Press release

Focus on efficiency: Bird flight deciphered

The herring gull and the elephant's trunk provide inspiration for new accomplishments in energy efficiency and lightweight design for automation

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What do the herring gull and the elephant's trunk have to do with automation technology? Festo is providing the answer at the 2011 Hanover Trade Fair, where it is presenting its latest Future Concepts that are inspired by nature and are put into practice in the Bionic Learning Network. With SmartBird, engineers from Festo have succeeded in decoding the flight of birds, thus accomplishing a further breakthrough in automation technology. Just as with the Bionic Handling Assistant – which in 2010 received the German Future Prize, the highest award in the field of technology – and with the learning system Robotino® XT and the Bionic Tripod 3.0, Festo is focusing this year on energy efficiency and lightweight construction. Festo is providing fresh impulse not only in factory automation, but also in process automation: OptoFluidic paves the way for efficient analysis and diagnostic processes that allow continuous non-destructive analysis of fluids.

With the Bionic Learning Network and 66 new products, Festo at the Hanover Trade Fair is setting the pace in various fields, from safe automation and intelligent mechatronics solutions up to new drive and handling technologies, energy efficiency and lightweight construction.

SmartBird: The fascination of bird flight

One of the oldest dreams of mankind is to fly like a bird – to move freely through the air in all dimensions and to take a “bird's-eye view” of the world from a distance. No less fascinating is bird flight in itself. Birds achieve lift and remain airborne using only the muscle power of their wings, with which they generate the necessary thrust to overcome the air resistance and set their bodies in motion – without any rotating “components”. Nature has ingeniously achieved the functional integration of lift and propulsion. Birds measure, control and regulate their motion through the air continuously and fully autonomously in order merely to survive. For this purpose they use their sense organs.

The flight of birds was long shrouded in mystery. Many scientists failed in their attempts to understand how birds fly, and this secret continued to remain unsolved. The research team from the family enterprise Festo has now, in 2011, succeeded in unravelling the mystery of bird flight. The key to its understanding is a unique movement that

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distinguishes SmartBird from all previous mechanical flapping wing constructions and allows the ultra-lightweight, powerful flight model to take off, fly and land autonomously.

SmartBird flies, glides and sails through the air just like its natural model – the herring gull – with no additional drive mechanism. Its wings not only beat up and down, but also twist at specific angles. This is made possible by an active articulated torsional drive unit, which in combination with a complex control system makes for unprecedented efficiency in flight operation. Festo has thus succeeded for the first time in attaining an energy-efficient technical adaptation of this model from nature.

In developing the model, the engineers were able to draw on their wealth of experience and innovations. The experience gained with the Bionic Learning projects AirRay and AirPenguin was incorporated into the creation of SmartBird. The fascination of building an artificial bird that could take off, fly and land by means of flapping wings alone provided the inspiration for the development team: as a global player in pneumatics, Festo's mastery of airflow is unparalleled. In the development and production of the latest generations of cylinders and valves, the objective is to make optimal, efficient use of airflow for automation technology.

An unusual feature of SmartBird is the active torsion of its wings and the fact that it dispenses with the use of additional lift devices. The aim of the SmartBird project was to achieve an overall structure that is efficient in terms of resource and energy consumption, with minimal overall weight, in conjunction with functional integration of propulsion and lift in the wings and a flight control unit in the torso and tail regions. Further requirements were excellent aerodynamics, high power density for propulsion, and maximum agility for the flying craft. The outcome is an intelligent biomechatronic overall system.

In practice, this system operates above all in an energy-efficient manner: the propulsion and lift, as intended, are achieved solely by the flapping of the wings and have a power requirement of only around 23 watts. SmartBird has a total weight of around 450 grams and a wingspan of two metres. Measurements have demonstrated an electromechanical efficiency factor of around 45 % and an aerodynamic efficiency factor of up to 80 %. SmartBird is thus an excellent example of functional integration and resource-efficient extreme lightweight design, and demonstrates optimal use of airflow phenomena. It will provide important impulses for the further optimisation of future generations of cylinders and valves.

The onboard electronics ensure precise wing control. In addition, the torsion control parameters can be adjusted and thus optimized in real time during flight. The wing flapping and twisting sequence is controlled to within only a few milliseconds and results in optimum airflow around the wings. The SmartBird flight model has no rotating parts on its exterior and therefore cannot cause injury. It is further pursuing an approach that already played an important role in the development of the Bionic Handling Assistant: human-machine interaction. This feature of both the Bionic Handling Assistant and SmartBird poses no risk to the human operator. SmartBird thus joins the list of Festo's future-oriented technologies that are expected to find practical application. Possible uses range from stroke wing generators in the energy sector up to actuators for process automation.

