Bionic Handling Assistant

FESTO

DEUTSCHER ZUKUNFTSPREIS
Preis des Bundespräsidenten
für Technik und Innovation

**Platform for
the development
of new technologies**

Systematic expertise through continuous further development

Platform for innovations from the Festo range of products
Flexible movement and precise gripping: at first glance, the Bionic Handling Assistant appears to be a resilient gripper arm whose structure and overall functional principle imitate an elephant's trunk. However, above and beyond its actual benefits, the Bionic Handling Assistant is a development platform combining a wide range of technologies and components – from manufacturing concepts to series products like sensors and valves, actuators and grippers, to control technology and software for developing applications and products.

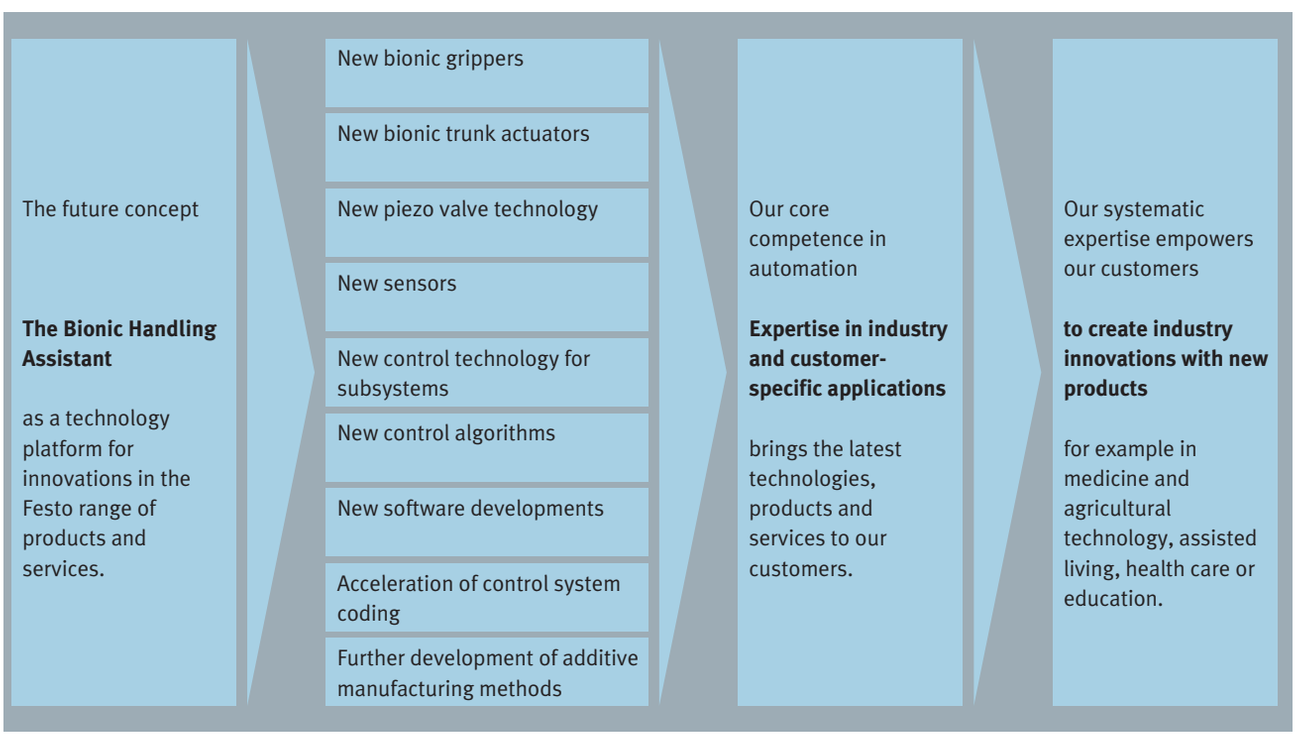
Future Concepts for tomorrow's industry
The Bionic Handling Assistant was developed as part of the Bionic Learning Network. The network is a joint research project between Festo and several universities, institutes and development companies. The objective of the initiative is to use bionics in order to transfer biological principles to technology and to produce innovative solutions and visions for industrial applications.

New perspectives in human-machine cooperation
The Bionic Handling Assistant is thus an example of how structural flexibility and new control concepts, based for example on speech and image recognition, can help humans to interact simply – and above all safely – with machinery in the factory environment of the future. In the event of a collision with the human operator, the system no longer presents a hazard and does not need to be carefully shielded from humans as in the case of conventional factory robots.

