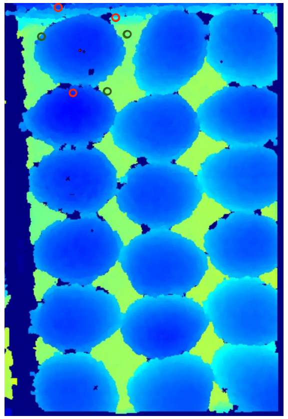
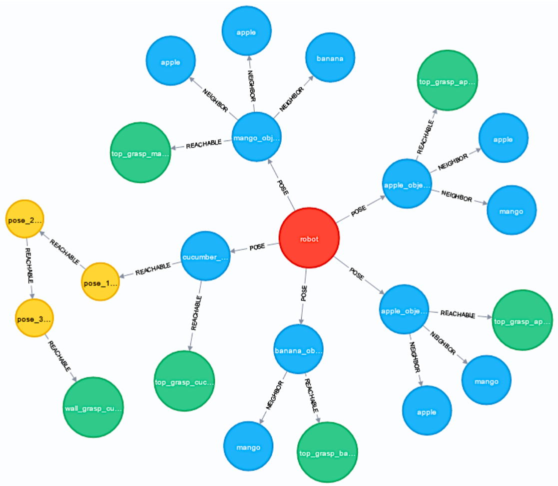
The performance of the hand is enchanced in several ways. The hand includes a self-checking system, which provides an initial diagnostic after power-up, and systems are continuously checked also during normal working conditions to detect hardware failures. A combination of sensor data and grasp success observers allows the quick detection of grasping failures, which triggers a reactive strategy either to keep the object grasped or to make a new grasp attempt due to a failure in the previous one. Finally, a manipulation planner was also developed to exploit the benefits of the hand, and it is capable of providing sequences for manipulation even in cluttered scenes.





About DLR

DLR is the Federal Republic of Germany's research centre for aeronautics and space. We conduct research and development activities in the fields of aeronautics, space, energy, transport, security and digitalisation. The German Space Agency at DLR plans and implements the national space programme on behalf of the federal government. Two DLR project management agencies oversee funding programmes and support knowledge transfer.

Climate, mobility and technology are changing globally. DLR uses the expertise of its 54 research institutes and facilities to develop solutions to these challenges. Our 10,000 employees share a mission – to explore Earth and space and develop technologies for a sustainable future. In doing so, DLR contributes to strengthening Germany's position as a prime location for research and industry.

Imprint

Publisher:
German Aerospace Center (DLR)
Institute of Robotics and Mechatronics

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Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

CLASH_GB_06/201

CLASH
Complient **l**ow cost **A**ntagonistic **S**ervo **H**and

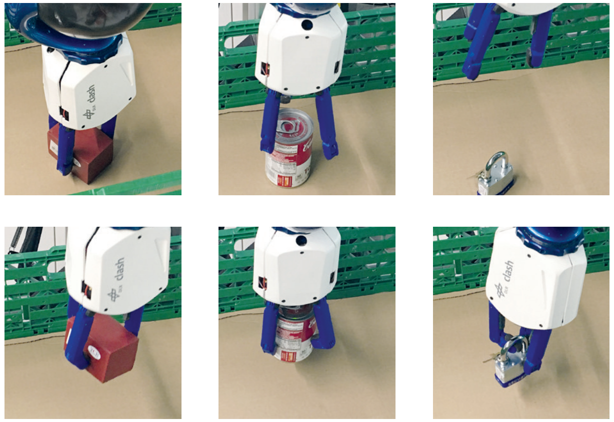
CLASH

The Compliant Low cost Antagonistic Servo Hand was developed during the EU H2020 project SOMA, mainly for applications in commercial food handling, including grasping fruits and vegetables in logistic scenarios, or harvesting fruits from a tree. The main feature of the hand is its variable stiffness, which allows it to change the passive stiffness between a low value, e.g. to easily adapt to the object or perform pre-manipulation actions, to a high value that allows it to apply high fingertip forces of up to 20 N.

When grasping an orange, for instance, the fingers can be made soft so that they can adapt to the object shape therefore increasing the number of contact points with the object. Afterwards, the fingers increase their stiffness without increasing the applied forces, in order to safely lift the object without damaging it. This mechanism is inspired by human hands, where cocontraction of antagonistic pairs of muscles leads to an increase of hand stiffness.
The hand is equipped with several sensors. Force and position sensors in the fingers allow the implementation of compliant torque-based control. Tactile sensors at the palm enable detection of contact with the object. Additionally, time of flight distance sensors in the palm can measure the distance to a desired object. Suitable exploitation of such sensors allows the hand to be robust to failures, either coming from the hand itself or from the grasp execution.

The hand is modular and self-contained, therefore it can be easily integrated in a robotic arm or even in special robotic setups, such as the wheelchair EDAN.

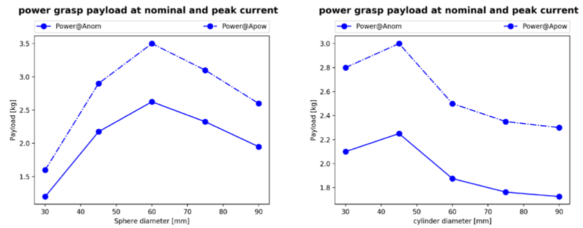
The hand design and its variable stiffness can be exploited for grasping from highly fragile objects to rigid and heavy ones (up to 2kg), using both fingertip and power grasps, and achieving success rates of up to 95% in continuous pick and place actions.The hand is further equipped with several sensors, such as tactile sensors at the palm and force and position sensors in the fingers. Another distance sensor in the palm can measure the distance to an object.



Technical data:

Size:	110 x 60 x 78 mm³
Weight:	640 g
Degrees of fredom:	7
Payload:	20N thumb, 10N fingers
Power Supply:	6-8 V
Joint velocity:	360 °/s
Interface:	USB 1kHz
Features:	• Linux computer can be integrated • battery powered, if necessary • 8 tendon force sensors • tactile sensors in palm • human inspired tendon routing

Maximun payload for spherical and cylindrical objects



Hand resilience heatmap for impact from different directions