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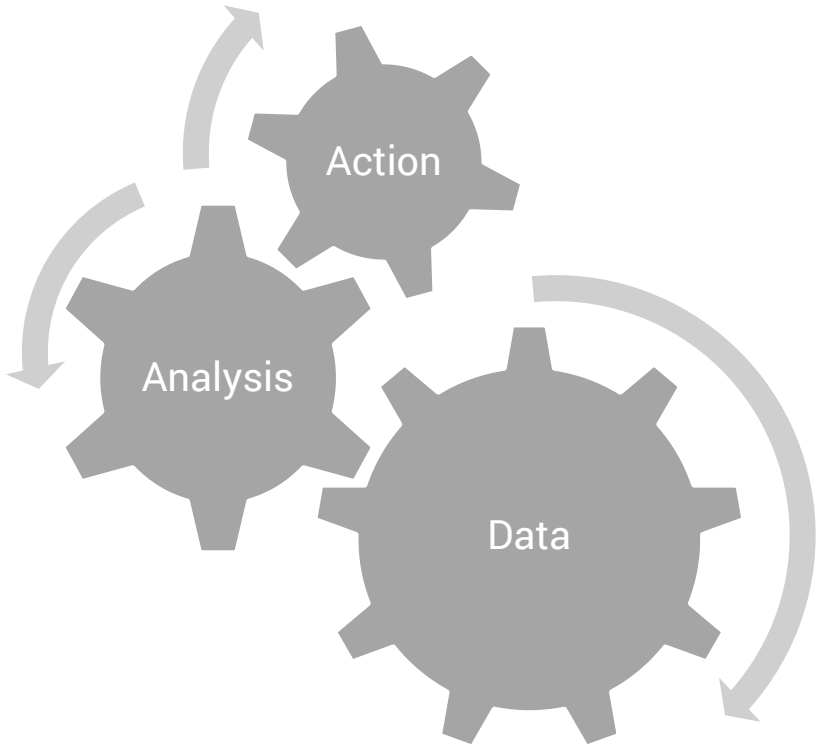
Process Mining
Motif Discovery

Motivation



Data can serve to benefit immediately when collected.

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Performance Measurement

Manual state logging (human operator).

- Prone to error, tedious, inaccurate.

Automatic logging inferred directly from sensory data.

- Accurate, tireless, more types of states can be defined.

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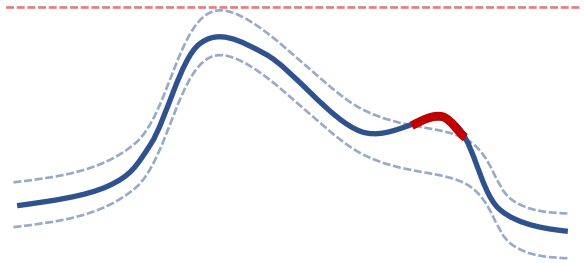
Process Deviations – Quality Fluctuations

- Alarms on thresholds are sometimes not enough to avoid quality drops.



- We can monitor the shape of process data and raise smart alarms.
- All the sensors combined create that shape.

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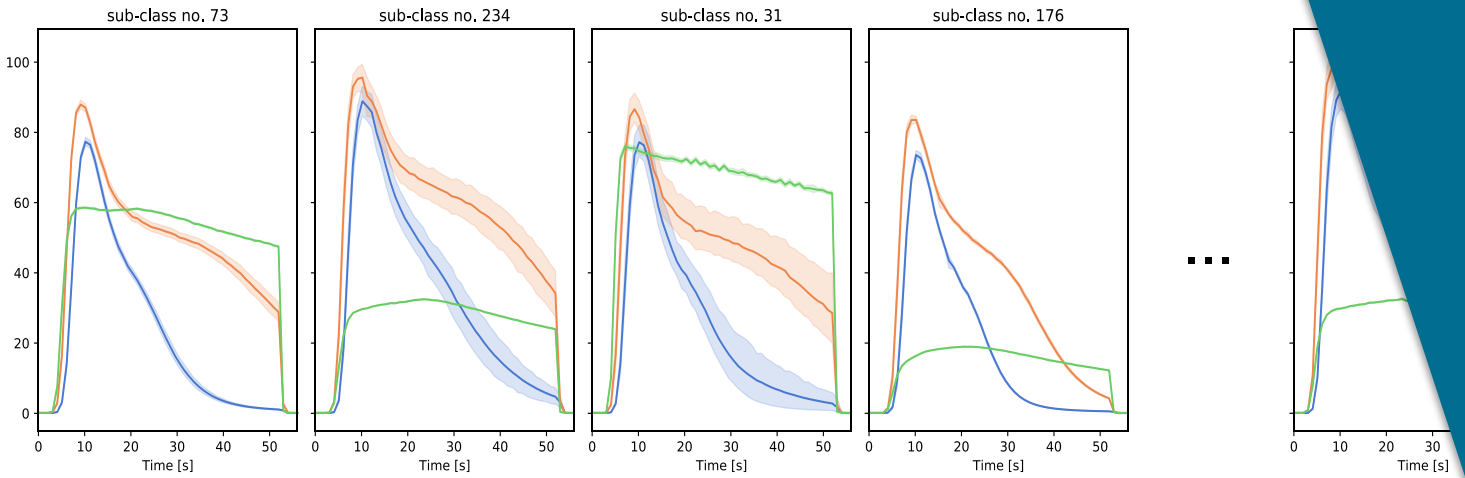
Shapes in Context

- Quality measurements do not contain enough information by themselves.

- **Process' shape** can be **connected** to the quality measurement to select the best performing shape.

