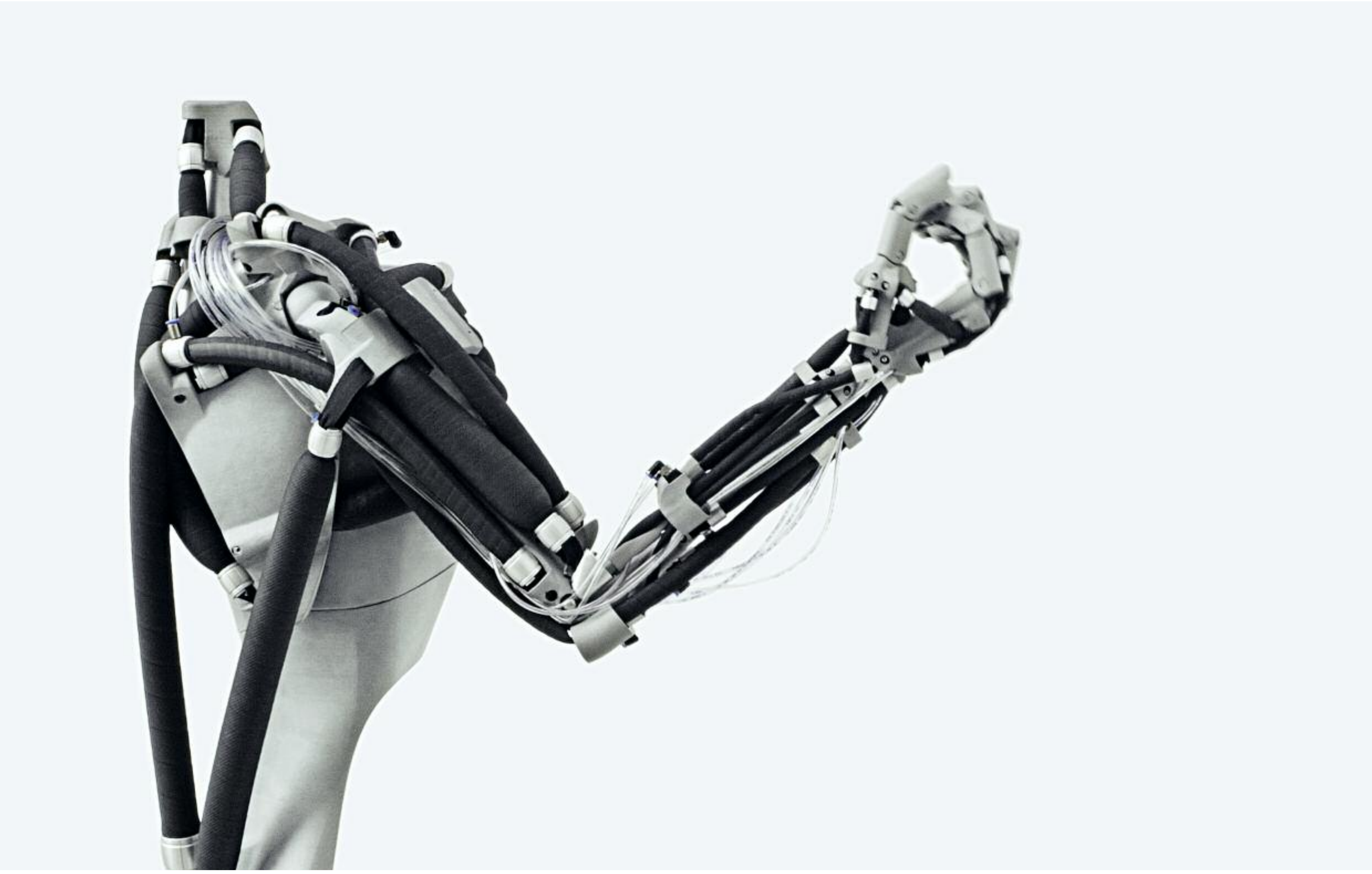
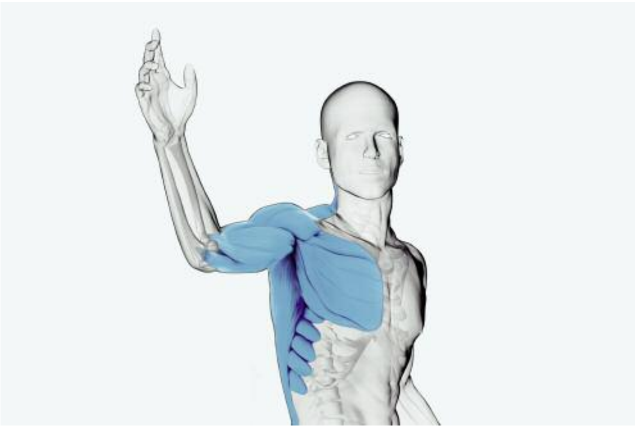
Airic's_arm



