



Perception-guided robust and reproducible robotic grasping and manipulation (PeGRoGAM)

CHIST-ERA Project 2019-2022

Object recognition and manipulation by robots: Data sharing and
experiment reproducibility (ORMR)

Objectives/Challenges

1. Perception and object recognition in difficult environments
2. Grasping/sorting strategies (feature guided).
3. Use of extrinsic dexterity for re-grasp and manipulation.
4. Generalisation/reproducibility

Potential Impact

Autonomous perception, grasping and manipulation in difficult environments:

- Industrial applications
- Applications in unstructured environments

Participants

- Université Laval, Québec, Qc, Canada
 - Perception and environment mapping (Profs. F. Pomerleau and P. Giguère)
 - Object recognition and reconstruction (Prof. D. Laurendeau)
 - Autonomous and robust grasping (Profs. P. Cardou and C. Gosselin)
 - Grasp performance indices (Prof. P. Cardou)

Students and post-docs: V. Babin, J. Courchesne, N. Benmesbah, S. Moradi, A. Gallant



Participants

- University of Pisa, Italy (A. Bicchi, M. Bianchi, M. Garabini, D. Caporale, L. Pallotino)
 - Grasp planning and grasping strategies
 - Use of deep learning for the detection of grasp failures
 - Use of deep learning for the modelling of human manipulation
 - Learning human inspired grasping strategies from few examples
 - Combine IMU-based tactile sensing and machine learning
 - Use Pisa/IIT hand to investigate extrinsic dexterity



Research Center E. Piaggio
University of Pisa

Participants

- University of Birmingham, UK (R. Stolkin, Y. Bekiroglu, N. Marturi, MA Roa, KJM Adjigble, T. Pardi, C. Grimm)
 - Created datasets for robotics applications in extreme environments (e.g. nuclear)
 - Benchmarking of grasp planning algorithms
 - Use of deep learning for object detection and grasp planning
 - Extension from grasping to other manipulative actions (e.g. tool use for cutting or unscrewing)



