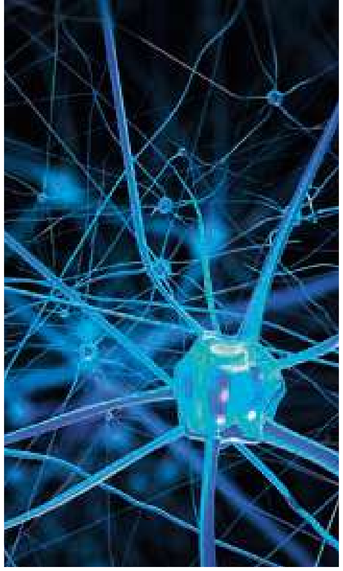
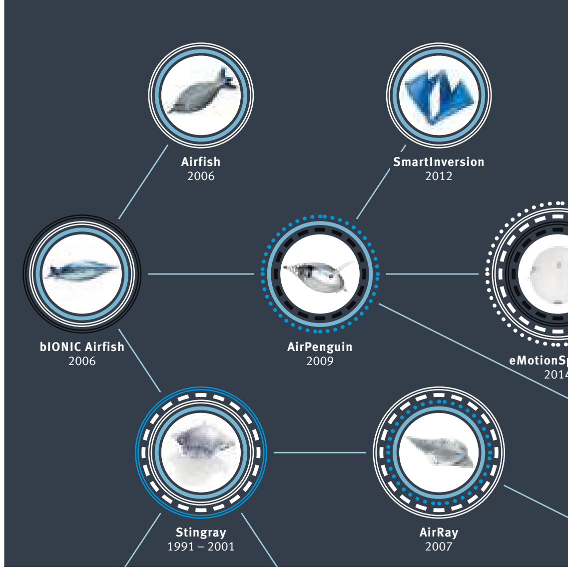
Bionics

Learning from nature – impulses for innovation



Inhalt



3D views and films are provided for the cover picture and selected bionics projects – as indicated by this symbol. Further information and links to the app stores are available at the website https://www.festo.com/bionicsbook and via the QR code.

