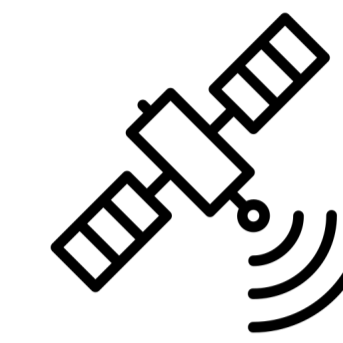


- [a] - Earth Observation Data Science, German Aerospace Center (DLR), Oberpfaffenhofen.
- [b] - Galileo Kompetenzzentrum, German Aerospace Center (DLR), Oberpfaffenhofen.

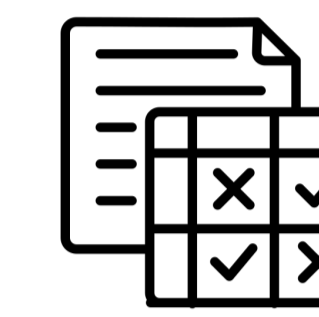
Introduction

- Modern TSAD algorithms thrive on individual anomaly types or particular distributions but may lack flexibility and fail in out-of-distributions scenarios [1].
- We explored the use of ensembles for improving robustness and trying to enable a root cause analysis in our pipeline.
- This work extends an initial benchmark of individual TSAD methods on the ESA Anomaly Detection Benchmark (ESA-ADB)[2].
- Early findings favor simple out-of-the box but robust unsupervised methods (e.g. iForest) over more advanced methods struggling with the heterogeneous dataset.

Challenges



Availability of real-world Satellite Telemetry Data.



Scarcity of Reliable Anomaly Labels.



Need for Explainability and Operator Trust.

Benchmark of performance

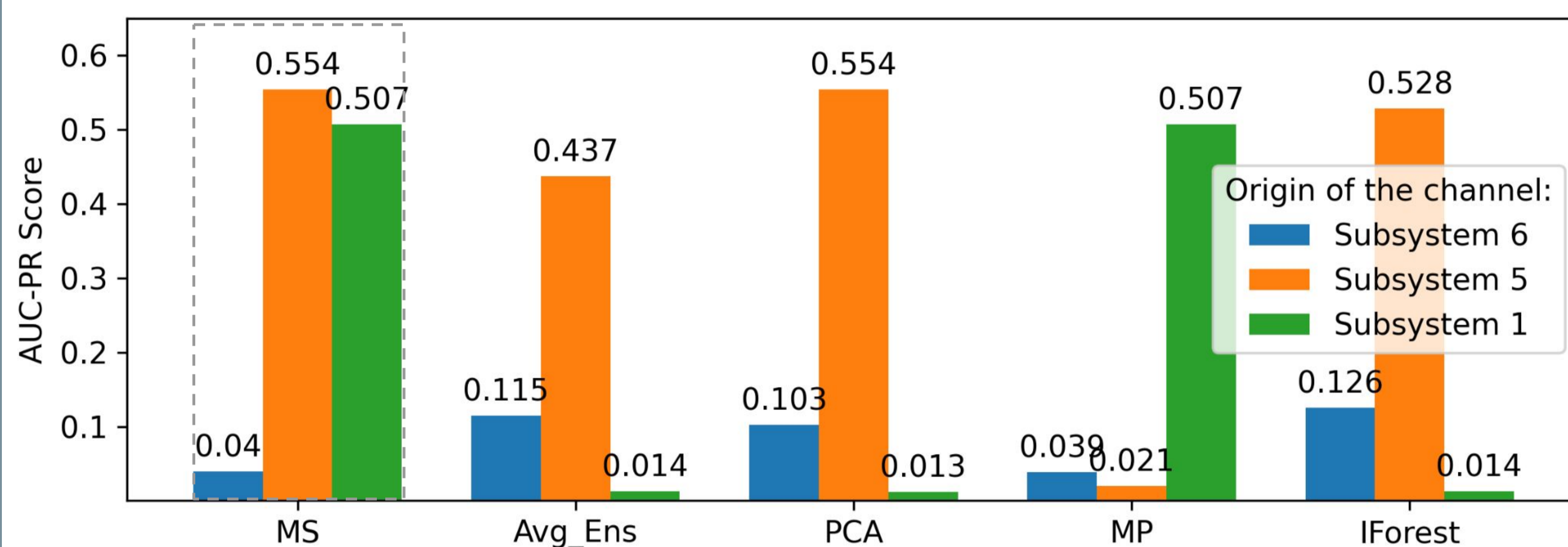


Figure 2. Benchmark of performances of the Model Selection (MS) approaches on Mission 1 of ESA-ADB dataset (test split).

