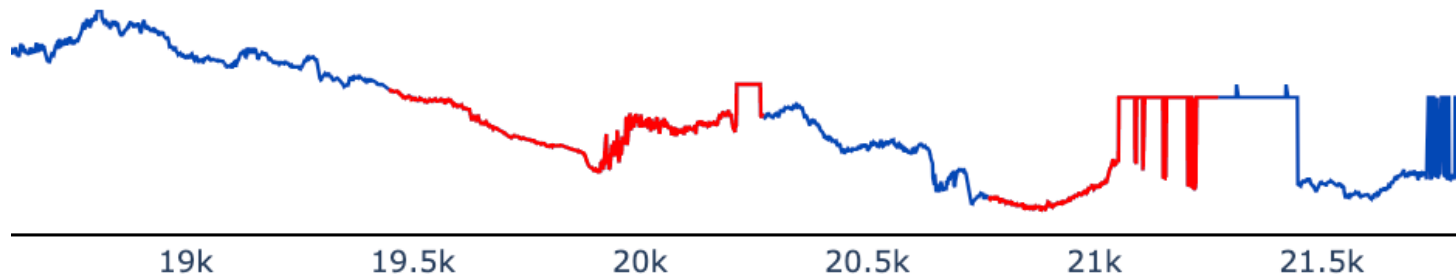
Common Flaws in Dataset

Mislabeling

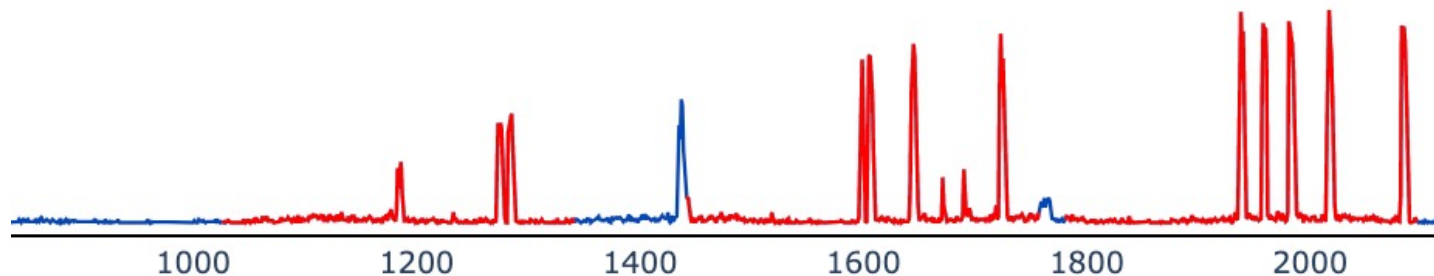
Bias

Feasibility

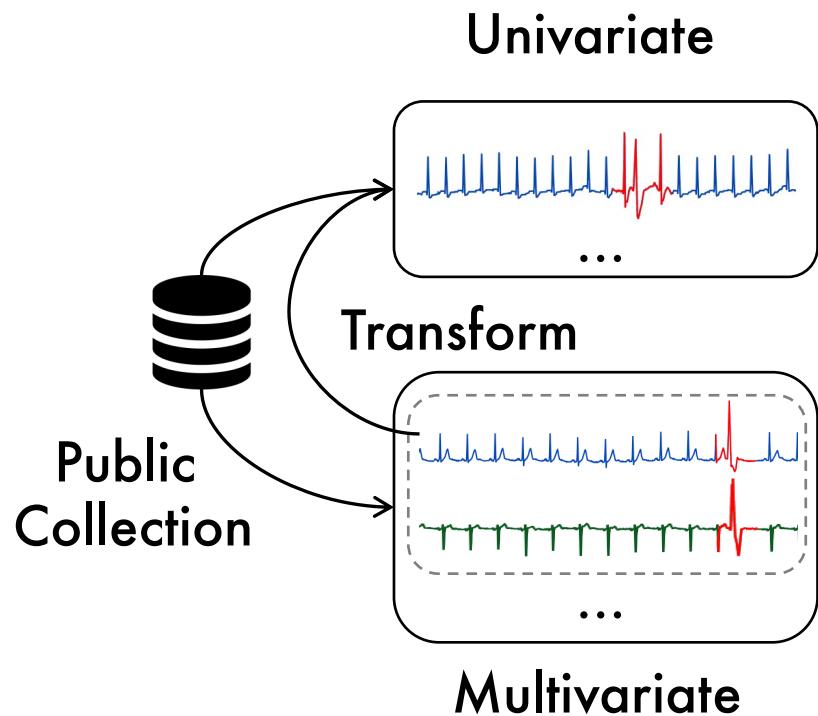
Lack of In-context Data



Unrealistic Anomaly Ratio

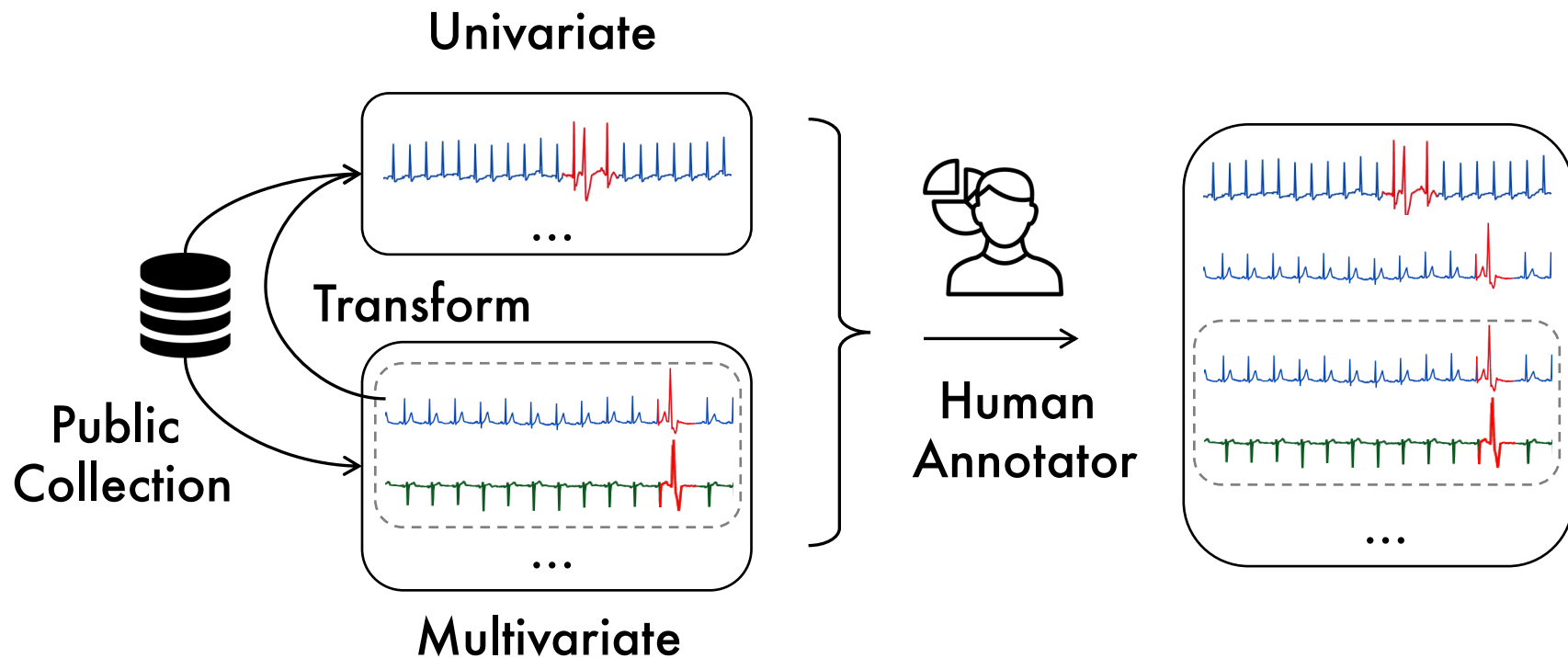


Dataset Construction Pipeline



Step 1:
Dataset Collection

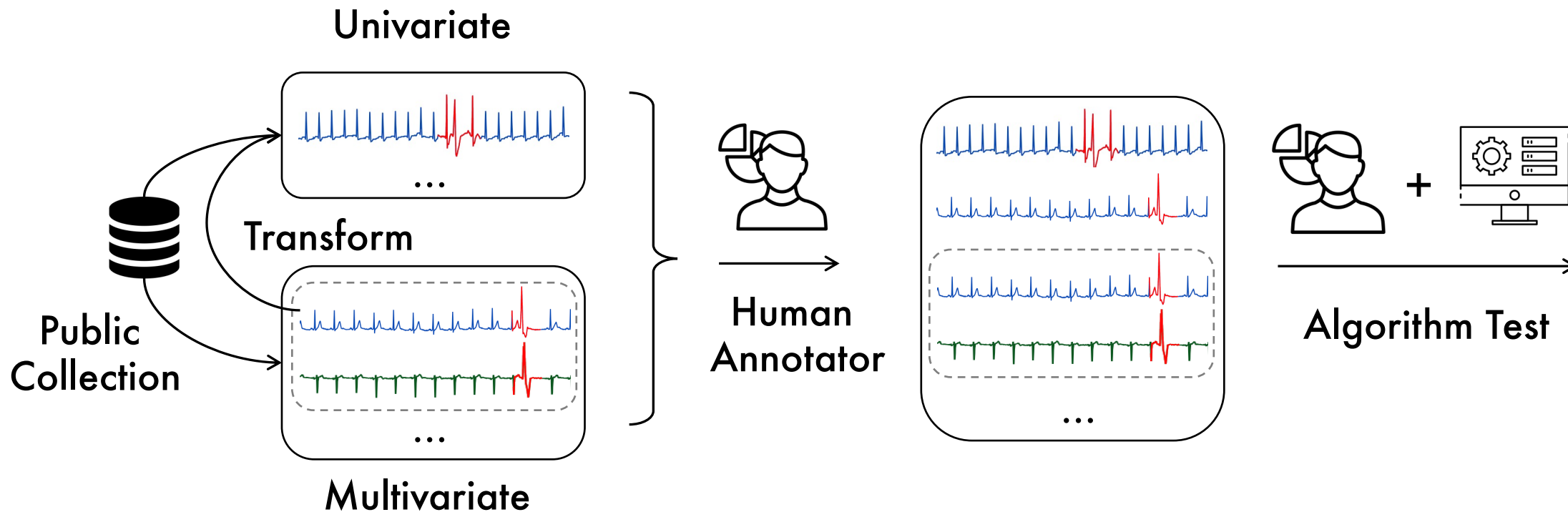
Dataset Construction Pipeline



Step 1:
Dataset Collection

Step 2:
Flaws Identification

Dataset Construction Pipeline



Step 1:
Dataset Collection

Step 2:
Flaws Identification

Step 3:
Label Quality Assessment

TSB-AD Dataset Overview

- **TSB-AD** is all you need !
- **Largest** heterogenous and curated time-series anomaly detection dataset

Category	Split	# TS	Avg Length	Avg Anomaly Length	Avg # Anomalies	Anomaly Ratio
TSB-AD-U	All	870	38814.1	179.5	39.7	2.4%
	Eval	350	51886.7	321.3	46.6	4.5%
	Tuning	48	47143.3	185.9	82.6	3.5%
TSB-AD-M	All	200	107760.4	582.6	71.1	5.1%
	Eval	180	108826.7	591.2	67.7	5.0%
	Tuning	20	98164.1	504.7	101.1	5.7%