MOD – Motif Discovery Tool



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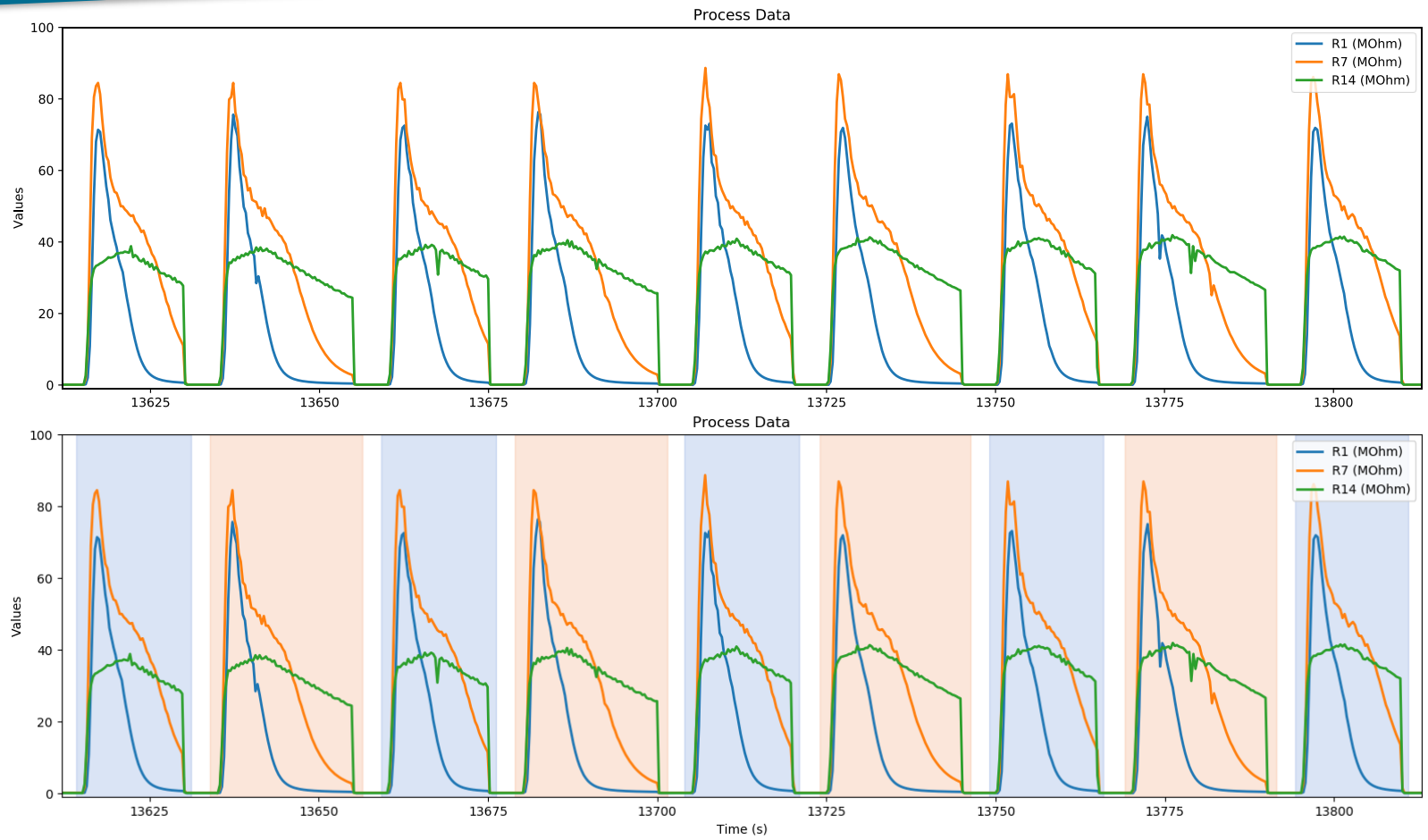
Process Data



- CO/air gas mixing platform composed of 14 (MOX) gas concentration sensors (only 3 visualized) – batched
- One data channel per sensor
- Segmentation of batches by motifs

- Can be any repetitive process

Burgués, Javier, Juan Manuel Jiménez-Soto, and Santiago Marco. "Estimation of the limit of detection in semiconductor gas sensors through linearized calibration models." Analytica chimica acta 1013 (2018): 13-25
Burgués, Javier, and Santiago Marco. "Multivariate estimation of the limit of detection by orthogonal partial least squares in temperature-modulated MOX sensors." Analytica chimica acta 1019 (2018): 49-64.

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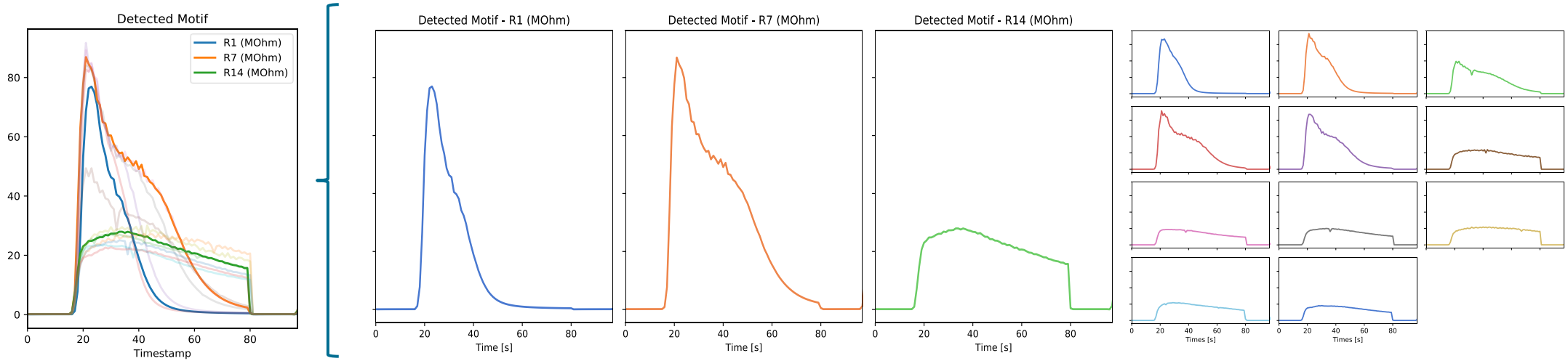
Motif – Definition

Motif is a subsequence that appears at least twice in (multichannel) timeseries.

