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SAFETY & SECURITY

# Improving Leakage Exploitability in Horizontal Side Channel Attacks through Anomaly Mitigation with Unsupervised Neural Networks

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# Outline


1 Horizontal Attacks

2 Impact of anomalies on PoI selection

3 Anomalies mitigation

4 Results

5 Conclusion


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# Horizontal Attacks

# Horizontal Attacks

- Single trace attack
- No profiling on open device possible, no leakage assessment.
- Usually on asymmetric implementations (RSA, ECC).
- Clustering approach:
  1. Divide trace into patterns
  2. Points of Interest (PoI) selection with univariate clustering
  3. Multidimensional clustering

**Attack success highly relies on the quality of the trace.**

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# Impact of anomalies on PoI selection

# Anomalies in data

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**Outliers (interquantile range)**

Distribution tails

$$x \notin [Q_1 - 1.5 \times IQR, Q_3 + 1.5 \times IQR]$$

# Anomalies in data

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## Outliers (interquantile range)

Distribution tails

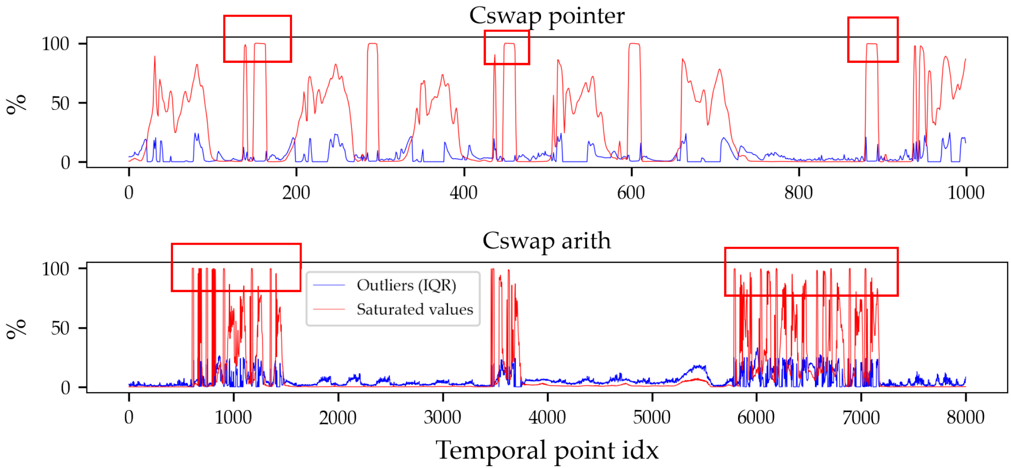
$$x \notin [Q_1 - 1.5 \times IQR, Q_3 + 1.5 \times IQR]$$

## Saturated values

min/max values of digital sampling, for 8bit:

$$x = -128 \vee x = 127$$

# Anomalies in data




[1] Average anomalies Pointer:33.3%, Arith:16.5%



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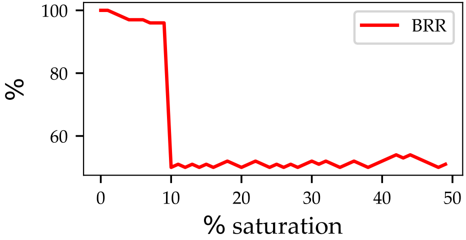
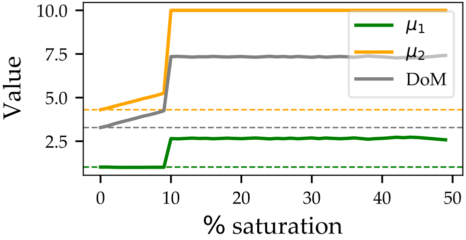
# Impact of anomalies on PoI selection

- Clustering is **not robust** to anomalies in data
- Can cause centroids shift, singularities,...