TSB-AD Dataset Overview

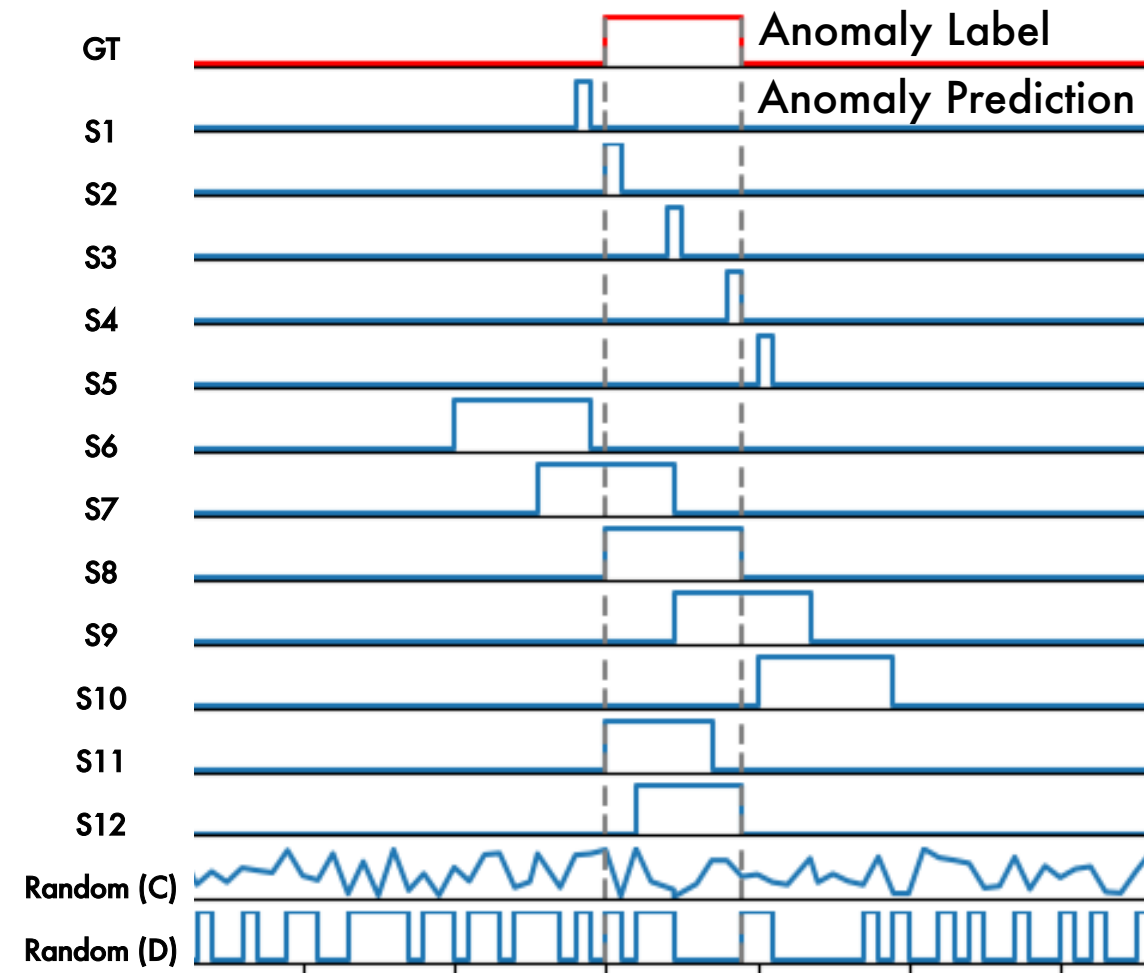
- **Double** the size of the previous largest collection
- **Four times** the number of existing curated datasets