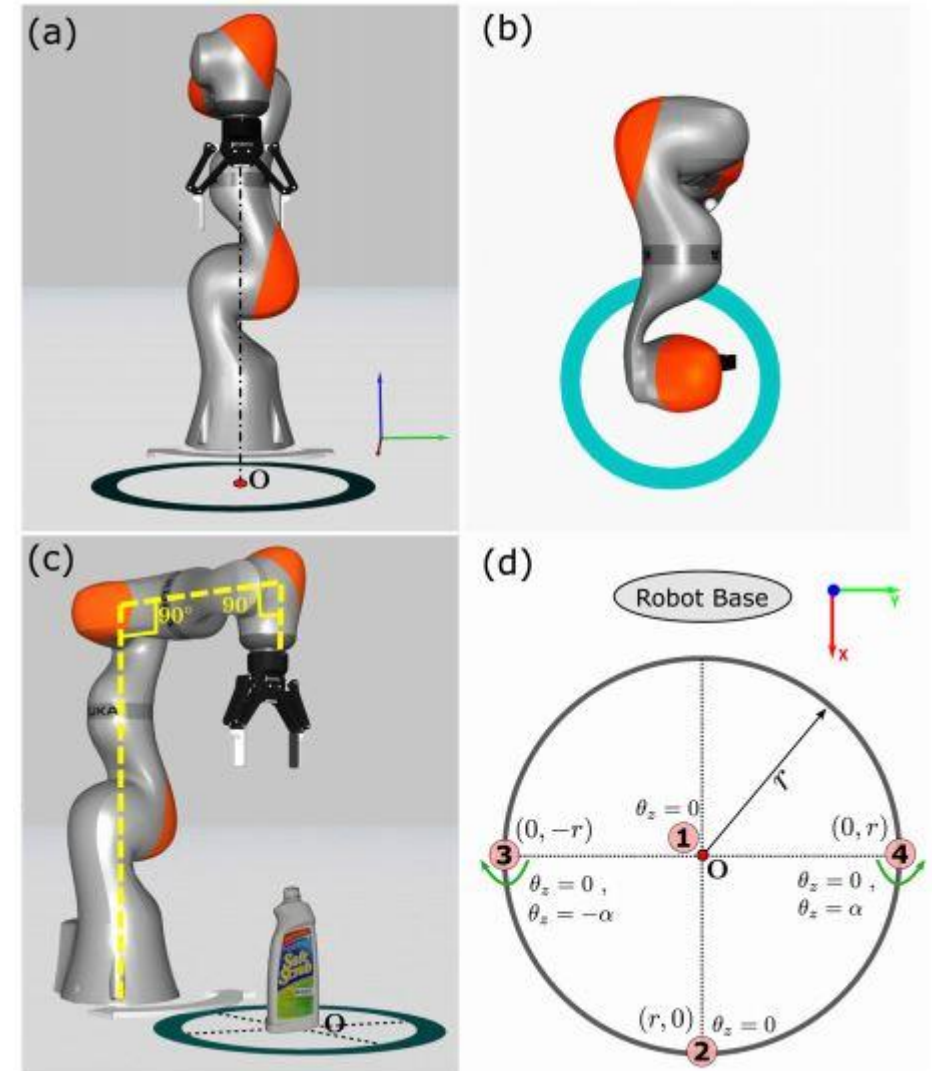
UNIVERSITY OF
BIRMINGHAM

Extreme Robotics Laboratory

National Centre for Nuclear Robotics

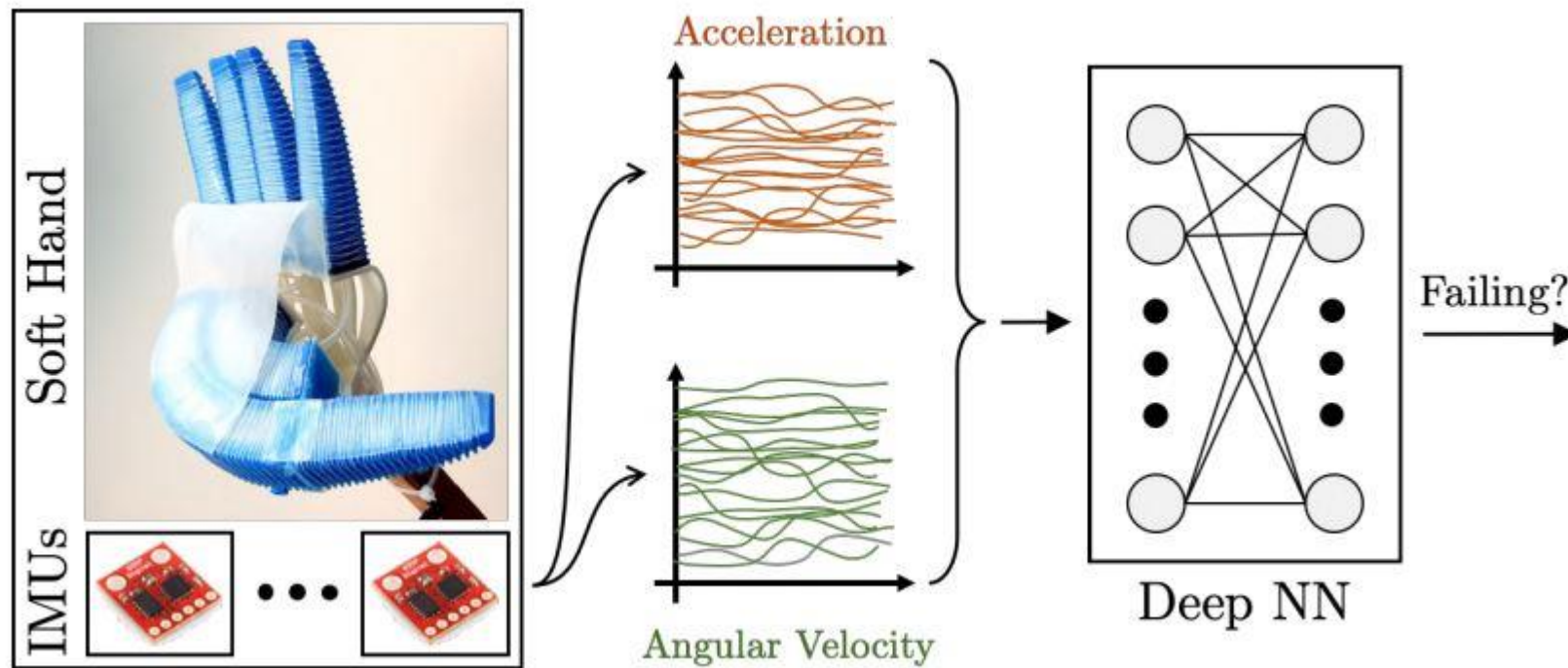
Results

- Benchmarking protocol for grasp planning algorithms
 - A methodology for reproducible experiments to compare the performance of a variety of grasp planning algorithms.
 - Improve the objectivity with which different grasp planners are compared by minimizing the influence of key components
- Scene understanding and object recognition and localisation from computer vision
- Demonstration with example industrial applications
 - Handling of legacy nuclear waste
 - Robotic disassembling of large and complex Lithium ion battery packs of electric vehicles