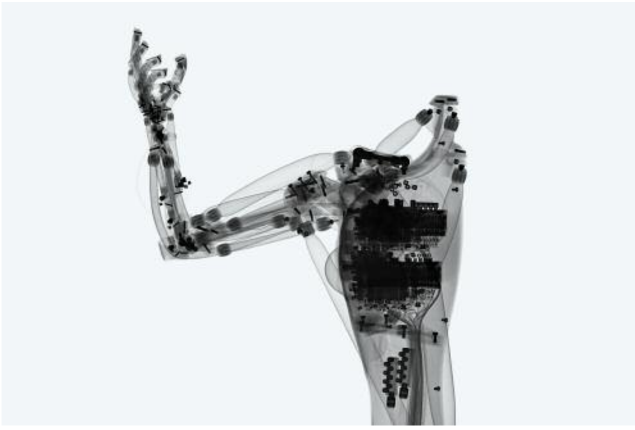
Robot arm
with Fluidic Muscles

Info

New opportunities in mechatronics and bionics



The human arm



X-ray images of Airic's_arm

How can technology be used to contrive a movement device which comes as close as possible to the human model in terms of overall concept, technical design and bionics Airic's_arm was inspired by nature. Its combination of mechatronics and bionics opens up new opportunities for shaping the future of automated movement.

The aim of this project is to gain detailed insights into the design principles of nature and to investigate modes of technical implementation. Although these anatomical and scientific principles have long been familiar, they are yet to find widespread application in technology.

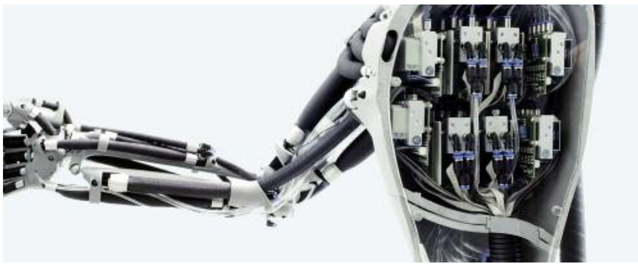
Today's technological world is characterised by high-precision, high-speed, sturdy, reliable long-life components that we can find in all areas of our lives. As a rule, machines carry out their assigned tasks in detail better than a human could. By the same token, however, there is no machine that can do everything that we can; this is due not merely to human intellect, but also to the enormous versatility of the human body. Unlike the world of construction design, our limbs are not rigid, and the body's structure is comparatively light, the human organism operates incredibly efficiently, the body is self-regenerating, and last but not least, the human is a universalist and - equipped with a few tools – can carry out practically any task.

With its hand and shoulder joint, the human arm has a total of 64 muscles and 28 bones along with a multitude of receptors for temperature, position, tactile sensation and pain. Thanks to the special structure of its joints, the human body develops astoundingly large forces and scope of movement in almost every direction. We can grasp objects in a defined manner with our hands and position them with high precision using our arms and shoulders. We are quick to react; a baseball, for example, reaches speeds of up to 150 km/h when thrown. We can grasp objects firmly with our hands and lift loads. In weightlifting, weights of up to 250 kg are raised.

All these characteristics are of great interest not only to us, but to the future of robotics; we shall soon be able to make use of them to leave more and more dangerous and hazardous tasks to technology.