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MEASURE RELIABILITY

Flaws in Evaluation Measures

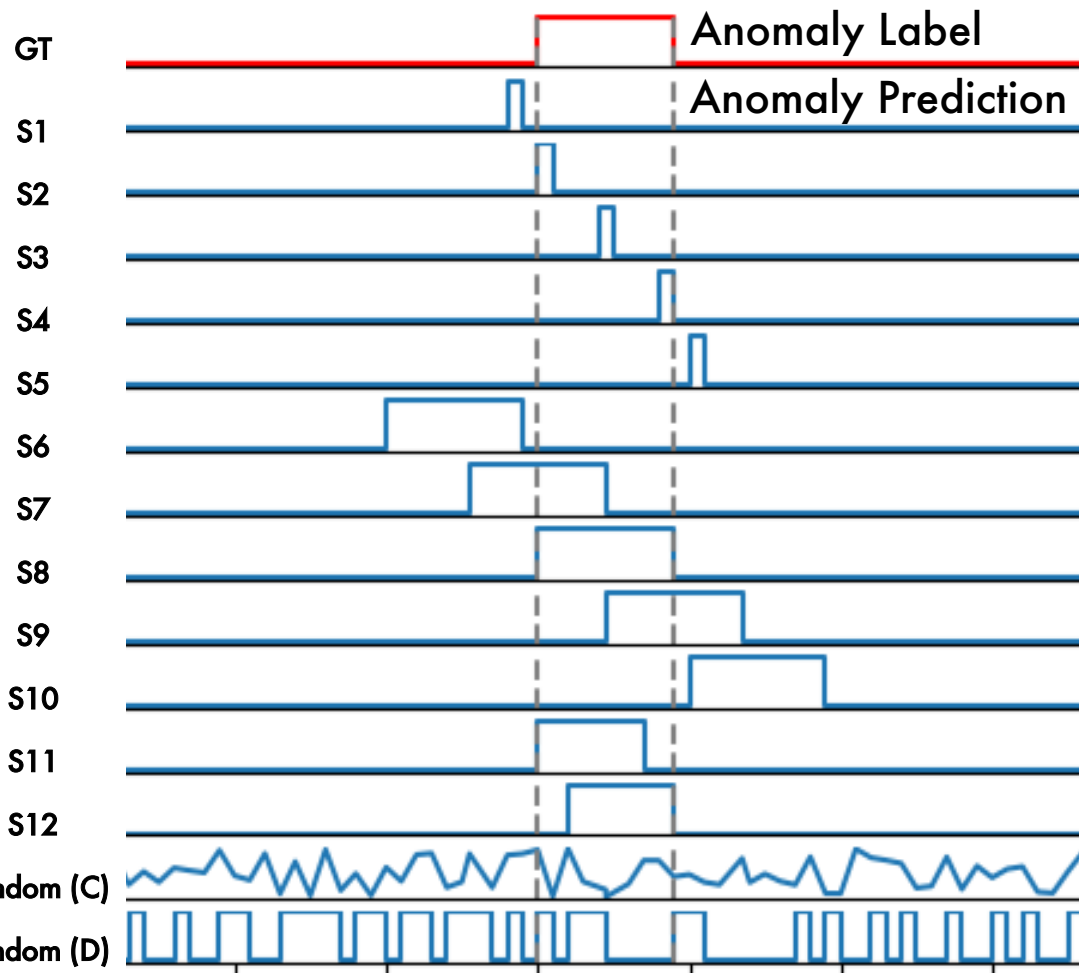


Flaws in Evaluation Measures

Bias

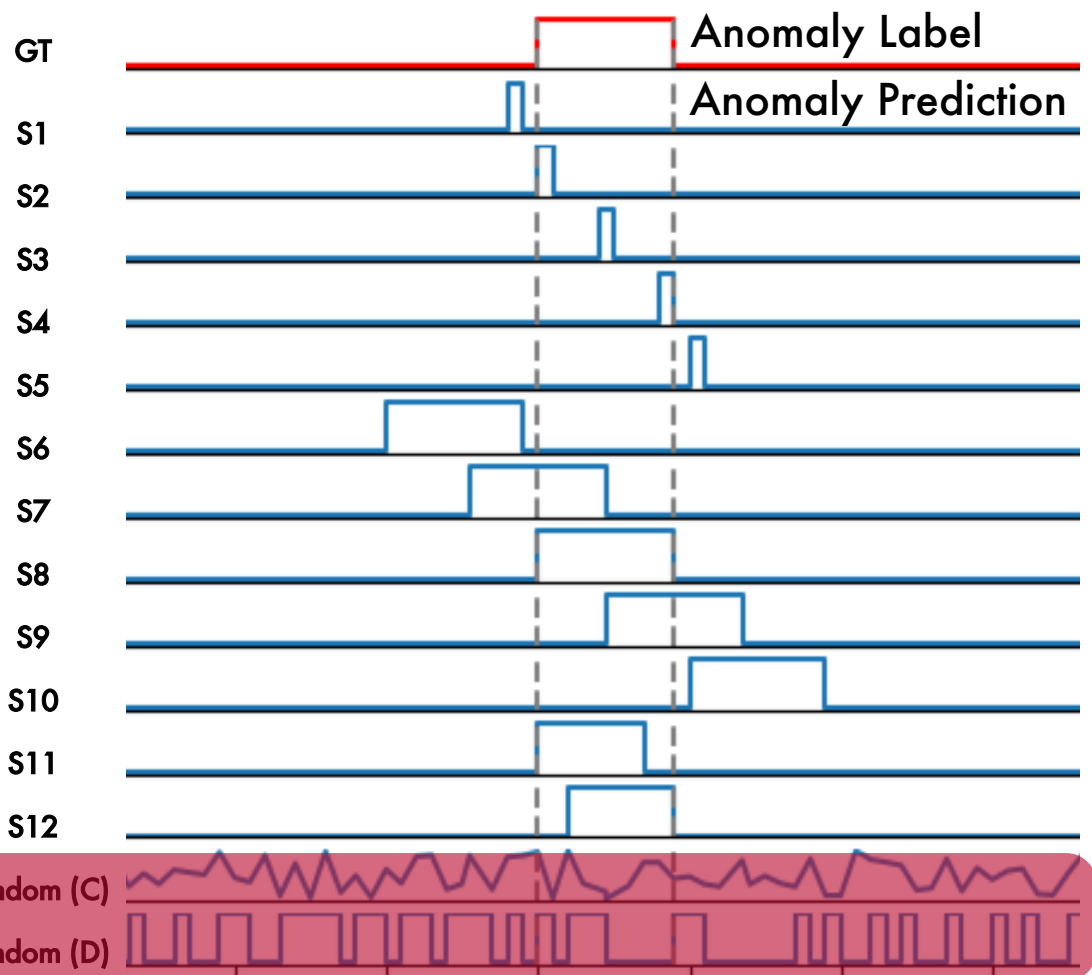
Indiscrimination

Lack of Adaptability



Scenario	Threshold-independent					Threshold-dependent				
	AUC-PR	AUC-ROC	VUS-PR	VUS-ROC	PATE	Standard-F1	PA-F1	Event-based-F1	R-based-F1	Affiliation-F1
S1	0.04	0.50	0.13	0.54	0.03	0.00	0.00	0.00	0.00	0.95
S2	0.14	0.55	0.17	0.56	0.58	0.18	1.00	1.00	0.44	0.98
S3	0.14	0.55	0.17	0.56	0.58	0.18	1.00	1.00	0.44	0.99
S4	0.14	0.55	0.17	0.56	0.58	0.18	1.00	1.00	0.44	0.98
S5	0.04	0.50	0.13	0.54	0.18	0.00	0.00	0.00	0.00	0.95
