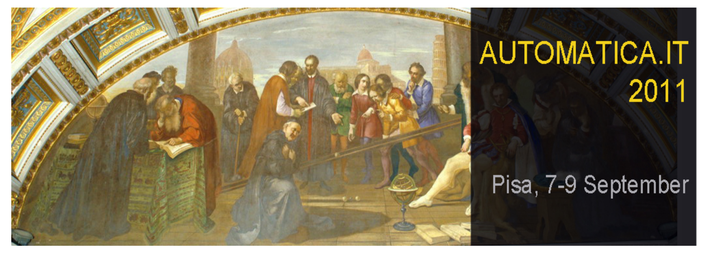
HANDS.DVI
A DeVice Indipendent programming and control framework for robotic HANDS

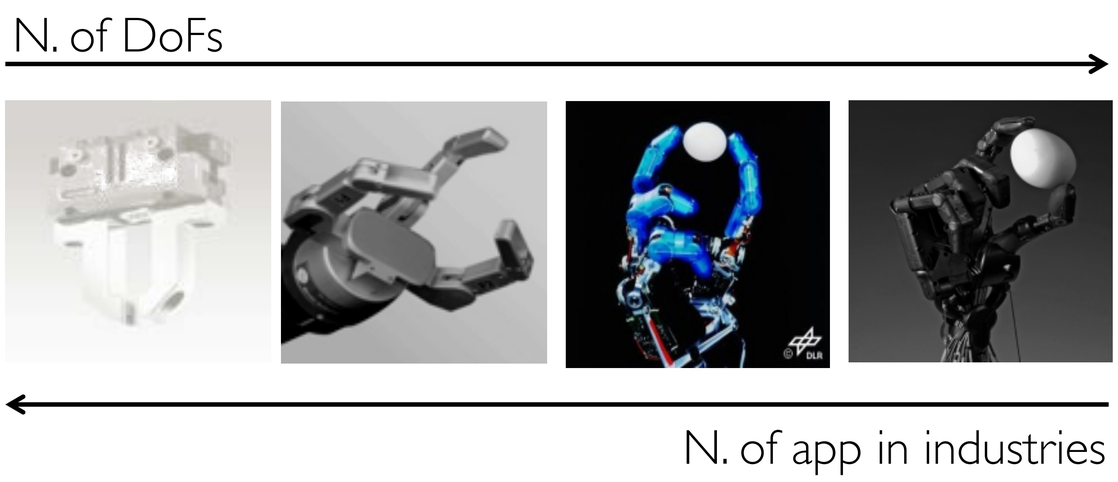


D. Prattichizzo, A. Bicchi and D. Caldwell
Department of Information Engineering, University of Siena
Centro "E. Piaggio", University of Pisa
Advanced Robotics Lab, Italian Institute of Technology

People involved in HANDS.DVI: at the University of Siena: Monica Malvezzi, Gionata Salvietti, Guido Gioioso and D. Prattichizzo; at the University of Pisa: M. Gabiccini, E. Farnioli and A. Bicchi and at the Italian Institute of Technology: N. Tsagarakis, I. Sarakoglou and D. Caldwell.

