TentacleGripper

Gripping modelled on an octopus tentacle

TentacleGripper
Bionic gripper for soft robotics

01

Picking up, holding and putting down workpieces – gripping applications have always played a key role in production. At the forefront of industrial automation, Festo is therefore constantly on the lookout for new gripping principles and innovative approaches to solutions for the production systems in the factory of tomorrow.

One source of inspiration for new knowledge and future technologies is nature. That is why Festo brought the Bionic Learning Network to life. In an alliance with international universities, institutes and development companies, Festo has already studied a range of different grip mechanisms on several occasions using biology as a model.

Flexible tentacles made of silicone
Festo now presents a bionic gripper called the TentacleGripper, which is derived from an octopus tentacle. The gripper consists of a soft silicone structure, which can be pneumatically controlled. If compressed air is applied to it, the tentacle bends inwards and can wrap around the respective item which is being gripped in a form-fitting and gentle manner.

Unique combination of force fitting and vacuum
Just as with its natural model, two rows of suction cups are arranged on the inside of the silicone tentacle. Whilst the small suction cups on the end of the gripper work passively, the larger ones are connected to a vacuum line and can be actively controlled during the gripping process.

As soon as the pneumatic tentacle wraps around the object, a vacuum is applied at the suction cups, making the object adhere securely to the gripper. This means that the TentacleGripper can pick up and hold a variety of different shapes.

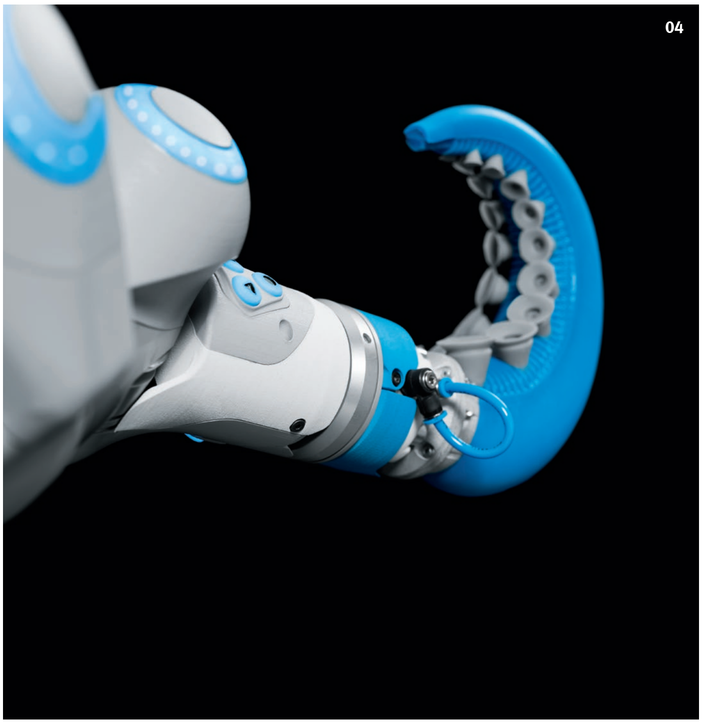
Safe soft robotic components
Thanks to its soft silicone structure, the artificial tentacle is not only able to grip in a gentle and form-fitting manner, however. As the other materials installed in the structure are also elastic and deformable, the gripper poses no danger to the user in direct contact. The TentacleGripper thus even fulfils the high requirements of soft robotics and can be used without hesitation for working immediately with humans.

01: **Safe overall system:** The flexible gripper on the BionicMotionRobot

02: **Technical implementation:** The inside of the artificial tentacle

03: **Natural model:** The free-moving tentacles on the octopus

04: **Wide range of uses:** The flexible gripper on the BionicCobot



For this purpose, Festo is testing the TentacleGripper on two pneumatic lightweight robots at once, which were also developed in the Bionic Learning Network: the BionicMotionRobot and the BionicCobot.

Both robots are thoroughly pliable and can be infinitely stiffened in terms of their kinematics. They can therefore interact directly with people. Even in the event of a collision, they are harmless and do not have to be shielded from the worker like conventional factory robots.

Precise control of the bionic gripper
The Festo Motion Terminal used controls and regulates both the respective robot arm as well as the gripper here. The Motion Terminal is the world's first pneumatic automation platform, which, using its software control system, combines the functionalities of over 50 individual components using apps. Not only does that enable the varied motion sequences of the two robots, but also the exact dosing of compressed air and vacuum in the silicone tentacle.

Due to this and its soft structure, the TentacleGripper has major potential for collaborative working spaces of the future. By using pneumatic kinematics with vacuum-based holding force, it can already solve the widest range of gripping tasks in the industrial sector.