BionicFlyingFox

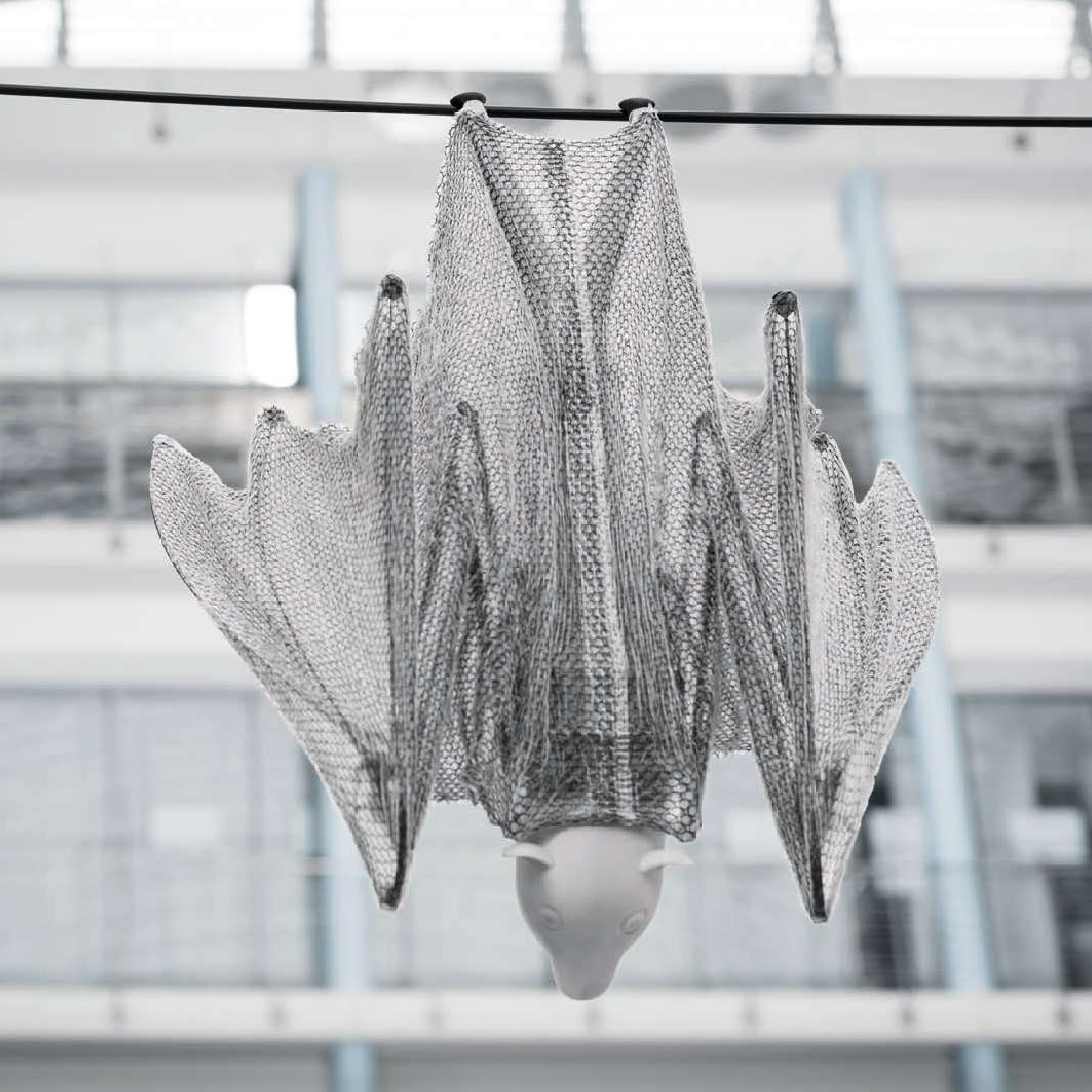
Fascinating flying membrane

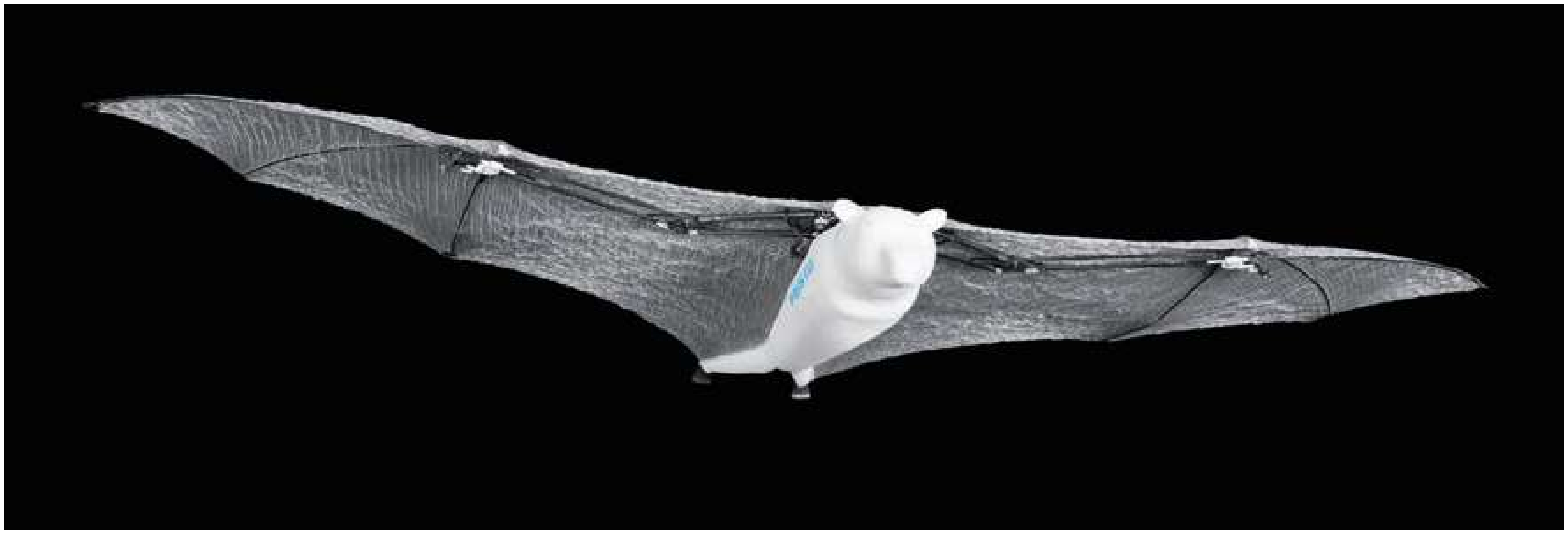
Flapping flight without feathers: bats are the only mammals that can actively fly. Their fine, elastic flying membrane is one of their salient characteristics. This so-called patagium, a double layer of epidermis, extends from the prolonged metacarpals and phalanges to the ankles. During sleep or periods of rest, bats retract their wings and hang upside-down by their rear toes – an optimal position for fleeing imminent danger. Some species form temporary or permanent colonies of several thousand individuals. Nocturnal bats primarily use echolocation by means of ultrasonic impulses for orientation in darkness, while most flying foxes, or fruit bats, rely on their very keen vision.