Motif – Example (Occurence)



- Motif's shape spans across all 14 channels (sensors)
- We visualize here only 3 channels (R1, R7, R14) for clarity

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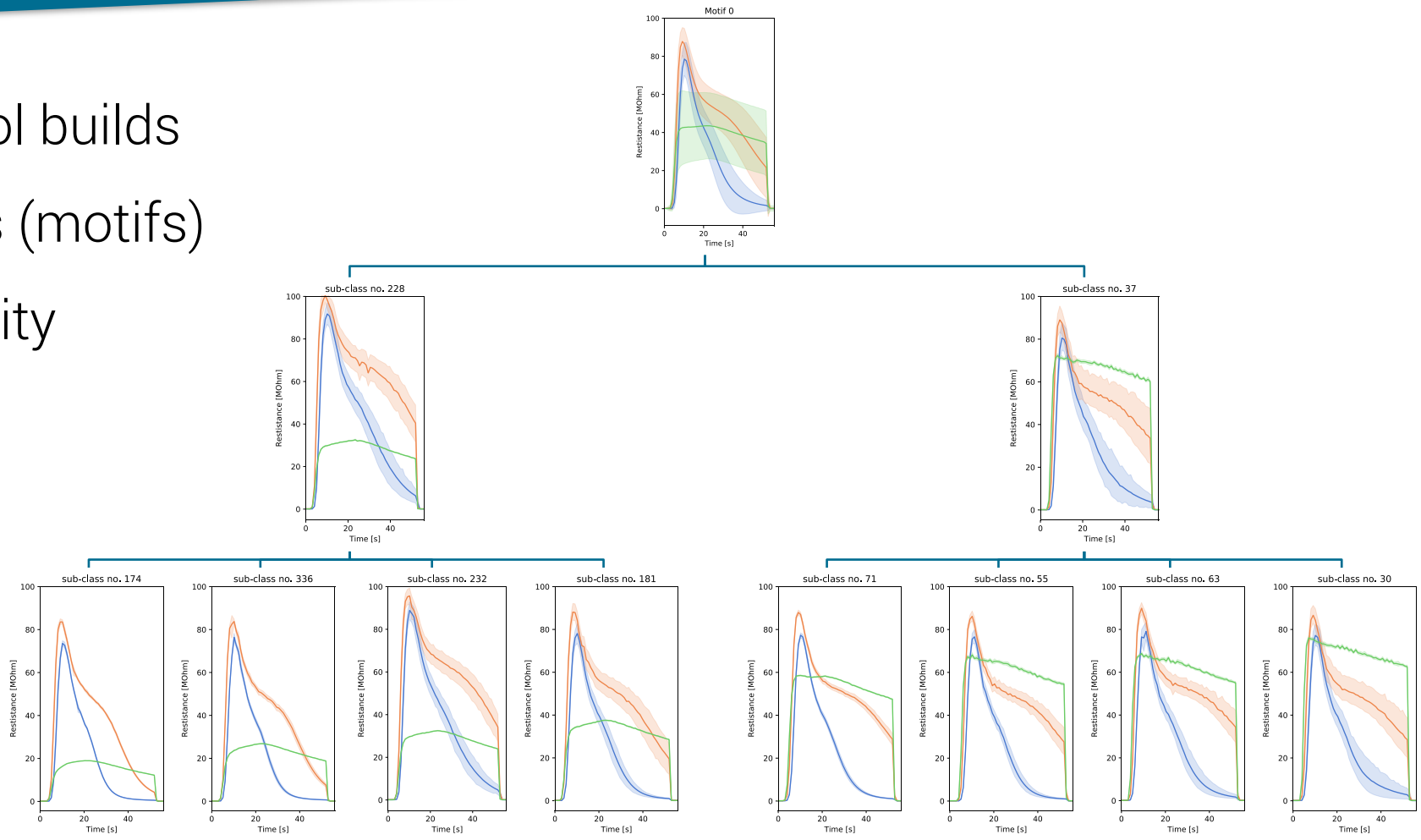
Motif – Similarity Hierarchy

- Motif Discovery Tool builds database of shapes (motifs)
- Hierarchy of similarity



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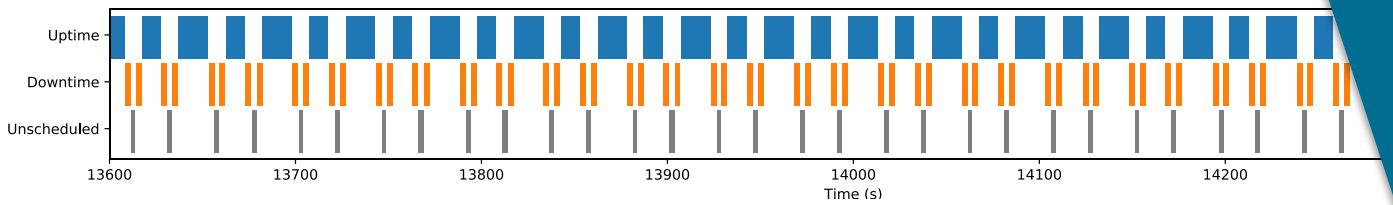
Performance Measurement of Device



