Recognizing periodic actions: invariants for visual discrimination between human gait patterns

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The human visual system is highly sensitive to animate motion patterns. It is able to classify and identify motion patterns on several levels ranging from the recognition of an action to the identification of the actor. How is such information encoded in visual motion data? We present a computational model that transforms visual motion data into a representation that allows identification of diagnostic invariants and we test the model for its ability to discriminate between human walking and running.

The model is based on an algorithm that transforms visual motion data such that they can be successfully analyzed with linear methods from statistics and pattern recognition. The input data can be either three-dimensional trajectories of feature points on the body or their two-dimensional projections. The transformation is based on a linear decomposition of postural data into a few components whose coefficients change with sinusoidal temporal patterns. Different aspects of this representation are diagnostic for different aspects of the motion patterns. We employ a linear discrimination function to classify different gait patterns.

We tested the model for its ability to discriminate between 10 walking and 10 running sequences using both 3D motion capture data as well as 2D projections from 12 different viewpoints. The algorithm is robust with respect to viewpoint and with respect to the position of the marker points on the body. Classification errors are below 4%. Discrimination is mainly based on phase relations between the postural components.

The algorithm does not employ any a-priori knowledge about the articulation of the body or the labels of the features. Together with a video based tracking algorithm, it can therefore be extended to work directly on video data. Hence, it is not only a powerful model for biological information processing but has also implications for both computer vision and computer graphics.