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[1] BRR: Bit Recovery Rate

# Anomalies mitigation

# Limits of simple mitigation

## Mitigation by ablation

- Remove time points based on anomalies threshold
- Possibly loosing information about the leakage

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# Limits of simple mitigation

### Mitigation by ablation

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### Mitigation by replacement

- Replace anomalies points with mean/median of non anomalies for each time point
- Decrease separability of mixture components

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# Contribution - Mitigation with neural networks

Consider alternative methods

- Able to be trained in an unsupervised manner
- Leakage/information conservation
- Two approaches:
  - Robust auto-encoder
  - CycleGAN

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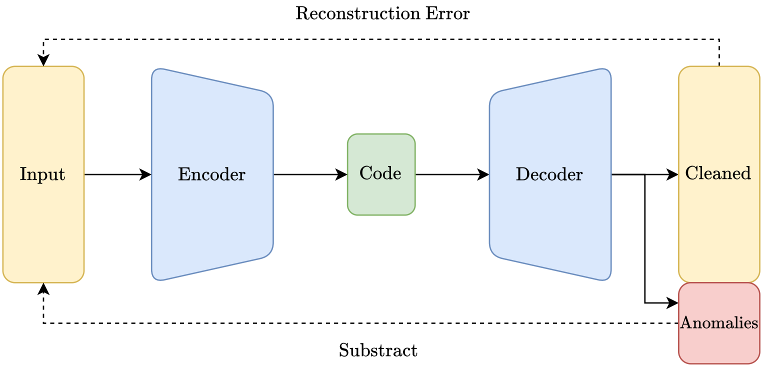
# Robust auto-encoder unsupervised mitigation

Decomposition of input data to **cleaned** and **anomalies** matrices.
Prior on the anomalies amount.

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# Limits

- RAE Generate new synthetic patterns
  $\rightarrow$ Can cause side effects on non anomalies points.
- RAE does not exploit the anomalies model.
  $\rightarrow$ Fully unsupervised

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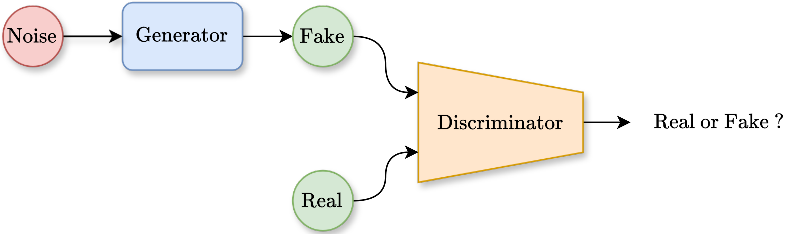
# Generative Adversarial Networks

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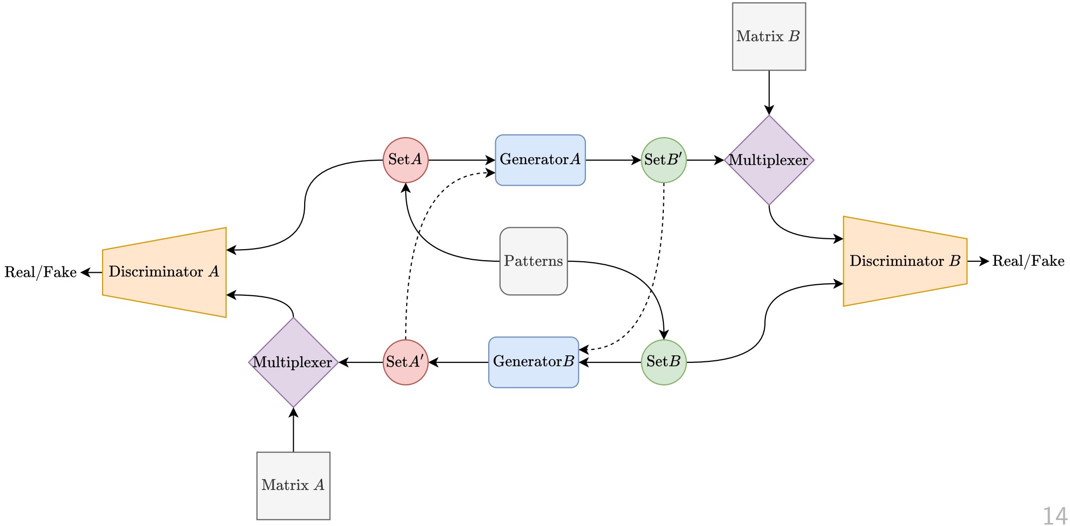
# Multiplexer CycleGAN self-supervised mitigation