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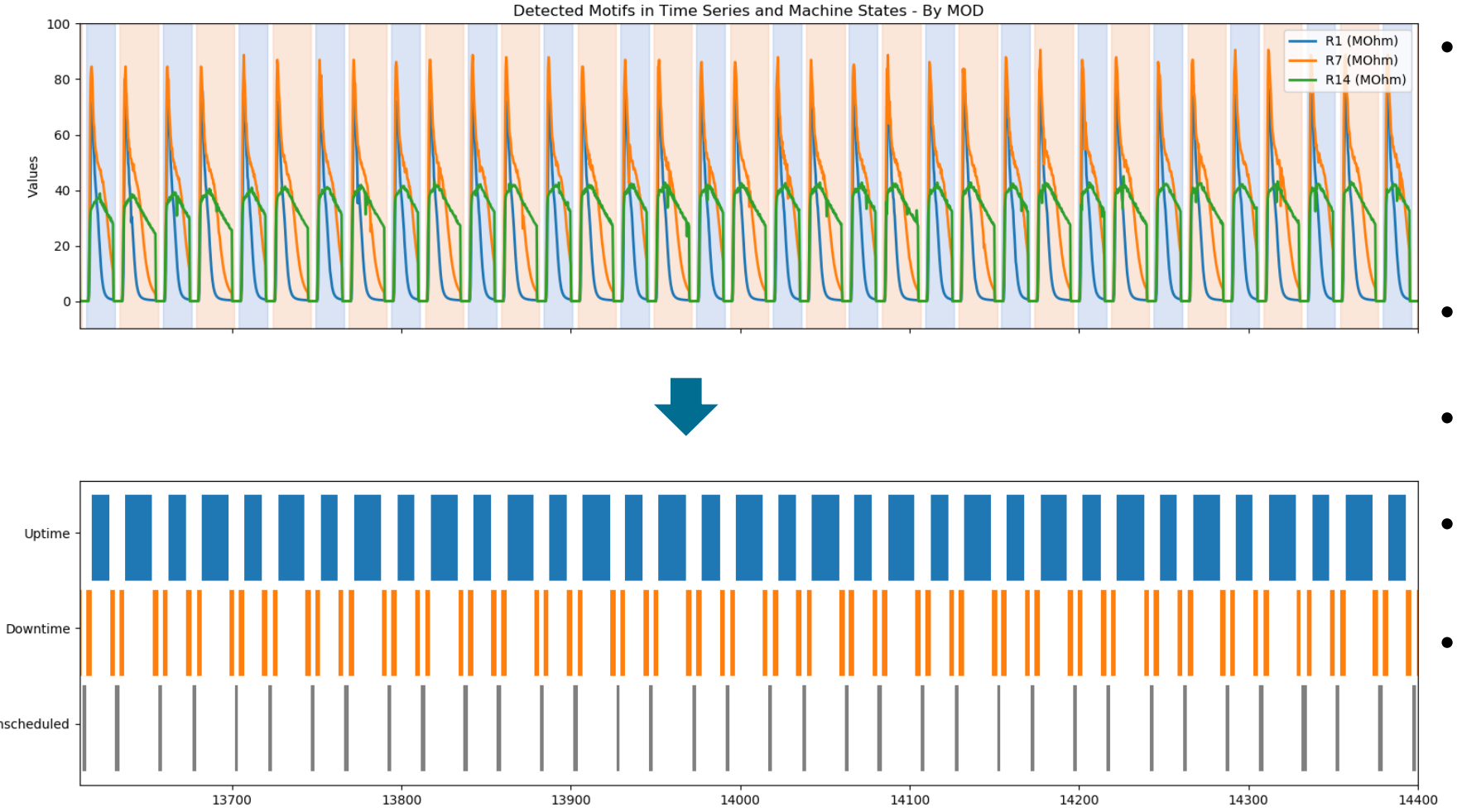
Automatic Availability



- Translate detected motifs into device states (Uptime, Downtime, Unscheduled).
- Example contains 2 kinds of Uptime.
- Downtime wraps each Uptime.
- The rest is Unscheduled.
- Reliable metric.

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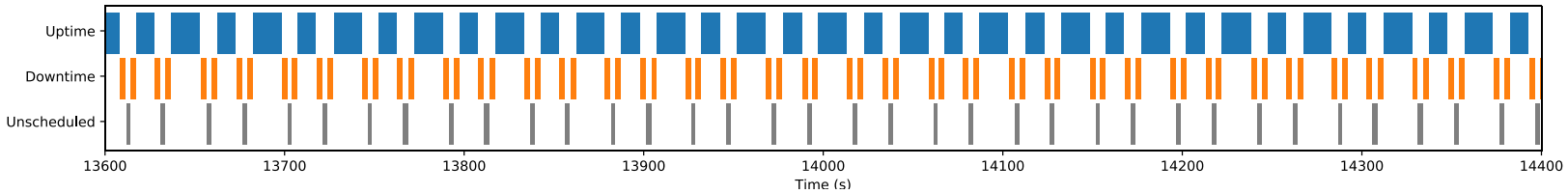
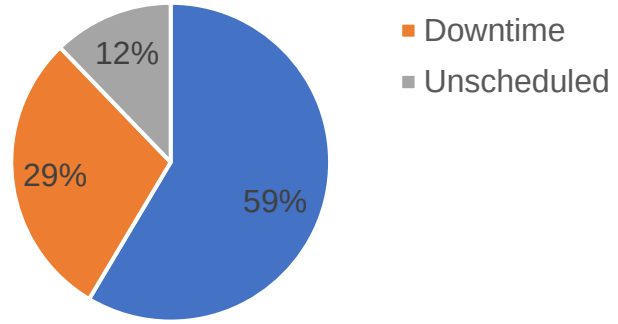
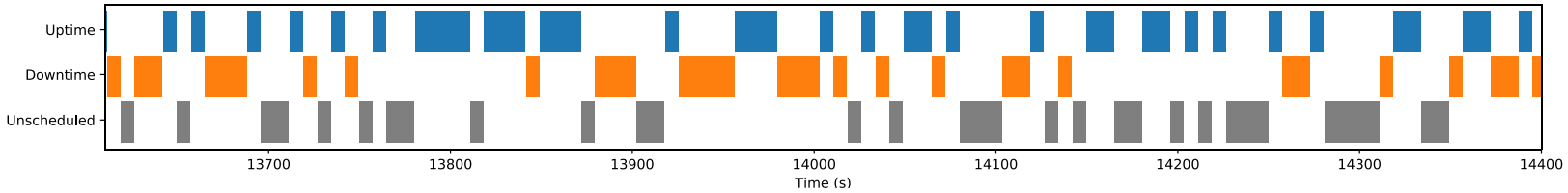
Manual vs. Detected Availability of Device