The Bionic Handling Assistant, winner of the 2010 German Future Prize: The elephant's trunk in further applications

For many years, the family enterprise Festo from Esslingen a. N. has been providing innovative products that prove their worth in practical application. In 2010 the Bionic Handling Assistant won the German Future Prize, the highest award in Germany for outstanding technical achievement. Modelled on the elephant's trunk, the Bionic Handling Assistant is now undergoing trial operation in production as a gripping tool and a “third arm”; is it paving the way for entirely new work processes in the future. With its inherent yielding ability, which allows hazard-free cooperation with humans, it is opening up wide range of applications.

Robotino® XT: A gripper arm extends the mobile learning system

Festo is now going a step further: With Robotino® XT, Festo is combining the existing mobile learning system with the Bionic Handling Assistant. Objects close to the ground can now be grasped and lifted; this system is now coming closer to finding practical everyday application.

The point of departure was the Robotino® mobile learning robot developed by Festo Didactic. This mobile robot system, which has already been established at universities and vocational schools, is capable of autonomous movement thanks to an inbuilt camera; it is now being extended with the addition of a compact version of the Bionic

Handling Assistant based on the elephant's trunk. In the latest version, this device is simply attached to Robotino®. Robotino® XT can thus not only manoeuvre in cramped spaces; by means of a control unit, it can be flexibly moved with precise alignment of the trunk unit. State-of-the-art piezo proportional valve terminals, which include their own integrated pressure regulators, precisely meter the pressurised air in the chambers.

The yielding nature of the system is defined by its design, by the material chosen – polyamide rather than metal – and by its control and regulation technology. Its inherently flexible structure is stiffened to a specific degree by the pneumatic control system, so that a predefined spatial movement can be performed. In the event of a collision the system immediately yields, but with no modification to its desired overall dynamic behaviour. The assistant does not constitute a hazard even if the electronics or the control system should fail, since its structurally inherent yielding capability then comes to the fore.

The entire trunk system, including the adaptive gripper, is designed as a lightweight arm. Every gram of weight that is saved enhances the mobility of the overall system. Robotino® XT is operated by means of a low-pressure pneumatic system, comprising two membrane pumps over a pressure range from 0.3 to 2.5 bar. Compared with standard pneumatics, this configuration has the advantage that less energy is required for pressure generation; the system is thus energy-efficient in its operation. Its manufacture is also cost-efficient, since its lightweight design is made possible by state-of-the-art methods in generative production technology – “3D printing”.

Bionic Tripod 3.0: Energy-efficient, highly dynamic overhead grasping
Lightweight construction and energy efficiency in combination with biological fundamental principles also provide the basis of a further product from Festo: the Bionic Tripod. The basic principle of the structure with Fin Ray Effect®, derived from the fish's fin, is applied several times over in Bionic Tripod 3.0 with its energy-efficient lightweight construction. The flexibility and yielding ability resulting from its energy-efficient lightweight construction make it ideal for tasks involving human-machine interaction.

With Bionic Tripod 3.0, Festo is adopting a new approach in handling technology as an alternative to the portal systems that are predominant in mechanical engineering. The drive unit and the handling system of Bionic Tripod 3.0 are entirely independent of each other. The working and drive levels are spatially separated by the work surface. Thanks to its low weight, this handling unit can be moved in a highly dynamic, energy-efficient manner. The low centre of gravity of the entire system provides additional stability for precise alignment with short travel, thus saving energy. With its adaptive gripping finger incorporating the Fin Ray Effect®, Bionic Tripod 3.0 can securely grasp objects of various shapes and contours located above it in a form-fitting manner and deposit them to the side. The flexible gripper arm can swivel up to an angle of 90 degrees in any spatial direction, which makes for a large scope of operation.

Bionic Tripod 3.0 combines the advantages of pneumatic and electrical automation technology with the latest bionic approaches. It is driven by two EGC 70-160 electrical linear axes, on each of which two DNC 32-160 standard pneumatic cylinders are mounted. The DSM 6 swivel module from Festo is attached to the receiving plate as a rotating unit at the end of the pyramid of rods. On each flange, the HGR-16-A radial gripper is fitted with two DHDG-W-80 adaptively gripping fingers, with which variously shaped objects such as test tubes, apples or light bulbs can be handled. Control and regulation are effected by a CPX terminal.

This technology can be used wherever small masses are to be moved rapidly and flexibly. Whether vertical or horizontal: with BionicTripod 3.0 and its two predecessors (BionicTripod 1.0 and BionicTripod 2.0), Festo is demonstrating that the separation of drive and working levels in all configurations makes for solutions with maximum flexibility.

OptoFluidic: Non-destructive real time analysis for process automation
While the BionicTripod already numbers among Festo's range of proven and refined products, a relatively new interdisciplinary technology by the name of OptoFluidic is being presented for the first time this year. It demonstrates both the realisation of optical effects and components and the analysis of fluids in motion such as liquids and gases, but also bulk solid materials that flow through pipelines and their fittings.