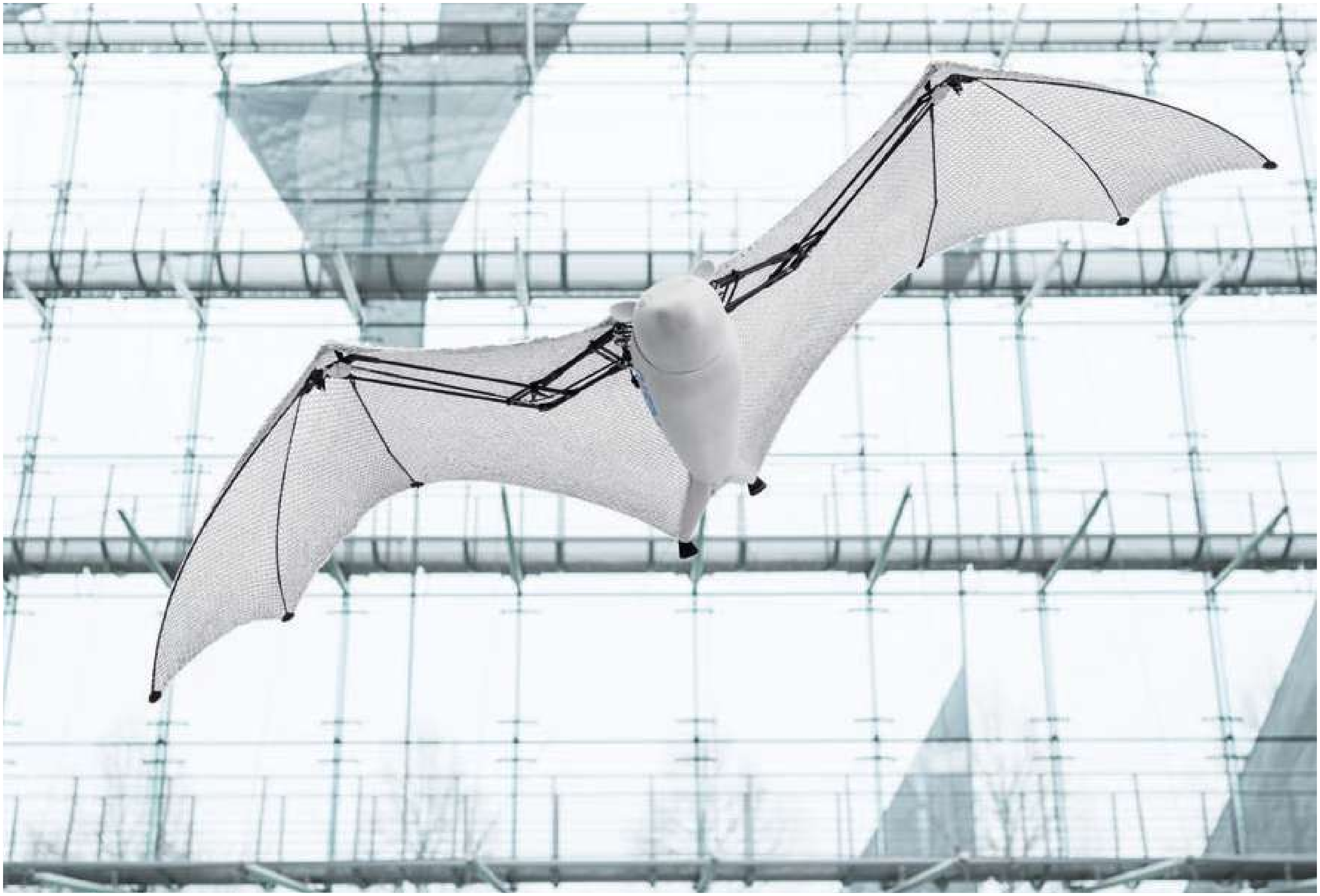
The BionicFlyingFox from 2018 is an individual flight object modelled on the natural flying fox. Its kinematics make a distinction between the primary and secondary wings, which are set in motion by a powerful brushless motor via an intricate lever mechanism. The joints are all located in the one plane, so that the wings can be completely folded; they can even be individually controlled and partially retracted during flight – a significant advantage for agile flight on the basis of the biological model.

