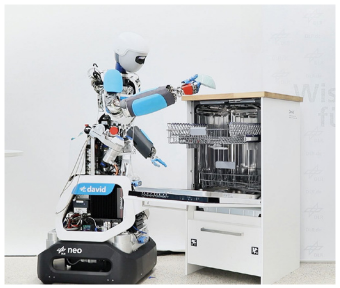
The main focus in the development of David is to get as close to human capabilities as possible – especially in terms of dynamics, dexterity and robustness.

The robot will operate in an environment designed for humans, such as a kitchen, and will use objects designed for humans, such as cups, plates, bowls, and cutlery.

David has a range of motion and size similar to that of a human. Its human-like shape enables easy operation and programming.

All finger joints can be controlled individually, giving the system exceptional dexterity.



Goals and Outlook

The vision is to use a gentle, humanoid robot as
- Assistance system for human-machine interaction.
- Assistance in the household.
- Support in dangerous situations.
- Support in maintenance tasks.

The research focus is on
- Better understanding of humans.
- Using robots in unstructured environments.
- Developing methods for better grasp planning.
- Increase of efficiency.

DLR at a glance

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. By transferring technology, DLR contributes to strengthening Germany's position as a prime location for research and industry.

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DAVID

A Robust Humanoid with Dexterous Manipulation Skills

Humanoid Robot

The anthropomorphic, light weight robot David is a DLR research robot developed at the Institute of Robotics and Mechatronics.

David has two arms, a torso, a neck, a head and an omnidirectional mobile platform called NEO.

David is intended to be employed in a barrier-free environment suitable for humans and manipulate objects made for humans.

The robots upper body should resemble a human as much as possible in size, strength, and flexibility.

Facts and figures

Size:	adult human
Speed:	comparable to humans
Working environment:	similar to that of humans
Weight:	55 kg David + 163 kg NEO
Degrees of freedom:	44 of David + 8 of NEO
Actuation:	95 brushless dc motors
Current control frequency:	100 kHz
Sensors:	184 position sensors & 3 force sensors
Robot control frequency:	3 kHz

David's mechatronic concept is based on powerful and efficient brushless dc motors combined with highly integrated power and digital electronics. The high-performance hands are slim and light.

Therefore, most of Davids joints are integrated through variable stiffness actuators (VSAs) with mechanical springs. These VSAs have a high mechanical elasticity.

The inherent stiffness in the joints can be continuously varied which results in a behaviour like co-contraction of human muscles.

Extending the upper body with a wheel-based omnidirectional platform as a lower body was an efficient solution to make the whole robot mobile.

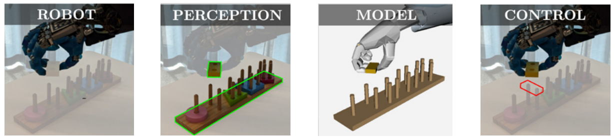
Advanced Technology

Dexterous In-Hand Manipulation

The human ability to dexterously manipulate objects with our hands is an essential element of everyday life. In order to seamlessly integrate robotic systems into our everyday life, they will require similar capabilities.

To enable David to manipulate objects with such precision, we are developing a dexterous manipulation framework, which enables the accurate control of grasped objects.

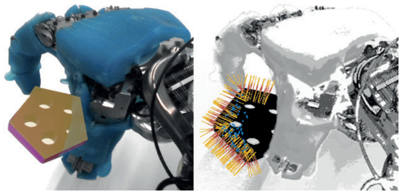
Accomplishing a demanding manipulation task requires knowledge about the state of the grasp. Our method to estimate the grasp state integrates information from tactile sensing, proprioception, and vision. Utilizing the estimated grasp state, the developed model-based controller realizes the compliant positioning of the object inside the hand.



Perception

The entire perception is designed to allow the tracking of untextured objects, be robust to self-occlusions, and fulfill real-time requirements.

David uses computer vision, tactile sensing, and proprioception to perceive his environment and himself. During operation, all this information is fused to continuously estimate the location of David and relevant objects.



Based on that data, David is able to perform complex manipulation tasks while dynamically reacting to changes.

Safety

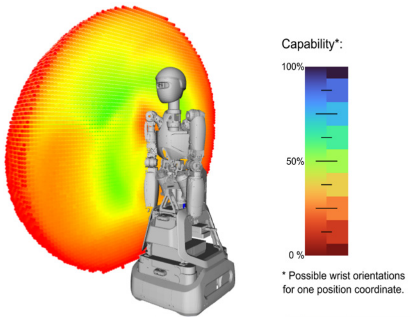
As David should be able to operate safely in an unstructured and dynamically changing environment, collisions with objects and obstacles can occur during normal use. These fast impacts damage conventional rigid humanoid robots, but not David.

To ensure the safety of both humans and the system, it is necessary to buffer collision energy. This is achieved through the high elasticity in David's joints.

The spring in the variable stiffness actuators reduces torque peaks / force peaks at the output. This leads to increased mechanical robustness.

Planning for Manipulation

By upgrading David with a Torso and the NEO mobile platform to a full humanoid robot, we expanded his workspace. To provide a graphical representation of the workspace and the capabilities we use capability maps.



The visualization of the capability maps allows to establish an area in the map which guarantees the required reachability and maximum dexterity for the task.

The motion planning interface is in operation along all applications and is responsible of generating smooth trajectories without self-collisions or collisions with the environment. We use our internally developed, state-of-the-art motion planner, the Robot Motion Planning Library (RMPL).