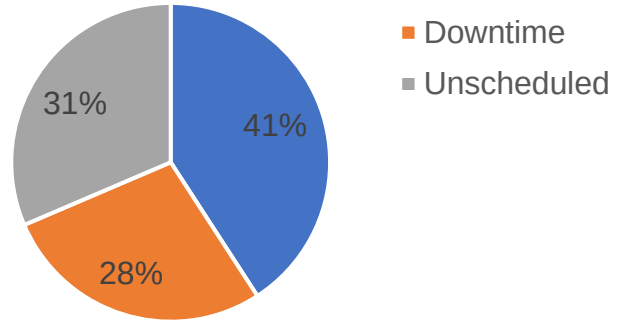
Automatic





Manual





- Manual is correct only 41% of the time

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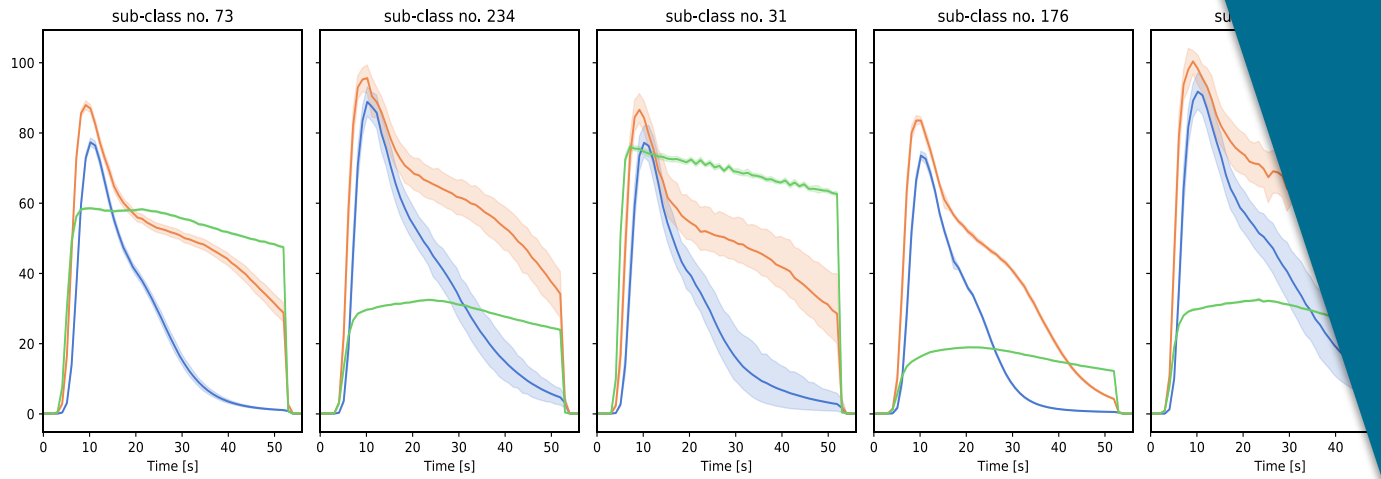
Selecting desirable motif shape



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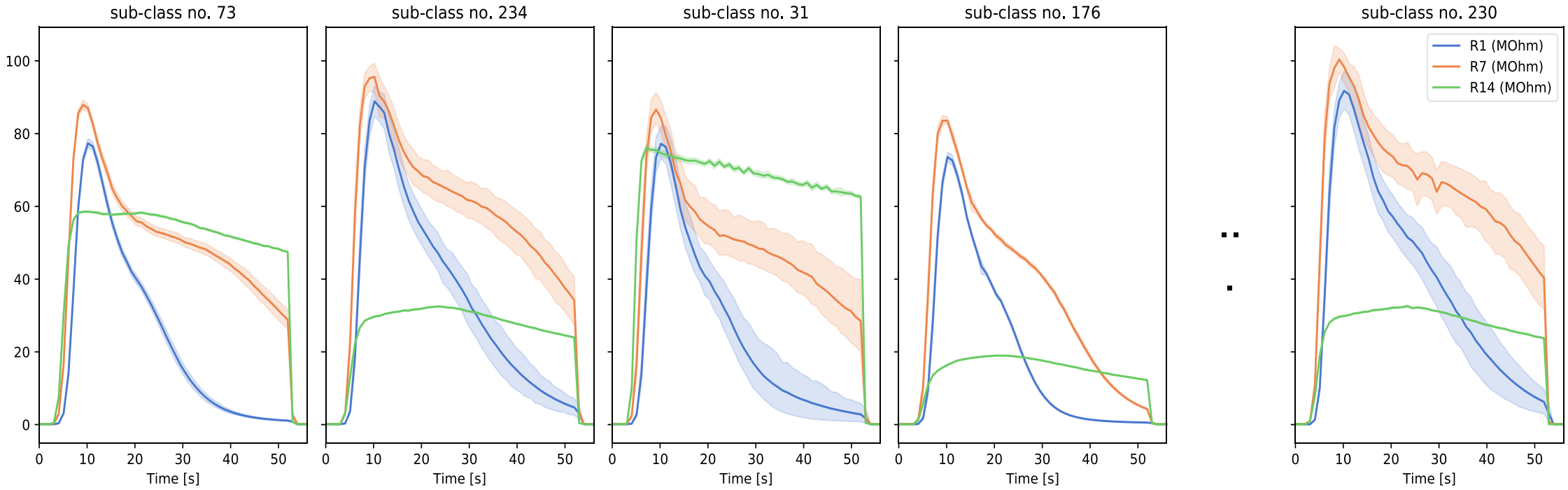
Motif Shapes in More Detail



