An Invariance-guided Stability Criterion for Time Series Clustering Validation

Time series clustering [1,2]

Time series: Type of data naturally organized as sequences. Functional data varying along one dimension (curve), often time but not necessarily.
Examples: sensor measurements, biological data, economic data...
Clustering: Finding groups called clusters such that elements sharing the same cluster are similar, and elements belonging to different clusters are dissimilar.

Challenges

- High dimensionality
- Temporal correlation
- **Invariance to transformations**
- Varying lengths... and many others!

Invariances

- Scale, offset
- Shifting
- Warping
- Occlusion
- Complexity, noise...

Algorithms

Method/Invariance	Scale	Shift	Warping
K-medoids + EUC	✗	✗	✗
K-medoids + COR	✓	✗	✗
K-medoids + DTW [3]	✗	✓	✓
K-shape [4]	✓	✓	✗

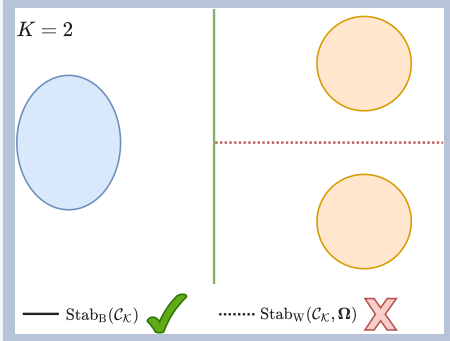
Cluster stability analysis for model selection [6,7]

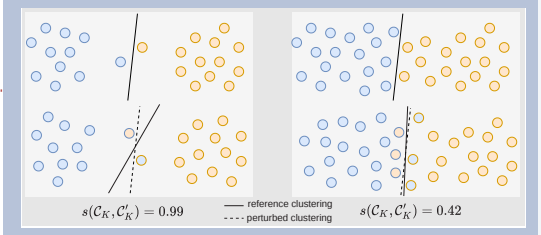
Model selection: Evaluating results of cluster analysis in a *quantitative* and *objective* fashion, in order to select the *right* number of clusters in a data set, or to tune any hyper-parameter of a clustering algorithm. **Internal clustering validity indices** [5] incorporate **strong priors on cluster geometry**.

Cluster stability analysis: a model-agnostic principle [6]

Principle: A clustering algorithm applied with the same parameters to perturbed versions of a data set should find the same structure and obtain similar results.

Stadion: trade off between- and within-cluster stability [7]





github.com/FlorentF9/skstab

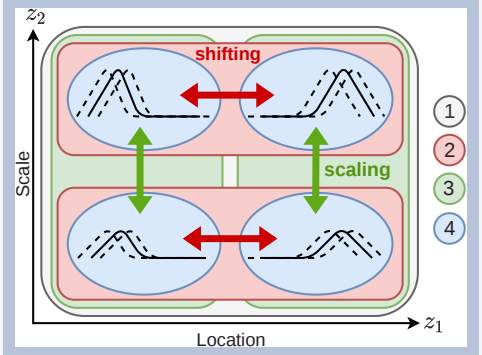
Invariance-guided stability-based model selection

Principle

Use prior knowledge on data invariances to guide the perturbation process.
E.g. shift-invariant and noisy data → random shifting and noise perturbation.

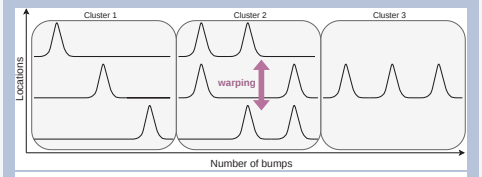
Perturbing latent factors of variation to discover resilient structures in the data.

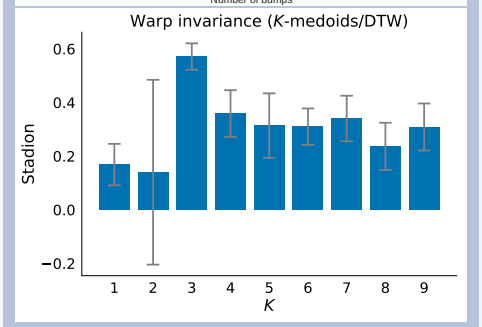
Data invariances in clustering

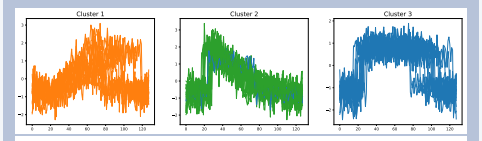


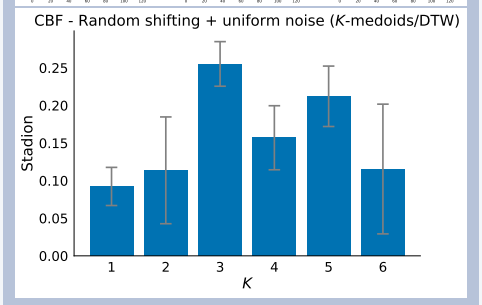
Invariances determine the cluster structure

Selecting K: a few results









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