Data

Data_Correct: raw measurements of the correct movements.

Data_Incorrect: raw measurements of the incorrect movements.

The movement data are for the Standing Shoulder Abduction exercise from the UI-PRMD dataset (University of Idaho – Physical Rehabilitation Movements Dataset). The data comprise angular joint displacements collected with a Vicon optical tracker. The tracking system captured 3-axial orientations of 39 skeletal joints, resulting in 117-dimensional data sequences.

Ten subjects performed 10 repetitions of the Standing Shoulder Abduction exercise (that is Exercise 7 in the UI-PRMD dataset). However, some of the subjects performed the exercise with the right hand and some with the left hand. Also, for all subjects the beginning measurements for the first repetitions were not captured with the Vicon system. We removed manually those inconsistent repetitions, hence, the above data includes 63 repetitions, as listed in the table below.

Exercise 7 - Standing Shoulder Abduction	
Subject 1 (9 repetitions)	2, 3, 4, 5, 6, 7, 8, 9, 10
Subject 2 (9 repetitions)	2, 3, 4, 5, 6, 7, 8, 9, 10
Subject 3 (9 repetitions)	2, 3, 4, 5, 6, 7, 8, 9, 10
Subject 4 (9 repetitions)	2, 3, 4, 5, 6, 7, 8, 9, 10
Subject 5 (9 repetitions)	2, 3, 4, 5, 6, 7, 8, 9, 10
Subject 6 (0 repetitions)	
Subject 7 (0 repetitions):	
Subject 8 (9 repetitions):	2, 3, 4, 5, 6, 7, 8, 9, 10
Subject 9 (9 repetitions):	2, 3, 4, 5, 6, 7, 8, 9, 10
Subject 10 (0 repetitions):	

The subjects performed the exercise in a correct and incorrect manner. Therefore, there are 63 incorrectly performed repetitions, performed by the same subjects and corresponding to the correctly performed repetitions.

All repetitions are linearly scaled to a length of 229 time steps (this is the average length of the repetitions). In addition, the sequences are centered to have a zero mean, and the angular values are scaled into the [-1, 1] range by dividing all sequences with a scaling_value found as the maximum value of all repetitions in the dataset.

Autoencoder_output_correct: the output data of the autoencoder for the correct sequences (63 sequences of size 229x4, since the autoencoder reduced the dimensionality to 4 dimensions).

Autoencoder_output_incorrect: the output data of the autoencoder for the incorrect sequences (63 sequences of size 229x4, since the autoencoder reduced the dimensionality to 4 dimensions).

Dimensionality Reduction

Autoencoder_Movements: trains an autoencoder on the correct movements data, and reduces the dimensionality of the correct and incorrect movements to four dimensions.

M07ViconDataLoader: is used for loading the data to the Autoencoder_Movements code.

Statistical Modeling

Autoencoder_GMM: employs a Gaussian Mixture Model (GMM) for modeling the data with reduced dimensionality obtained by the autoencoder.

PCA_GMM: employs a GMM for modeling the data with reduced dimensionality obtained by PCA.

Max_Variance_GMM: employs a GMM for modeling the data with reduced dimensionality obtained by the maximum variance approach.

GMM_Loglikelihood_Scores: uses loglikelihood of the trained GMM model on the autoencoder data for assessment of correct and incorrect sequences.

GMM_Performance_Indicators: calculates performance indicators in the [0,1] range based on a trained GMM model on the autoencoder data.

Prepare_Data_for_NN: reads the data for the Standing Shoulder Abduction exercise from the UI-PRMD dataset and prepares the data for autoencoder neural network.

Utility Functions

EM_boundingCov: learns the parameters of a GMM using a recursive Expectation-Maximization (EM) algorithm by bounding the covariance matrices to avoid numerical instability.

EM_init_regularTiming: initializes the parameters of a GMM by using the *k*-means clustering algorithm.

gausPDF: computes the Probability Density Function (PDF) of a multivariate Gaussian represented by means and covariance matrix.

loglik: computes the loglikelihood of a GMM model.

plotGMM1: plots the means and covariance matrix of a GMM model.

Results

Contains figures produced by the above functions.