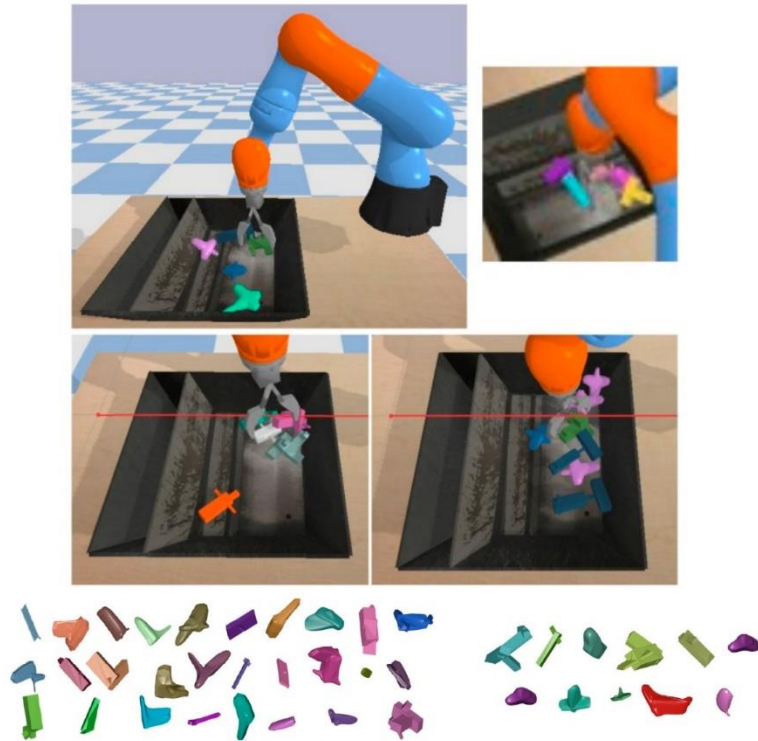
Results

- End-to-end deep-learning approach for predicting grasping failures in soft hands
 - Predict grasp failures in soft hands before they happen
 - Pisa/IIT Softhand and RBO Hand
 - Predict 100% of failures (on average 1.96 s. before they occur)



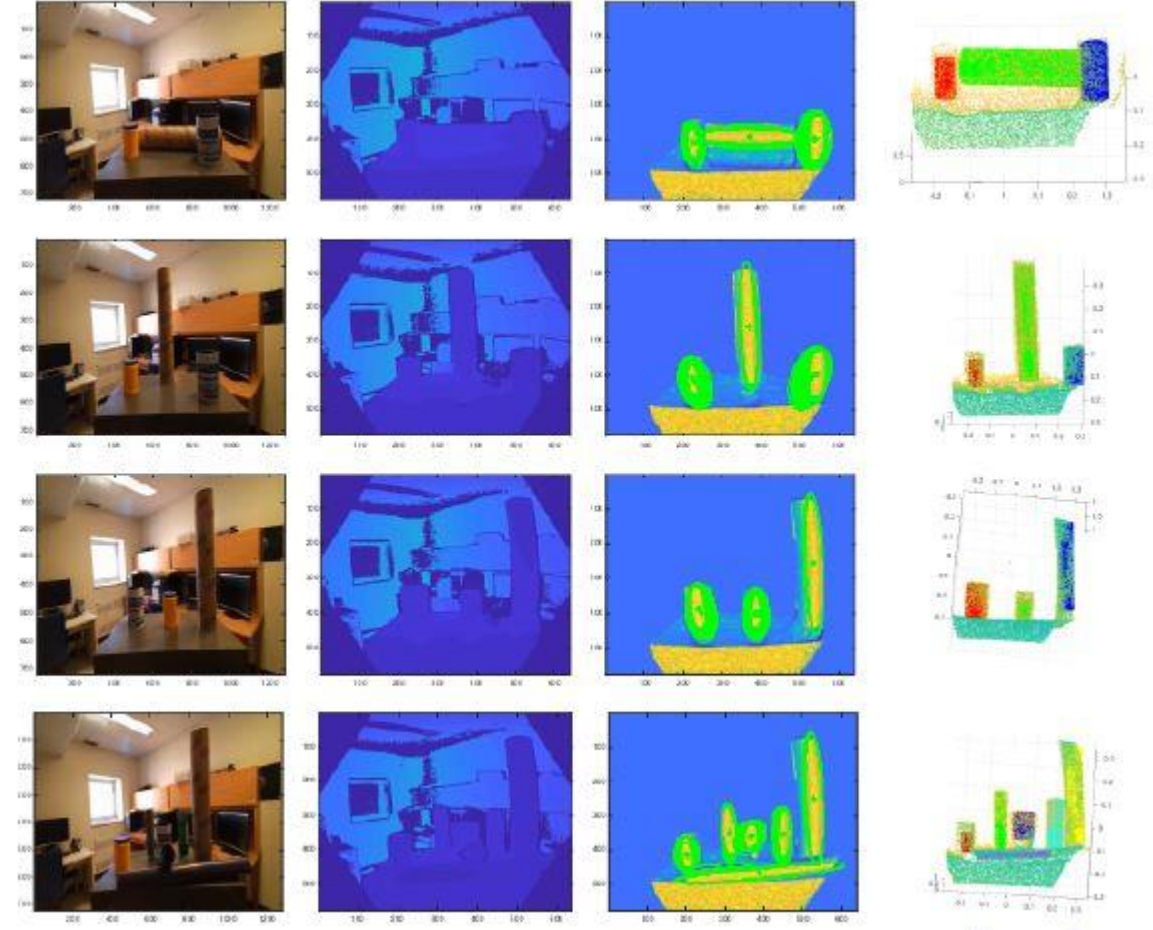
Results

- Autonomous grasping using deep reinforcement learning
 - Simulator: 900 training objects /100 test objects
 - Implementation with PyTorch
 - Real experiments: UR10e robot (preliminary)