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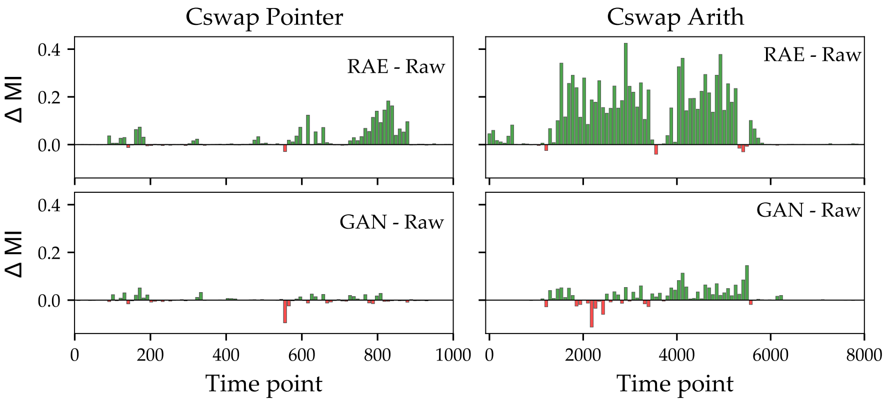
# Results

# Information conservation

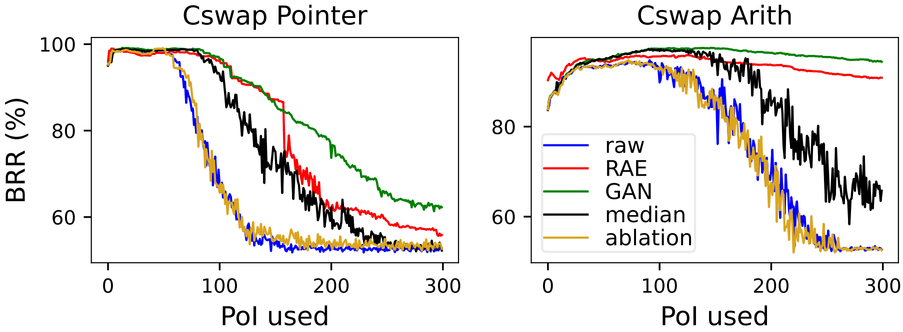
No change in the global MI. [1]




[1] Estimated with MINE.

# Supervised selection - upper bound

Select $k$ PoI with highest $t$-values and apply multidimensional clustering.

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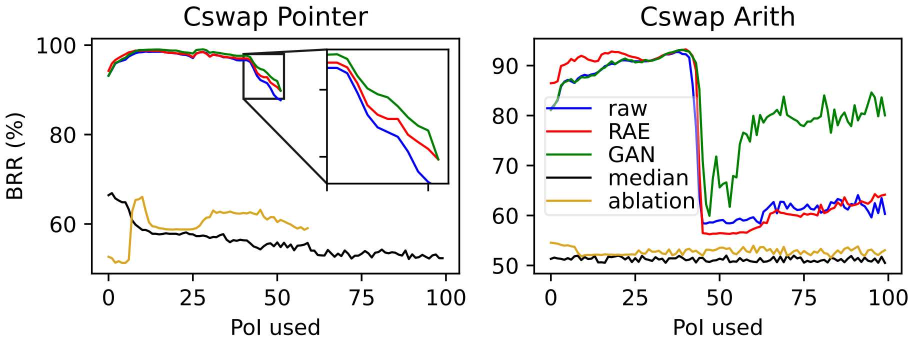
# Unsupervised selection

Multidimensional clustering on the best $k$ PoI from Cler *et al.* 2023 unsupervised selection.

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# Conclusion

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## Benefits

- Anomalies mitigation **improves leakage exploitability**
- Methods are applicable in a completely unsupervised context

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# Conclusion

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## Limitations

- Architecture choice and parameters tuning can be hard in practice
- Attack success **still** depends on the exploitation method

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# Conclusion

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- Architecture choice and parameters tuning can be hard in practice
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## Future work

- Consider additional anomalies models
- Generalize on other targets/algorithms

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# Thank you for your attention.

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Do you have any question?

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# Bonus

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