S6	0.04	0.48	0.18	0.62	0.03	0.00	0.00	0.00	0.00	0.93
S7	0.27	0.74	0.61	0.85	0.68	0.50	0.80	0.67	0.55	0.98
S8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S9	0.27	0.74	0.61	0.85	0.60	0.50	0.80	0.67	0.55	0.98
S10	0.04	0.48	0.18	0.62	0.14	0.00	0.00	0.00	0.00	0.93
S11	0.81	0.90	0.81	0.90	0.96	0.89	1.00	1.00	0.91	1.00
S12	0.81	0.90	0.81	0.90	0.91	0.89	1.00	1.00	0.91	1.00
Random (C)	0.06	0.56	0.09	0.72	0.06	0.12	0.73	0.21	0.16	0.70
Random (D)	0.04	0.51	0.08	0.66	0.34	0.08	0.15	0.08	0.09	0.68

Flaws in Evaluation Measures



Bias

Indiscrimination

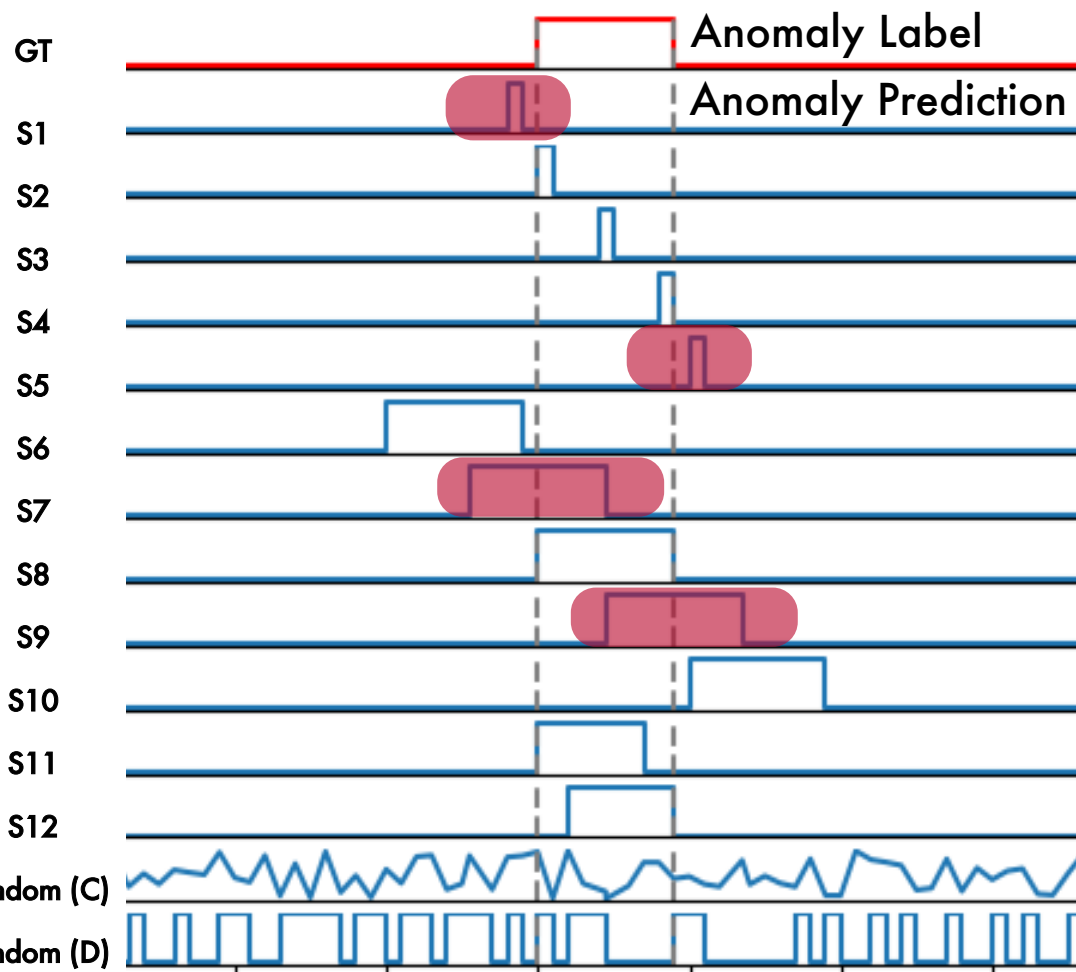
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Bias towards random score