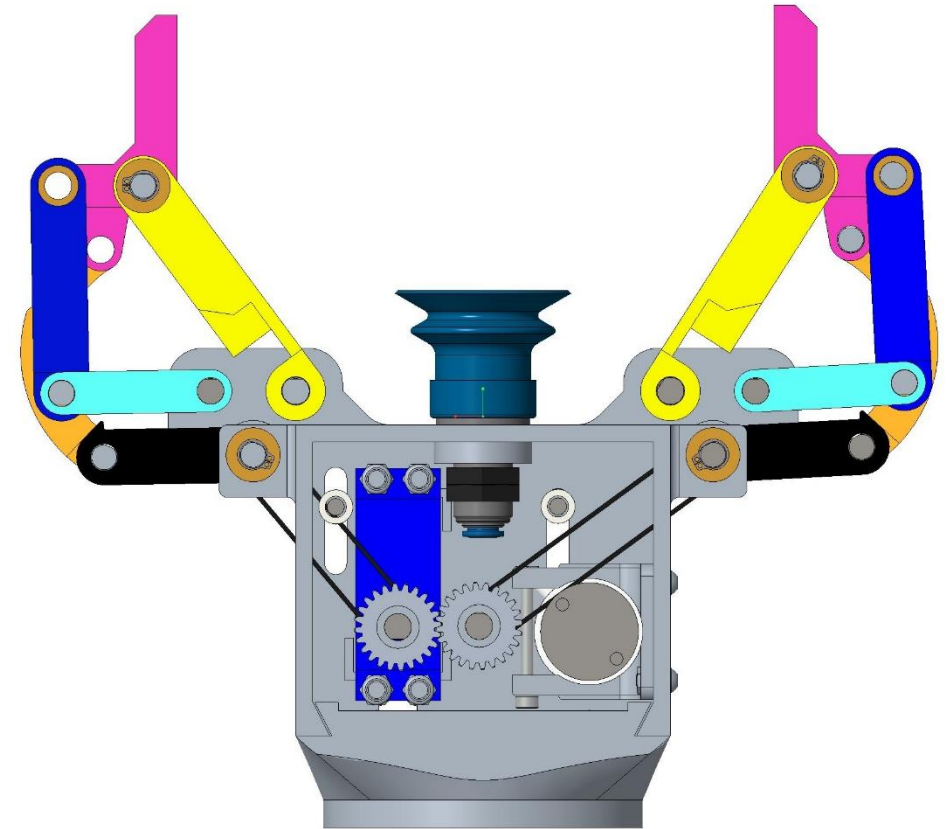
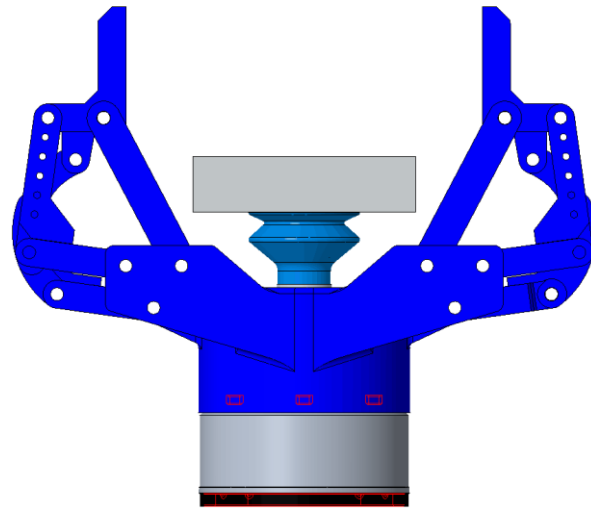
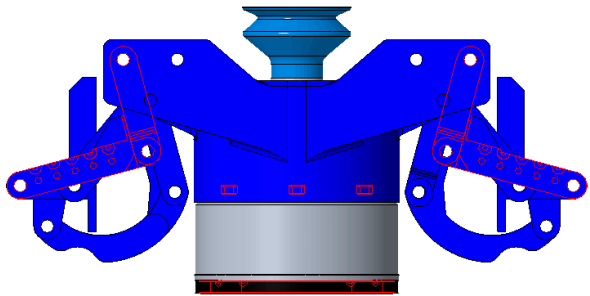
Results

- Multiple Cylinders Extraction from Organized Point Clouds
 - Detecting Good Sample Points for Initial Sample Selection
 - Dealing with point clouds with non-uniform densities
 - Noisy point clouds
 - Low computational complexity



