Distance Matrices as Invariant Features for Classifying MoCap Data

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I. Introduction

This work proposes distance matrices as features for classifying MoCap data with the following benefits:

- Invariant under rigid transformation;
- No need of reference frame construction;
- Complete representation of a posture up to global rotation/translation;
- Suitable for dimension reduction techniques;

II. Posture classes

A motion is defined by a sequence of postures in time. A posture is a set of 3D coordinates.

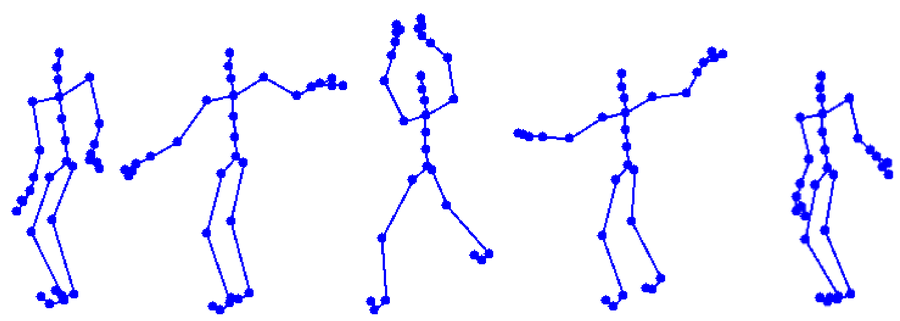

Figure 1. Example of posture sequence of action JumpingJack.

We define a posture class as a set of postures that are equivalent by a rigid transformation by defining an equivalence relation $\mathcal{R}$ over the set of all possible postures, H, in which two postures $(S, S') \in H^2$ are equivalent if there exists a rigid transformation T of $\mathbb{R}^3$ such that $T(S) = S'$.

III. Distance matrix feature

For a posture S, we define its $n \times n$ matrix $d(S) = \left[\|p_j - p_i\|\right]_{i,j}$ of distances among all joints.

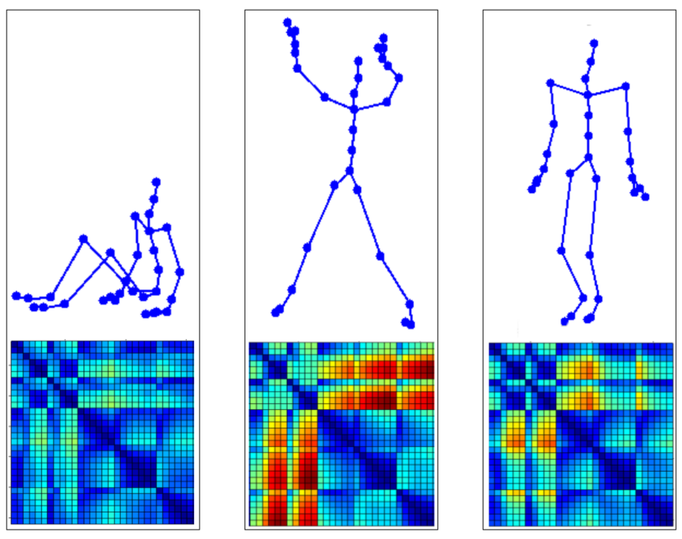

Figure 2. Skeleton postures and their respective distance matrices.

The high dimensional distance matrices features fully characterize a class of equivalent postures, that is, $\forall S, S' \in H,\ d(S) = d(S') \Rightarrow \exists\, T\ rigid\ ,\ T(S) = S'$.

IV. Motion classification

We use PCA on the distance matrix features to obtain a lower dimensional feature vector for each posture. Motion classes define curves in the low dimensional space.

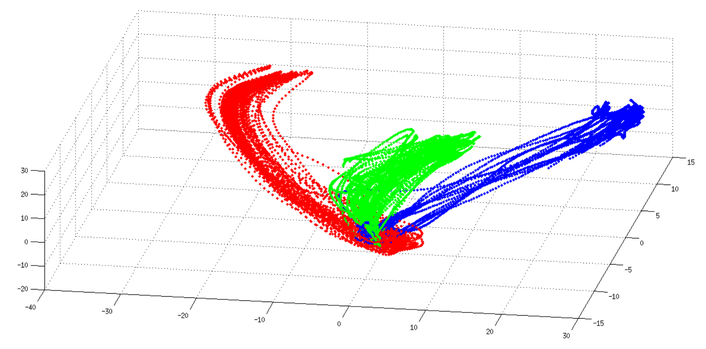

Figure 3. Example of curves from three different motion classes in a low dimensional feature space.

Low dimensional features are used to classify motion sequences using an action graph strategy.

V. Results

Publicly available MoCap data from HDM05 database were used to perform experiments with our features for motion classification. A total of 156 motion sequences were used in a 10-fold cross-validation.

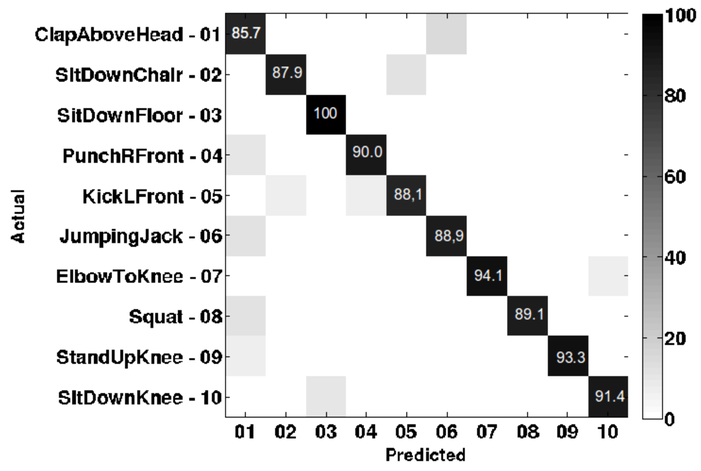

Figure 4. Confusion matrix with the results for 10 different action classes.

Results showed that the distance matrix is suitable for classifying motion sequences.

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