

# Cursor Controlled Prosthetic Grasping from 2D Subspaces

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Neurally controlled prosthetic devices capable of object manipulation have much potential towards restoring the physical functionality of disabled individuals. However, the number of user input variables provided by current neural decoding systems is much less than the number of control degrees-of-freedom (DOFs) of a prosthetic hand and/or arm. More specifically, efforts to decode user neural activity coming from feasible sensing technologies, such as electroencephalogram (EEG) [3] and cortical neural implants [4], [8], into control signals have demonstrated success limited to 2-3 DOFs with bandwidth approximately 15 bits/sec.



Fig. 1. Snapshot of our control system driving a DLR/HIT robot hand to assist a human eat a meal. The user selects points on the 2D control space displayed on the screen using the mouse.

With such decoding bandwidth limitations, previous attempts to control robot systems from low-dimensional user input have focused on low-DOF systems. Example control applications are 2D cursor control [7], planar mobile robots [3], and discrete control of 4 DOF robot arms [5], [2]. Also, Bitzer and van der Smagt [1] have performed high-DOF robot hand control by reducing the DOFs to a discrete set of poses that can be indexed through kernel-based classification.

In our work, based on the control approach in [6], we propose the use of low-dimensional subspaces embedded within the pose space of a robotic limb. As shown in Figure 2, first, a 2D control subspace is derived from human hand motion capture data ( $x$ ) and displayed on a 2D screen. Our assumption about a 2D control subspace is enhanced by the fact that efforts in neural decoding [5], [8], [7] have shown that disabled individuals physically incapable of moving 2D mouse can drive a 2D cursor from neural activity. Then, in order to control a robot hand, the user clicks on points on a 2D screen ( $z$ ) and their corresponding hand pose is sent as a motor command to the robot hand. After the user observes the result of his action, he selects another point on the screen and so on until he achieves a predefined grasping task.

To evaluate our approach, we explore a set of current state-of-the-art dimension reduction techniques and show results

for effective control of a DLR/HIT robot hand with 13 DOF. The grasping tasks performed contain finger tapping motions, powergrasps and precision grasps. Example tasks include grasping of a bottle of water, an eraser, an oscillating box and simulation of the grasping actions taking place while having a meal. This work is illustrated in more detail in <http://robotics.cs.brown.edu/projects/bpdenoising>.

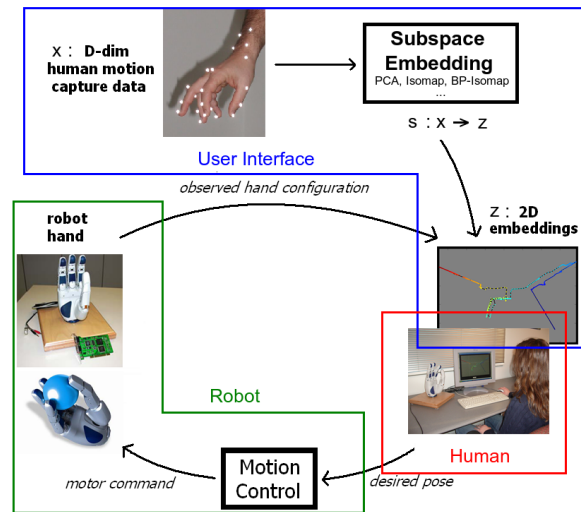


Fig. 2. Diagram for hand control by the user using human hand motion capture data for training

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