A taut, flexible airtight skin extends from the fingertips to the feet of the artificial flying fox. Since it is highly elastic, it remains almost free of wrinkles when the wings are retracted. This specially developed membrane consists of a knitted elastane textile covered with spot-welded foils. Thanks to this honeycomb structure, the BionicFlyingFox can even continue to fly in case of minor damage to the bionic textile.

The onboard electronics regulate the flight behaviour of the BionicFlyingFox by means of inertial sensors and complex algorithms. An external camera system provides the control commands and positional data required for planning the flight path: two movable infrared cameras are sufficient to keep a constant track of the flying fox, which is fitted with infrared markers. The cameras are mounted on so-called pan-tilt units that make the corresponding movements possible. By contrast with the fixed cameras used to date, the innovative tracking system can be put into operation within only a short time and rapidly and easily calibrated.



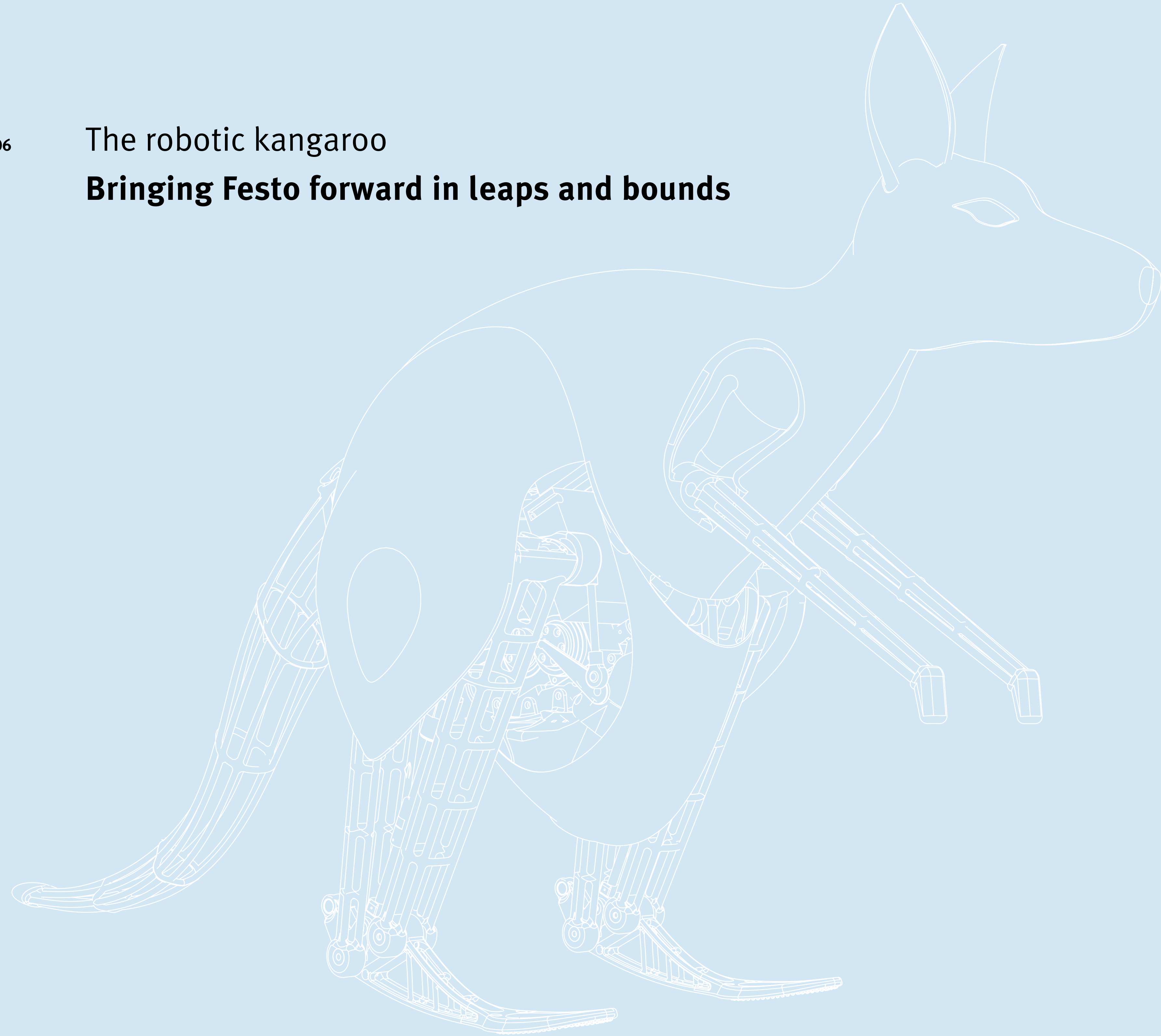




Innovative flying membrane of knitted elastane textile covered with foils: the honeycomb structure enables the BionicFlyingFox to fly even in case of minor damage to the textile

