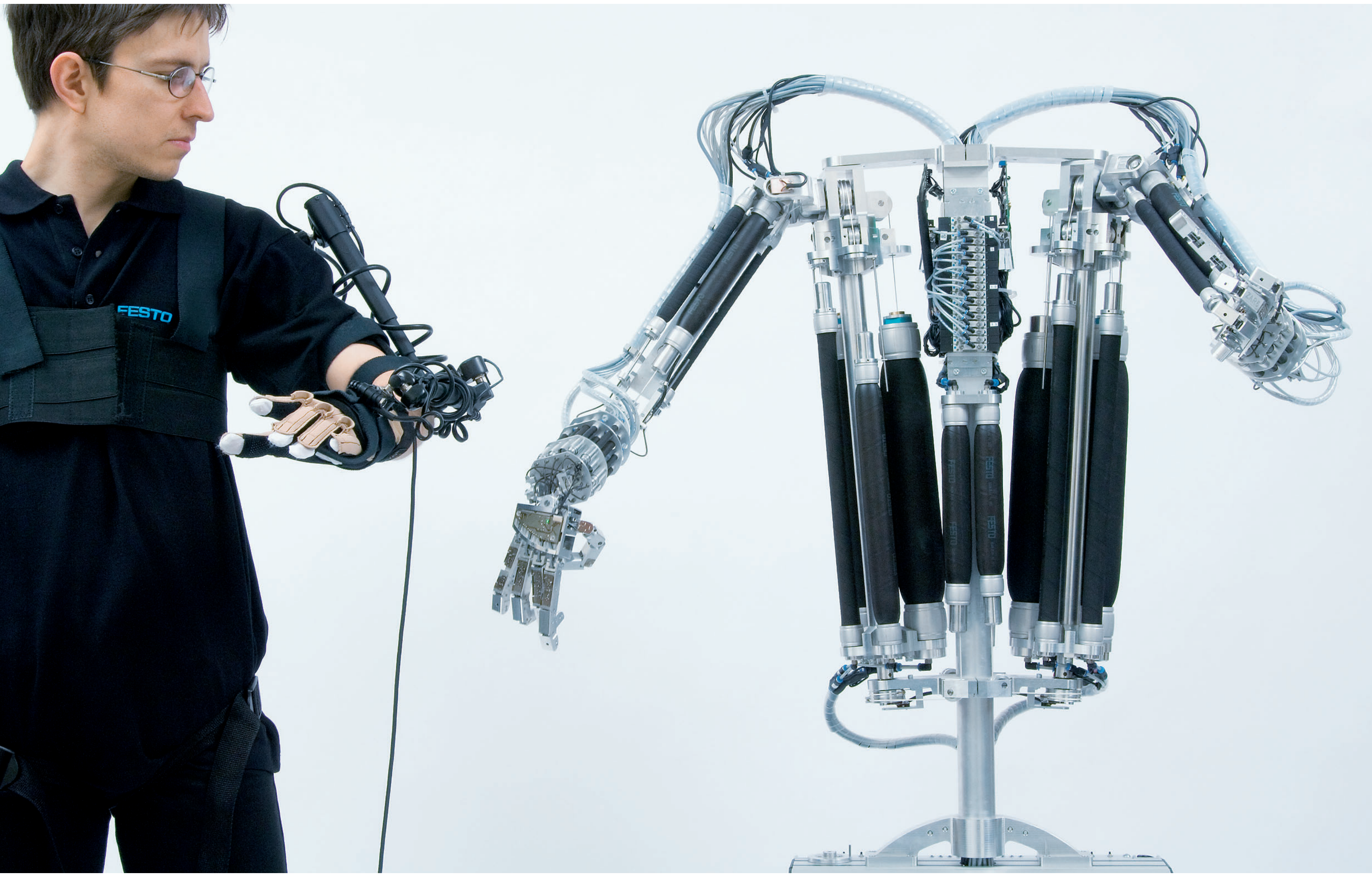
Humanoid Muscle-Robot

FESTO

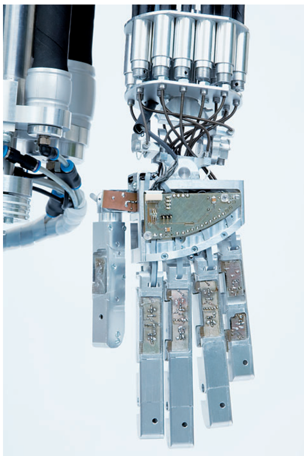


**A robot using
Fluidic Muscle
as actuator!**

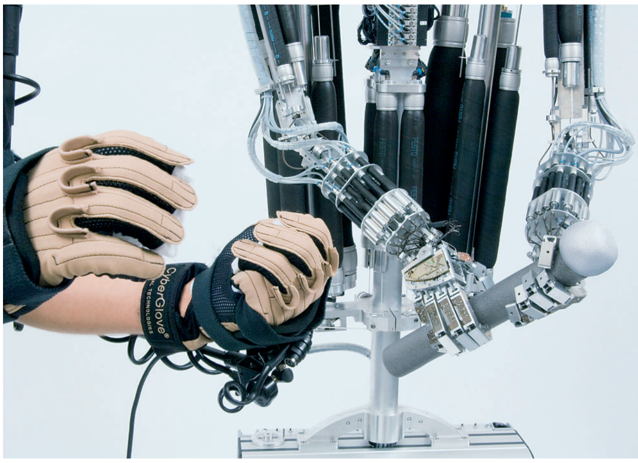
Info

The human role model

Data glove control



Artificial hand



Transferring a weight of 1 kg

The humanoid muscle-robot is the result of a joint venture between the Evologics GmbH, the department of bionics and evolutionary technology at the Technical University of Berlin and the Festo AG & Co. KG.

From a functional prototype employing a simple robotic arm in 2000 the project evolved into various intermediary designs to eventually generate a complete torso using two anthropomorphic robotic arms as well as fully elaborated hands with five fingers each.

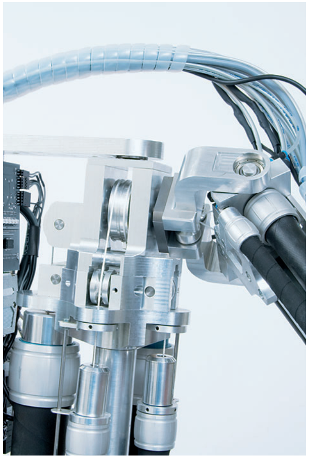
The development is based on studies focused at bio-mechanics of the human loco-motor system. Particular emphasis was put on incorporating insights into technical designs, which provide for human-like performance by using simple means.

Key elements for the technical implementation was the Fluidic Muscle by Festo. By using artificial tendons made from extremely tear proof Dyneema® cables the tension forces generated by the muscles can be transmitted to the actual position elements without torque and across multiple joints. As a benefit, the