Transfer of Human Movements to Humanoid Robots

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For the design of a cooperating and independent acting humanoid robot assisting people in everyday life, it is especially important to create a machine which does not only feature a human like appearance, but also human like actions. In this talk, we present techniques for transferring of human motion to humanoid robots. For the generation of human motion trajectories, real motion sequences of kitchen actions performed by different human subjects are captured and analyzed.

Using the VICON system with a setup of 10 infra-red cameras markers placed on the upper body are captured and their 3D positions are calculated. Based on the 3D marker positions, a joint angle trajectory is determined for every modeled joint connecting two body segments of the human model of the subject.
Using a markerless human motion capture system and a model-based approach, the joint angles are calculated from stereo images by applying a particle filter for matching model configurations with the current observations.

To overcome the data compatibility problems arising from using different demonstrators and sensor setups, we have specified the so-called *Master Motor Map* (MMM). The goal was to enable the development and evaluation of action recognition systems independent from the data source. The MMM is a full specification of a high dimensional but yet simplified kinematics model of a human, having 52 degrees of freedom (DoF). Based on the MMM, a connecting module between the motion capture system, the motion analyze tool and the robot control is implemented, which realizes the transformation of the original captured motion sequences to the humanoid robot ARMAR IIIb. Since the focus is set on upper body movements, only 17 DoF (7 for each arm and 3 for the head) are used, while 23 DoF are controlled in simulation including 3 DoF for each hand.

Since not all human joints can be realized on a humanoid robot, a pure mapping of a trajectory on the existing joints, while disregarding the missing ones, will lead to an incorrect reproduction of the captured movement. In order to retain the human characteristics and the goal-directedness of an observed movement, a transformation approach is developed which fits a joint angle trajectory of a human movement to the less complex kinematic structure of a humanoid robot and compensate missing joints by applying an optimization algorithm concerning given joint angles and tool center point positions.

Results on the reproduction of human motion captured using the VICON system ARMAR IIIb is attained by an offline procedure. The markerless motion capture system enables the online imitation of the currently observed human motion. Despite the smaller number of human joints, which can be captured, the application of the proposed optimization approach leads to a human-like and goal-directed reproduction of observed human movements.

For the representation of captured human movements, both Hidden Markov Models and Dynamic Movement Primitives are studied as a way for extracting motor knowledge from observed human motion that can be used for both motion reproduction on a humanoid robot and action recognition purposes.