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Subspace Clustering for Action Recognition with Covariance Representations and Temporal Pruning




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Overview

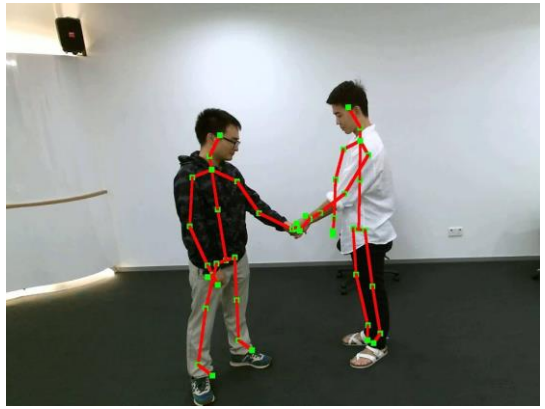
Unsupervised Human Action Recognition

- HAR using RGB videos: a challenging task
  - Background clutter,
  - Lighting and clothing variations,
  - etc.

- Skeleton-based action sequences
  - Multi-dimensional time series of *skeletal joints*

- *Subspace Clustering* on skeleton HAR
  - How to handle temporal data?

- Temporal regularization heuristics:
  - Covariance Subspace Clustering
  - Temporal Subspace Clustering
  - Time-pruning Subspace Clustering



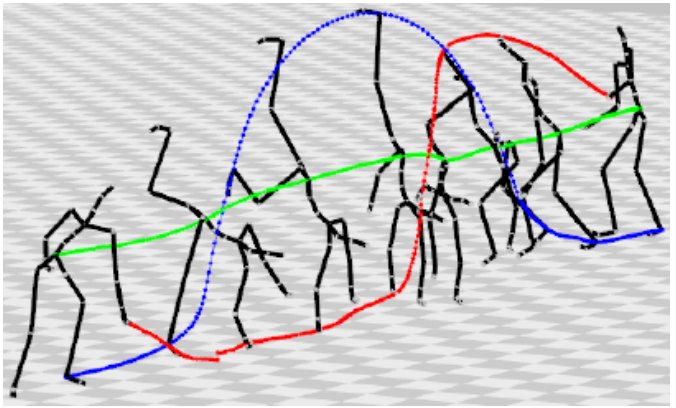
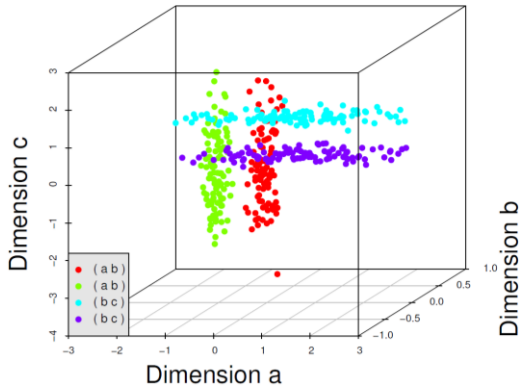


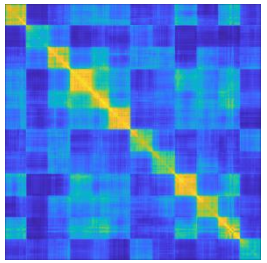
Image credit (top): Shahroudy, A., Liu, J., Ng, T. T., & Wang, G. (2016). Ntu rgb+ d: A large scale dataset for 3d human activity analysis. CVPR 2016
Image credit (bottom): Müller, M., Röder, T., Clausen, M., Eberhardt, B., Krüger, B., & Weber, A. (2007). Mocap database hdm05.

Subspace Clustering

- High-dimensional data represented as a union of *subspaces*
  - Lower dimensionality
  - Simpler geometrical structure
  - Each subspace = action class
  - Affinity matrix + spectral clustering = unsupervised action labels



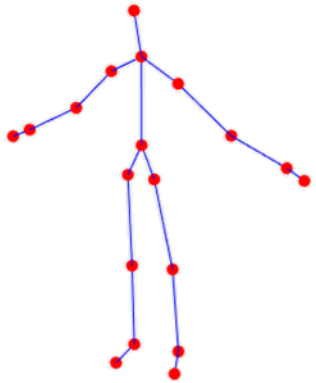
- Subspace Clustering on skeleton-based HAR
  - Limitedly explored due to noisy data, missing joints, etc.