actuators, thus, can be placed inside the body in order to keep the mass of the movable parts at a minimum. For antagonistic operation, powerful, yet ultra-light actuators are combined into pairs, which allows for smooth, continuous, and elastic movements as well as short-term energy storage. As a result, deployment of basic functions such as bending, stretching, and turning enable movements of high complexity across the construction's total of 48 degrees of freedom.

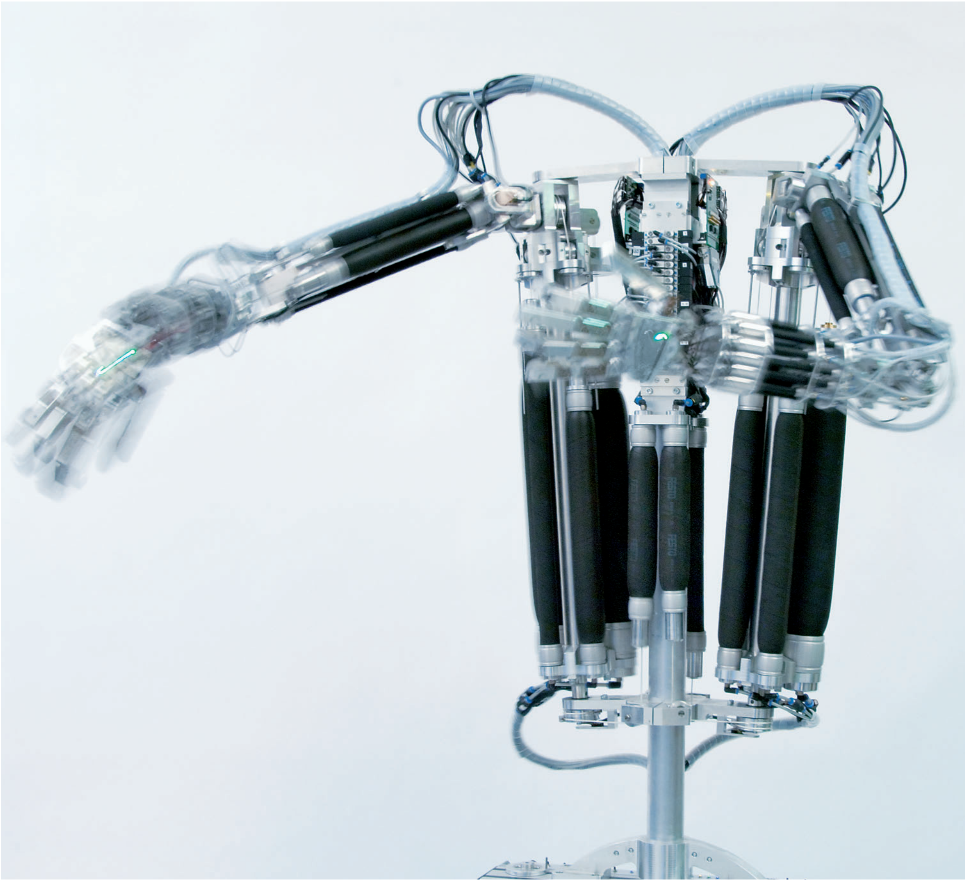
With humans, various muscles, e. g. the big chest muscles as well as the deltoid related to the shoulder joint are laminar type muscles. As such, when contracting, various groups of muscle fibers can stabilize ball joints by simply pulling into different directions. The Fluidic Muscle provides for the axial component of the tension forces. Instead of mimicking nature, however, and building a laminar structure from various individual elements, the bionic version of the shoulder joint utilizes the three axis cardan principle.As a consequence, each of the three main axes of movement can be controlled precisely and independently by just three pairs of muscles. Beyond this example, a whole array of structurally intelligent solutions and mechanical couplings has been realized, which can also be used in other technical applications.