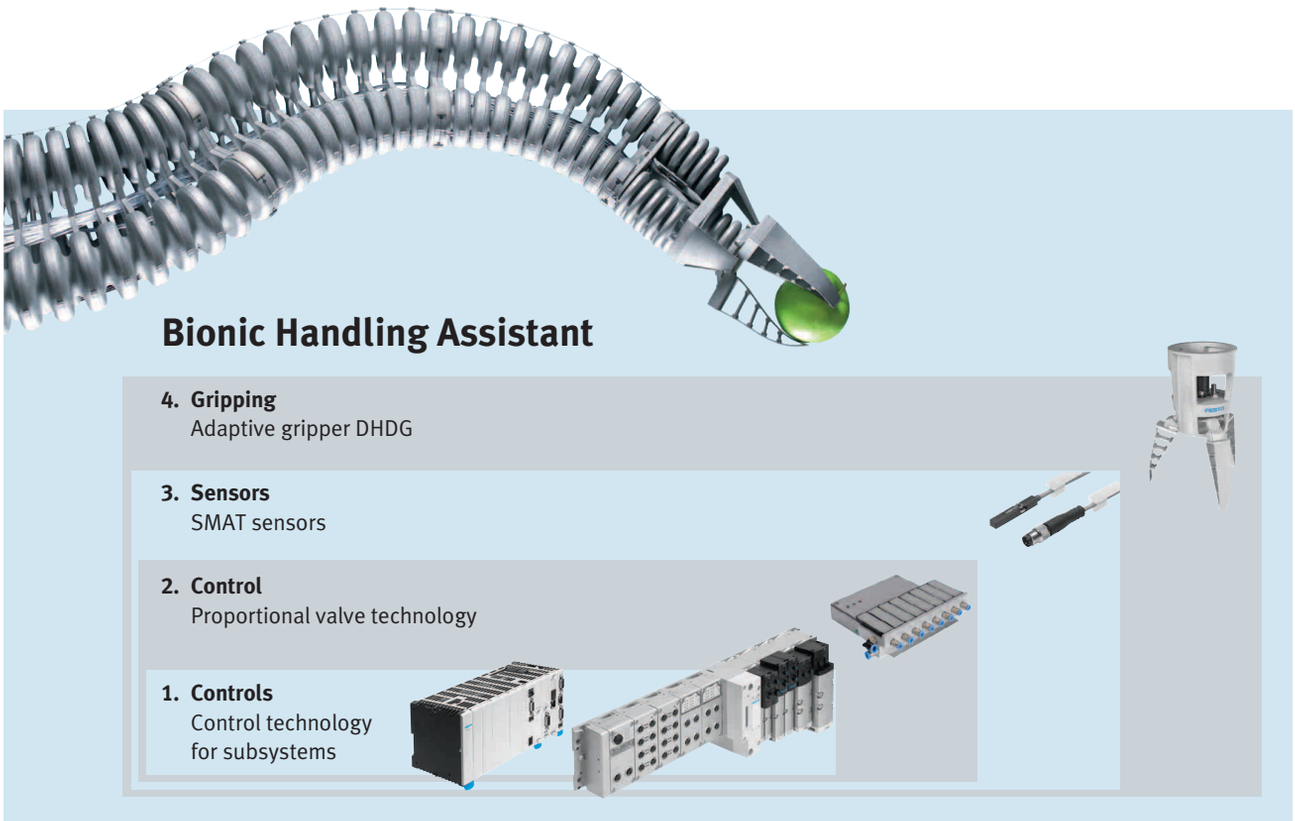
In view of technologies that are coming into increasingly close contact with humans, along with demographic change and the ongoing mechanization of our everyday lives, this hazard-free operation opens up new perspectives for the research field of human-computer cooperation. Safe, direct contact paves the way for new forms of interaction between humans and technology.

The competitive advantage for our customers
Whether it's about using additive manufacturing technologies, the individual serial components or controlling the mobile bellows structure, continuous optimisation of the individual technologies not only means that engineers and designers developed the Bionic Handling Assistant itself. It also means that Festo as a technology provider gives its partners and customers in-depth knowledge and approaches to developing and improving new products and applications together.

Partner for developing industry innovations
The resulting expertise makes Festo the ideal partner for its OEM customers from a wide range of industries and with a wide range of requirements, e.g. in medicine and agricultural technology, ambient living or health care. With the appropriate components and solutions, services and expertise, Festo supports product development of its customers from the outset, from market analysis to function simulation, and from prototypes to efficient and productive volume manufacturing.



Festo enables customer innovations with, for example, the Bionic Handling Assistant



Used for the Bionic Handling Assistant – and already available from the Festo product range

Additive manufacturing technologies make construction easy
The manufacturing requirements for the Bionic Handling Assistant were driven by the use of the modern technology of additive manufacturing. It enables the production of individual, moving system parts from polyamide, which is highly flexible and has a low density.