Grippers in today's automation
There are already a number of different grippers in the industrial automation sector today, and each of them has been developed for a special task. If the shape of a workpiece changes, the corresponding gripper must be replaced on the machine or converted, which requires a great deal of effort. In facilities that make various products, changeover systems are therefore frequently used, which are fitted with different grippers.

Requirements of tomorrow's factory
In the production of the future, however, there will be a need for more flexible installations and components, which are independently adjusted to the respective product being made in accordance with plug and produce. Adaptable grippers like the TentacleGripper can assume a significant role in this respect.

TentacleGripper
Gripping modelled on an octopus tentacle

The natural model

The octopus is a fascinating creature: depending on its mood and environment, it can not only change colour as quick as a flash; for camouflage purposes, it can also adapt the surface structure of its body to the ground underneath. As it has no skeleton and is made almost entirely of muscle, it is also extremely flexible. It can thus force itself through even the smallest crannies, swim agilely in all directions and grip a wide range of objects in a form-fitting manner. With the aid of the suction cups on the inside of its eight tentacles, it can also grip with great force and hold tight onto smooth surfaces.

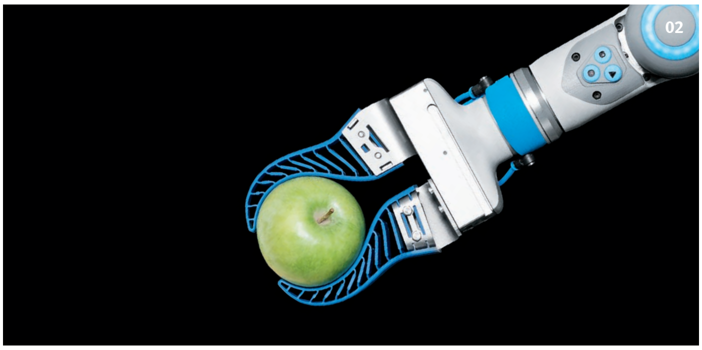
The technical implementation

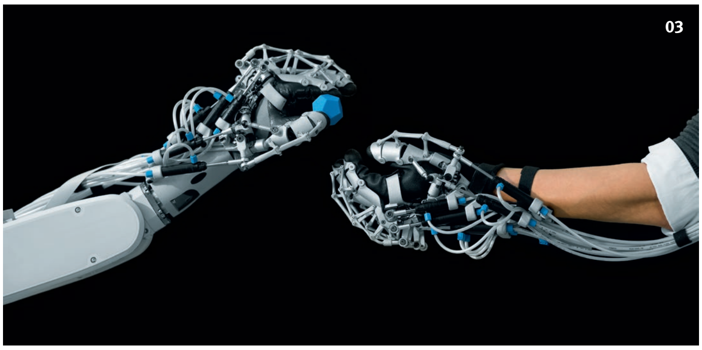
The TentacleGripper consists of a soft silicone structure, which pneumatically deforms and thus wraps around the object being gripped. For this purpose, a chamber running lengthways is cut out in the back of the tentacle and is filled with compressed air. A textile cover is embedded around the air chamber, restricting its expansion and protecting the silicone from bursting. In the middle of the tentacle is a wafer-thin film. Together with the small recesses on the inside of the gripper, it ensures that the structure only bends inwards. The gripping process is supported by passive and active suction cups, which provide additional grip on the object.

The industrial benefit

This combination of interlocking gripping and secure adhesion makes the TentacleGripper suitable for a number of objects with different shapes and geometries, with a smooth surface and high sensitivity. Furthermore, its safe structure already meets the strict criteria of a soft robotics component and guarantees a safe working relationship with people.

The Bionic Learning Network
New impetus through open innovation





The aims of the Bionic Learning Network not only include learning from nature, however, but also identifying good ideas at an early stage and fostering them and implementing them jointly beyond company borders. The TentacleGripper is another outstanding example of the close collaboration by Festo with universities as part of the network.

Interdisciplinary university project
The silicone tentacle was developed in cooperation with the School of Mechanical Engineering and Automation at Beihang University (BUAA) in China. After a loose exchange at first about possible bionic technology platforms and soft robotics in general, the joint decision came about to implement the octopus tentacle as a pneumatic gripper.

Following that, two students from the university started looking at how to technically derive the natural working principle with support from Festo. At the Hannover Messe in April 2016, the project managers then met in person and their work together was intensified.

Online conferences and joint implementation
The team then got in touch every month by video to share the latest development statuses and new ideas with each other. By integrating the suction cups, it was possible to considerably improve the gripping properties of the silicone tentacles in this phase of the project.