- Subsystems have features that are not handled well by all algorithms.
 - Matrix Profile (MP) suits best Subsystem 1; PCA for Subsystem 5.
- On average, Model Selection improving over all other methods.

Computational cost

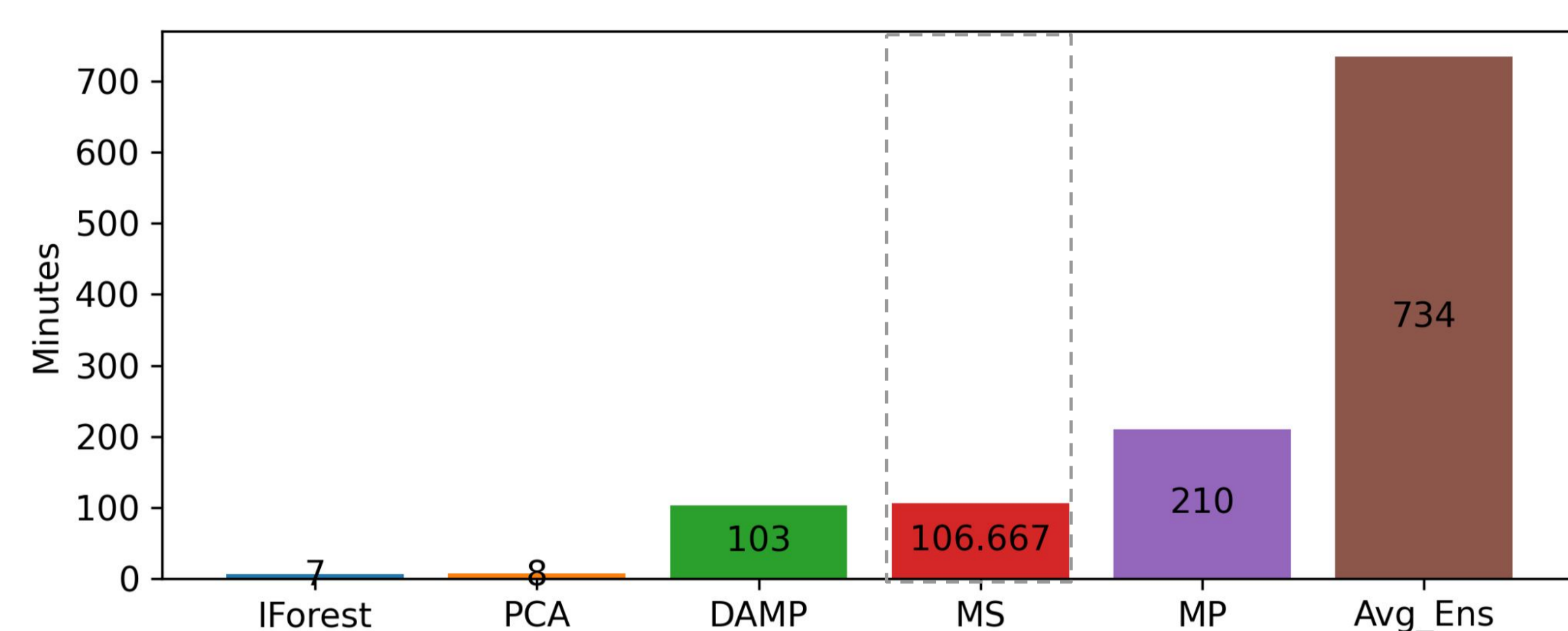


Figure 3. Execution time of the algorithms on the Mission 1 of ESA-ADB dataset.

- Non-DL methods can be very efficient: see iForest and PCA.
- Model Selection keeps costs low by recommending a single most favorable algorithm only, per subsystem.