Selective Laser Sintering (SLS)
At the start of this production process, the material is in powder form and is applied to a building platform in thin layers. A laser fuses each new layer with the layer below, and hardens it only where the control program requires it. Any powder in the cavities is not hardened, and can therefore be removed later. That permits the individual 3D printing of complex products.

Cost-efficient production
In additive manufacturing, there are no costs for tools, while additional costs for auxiliary materials and equipment are reduced. There are no delays when creating tools and the resulting faster market launch contributes to increasing overall profitability. Rapid response times generate efficiency and facilitate time-critical projects.

Flexible and resilient bellows structure
The flexibility of the Bionic Handling Assistant's bellows structure is down to the use of polyamide, while the necessary stiffness is provided by the pneumatic control when required. The resilient structure prevents danger in the event of contact between the machine and people – whether intentional or unintentional. If a collision occurs, the system yields immediately, without changing the required overall dynamic movement.

Cable potentiometer for true position control
The looped design of the actuators controls the resetting movement by acting like a tension spring when the compressed air is released. An additional vacuum enhances the resetting force. Cable potentiometers on the outside of the actuators determine its extension and carefully control the position of the system in space.

Festo SMAT sensors precisely determine the distance and path
The hand axis contains three further actuators around a ball joint. Their activation changes the angle of the gripper by up to 30 degrees. Festo SMAT sensors detect the travel paths and allow precise alignment. Overall, the Bionic Handling Assistant has eleven degrees of freedom. They permit a variety of taskspecific travel paths that are not linear, in contrast with conventional handling systems.

Open and closed-loop control with smart solution packages
The system's "brain" is a multi-axis controller. The control systems used can even control complex subsystems easily and reliably. The integrated automation platform CPX is a decentralised control solution for field applications. The electric terminal is equipped with a wide range of functions: electric and pneumatic movement, measurement, control and more – all in one. That makes CPX a prerequisite for comprehensive function integration.

Rapid and precise position control
The robotic controller CMXR can also control movement intelligently. It operates smoothly in conjunction with the so-called tripod from Festo, a complex mechatronic handling system with electric linear axes for rapid movement of small items. It is robust and makes programming easy. Automatic code generation allows you to configure position control in less than ten minutes. This is particularly advantageous for automated small-series production, where processes must be changed and corrected rapidly.

A flexible polyamide structure from additive manufacturing

Piezo valve technology for an efficient use of compressed air
For pressure control in the chambers of the three-part gripper arm, Festo uses proportional valves. These are also used to make vehicle seats more comfortable. They allow the development team to use compressed air precisely and lower air consumption, thus generating significant cost savings and optimising the installation space compared with other valves.

Simple motion control thanks to integrated image recognition

Gripping with fingertip control
The adaptive gripper of the Bionic Handling Assistant consists of a pneumatic drive and three fingers based on the Fin Ray Effect®, derived from the movement of a fish's tail fin. The structure with the Fin Ray Effect® was developed by Leif Kniese from EvoLogics in Berlin. The gripper's flexibility and resilience come to the fore in particular when holding and transporting sensitive objects or objects with varying contours. Compared with standard metal grippers, the adaptive gripper's outstanding feature is its 80 % lower weight. That allows the gripper to operate economically and reduces cycle times.

Robotic controller CMXR
Allows free 3D path control of complex kinematics like the tripod

CPX terminal
Used as remote I/O or as a valve terminal in pneumatic and electrical control chains

Proportional directional control valve VPWP
For control and positioning on one platform, for both pneumatics and electrics

SMAT sensor
Its compact design enables new areas of application in compact cylinders and grippers

New processes, applications and solutions

Winner of the 2010 German Future Award
The Bionic Handling Assistant was awarded the German Future Award in 2010. Since 1997 the German President has presented this prize for innovation and technology every year to researchers and developers whose inventions represent a step forwards, benefit mankind, improve life and create jobs.

Bionic Handling Assistant as a development platform
During the development process of the Bionic Handling Assistant, Festo broke new ground in many areas. The new technologies, which had never been used before in this way, ranged from the manufacturing method to the use of new control algorithms. Together with the development partners from research, education and industry, some interim objectives have already been achieved.

1. Continuous optimisation of the manufacturing process
Manufacturing components which are dynamically pressurised is a demanding process. In order to meet this demand, Festo continuously improves this process in collaboration with the manufacturer of the SLS systems. New exposure parameters make it more stable, thus reducing the number of rejects. By investing in research, Festo is creating a state-of-the-art manufacturing process that can be used in future especially to produce prototypes, one-offs and small series.

2. Preparing sub-projects for series production
The adaptive gripper DHDG used in the Bionic Handling Assistant is the first product which has made the leap from a future concept to series production. Festo now sells the gripper in three sizes to ensure safe and damage-free gripping of fragile and irregularly shaped workpieces or goods. The minimal pressure on the gripped surface makes the DHDG ideal for pressure-sensitive components or goods.