Airic's_arm is a robot arm with artificial bones and muscles. A total of 30 muscles move the bone structure which, as with our own arms, consists of ulna and radius, metacarpal and finger bones, a shoulder joint and a shoulder bone-joints that are otherwise not encountered in this form in the world of technology. Airic's bones have not grown of their own accord, nor do they automatic-ally heal following a fracture. They were designed on computer and are grown in a three-dimensional polyamide structure using a state-of-the-art laser sintering process. The muscles, a product of Festo, are already widely found in industrial application under the name of Fluidic Muscles. These are tubes of elastomer reinforced with aramide fibres. When a Fluidic Muscle is filled with compressed air, its diameter increases and it is simultaneously shortened. This artificial muscle has immense starting power, and its dynamic behaviour is similar to that of a human muscle. Its greatest advantage over its human counterpart is that when contracted, it requires no further supply of energy. A weight once lifted can thus be held in any position indefinitely by Airic's_arm.

Airic's_arm with artificial bones and muscles



Piezo proportional valves

With this technology, the forces applied and the muscle's rigidity can be precisely metered. This is effected with very small, highly innovative proportional valves from Festo based on piezo technology. It was only the compact design that made it possible to position the 72 proportional valves, together with the pressure sensors and the power electronics in the form of 8 valve modules, close to the muscles; this was a prerequisite for reliable muscle control. The tensile forces and the contraction of the individual muscles are measured by pressure and length sensors. A mechatronic unit developed by Festo then regulates the pressure distribution within the system, allowing movements that closely approach the action of human muscles in terms of kinematics, rapidity, force, but also refinement.

Coordinating all these actuators is only possible using the most up-to-date mechatronic systems and software available. Movements which we humans carry out subconsciously, or even in a reflex action, still require a great amount of effort using computer-supported control and regulation. Extending the sensory range of Airic's_arm, e.g. by means of cameras or tactile perception elements, would be conceivable in the future along with further developments in designing a back, hip, neck etc.

With bionic projects, Festo is setting out to investigate new approaches to automation beyond the confines of its customary field of activity; its highly innovative industrial components are finding many areas of application. The complex automation modes of the more distant future can be modelled on phenomena in air and water as sources of inspiration - but above all on the human being itself.

Technical data

Dimensions	
When deployed:	85 x 85 x 65 cm
Total weight:	6.3 kg
The valves	
32 piezo proportional valves:	flow rate 50 l/min
Dimensions:	62 mm x 15 mm x 7.5 mm
40 Piezo_Pico:	flow rate 9 l/min
Dimensions:	30 mm x 5 mm x 13 mm
Actuators	
Muscle ø 20 :	1
Muscle ø 10 :	12
Muscle ø 5 :	19
Sensors:	32 pressure sensors 6 length sensors

Project partners

Project initiator:
Dr. Wilfried Stoll, Chairman of the Supervisory Board, Festo AG

Concept and design, Festo AG & Co. KG:
Dipl.-Des. Elias Maria Knubben, Corporate Design
Dipl.-Ing. (FH) Markus Fischer, Corporate Design

Control and regulation, Festo AG & Co. KG:
Dipl.-Ing. Alexander Hildebrandt, Research Mechatronics Systems
Dr.-Ing. Rüdiger Neumann, Research Mechatronics Systems

Valve technology and electronics, Festo AG & Co. KG:
Dipl.-Ing. (FH) Andreas Risle, Mechatronic Components
Dietmar Lösche, Research Mechatronics
Markus Trick, Future Technologies
Dr.-Ing. Otto Szenn, Process Hardware Software

Membrane technology, Festo AG & Co. KG:
Bernd Lorenz, Membrane Technology
Walter Harrer, Membrane Technology
Dipl.-Ing. (FH) Achim Schantze, Membrane Technology

Photos:
Walter Fogel, Angelbachtal, Germany
Carl Zeiss, 3-D Metrology Services, Aalen, Germany
www.zeiss3d.de

Festo AG & Co. KG

Corporate Design
Rechbergstraße 3
73770 Denkendorf
Germany
www.festo.com/bionic
Phone +49 711 347-3880
Telefax +49 711 347-3899
fish@de.festo.com

50115 EN