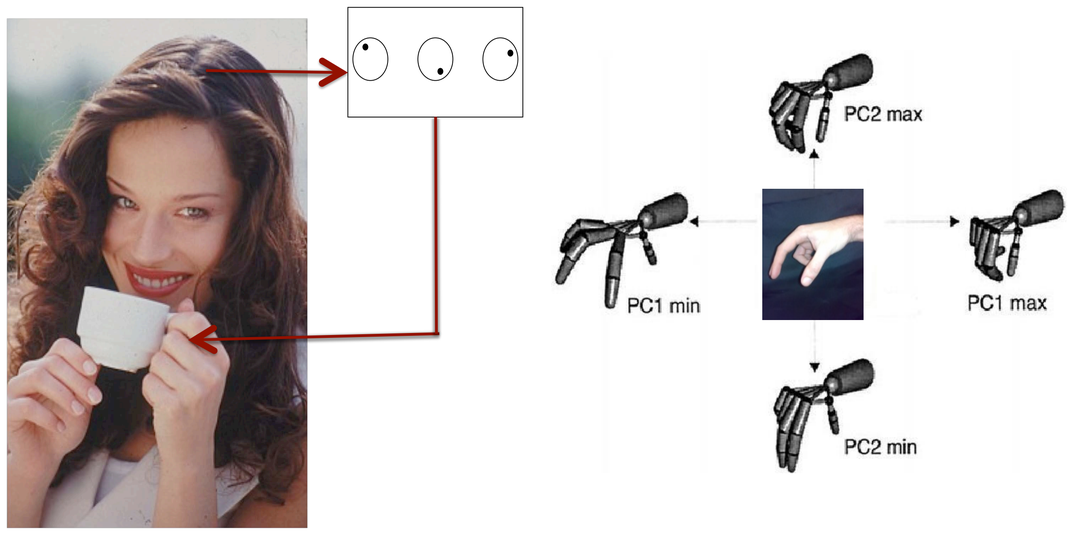
Motivation

Problem Definition



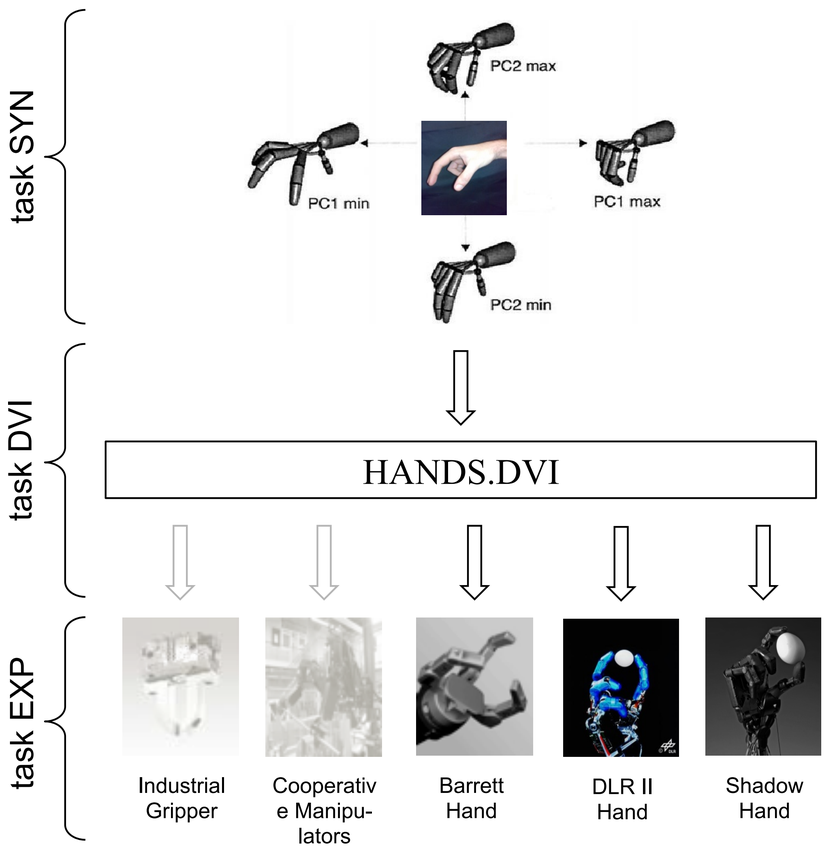
Borrowing the terminology of software engineering, there is a need for middleware solutions for manipulation and grasping tasks to seamlessly integrate robotic hands in flexible cells.

DoC inspired by sensorimotor synergies.



Recent results on the organization of the human hand in grasping and manipulation [1] are the inspiration: these results have demonstrated that, notwithstanding the complexity of the human hand, *a few variables are able to account for most of the variance in the patterns of human hands configuration* and movement.

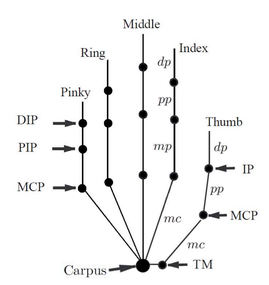
Implementation



- Modeling: developing strategies for grasp force control based on synergies. These strategies are built on the basis of the kinematic and grasping model of a paradigmatic hand with a kinematic structure similar to the human hand.
- DVI-Control Strategy: designing control algorithms based on synergies for robotic hands having a generic kinematic structure, not necessarily bio-inspired. The final target is to find a way to map human synergies to several robotic hands type including non-anthropomorphic hands.
- Validation: evaluating the synergy based approach on different models of robotic hands through a sensorized object.

Preliminary results

Paradigmatic hand



Finger	q_1	q_2	q_3	q_4
Thumb	-10^o, 80^o	0^o, -55^o	0^o, -55^o	0^o, -40^o
Index	0^o, 90^o	-15^o, 15^o	0^o, 110^o	0^o, 90^o
Middle	0^o, 90^o	-12^o, 12^o	0^o, 110^o	0^o, 90^o
Ring	0^o, 90^o	-10^o, 10^o	0^o, 110^o	0^o, 90^o
Pinky	0^o, 90^o	-12^o, 12^o	0^o, 110^o	0^o, 90^o

