Experimental Test of Synergies Computed on the SCHUNK S5FH under-actuated Hand

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***Abstract*— In this paper, a method for synergies calculation developed for an anthropomorphic 15 DOFs hand, characterized by one to one mapping between configuration space and fingertip position in the Cartesian space, has been tested on the under-actuated SCHUNK S5FH anthropomorphic hand. The grasping capabilities of the hand controlled in a three dimension synergies subspace have been tested. The results demonstrate that the data set of grasps, measured on human hands, and the mapping method of human hand synergies, based on fingertip measurements and inverse kinematics, is efficient enough to compute suitable synergies subspace where it is possible to plan and control anthropomorphic hands for grasping actions, despite on the hand kinematics and actuation system.**

I. The Schunk S5FH

The Schunk S5FH has anthropomorphic structure very similar to the human hand for shape, size and overall cosmetic appearance. Indeed, the Schunk hand is $1:1$ ratio to the human hand and weights 1.3 $[kg]$. The control, regulator and power electronics is integrated in the wrist, this allow an easy connection with market-standard industrial and lightweight robots. The current technology, however, does not allow to arrange twenty or more motors within a robotic hand having dimensions similar to those of human and ensuring appropriate requirements of speed and strength. As the matter of fact, the S5FH has 20 joints and 9 DOFs led by as many servo motors. The number of motors is significantly lower than the number of joints, thus joint motion couplings are regulated by means of mechanical synergies defined via mechanical transmission design. The reader can find the whole technical data, hardware and software specifications in [1] and [2].

II. Postural Synergies

About synergies computation, a data set of grasping configurations measured on human hands have been used to apply a mapping method, available from previous works, consisting on mapping human synergies to a robotic hand. This method has been adapted to the under-actuated S5FH hand that already has its own mechanical synergies. To go into details of grasping data and mapping method the reader is referred to the works [3], [4]. The differential kinematic mapping between the mechanical synergies subspace and the Cartesian space, used in the inverse kinematic algorithm

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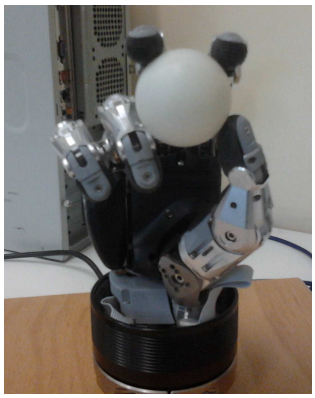

Fig. 1. The Schunk 5 Fingered Hand.

used for synergies mapping is represented by the following equation

$$\dot{\mathbf{x}} = \boldsymbol{J}_{h_s}\dot{\boldsymbol{m}}, \tag{1}$$

where $\boldsymbol{J}_{h_s}$ is the synergies Jacobian and is computed as

$$\boldsymbol{J}_{h_s} = \boldsymbol{J}_h S_m \tag{2}$$

and $\mathbf{x} \in \boldsymbol{R}^{\mathbf{15}}$ is the position vector of the five fingertips, $\boldsymbol{J}_{h_s}$ is the S5FH jacobian, $\boldsymbol{S}_m$ is the matrix of the mechanical synergies, and finally $\boldsymbol{m}$ is the vector of the motor angles. Once the synergy matrix has been computed different power and precision grasps have been reproduced using only the first three synergies in order to test the efficiency of the mapping method on an under-actuated hand kinematics. In Fig. 1 a tripodal grasp executed in the synergies subspace is depicted. The experiments demonstrate the efficiency of the mapping method and the potentialities of controlling the hand in a 3 DOFs synergies subspace.

References

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