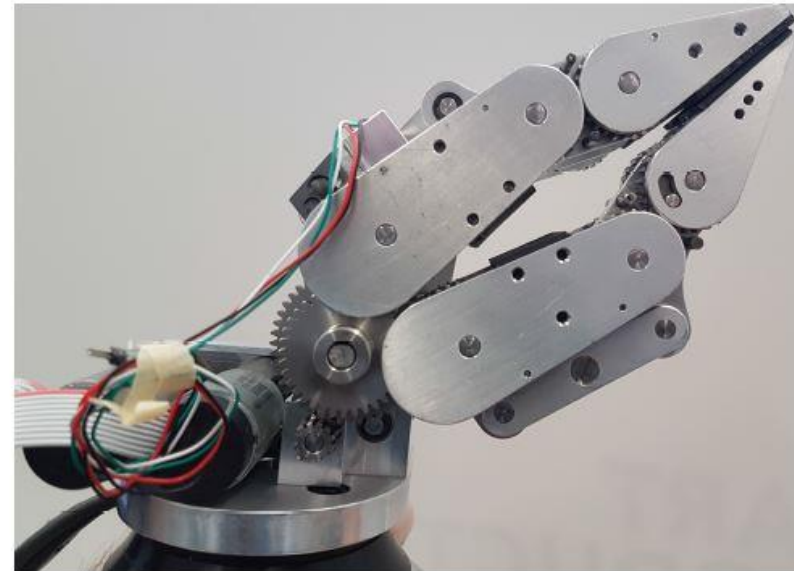
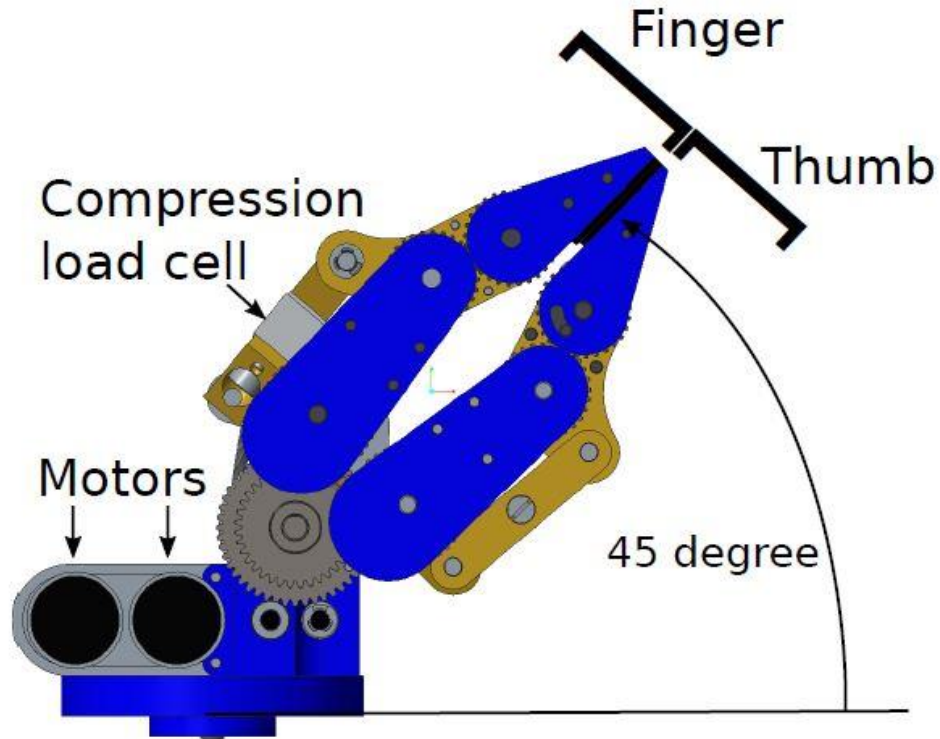
Results

- Single-actuator adaptive gripper with an integrated suction cup
 - Grasping in cluttered environments
 - Fully retractable fingers
 - Combining suction cup and articulated fingers
 - Integrated pump (no air supply needed)
 - Experimentally demonstrated



