Dealing with irregularly sampled and distorted data for anomaly detection of industrial robots

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**Industrial context and challenges**

- A monitoring platform will connect 800 cobots from VT plants with a diagnosis and predictive solution

- Challenges: **Intra-series irregularities** and distortion
- Goal: detect deviations on the whole trajectory
- Industrial application = frugal and glass-box approach

How can we identify outliers from a set of irregular and distorted trajectories?
Assessing the similarity between irregularly sampled time series

Dynamic Time Warping (DTW):

- The best similarity measure for distorted signals: it maps their elements non-linearly by finding the optimal warping path \( \pi_{opt} \).

Variants:

- **Subsequence-DTW**: search for a pattern allowing temporal distortions
- **Soft-DTW**: a differentiable version of the DTW measure, designed to be used in an optimization pipeline.

Solution proposal

1. Segmentation based on Subsequence-DTW
2. Synthesis of a reference trajectory
3. **Outlier detection** based on a similarity score between the designed reference and the monitored cycles

Diagnosis of cyclic behavior systems

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Abnormal trajectories monitoring: the architecture

Angular position from 6-axis manipulators

Dataset segmentation with Sub-DTW

Test dataset acquisition

Unseen operating cycles

\[ d_{score} \]

Dataset of D barycenters

Labeled trajectories

Diagnosis of cyclic behavior systems

Dataset of D barycenters

Unseen operating cycles

Angular position from 6-axis manipulators

Test dataset acquisition

\[ d = 6 \text{ joints} \]
Diagnosis of cyclic behavior systems

Trajectories labeling: some results

- The barycenter of each joint is trained with a set of 20 cycles
- The $d_{score}$ is computed between results and a test set of 70 unseen cycles
- Threshold: 2 std + mean
Conclusion

- Framework based on Sub- and Soft-DTW can:
  - Identify cycles
  - Synthesize a prototype
  - Detect abnormal trajectories

- This approach is explainable

- Possibility to find the root cause with the warping path

- Convergence is fast

Future work

- Ongoing work on a GPU-based parallelization of Soft-DTW

- Ongoing evaluation of the results depending on the quality and length of the input sequence set

- Comparison with the results of a generative model
Thank you for listening 😊