Flaws in Evaluation Measures

Bias Indiscrimination Lack of Adaptability



Scenario	Threshold-independent					Threshold-dependent				
	AUC-PR	AUC-ROC	VUS-PR	VUS-ROC	PATE	Standard-F1	PA-F1	Event-based-F1	R-based-F1	Affiliation-F1
S1	0.04	0.50	0.13	0.54	0.03	0.00	0.00	0.00	0.00	0.95
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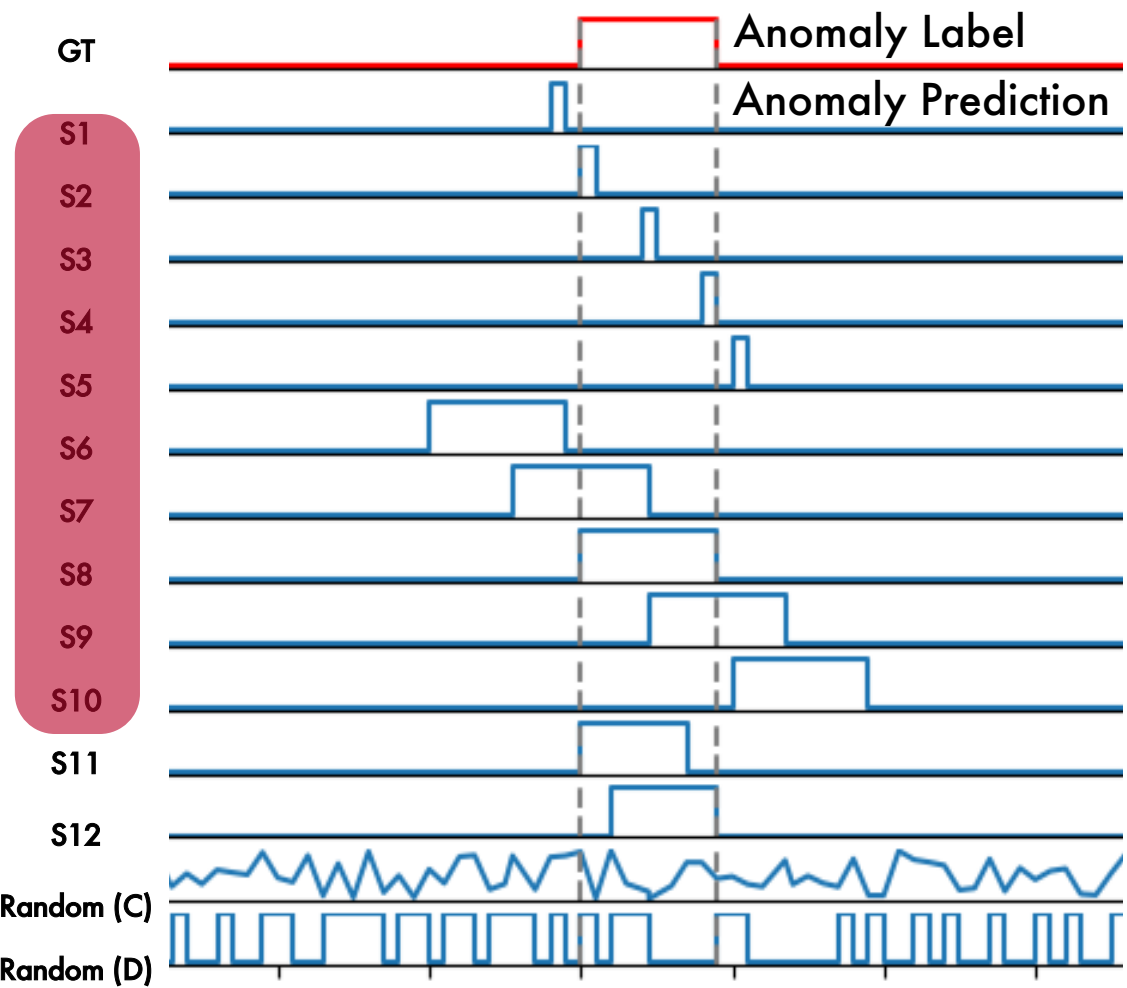
Inconsistent evaluation across different scenarios