3. Establishing the basic principles
With eleven degrees of freedom, the Bionic Handling Assistant can be moved freely in all directions. Before now, no other system this flexible has permitted such precise position calculation. Festo used entirely new control algorithms to develop a kinematic model to calculate the exact position of the gripper. Using reverse transformation to determine the position in global coordinates is another innovative technology in the Bionic Handling Assistant and highlights Festo's control engineering expertise.

4. Motion control with image and speech recognition
The system is now being supplemented by a simplified interface for image and speech recognition. The Bionic Handling Assistant is thus now able to autonomously grasp objects, without the need for programming or manual control. For this purpose, a miniature camera module is implanted in the gripper module so that it can register the working area, detect target objects, follow them and issue the command to grasp them at the appropriate time. For speech recognition, the engineers made use of an appropriate interface: via a defined series of commands, the system grasps, conveys and moves the objects – simply and reliably.

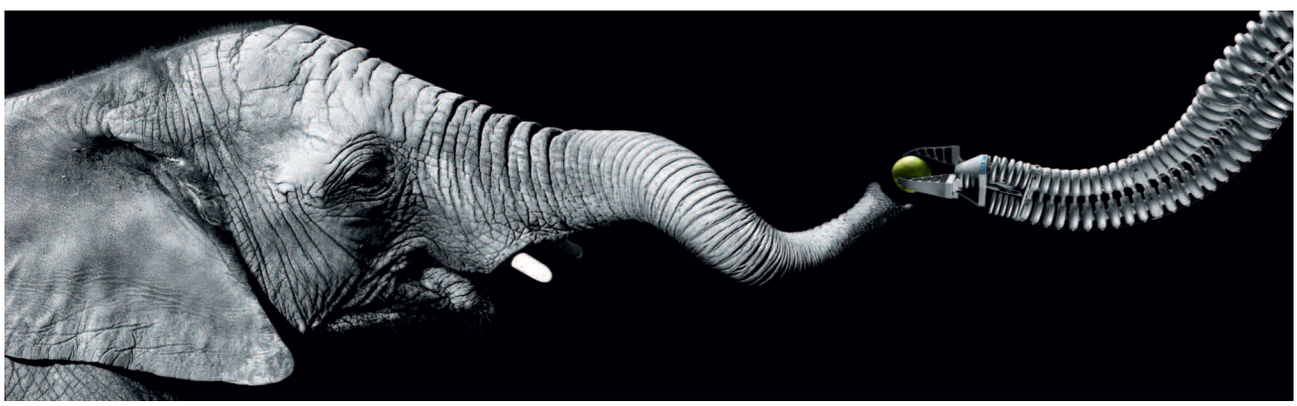
5. Ongoing development with a mobile learning system
During the further development of the Bionic Handling Assistant, Festo designed a compact version of the "trunk", which was installed on the mobile learning system Robotino®. It allows the mobile robot to grip and transport objects. The robot can be moved flexibly and the adaptive gripper can be aligned precisely via a game pad.

The latest piezo proportional valve terminal has its own integrated pressure regulator, and accurately meters the compressed air required in the air chambers of the gripper arm. Robotino® XT, a mobile robot application which is both a learning system and a research subject, has now gone into series production.


Mobile further development on the Robotino® learning system


From future concept to series product: adaptive gripper DHDG

Bionic Learning Network



The elephant’s trunk as the model for the Bionic Handling Assistant

A key part of Festo’s innovation process
The Bionic Learning Network is essential to Festo’s innovation process. In association with renowned universities, institutes and development companies, it considers natural principles that provide inspiration for technology and industrial applications. Festo developed the Bionic Handling Assistant in conjunction with the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA). The project was based on the development of lightweight pneumatic structures by Professor Dieter Mankau at the College of Design in Offenbach.

Biomechatronics: inspired by nature
Automated motion sequences can be made even more energy-efficient and productive using bionics, thus providing industry with completely new solutions for practical problems. Following the example of nature, the focus is on action principles and on implementing those using technologies that are based on natural phenomena.

Future concepts: a new impetus for automation
The Bionic Handling Assistant and the further development of Robotino® XT are not the only future concepts derived from the Bionic Learning Network. Every year, Festo develops new test objects, technology and development platforms that are important for transferring the core competencies in automation – from pneumatic muscles and bionic tripods to floating and flying models, all with functionalities based on natural principles.

Focus on efficiency
In 2011, Festo decoded bird flight with the SmartBird. The wings of the ultralight flying model not only beat up and down, the active articulated torsional drive meticulously rotates the wings, combining lift and forward motion. The integration of several functions in such a small space provides us with important information for the development of hybrid drives. The minimal use of materials and the extremely lightweight construction point the way to resource and energy-efficient designs.

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