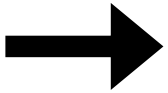


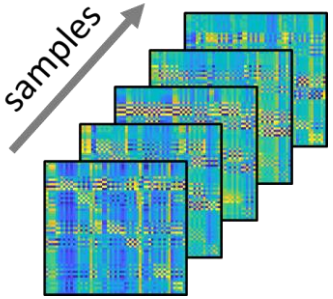
- Subspace Clustering methods to build affinity matrix
  - *Self-expressiveness* based Subspace Clustering
  - *Dictionary* based Subspace Clustering

Image credit: Parsons, L., Haque, E., & Liu, H. (2004). Subspace clustering for high dimensional data: a review.

Temporal regularization heuristics







Covariance Subspace Clustering

- Covariance encoding as descriptor to each skeleton data
- Flattened covariance as input
- Self-expressiveness based Subspace Clustering
- Spectral Clustering + Hungarian

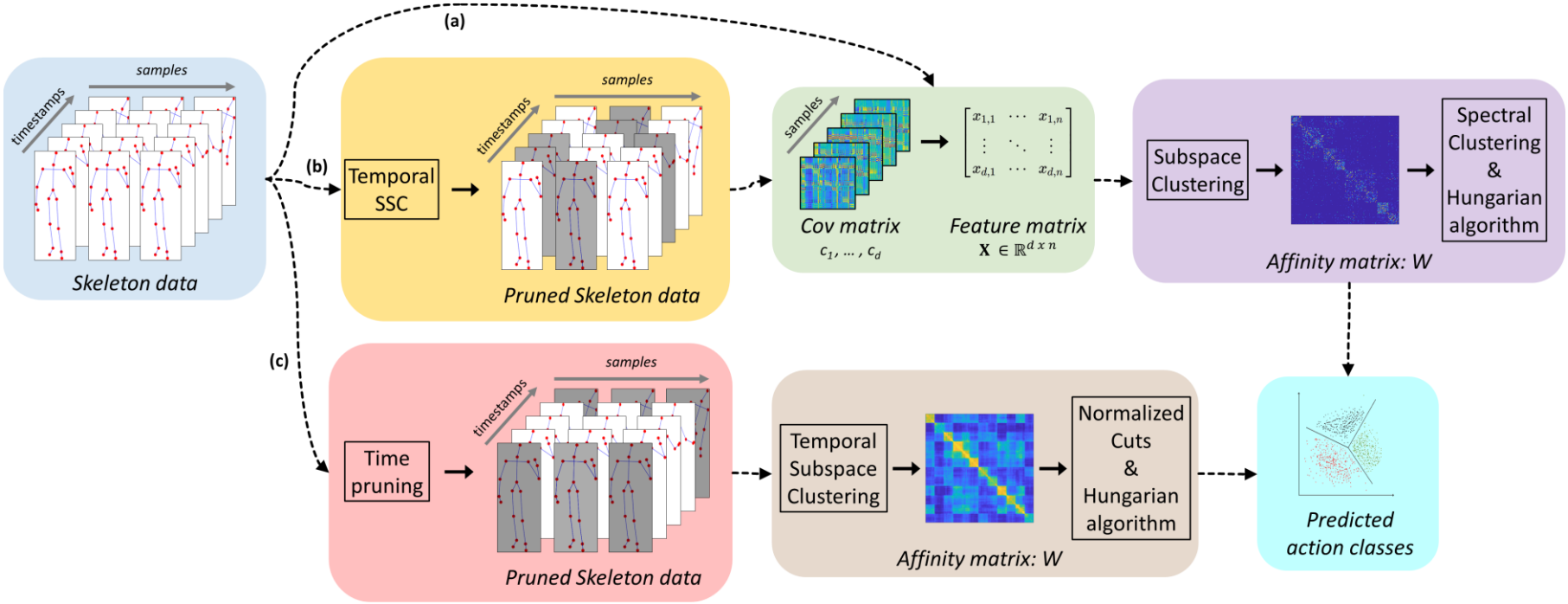
Temporal Subspace Clustering

- Subspace Clustering as a pre-processing stage
- Fixed length action sequence compression
- Self-expressiveness based Subspace Clustering
- Spectral Clustering + Hungarian

Time-pruning Subspace Clustering

- Fixed length action sequence compression
- Dictionary-based Subspace Clustering [1]
- Normalized cuts + Hungarian

Unsupervised HAR pipeline



- Temporal information heuristics
  a) Covariance Subspace Clustering
  b) Temporal Subspace Clustering
  c) Time-pruning Subspace Clustering
- Spectral Clustering / Normalized Cuts
- Hungarian algorithm

We provide…

- Subspace clustering approaches for HAR
- Extensive experiments on skeleton-joints datasets
- Covariance representations and time-pruning strategies for temporal data
- Favorable results w.r.t. supervised state-of-the-art
  - …in some cases even surpassing them!

Code available!

https://github.com/IIT-PAVIS/subspace-clustering-action-recognition

Thank you!