The technology of OptoFluidic provides its user with diagnostic and analytical methods in which certain characteristics of fluids in motion are detected and evaluated. For this purpose, the fluid is “charged” with information that can be subsequently read and assessed by optical components. The fluid thus becomes a medium that carries in itself the code for optical analysis. System components such as cameras and sensors visualize the diagnosis in real time, without the process flow having to be interrupted. In future, these analysis methods could replace time-consuming sampling and stabilize process flow, while reducing the number of components required and maintenance costs.

In this technology too, Festo uses natural phenomena as the basis: a rainbow, for example, is formed when the sun's rays strike raindrops. Here, the sunlight is refracted by the almost spherical water droplets and is separated into its spectral colour components. The sun's rays are analysed by means of the raindrops and become visible as a colourful rainbow. This optical analysis demonstrates that solar radiation is composed of the colours of the spectrum. Conversely, the sun's rays analyse each drop of rain in real time. They present the result in the visual form of a rainbow.

To demonstrate processes in the field of optofluidics and to record them in the form of data, Festo has developed OptoFluidic, a bionic test medium. For this purpose, Festo makes use of optical components such as cameras, sensors, LEDs, lasers and photodiodes. These are combined with fluid engineering devices such as valves, pumps and mixers which control the flow of the media.

With OptoFluidic, the analysis process comprises a number of stages: a blue liquid is first introduced into a transparent fluid by means of a valve; the two immiscible fluids then flow through the lines of the display. The blue liquid is the “intelligent medium” that conveys the information required for optical diagnosis. Possible steps in optofluidic analysis and separation are demonstrated in three stations:

The first station incorporates an SOEC optical sensor and an SBOC compact camera that analyses the blue fluid in real time in terms of its composition and characteristics and evaluates parameters such as the blue drop's volume. CheckKon and CheckOpti software is used for this purpose. A monitor displays the collected data and allows real-time monitoring of the processes.

At the second station, a blue LED with a wavelength of 490 nm renders a previously introduced fluorescent dye visible. This process shows how optofluidics can allow certain desired parameters and information to be registered and displayed in readable form by means of optical components.

At the third station, the blue liquid is detected by an SOEC optical sensor. The system separates the blue medium from the transparent liquid by means of a VODA valve. This separation process demonstrates how precisely process automation components from Festo can be used to analyse and control various fluids. The overall application is controlled by a CPX-CEC-C1 type CoDeSys front end controller and a number of CPX I/O modules. The CoDeSys-capable compact camera is directly connected to the CPX control and communicates in real time via Ethernet.

OptoFluidic shows how efficiently this technology can be used for diagnosis and analysis in process automation in future. The data and key figures collected are transmitted in real time with no interruption to the process. By means of real-time analysis, optofluidics dispenses with the time-consuming sampling of liquids and their subsequent analysis, thus automating laboratory processes. The choice of appropriately dimensioned light sources maximises resource efficiency and reduces energy consumption.

Optofluidic measurement techniques can play a major role in future – whenever fluids are to be automatically transported, treated, filled or disposed of: at sewage and power plants, breweries, in paper manufacture, at natural gas plants, in laboratory automation or in the chemical, pharmaceutical and petrochemical industries.

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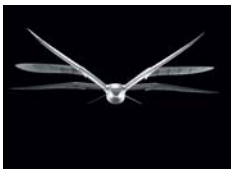


Caption to illustration: In 2011, the research team from the family enterprise Festo succeeded in unravelling the mystery of bird flight. The key to its understanding is a unique movement that distinguishes SmartBird from previous mechanical flapping wing constructions and allows this ultra-lightweight, powerful flight model to take off, fly and land autonomously.

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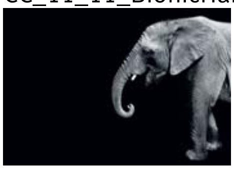


Caption to illustration: Award-winning research and development: Dr. Eberhard Veit, Chairman of the Management Board of Festo AG, with the Bionic Handling Assistant from Festo, which was awarded the 2010 German Future Prize.

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Caption to illustration: In the Robotino® XT model, the mobile robot application Robotino® has been extended with the addition of a compact version of the Bionic Handling Assistant. It can thus not only manoeuvre in cramped spaces; the gripper arm can also be flexibly moved and precisely aligned.

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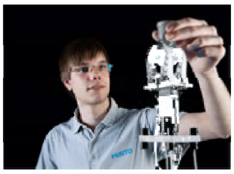


Caption to illustration:

Lightweight construction and energy efficiency in combination with biological fundamental principles also provide the basis of a further product from Festo: the Bionic Tripod. The basic principle of the structure with Fin Ray Effect®, derived from the fish's fin, is applied several times over in Bionic Tripod 3.0 with its energy-efficient lightweight construction.

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Caption to illustration: OptoFluidic technology provides its users with methods of diagnosis and analysis in which specific properties of fluids can be detected and analysed.

Press texts and images are available on the Internet at www.festo.com/press; for further information on the Bionic Learning Network, visit www.festo.com/bionic

Please contact us for footage material on all projects.