Methodology

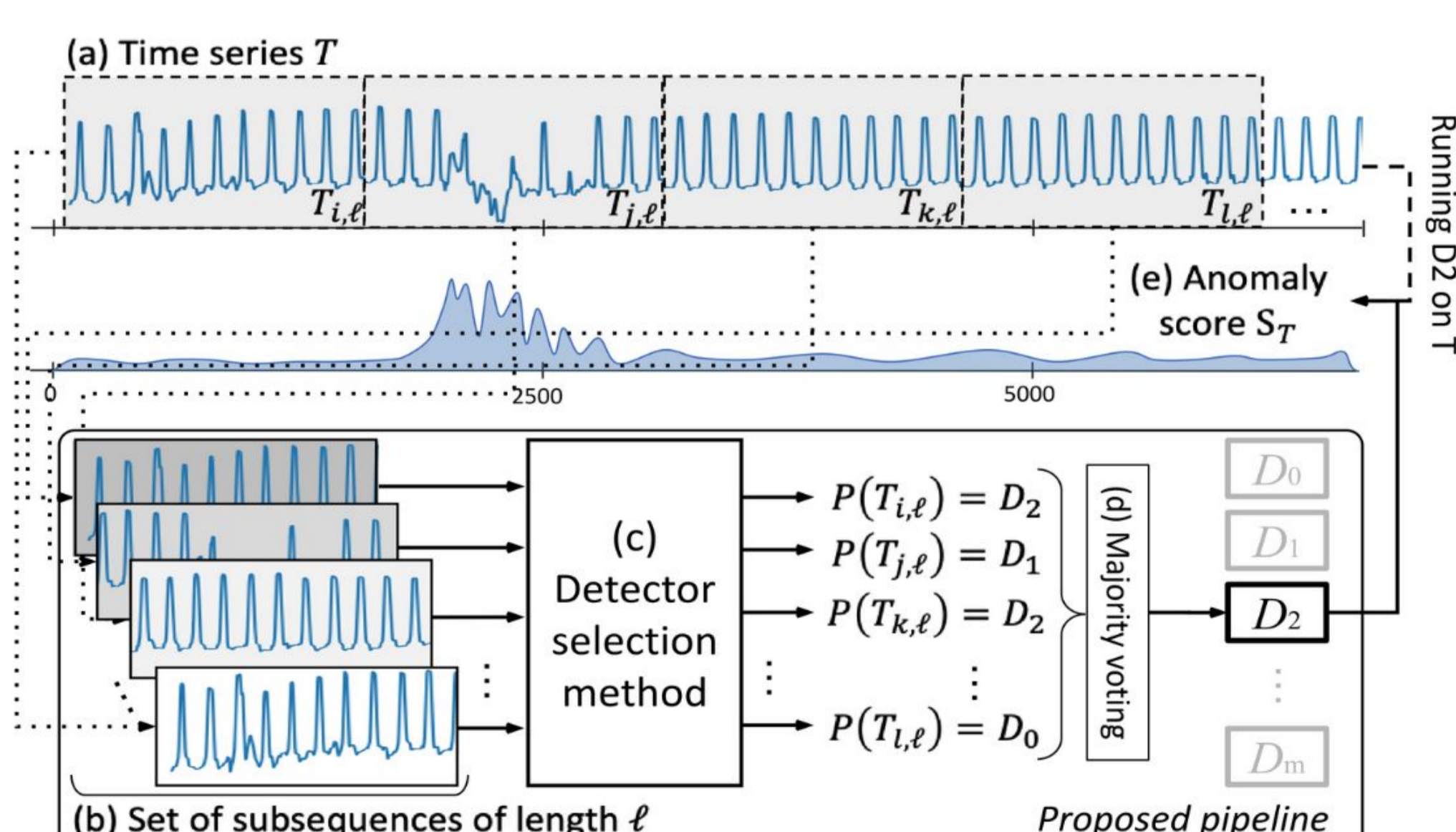


Figure 4. Pipeline of the data-driven Model Selection approach, authored by [3].

Conclusion

- Model selection is a computationally efficient solution: It selects the most suitable algorithm per subsystem, improving scalability without compromising accuracy.
- Future work:
 - Expanding to satellite constellations could enable cooperative fault detection and shared learning.
 - Exploring energy-efficient and resource-aware methods for on-board & near real-time anomaly detection.

References

- [1] Schmidl and Wenig, et al., *Anomaly Detection in Time Series: A Comprehensive Evaluation*, PVLDB 2022.
- [2] Krzysztof Kotowski et al., *European Space Agency Benchmark for Anomaly Detection in Satellite Telemetry*, Arxiv 2024.
- [3] Sylligardos et al., *Choose Wisely: An Extensive Evaluation of Model Selection for Anomaly Detection in Time Series*, PVLDB 2023.

Acknowledgment