- Classes belong to the same program execution but their shape is a bit different.
- Certain shapes produce higher quality products than others.

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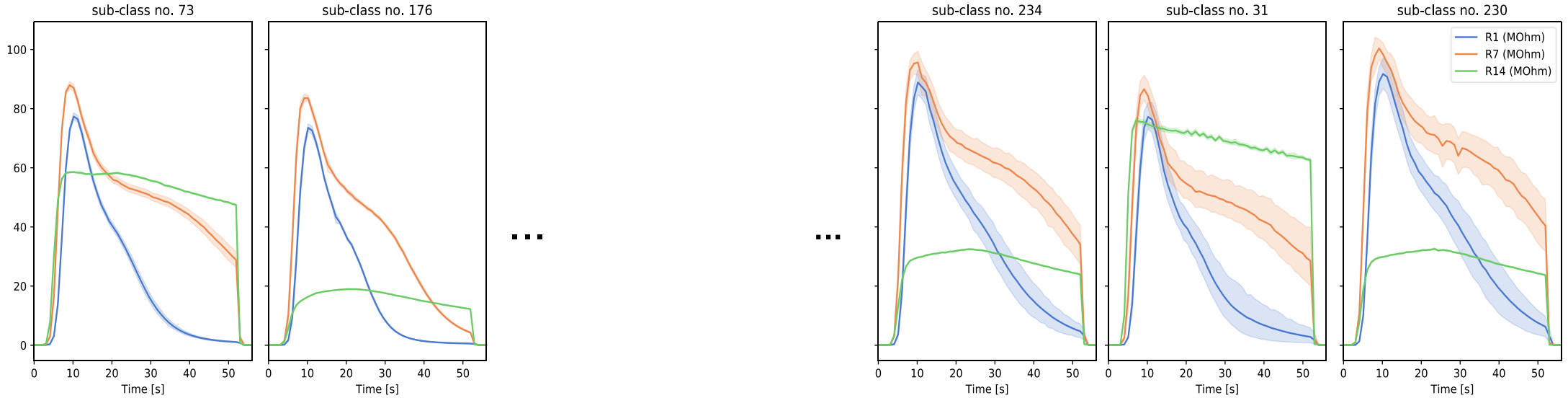
Motif Shapes in More Detail



- Ordered by their respective output quality (higher ratio of OK parts).
- All these shapes are the same motif.

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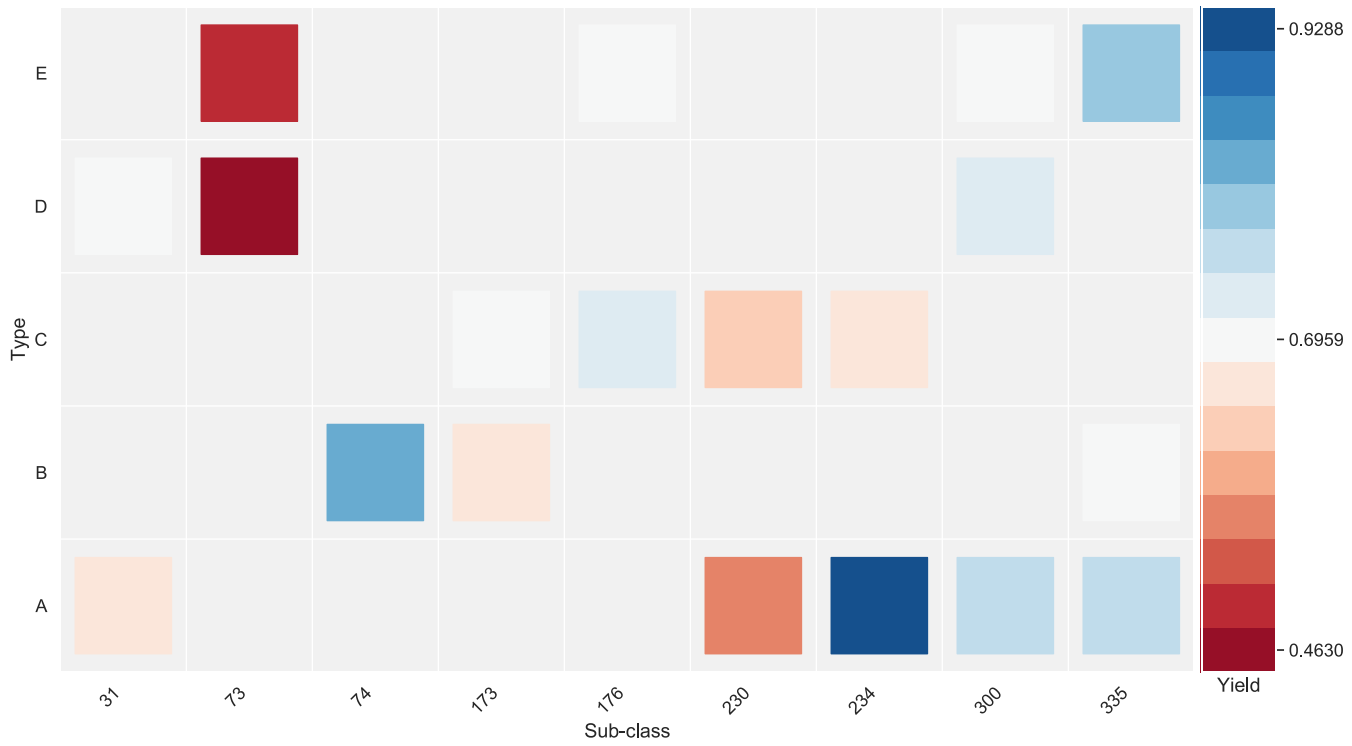
Association of Motifs with Quality