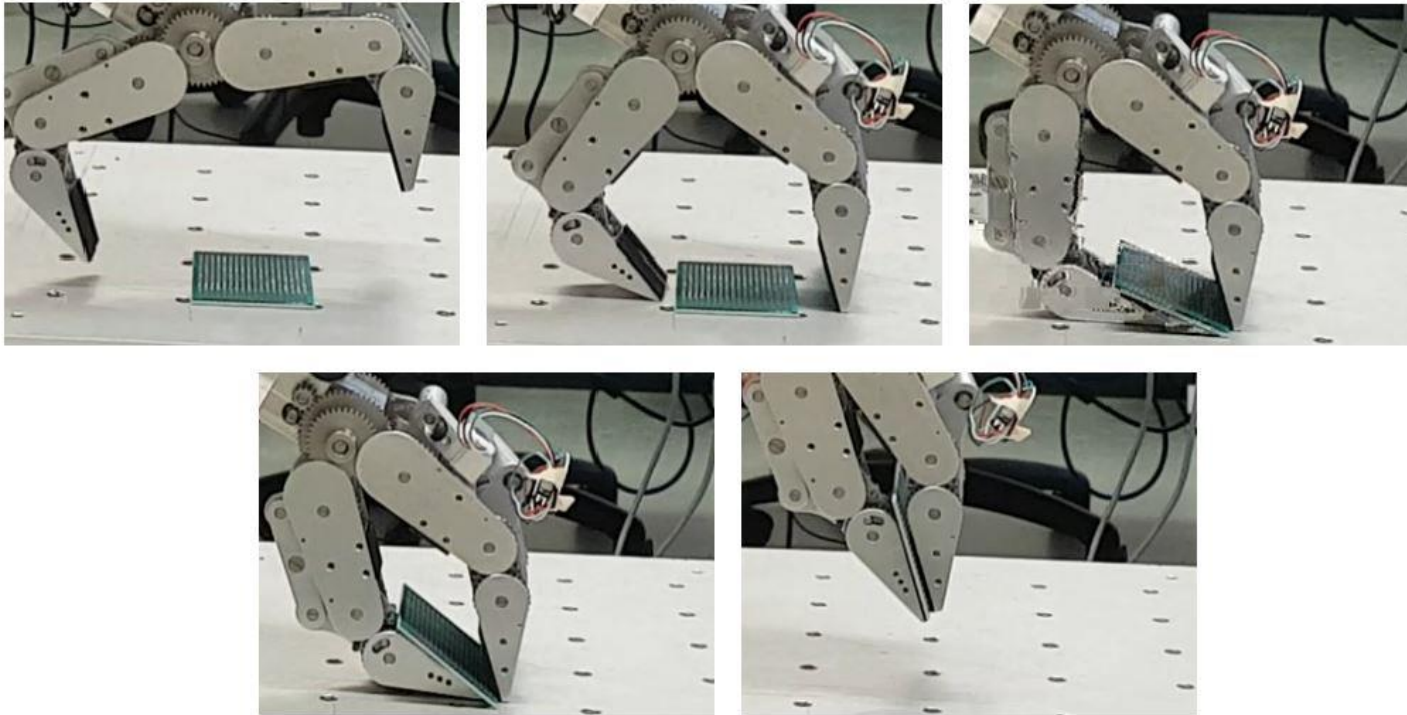
Results

- Adaptive gripper for the grasping and scooping of difficult objects
 - Grasping of flat objects
 - Implementation of underactuation in the scooping gripper
 - Shearing motion for the grasping of objects in cluttered environments