Table 1: Allowed ranges for the joint angle variables

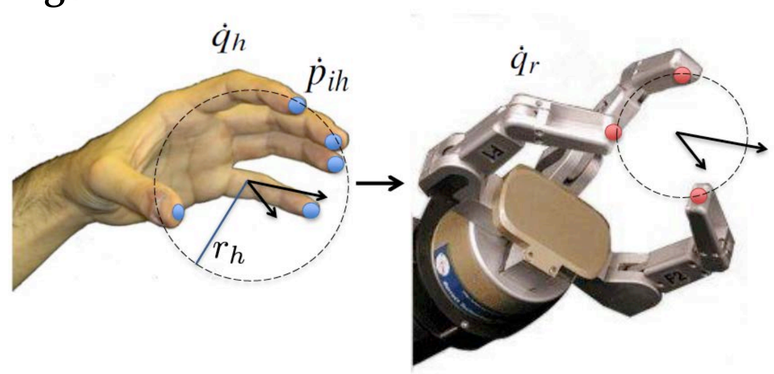
Limb	a (mm)	α (rad)	d (mm)	q (rad)
l_{11}	0	$-\pi/2$	0	q_{11}
l_{12}	a_{12}	0	0	q_{12}
l_{13}	a_{13}	0	0	q_{13}
l_{14}	a_{14}	0	0	q_{14}

Limb	a (mm)	α (rad)	d (mm)	q (rad)
l_{i1}	0	$-\pi/2$	0	q_{i1}
l_{i2}	a_{i2}	0	0	q_{i2}
l_{i3}	a_{i3}	0	0	q_{i3}
l_{i4}	a_{i4}	0	0	q_{i4}

Table 2: D-H table for the Thumb finger (left) and for Index, Middle, Ring and Little fingers (right). Indices take the following values: i = 2, 4, 5.

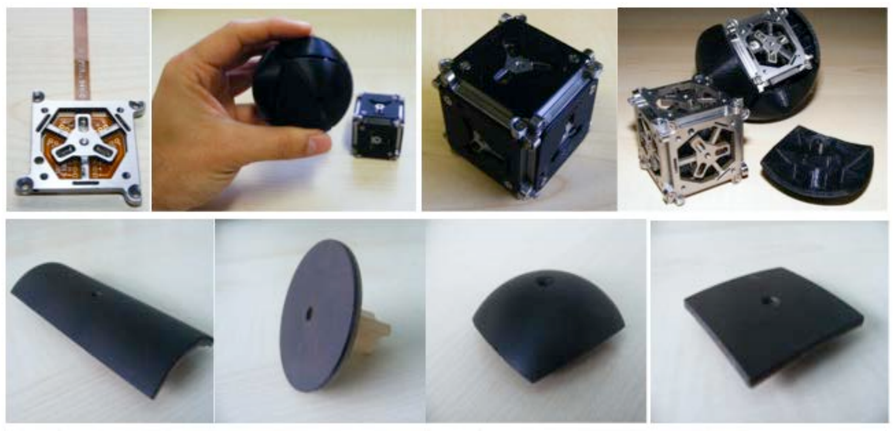
The chosen paradigmatic hand [2, 3, 4] is represented on the left. The equivalent D-H table and allowed ranges for the joint angle variables are reported on the right.

Mapping Algorithm



The algorithm is focused on the reproduction, on the robotic hand, of the movement and deformation that the human reference hand would perform on a virtual object, namely a sphere, whose geometry is step by step defined by the hand posture itself [5, 6].

Sensorized object



It has the possibility to change shape (cube, sphere, cylinder), and to measure positions, forces and torques at selected contact points [7].

References

[1] M. Santello, M. Flanders, and J. F. Soechting, Postural hand synergies for tool use, Journal of Neuroscience, vol. 18, no. 23, pp. 10 105– 10 115, 1998.
[2] M. Gabiccini and A. Bicchi. On the Role of Hand Synergies in the Optimal Choice of Grasping Forces. In Proc. of Robotics: Science and Systems, Zaragoza, Spain, June 2010.
[3] D. Prattichizzo, M. Malvezzi, and A. Bicchi. On motion and force controllability of grasping hands with postural synergies. In Proceedings of Robotics: Science and Systems, Zaragoza, Spain, June 2010.
[4] M. Gabiccini, A. Bicchi, D. Prattichizzo, M. Malvezzi. On the Role of Hand Synergies in the Optimal Choice of Grasping Forces. Autonomous Robots, Springer, In press 2011.
[5] G. Gioioso, G. Salvietti, M. Malvezzi, and D. Prattichizzo. Mapping synergies from human to robotic hands with dissimilar kinematics: an object based approach. In Proc. IEEE Int. Conf. on Robotics and Automation, Shanghai, China, May 2011.
[6] D. Prattichizzo, M. Malvezzi, M. Gabiccini, A. Bicchi. On the Manipulability Ellipsoids of Underactuated Robotic Hands with Compliance. Robotics and Autonomous Systems, Elsevier, In press, 2011.
[7] N. Tsagarakis, I. Sarakoglou and D. Caldwell. "Sensorized object for grasping evaluation," Technical report, Advanced Robotic Lab, Italian Institute of Technology 2011.

ECHORD | European Clearing House for Open Robotics Development