- Notion of Motifs enables Association analysis of sequences shapes
- Connection of motifs and their product quality

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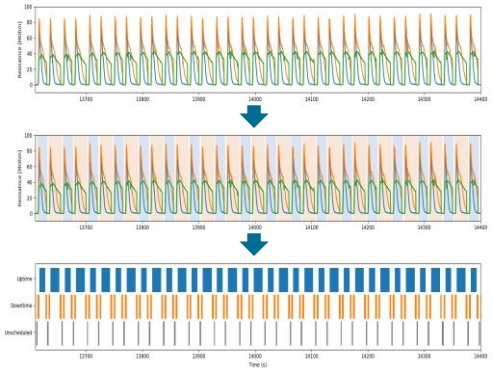
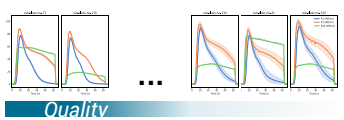
Conclusion

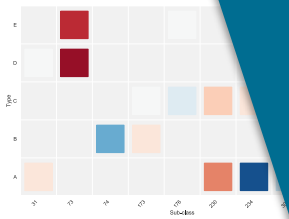
Data Acquisition



States Detection

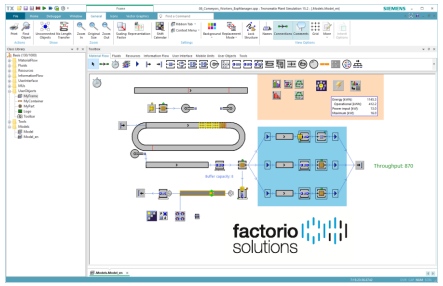


Quality Grading



Fine Tuning

Performance Metrics



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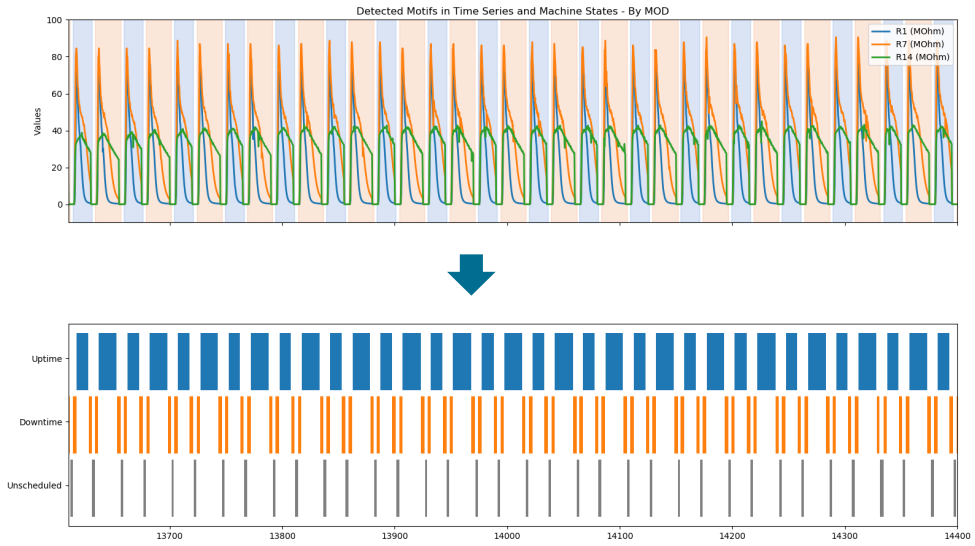
Automating Performance Measurement

- Motif Discovery Tool automates the logging process based on the process data.
- Performance estimate of the asset is reliable.



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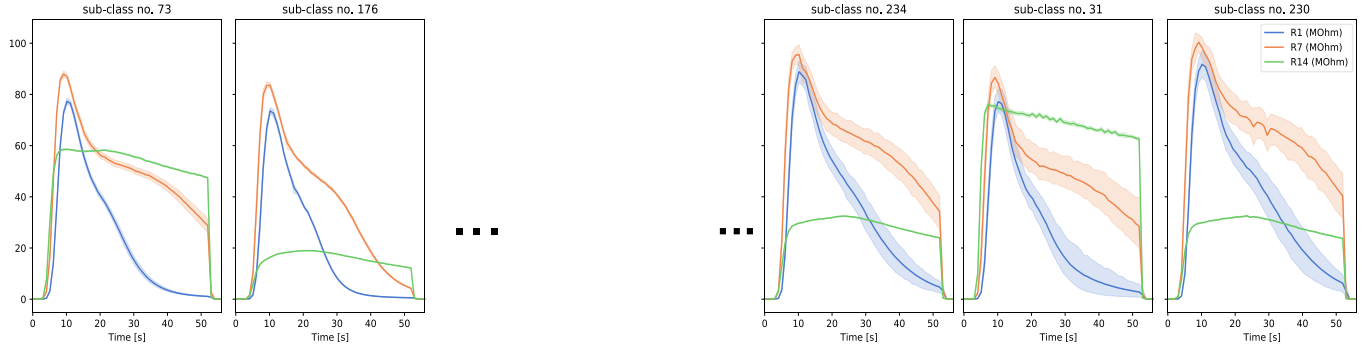
Quality and Motif Shapes

- Detailed analysis of motifs associates the motif shape to the output quality rate.
- Execute shape that perform best.



