



# Classification of Graph Sequences Utilizing the Eigenvalues of the Distance Matrices and Hidden Markov Model

Miriam Schmidt, Friedhelm Schwenker

# Classification Task

- Classification of human activities based on sequences of camera images.
- 289 video clips
- Length between one and eight seconds
- Resolution: 356 x 474 pixels
- Frame rate: 24 fps
- A male person is recorded, sitting at a table, acting different action classes.
- Every sequence belongs to one of the three classes:
  - Person **drinks** out of the cup.
  - Person **moves** the cup on the table.
  - Person **scratches** his head.



# Graph and Feature Extraction

For each single image:

- Locations of the person's body parts (hand, head) and objects (cup) have to be estimated.
- Objects refer to the nodes of a graph.
- Euclidean distances between all pairs of detected objects are computed:  $d(i, j) \forall i, j \in \text{nodes}$
- Nodes labeled with the coordinates, edges with the Euclidean distances between the adjacent nodes.



- Computation of the eigenvalues of the weighted adjacency matrix  $\mathbf{A}$  with  $a_{ij} = d(i, j)$  for  $i \neq j$  and  $a_{ij} = 0$  for  $i = j$ .
- Computation of the eigenvalues of the extension  $\mathbf{A}^+$  with  $a_{ij}^+ = a_{ij}$  for  $i \neq j$  and  $a_{ij}^+ = \sum_k d(i, k)$  for  $i = j$ .

The spectra (one spectrum taken from one single image) are forming a sequence, which serves as the input to Gaussian mixture models (GMMs), which are utilized to estimate the emission probabilities of hidden Markov models (HMMs).



# Experiments

## Settings of the HMMs and GMMs:

- 3 HMMs: The probability  $P(O|\lambda_i)$ ,  $i=1,\dots,3$ , that the HMM  $\lambda_i$  generated the test sequence  $O$ , was estimated with the forward algorithm. The maximum of the three achieved values  $P(O|\lambda_i)$  leads to the most likely class.
- Verification of the number of states in each HMM and the number of Gaussian distributions in each state.
- Fully connected models and left-right models were tested.
- Full and diagonal covariance matrices were tested.

## Classification experiments:

- Investigation of the temporal development of the eigenvalues.
- How many eigenvalues are necessary to get still satisfying classification rates?
- What happens, if a second cup stands on the table and/or a second person is sitting at the table (more objects and different number of nodes)?

**For the answers and a more detailed discussion, meet me at my poster no.7!**