Flaws in Evaluation Measures

Bias

Indiscrimination

Lack of Adaptability



Scenario	Threshold-independent					Threshold-dependent				
	AUC-PR	AUC-ROC	VUS-PR	VUS-ROC	PATE	Standard-F1	PA-F1	Event-based-F1	R-based-F1	Affiliation-F1
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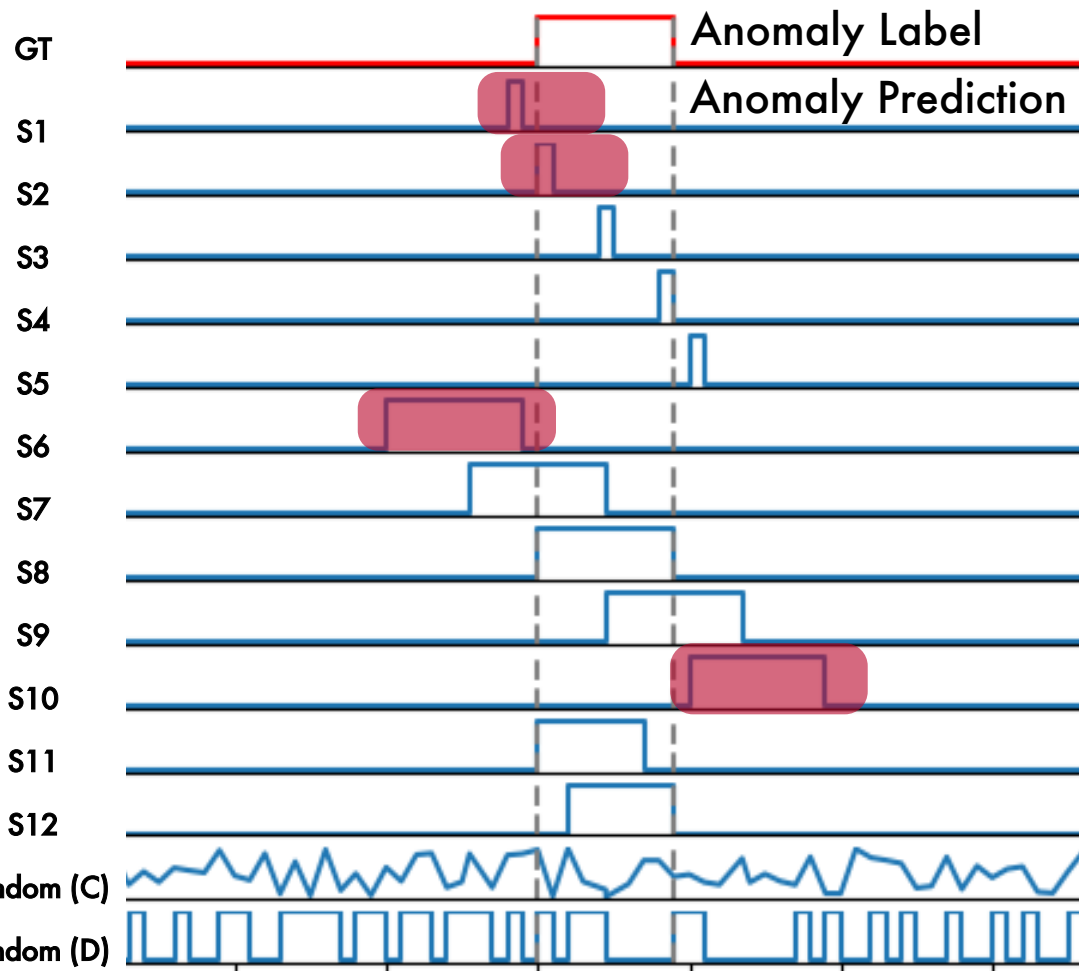
No differentiation across S1 to S10

Flaws in Evaluation Measures

Bias

Indiscrimination

Lack of Adaptability

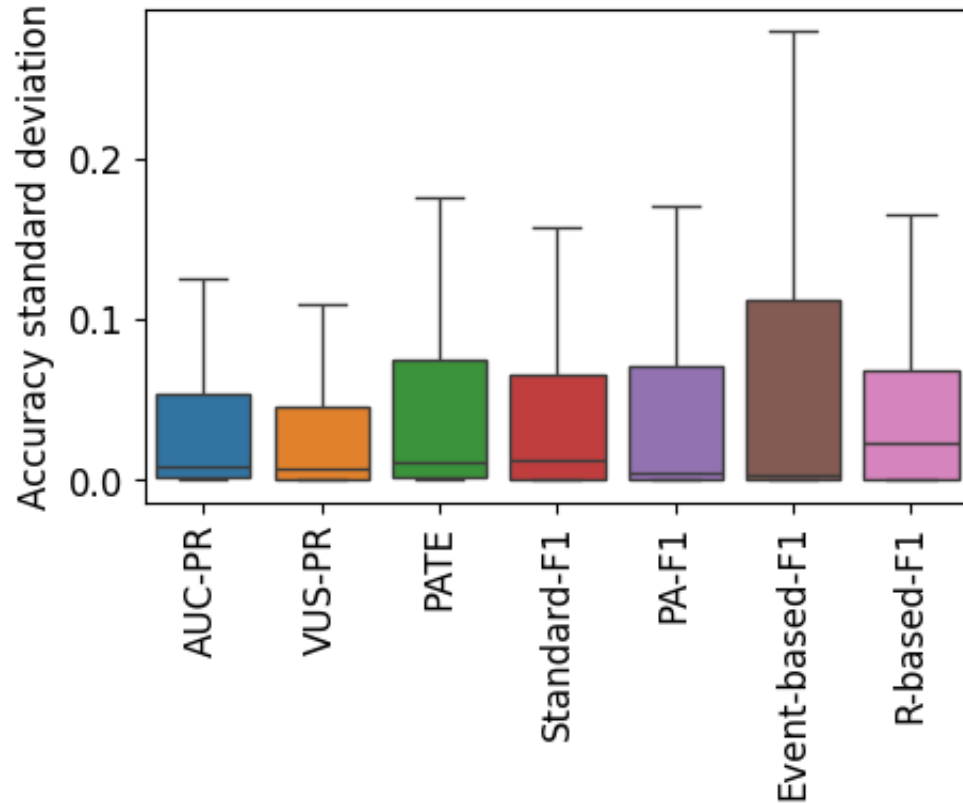


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Fail to account for time series nature

Investigation of Evaluation Measures

Sensitivity to Lags



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Investigation of Evaluation Measures

VUS-PR emerges to be the most accurate and reliable evaluation measure

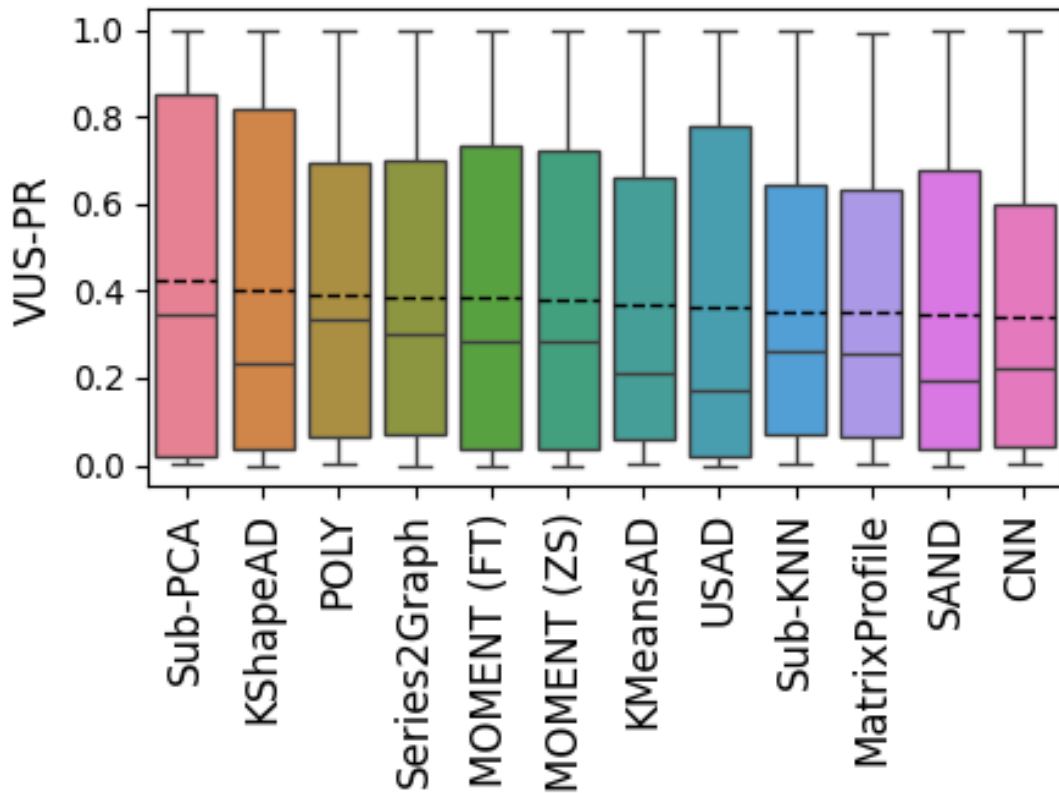
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BENCHMARKING