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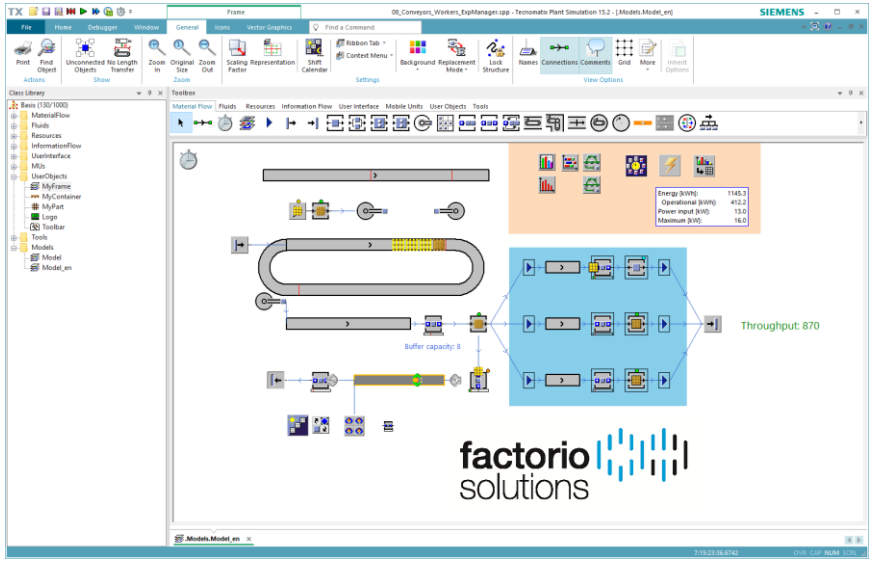
What to do next?

- Parameters of simulations can be updated by data.

  Timing of operations, yield of operations, downtimes.

- Parameters tuning based on desirable motifs.



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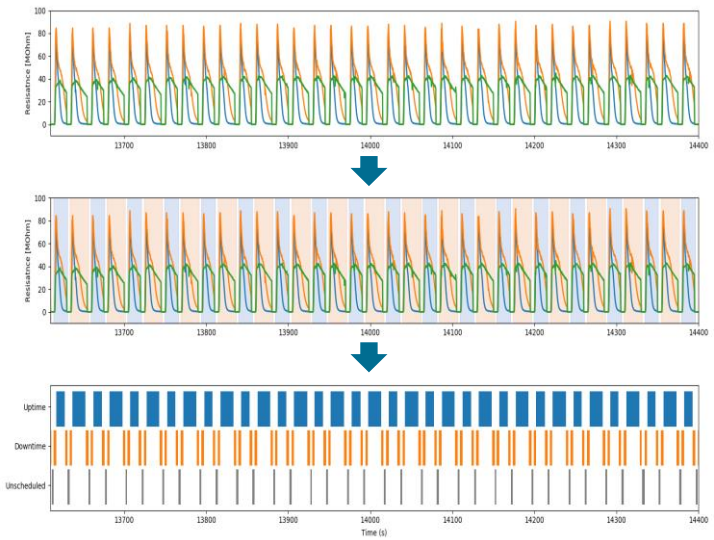
Workflow Overview

Data Acquisition



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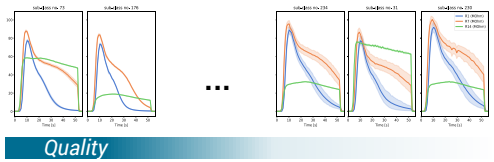

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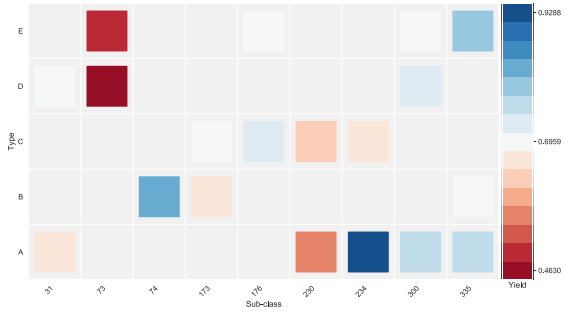

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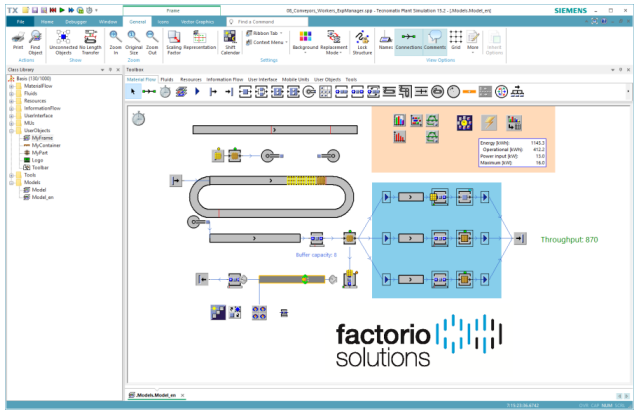
Performance Metrics



Simulation

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