Understanding Manifolds of Grasping Actions

Javier Romero Thomas Feix Hedvig Kjellström Danica Kragic

A multitude of grasping taxonomies have been proposed for grasping actions, [1]. Most of them have been designed heuristically and were never compared or evaluated with respect to how effectively they describe the space of natural grasping motions. Furthermore, they are based solely on the final grasp posture of the hand, leaving out of the picture the approach and retreat phases.

In the work presented here we study the generation of a latent space which can help us to understand similarity between grasps presented by different taxonomies [1]. Since the approach and retreat phase are also modeled in this space, this representation can be particularly useful for generating complete grasp actions subject to different constraints.

The data used in the system was extracted from human demonstrations (5 subjects) of 31 different grasp types recorded with a Polhemus magnetic tracker. We used Gaussian Process Latent Variable Models (GPLVMs) from Lawrence Matlab toolbox ([2]) to construct our latent space. GPLVMs have been used in the last years for modeling full-body motion, showing some advantages over other dimensionality reduction techniques [3]. The results of our 2D latent space were compared with other dimensionality reduction techniques, showing that GPLVM space had a better inter-grasp separability and lower inter-subject variance, as well as better time continuity.

A continuous temporal path for each grasp was estimated on the latent space using Gaussian Mixture Regression (GMR) toolbox from Calinon [4], see Figure 1. As can be seen in [4], the GMR representation can be used for generating actions that resemble the demonstrated examples but also preserve constraints in the latent space. In our work we used the GMR representation to compute the similarity of different grasps, including the approach and retreat phase. This similarity measure was used for clustering the demonstrated grasps, creating in that way a taxonomy based on demonstrated grasps.

In conclusion, we showed that GPLVMs are a powerful tool for embedding grasp demonstration data into a low dimensional space which preserves time continuity and is robust to inter-subject variance. Such a space could be used for classification, generation and understanding of human grasping actions.

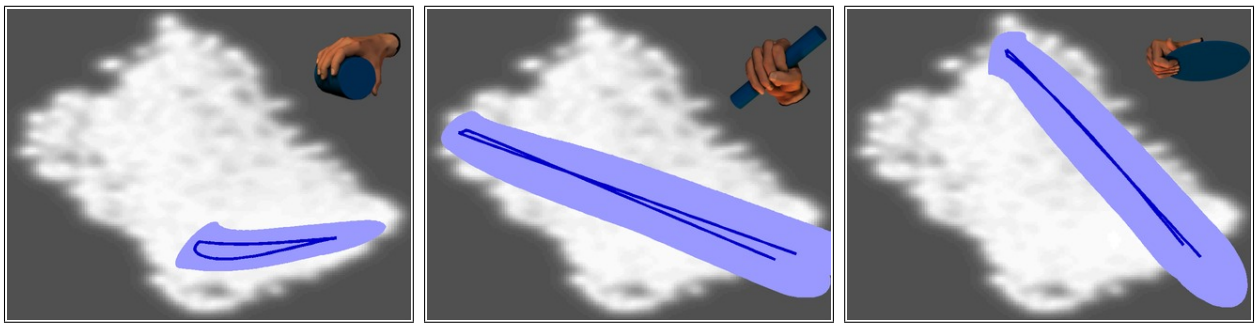

Fig. 1. GMR regression for 3 of the 31 grasp movements of all subjects. The dark line indicates the mean trajectory and the light area correspond to the variance

References

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