The robotic kangaroo

Bringing Festo forward in leaps and bounds





“What do you think – could we perhaps even build a kangaroo?” asked a student on our way home from an exhausting but successful trade fair appearance. This question jump-started our minds. What are the salient characteristics of a kangaroo? Where would the challenges lie for such a project? Would a kangaroo suit Festo at all – and could this really be a topic worth pursuing?

Once we arrived back in Esslingen, we got down to some more biological research. It was clear to everyone that the kangaroo has a highly characteristic way of moving, constantly alternating between the grounded and airborne phases. It is the only animal that can jump faster and further without having to expend additional energy. Most of the energy generated on landing is momentarily stored in its powerful Achilles tendon and released once more on the next jump.

With our first few simple functional models, we could already see that this all added up to a genuine challenge in engineering terms. If the robotic kangaroo was to land without falling over, it would have to anticipate its future motion during the extremely short grounded phase. A bad take-off cannot be corrected while the kangaroo is airborne. And so it came about that this marsupial served Festo as a model of energy efficiency, energy recuperation and complex control technology – especially in view of the structural changes that constantly took place in its movement between the grounded and airborne phases.








We jumped at this opportunity to get our kangaroo out of the starting block. Our point of departure was a single leg that we fitted out with a pneumatic cylinder to give it the necessary bounce. We attached the leg to a treadmill mechanism with angular sensors and made it hop around in circles. At first we controlled the air valve by hand to get a feel for its operation: at what point in time and in what rhythm are the jumps performed the most successfully?

A leg alone does not make a fully functional robotic kangaroo. We would need at least two of them, along with a head, a tail – and a torso that could accommodate all the technical components. At this juncture, an automotive engineering student offered his support. In his Master's thesis, he determined the most favourable position for the kangaroo's centre of mass during the various phases of the jump. His findings enabled us to appropriately modify our drafts and design drawings. In parallel, we tested various gear motors on prototypes, looked for suitable sensors – and came to realise just how complex the matter of regulation would become. As a consequence, we took some control engineering researchers from Ulm on board and pooled our resources.


However, just over half way through our scheduled development period, we were overcome with trepidation as to whether we had bitten off more than we could chew with this project. The kangaroo still kept falling over, and the clock was ticking away – this all placed an immense strain on us. Time and again, we studied the anatomy of the real-life animal and came up with more and more complicated solutions. Fortunately, it occurred to us to reduce the complexity by forming the kangaroo's lower legs as skids, which could then simply unroll as with a rocking chair; we thereby gained some valuable milliseconds after every jump during the grounded phase, which considerably simplified the control technology.

Thanks to this simple measure the kangaroo no longer tipped over so often, and we found renewed hope. We fine-tuned the hardware and the control engineering in countless tests and diverse series of measurements. We scrutinised the landing phase with slow-motion cameras, since it was impossible to see with the naked eye why the kangaroo had kept falling over. An increasing number of specialists from various disciplines were called in to work on the team. Many a midnight pizza helped us to maintain our stamina and soothed some jangled nerves. Our BionicKangaroo finally hopped its merry way across the booth area in time for the Hannover Messe trade fair.

Ant robots with a sense of community, a robotic arm modelled on the octopus, a gripping tentacle with suckers, bats with bionic flying membranes, robots with a refined sense of touch, workplaces with artificial intelligence, and machines controlled by mere thoughts: 25 years of bionics at Festo have yielded an enormous variety of projects. This science is giving rise to new solution spaces for the automation of tomorrow.

Nevertheless, bionics is more than just biology and technology. It enthuses and sensitises, it arouses curiosity and generates knowledge – and it unites people around the globe. Bionic Thinking shows the way ahead in shaping future lifeworlds in a responsible manner. Technological innovations should always create added value both for humans and for the worlds of flora and fauna. Nature constitutes the basis of bionics and is at the same time its ultimate objective.

Even cooperation between humans and machines is increasingly oriented towards biological principles: robots interact with people sensitively and with consideration. Evolution devises impressive adaptation strategies under changing environmental conditions; inspired by this model, Festo sees evolution, society and technology as an integral whole. Bionics is enabling complex questions to be resolved and the fourth industrial revolution to become reality.

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