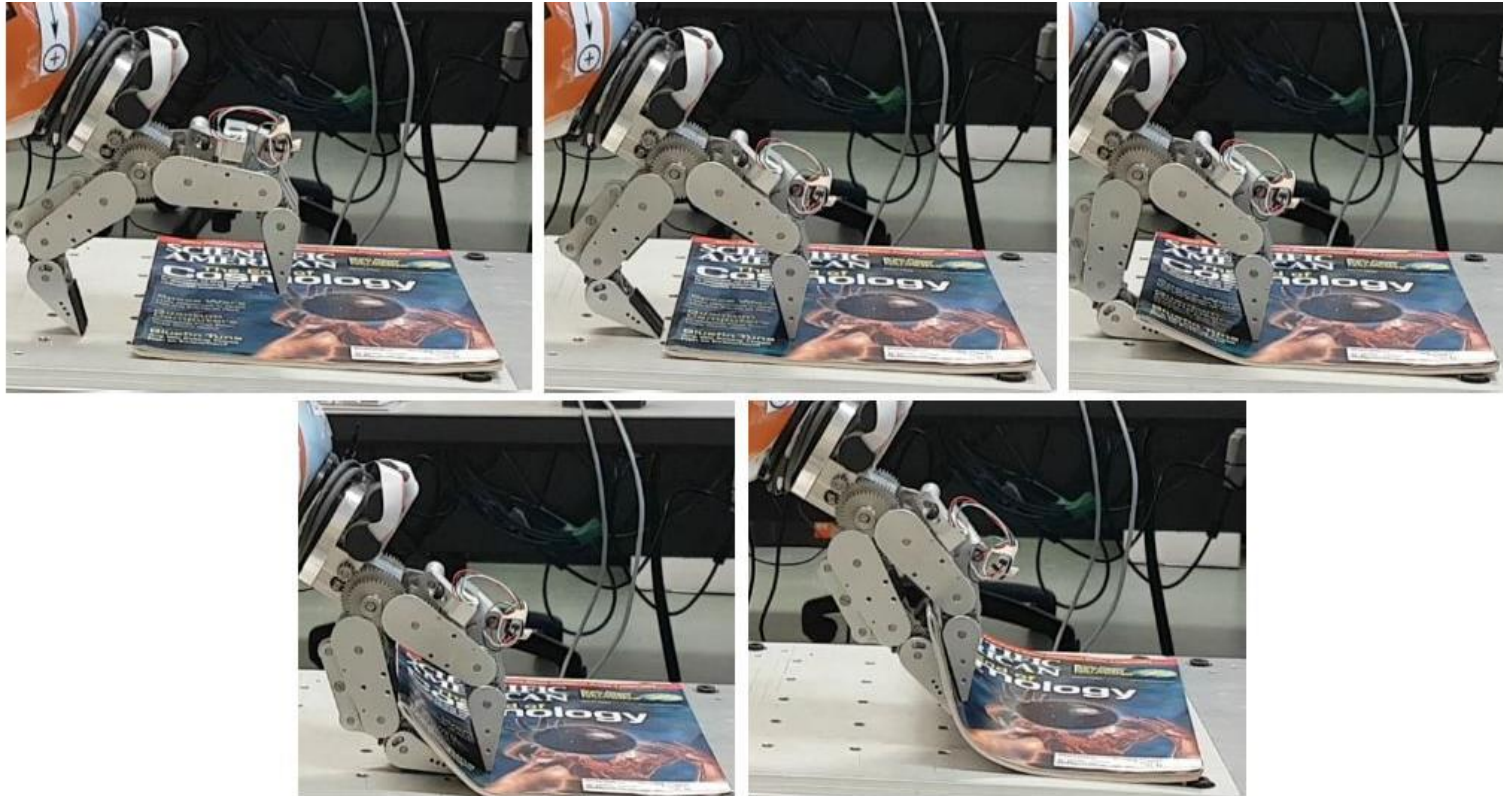
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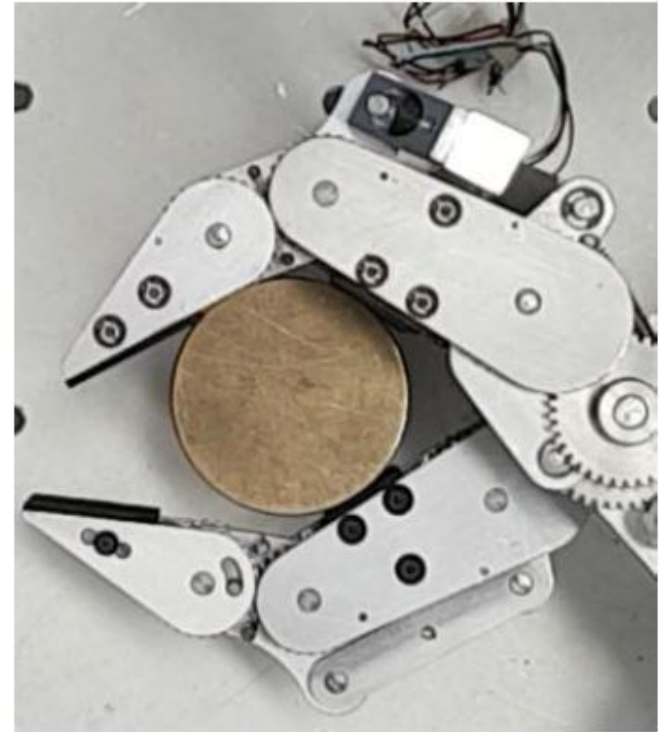
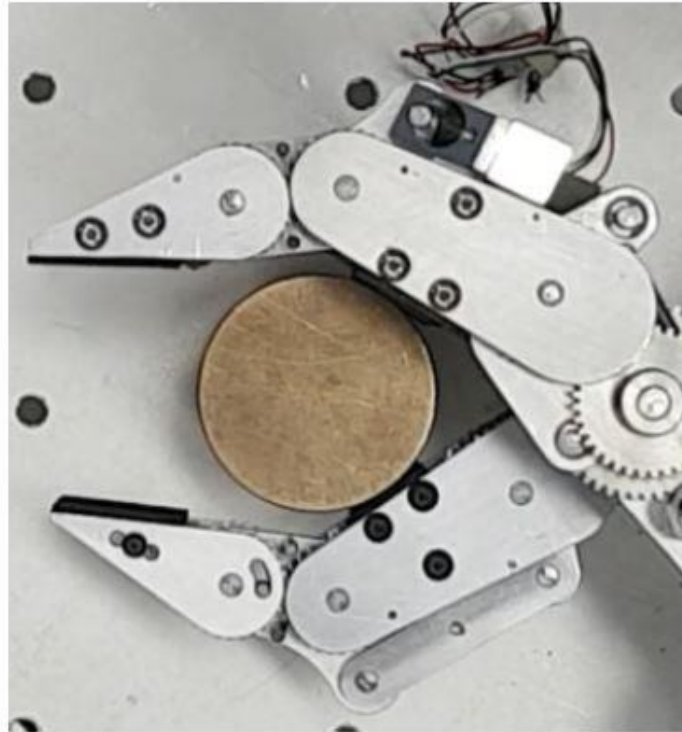
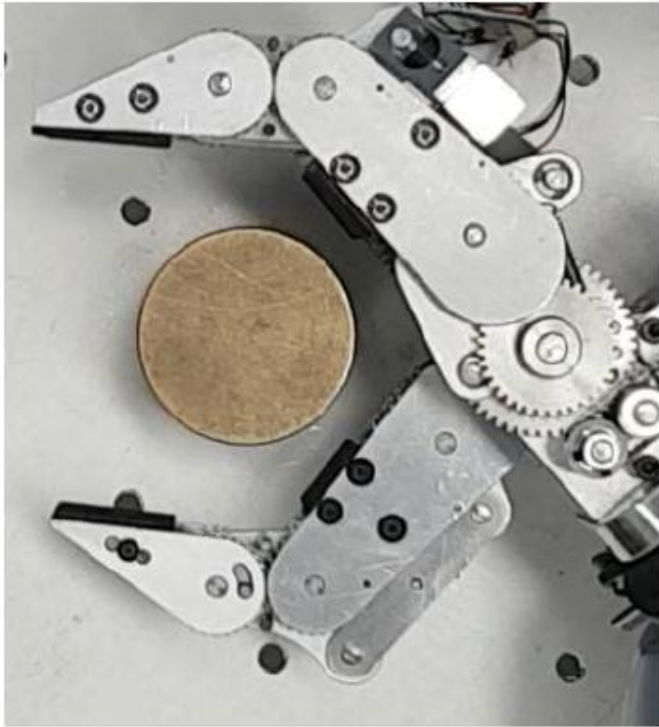
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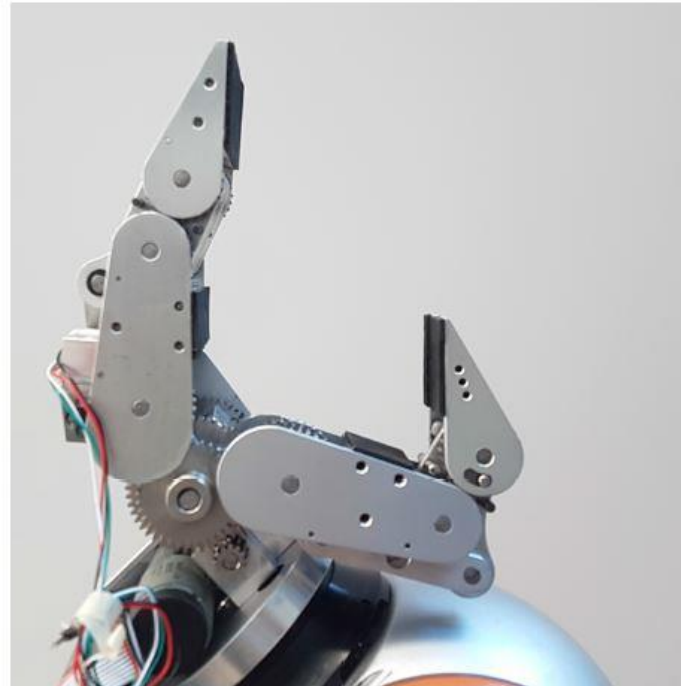
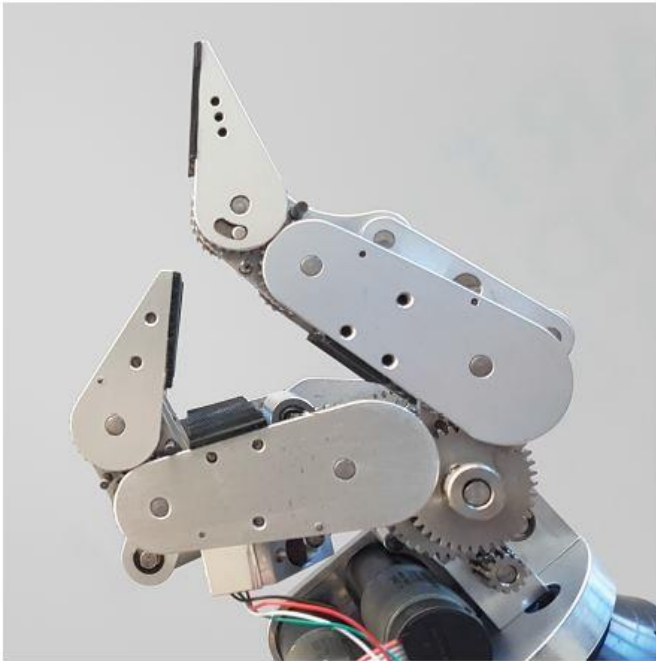
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Results