The next milestone came during a two-day workshop organised by Festo on the subject of bionics in Beijing, where the project team met and developed the gripper further together on-site. On their return visit to the Festo headquarters, the two students were able to optimise their designs together with the Festo engineers and put them into practice with the help of the latest prototyping technology. This allowed both the robustness and the flexibility of the tentacle to be significantly increased and to take the concept forward to the functional gripper.

The TentacleGripper is thus added to a series of grippers, which have already emerged from the interdisciplinary research work of the Bionic Learning Network.

01: **TentacleGripper 2017:** Gripping like an octopus tentacle

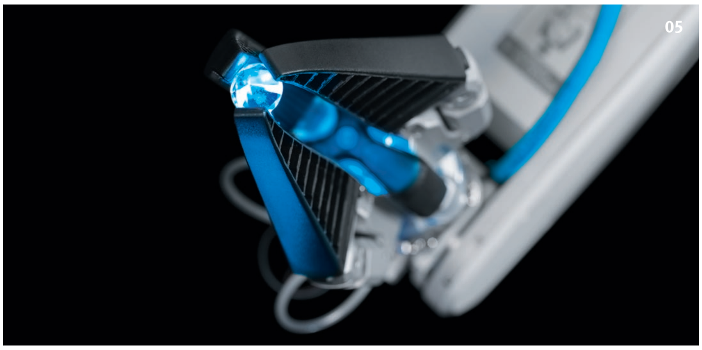
02: **Adaptive gripper DHAS:** From the research project to the production stage

03: **ExoHand 2012:** Power boost for human-technical cooperation

04: **LearningGripper 2013:** Gripping and learning – working together

05: **MultiChoiceGripper 2014:** Variable gripping of different shapes

06: **FlexShapeGripper 2015:** Form fit of the chameleon's tongue



Widest range of grippers based on a natural archetype
The developers were inspired by the animal world for the first time in 2009 when it came to the adaptive gripper fingers on the BionicTripod. Like a fish's fin, the structure with Fin Ray Effect® does not give way under lateral pressure, but instead bends around the pressure point. The fingers therefore close softly around the items being gripped, which enables fragile and irregularly shaped objects to be safely gripped. In the meantime, Festo has developed the gripper finger into a serial product under the name DHAS.

Another gripper project from the Bionic Learning Network is the NanoForceGripper from 2012, whose gripping area imitates a gecko's foot. It is used to grip especially sensitive objects with smooth surfaces without leaving any residue and almost energy-free.

Do you want to find out more about the bionic gripper from Festo?
Visit **www.festo.com/bionics** on your smartphone, tablet or PC and click through the projects.

With the PowerGripper, Festo implemented the complex kinematics of a bird's beak in the same year. And with the ExoHand, the developers presented an exoskeleton that can be put on like a glove: it is used to actively move fingers, boost the power in the fingers and detect movements of the hand and transfer them in real time to robot hands. By means of force feedback, the person feels what the robot is gripping.

In 2013, Festo used the LearningGripper to develop a research platform, which is able to learn and can adopt complex actions by itself. One year later, the opposable thumb of the human hand served as an inspiration for the MultiChoiceGripper: like its natural counterpart, the gripper is able to change its fingers over so that it can grip either in a parallel or centric direction, without requiring any conversion.

The operating principle of the FlexShapeGripper from 2015 is derived from a chameleon's tongue. With its elastic cap made of silicone, it can pick up several objects with the widest range of shapes in one procedure and set them back down together.

Technical data

Length: .... 22 cm
Weight: .... 190 g
Working pressure: .... 2 bar

Structure material: .... moulded silicone
Textile cover material: .... LYCRA® fibres
Film material: .... polystyrene

Active suction cups: 8
Passive suction cups: 10

Fin Ray Effect® is a brand of Evologics GmbH, Berlin
LYCRA® is a trademark of INVISTA

Project participants

Project initiator:
Dr Wilfried Stoll, managing partner,
Festo Holding GmbH

Project management:
Dr Heinrich Frontzek, Dr Elias Knubben,
Festo AG & Co. KG

Project team:
Professor Li Wen, Xie Zhexin, Gong Zheyuan,
School of Mechanical Engineering and Automation,
Beihang University (BUAA), China
Nathanael Peltzer, Festo AG & Co. KG

Scientific support:
Dr Nina Gaißert,
Festo AG & Co. KG

Festo AG & Co. KG

Ruiter Strasse 82
73734 Esslingen
Germany
Phone +49 711 347-0
Fax +49 711 347-21 55
cc@festo.com
→ **www.festo.com/bionics**

50135 en 3/2017