Compared to our hand - which is activated by a number of different muscles - for the muscle-robot the amount of actuators could be significantly reduced by substituting retaining springs for the finger extensor muscles. The remaining flexor muscles, which facilitate secure grabbing and holding of objects of different size and weight, as well as the muscles for the hand's positioning have been mounted revolving around the lower arm. Special Bowden controls using Dyneema® cables transmit the forces generated by the muscles to the respective joint sections.

The robot's joints are equipped with angle-sensors enabling precise positioning at 1° increments. Further sensors measure the pressure at each individual muscle of the body as well as the strain each joint is exposed to. The combined sensor information allows for addressing any position in space in a force-guided manner.



Shoulder joint



Humanoid moving

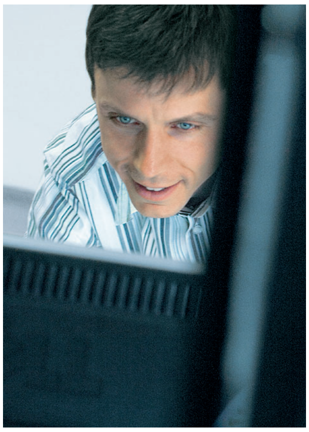
By doing so, the muscle tone can be regulated such that the resulting kinematical motion ranges from loose oscillating or swinging to precise force-controlled movement.

Two microprocessors control each arm and hand. The first microprocessor reads and computes the information coming from the sensors, carries out related controls, and eventually sends the control values on to the second microprocessor. Via related amplifier modules, the second microprocessor manages the valves which control the air supply to the muscles. All sensor-processors receive their target data from a central computer located in the base of the robot. The central computer, in turn, obtains its information via radio waves from the data-suit and data-gloves worn by the operator.

The humanoid has a deployable radius similar to the one of a human being of the same size. Due to its excellent weight-power ratio, its ability to pick objects and position them in space, as well as its human-like proportions, the humanoid doesn't deny its origin. The robot can either execute a predefined program or mimic motions entered remotely through data-suits and -gloves. As such, it is possible to transfer movements executed by a human protagonist directly onto the robot – related time delays are in the vicinity of about 0.5 seconds. This remote control also works over long distances.

In particular, the project shows – besides numerous exciting and versatile technical applications – how human beings and humanoids can easily work together in the future. As such, a humanoid muscle-robot can be considered a feasible extension and place holder of men capable of operating in places either too dangerous or inaccessible for human beings. Overall, potential applications may range from terrestrial and deep sea operations to tasks carried out in outer space.

This anthropomorphic robot, built from Fluidic Muscle, can perform static labor without risking actuator system failures. The floating and human-like motions can only be accomplished by using Fluidic Muscle by Festo.



Specifications

Dimensions:		
Idle mode:	Base size:	82 x 50 cm
	Height:	175 cm
Active mode:	Deployable radius:	110 cm
	Deployable height:	220 cm
Number of actuators, Festo Fluidic Muscles:		
Body:	MAS40	2 x 2
	MAS20	2 x 6
	MAS10	2 x 2
Hand:	MAS5 (Prototype)	2 x 16
Number of sensors:		
Body:	Angle:	2 x 5
	Pressure:	2 x 10
Hand:	Angle:	2 x 11
	Pressure:	under way
Number of microprocessors:		
Body:		2 x 2
Hand:		2 x 2
Power supply:		
Valves:		12 V
Electronics:		5 V
PC:		220 V
Fuse protection:		10 A
Air:		8 bar
Material:		Aluminum
Weight:		90 kg
Manageable weight:		2 kg
Precision of positioning:		1°

Project participants

Project initiator:
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Dr. Rudolf Bannasch, Evologics GmbH, Berlin, Germany

Head of bionic sensoring, measurement and control:
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