- Shearing motion for the scooping of difficult objects



Dissemination

- Optimized hybrid decoupled visual servoing with supervised learning. A Rastegarpanah, A Aflakian, R Stolkin. Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering, 2022.
- Benchmarking Protocol for Grasp Planning Algorithms, Bekiroglu, Y., Marturi, N., Roa, M.A., Adjigble, K.J.M., Pardi, T., Grimm, C., Balasubramanian, R., Hang, K, and Stolkin, R., IEEE Robotics and Automation Letters, Vol. 5, No. 2, 2020.
- Learning With Few Examples the Semantic Description of Novel Human-Inspired Grasp Strategies From RGB Data," L. Collodi, D. Bacciu, M. Bianchi and G. Averta, IEEE Robotics and Automation Letters, vol. 7, no. 2, pp. 2573-2580, April 2022.
- Learning to Prevent Grasp Failure with Soft Hands: From Online Prediction to Dual-Arm Grasp Recovery. Averta, G., Barontini, F., Valdambrini, I., Cheli, P., Bacciu, D. and Bianchi, M., Adv. Intell. Syst. 2100146, 2021.

Dissemination

- To grasp or not to grasp: an end-to-end deep-learning approach for predicting grasping failures in soft hands, V. Arapi, Zhang, Y., Averta, G., Catalano, M. G., Rus, D., Santina, C. Della, and Bianchi, M., in 3rd IEEE International Conference on Soft Robotics (RoboSoft), 2020, pp. 653–660.
- Stable and repeatable grasping of flat objects on hard surfaces using passive and epicyclic mechanisms, Babin, V., St-Onge, D. and Gosselin, C., Robotics and Computer-Integrated Manufacturing, Vol. 55, February, pp. 1-10, 2019.
- Mechanisms for Robotic Grasping and Manipulation, Babin, V. and Gosselin, C., Annual Review of Control, Robotics, and Autonomous Systems, Vol. 4, 2021.
- A Single-Actuator Adaptive Gripper with an Integrated Suction Cup, Courchesne, J., and Cardou, P., CCToMM Mechanisms, Machines, and Mechatronics (M3) Symposium, pp. 1-12 , 2021.

Sustainability/Exploitation

- Possibility to extend the collaboration using other programs
- Possible exploitation of the results in different industrial areas:
 - Nuclear industry
 - Automotive industry
 - Logistics industry
 - Manufacturing industry
 - Food industry
 - Recycling industry