

Representing grasps in an interaction space

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Grasping is inherently a contact based activity. We can see it as choosing appropriate grasping surfaces to impart task relevant forces and motions on a grasped object. A grasping surface is any region of the hand which acts cohesively to apply a grasping force. Grasps that have outwardly similar shapes can be widely different in functional meaning based on which surfaces are engaged and how surfaces interact. From a task perspective, it is of interest therefore to represent a grasp based on the usage of the grasping surface.

The increasing availability of tactile sensors and methods to record joint configurations allow us to capture raw information about how the hand grasping surface is used. However, this has so far been considered as disconnected pieces of information, commonly used for the purpose of identifying a taxonomy category [1], [2]. We propose a new representation that uses tactile force and surface geometry to quantify the strength of pairwise interactions between the elements of a patch-decomposition imposed on the grasping surface of the hand. The result is a 144 dimensional continuous feature residing in an interaction space - the space of all interactions possible for the grasping surfaces of the hand (Figure 1). This forms an intermediate representation of a grasp which no longer views tactile and configuration data as disconnected information but captures what is task relevant i.e. how grasping surfaces interact.

With the help of a data glove covered with tactile sensors, grasps used for common daily activities, such as writing, opening a tight bottle or screw-driving, as well as grasps taken from standard taxonomies, have been captured using the new representation. Grasping experiments show that this view clearly exposes the different oppositional roles of the thumb - against palm, against finger surface, against finger sides - which play an important part in many commonly encountered real-world tasks (Figure 1). In [3] we have leveraged this information to separate the grasp into multiple cooperating and overlapping (in the underlying hand surfaces used) components which reflect how the grasping surfaces were employed (Figures 1 and 2).¹

It is worthwhile to note also that for an interaction-based representation, the notion of grasping surface need not be limited to the hand and can be extended to the environment and/or different parts of the body.

¹This research was funded by a doctoral grant (SFRH/BD/ 51071/ 2010) from the portuguese Fundação para a Ciência e a Tecnologia and by the Swiss National Science Foundation through the National Centre of Competence in Research (NCCR) in Robotics.

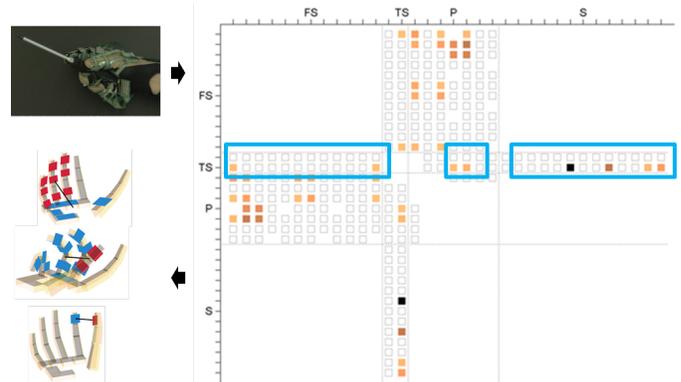


Fig. 1. Interaction space representation for a screw-driving grasp. The x and y axes denote elements of the grasping patch decomposition imposed on the hand and the colors denote strength of interaction between grasping-patch pairs. The 3 blue rectangles highlight action of thumb surfaces against finger surface, palm and finger side that become exposed with this representation. The grasp is separated into components as shown. See [3] for details.

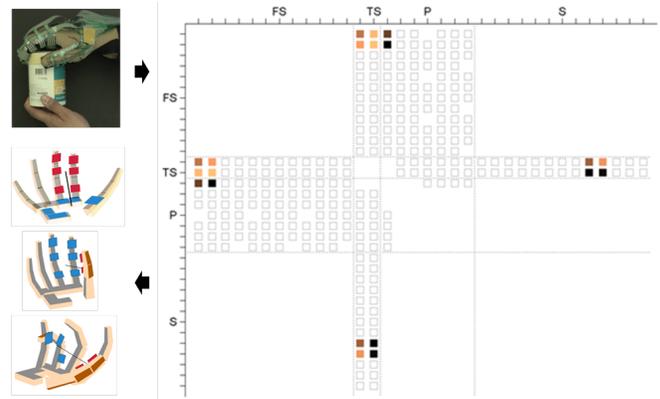


Fig. 2. Interaction space representation for an open-cap grasp. The grasp is separated into components as shown. See [3] for details.

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