Benchmark Accuracy Evaluation

TSB-AD-U

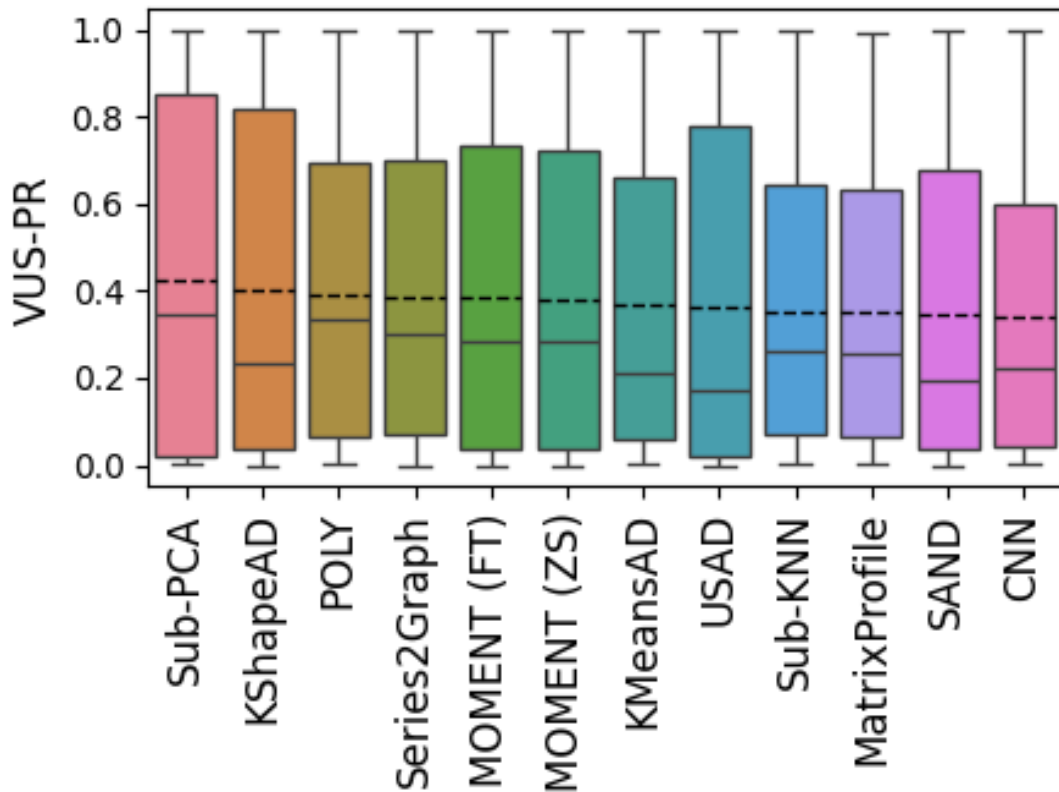


VUS-PR Ranking

1	Sub-PCA
2	KShapeAD
3	POLY
4	Series2Graph
5	MOMENT (FT)
6	MOMENT (ZS)
7	KMeansAD
8	USAD
9	Sub-KNN
10	MatrixProfile
11	SAND
12	CNN

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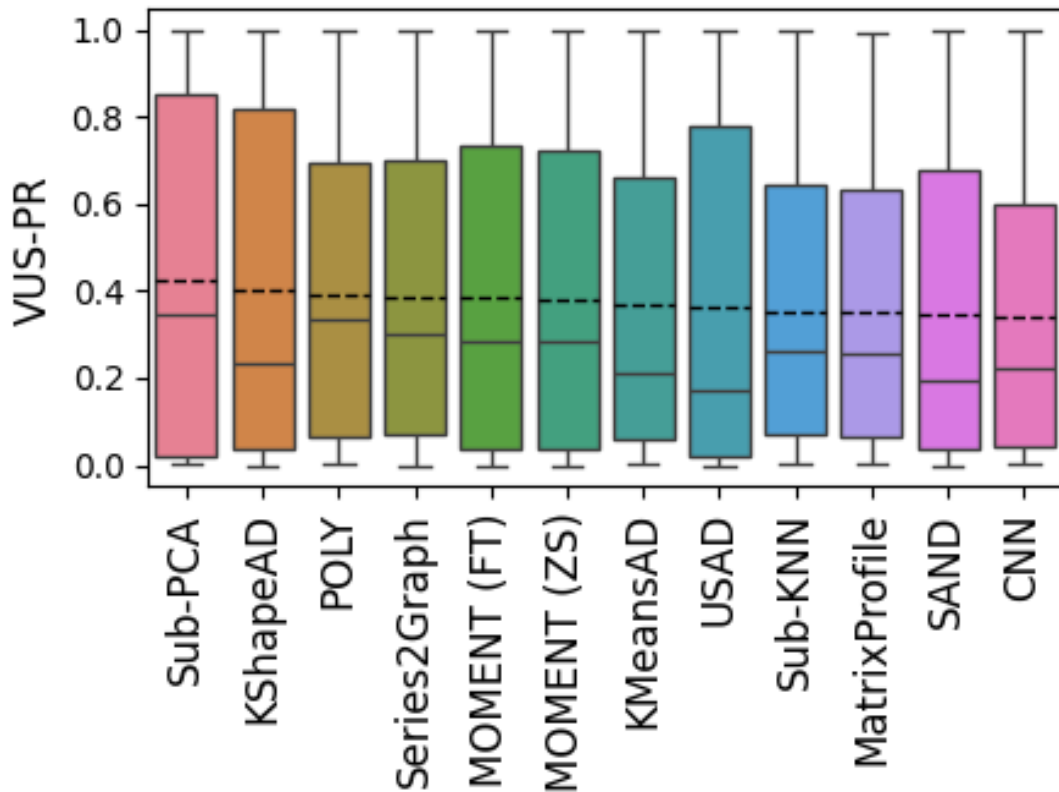
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① Top-performing methods been overlooked for many years

