HUMAN MOVEMENT LEARNING WITH DYNAMIC MOVEMENT PRIMITIVES COMBINED WITH MIXTURE MODELS

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Introduction. The proposed research is to provide a probabilistic approach to learn human movements. Dynamical Movement Primitives (DMP) have been extensively used in robotics in order to learn human motions [1]. The DMP modulates a virtual spring with a learned non-linear force profile $f(x)$, perturbing the system to make it follow a desired trajectory. It is basically a second order system which can be described as:

$$\tau^2 \ddot{y} = \alpha_z(\beta_z(g - y) - \tau \dot{y}) + f(x), \qquad \tau \dot{x} = -\alpha_x x, \qquad f(x) = \frac{\sum_{i=1}^{N} \psi_i(x) w_i}{\sum_{i=1}^{N} \psi_i(x)} x, \qquad \psi_i(x) = \exp(-h_i(x - c_i)^2)$$

where y, $\dot{y}$ and $\ddot{y}$ are position, velocity and acceleration of the system. The centers and width of the basis functions $\psi_i(x)$ are predetermined. Conventional regression methods, such as weighted least squares (WLS) is then used to estimate the weights **(w.)** of the DMP.

Methodology. We propose to model the phase variable and the forcing term $[x,f]^T$ using Gaussian mixture regression (GMR) [2]. In this way, the centers and the width of the basis functions will be learned from data instead of being predetermined. Different covariance matrix types can be used for the GMM (diagonal, full or in between the two). Using full covariance matrix, the covariance information between the phase variable and the different dimensions of the force profile are taken into account.

Results and discussion. We have used some motions from the Human motion database [3] in order to verify our approach. Two GMMs with diagonal (GMM_1) and full (GMM_2) covariance matrix are used. The resulting RMS errors for two motions are depicted in Figs.1 and 2.

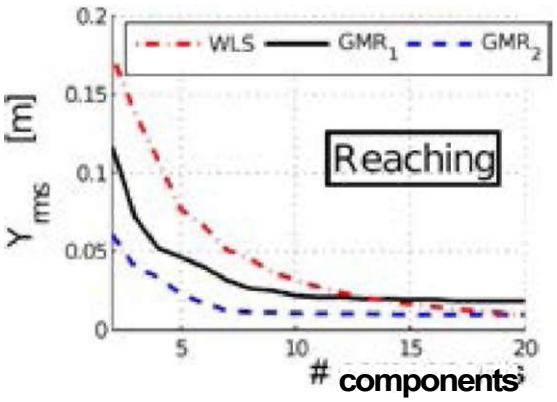

Figure 1. RMS error for reaching motion

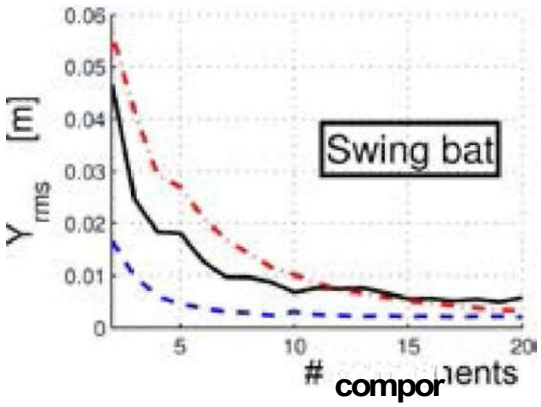

Figure 2. RMS error for Swing bat motion

Conclusions. A new approach is proposed to learn DMP which leads to better results than the conventional approache. The proposed approach can be exploited in some directions (using the synergies between different DOFs, for example).

References.

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