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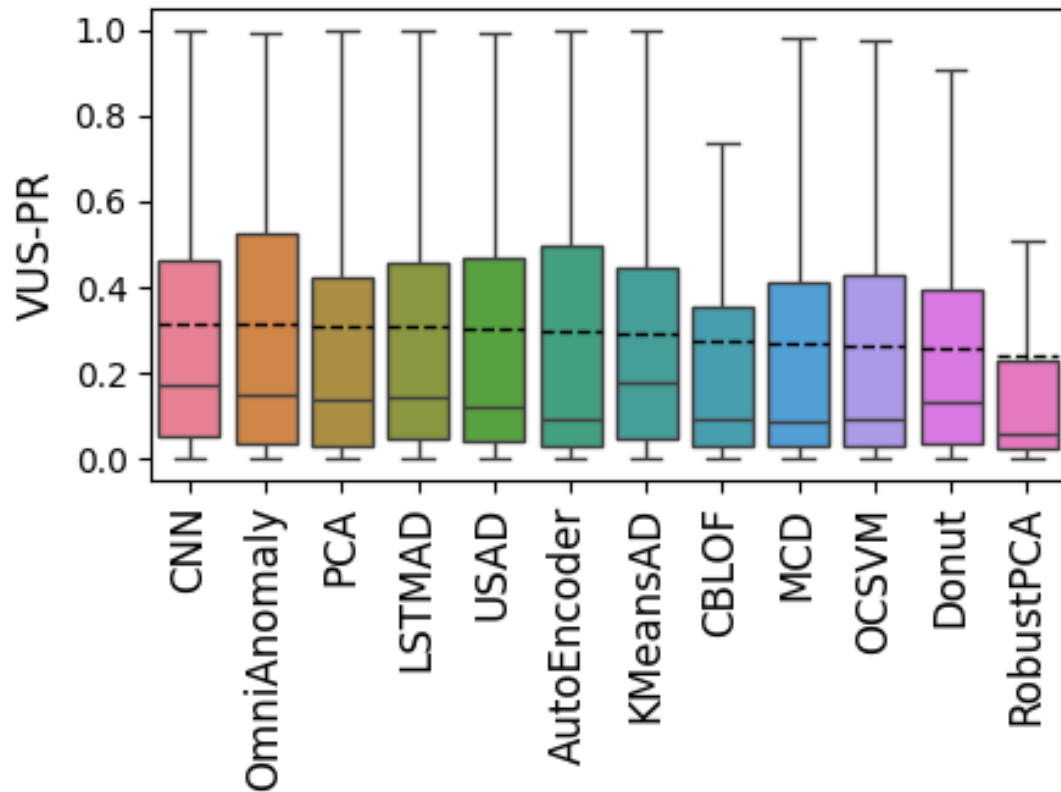
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② Performance of time-series foundation models shows promise

Benchmark Accuracy Evaluation

TSB-AD-M



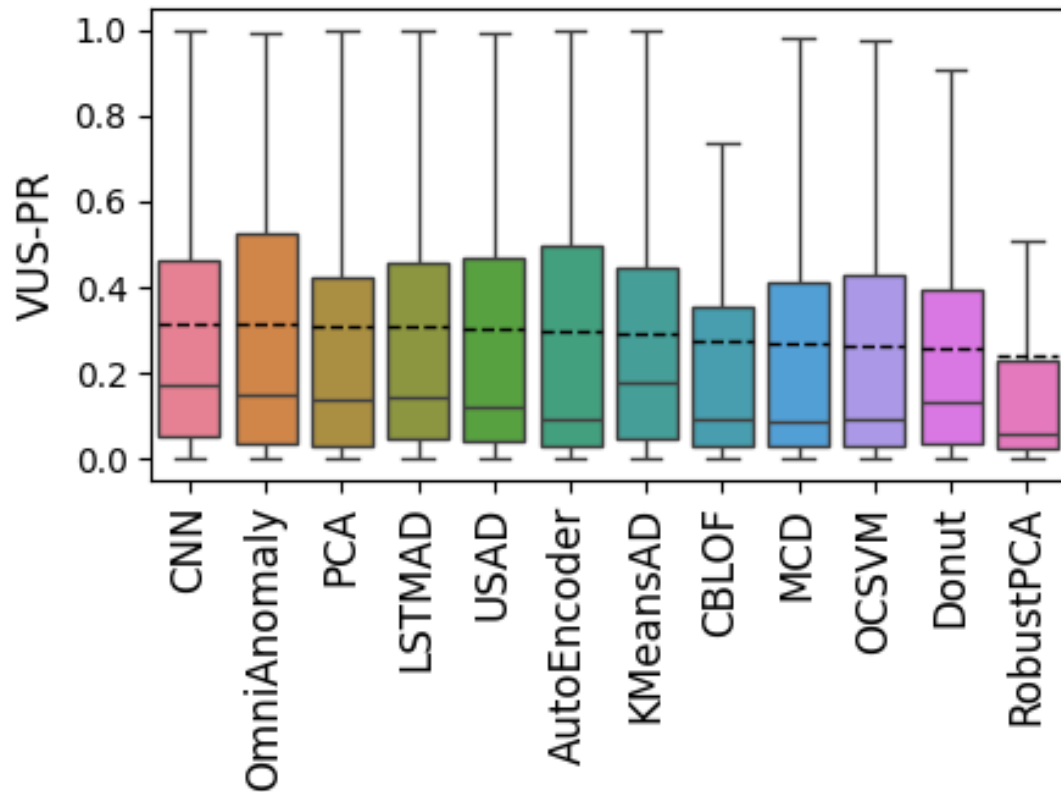
VUS-PR Ranking

1	CNN
2	OmniAnomaly
3	PCA
4	LSTMAD
5	USAD
6	AutoEncoder
7	KMeansAD
8	CBLOF
9	MCD
10	OCSVM
11	Donut
12	RobustPCA

③ Neural-network-based methods strive in multivariate cases

Benchmark Accuracy Evaluation

TSB-AD-M



VUS-PR Ranking

1	CNN
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③ Neural-network-based methods strive in multivariate cases

④ Simpler architectures generally outperform more complex designs

THANK YOU



Benchmark



Leaderboard

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