# Bionic E-Trunk

Motion concept modelled on a natural archetype

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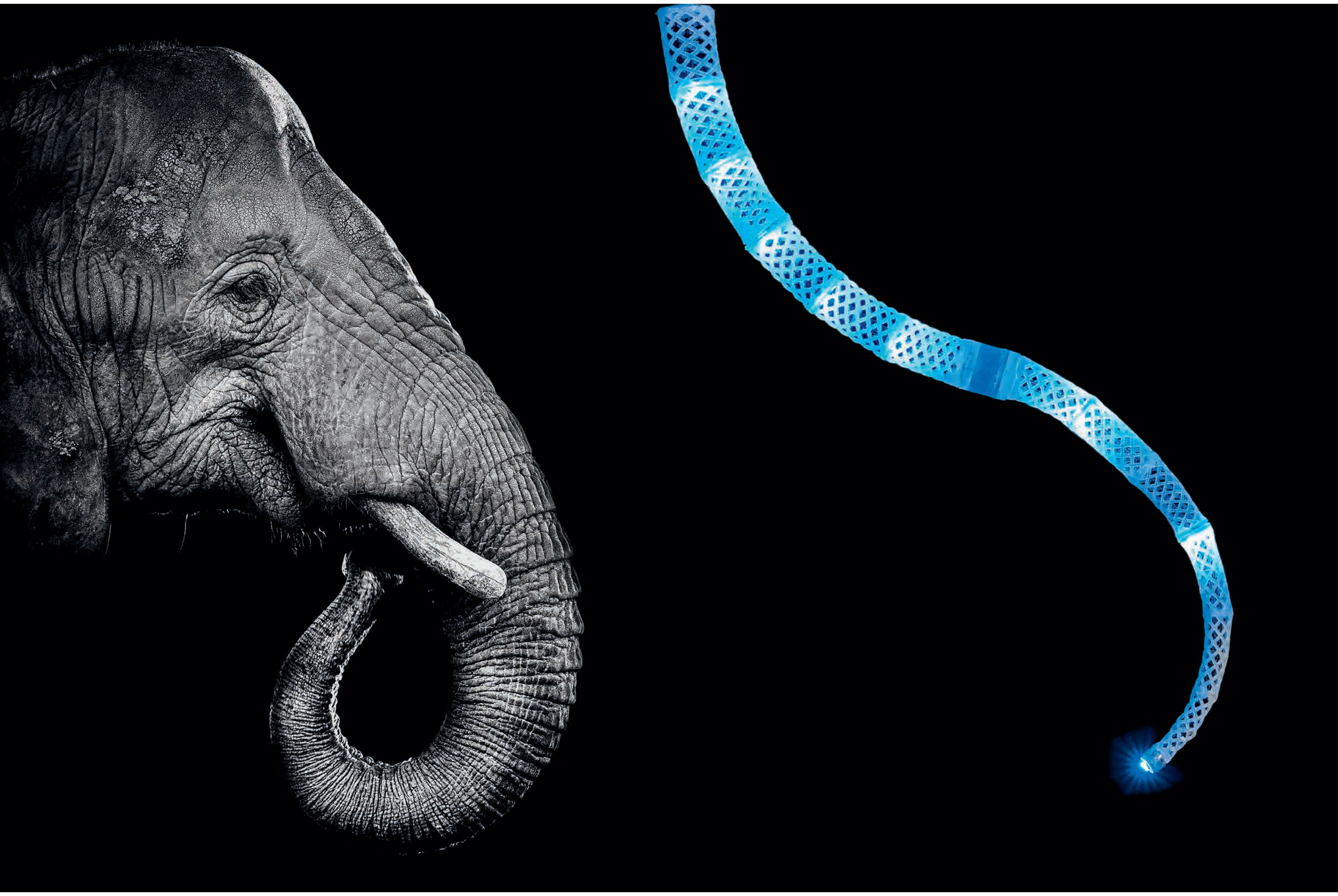

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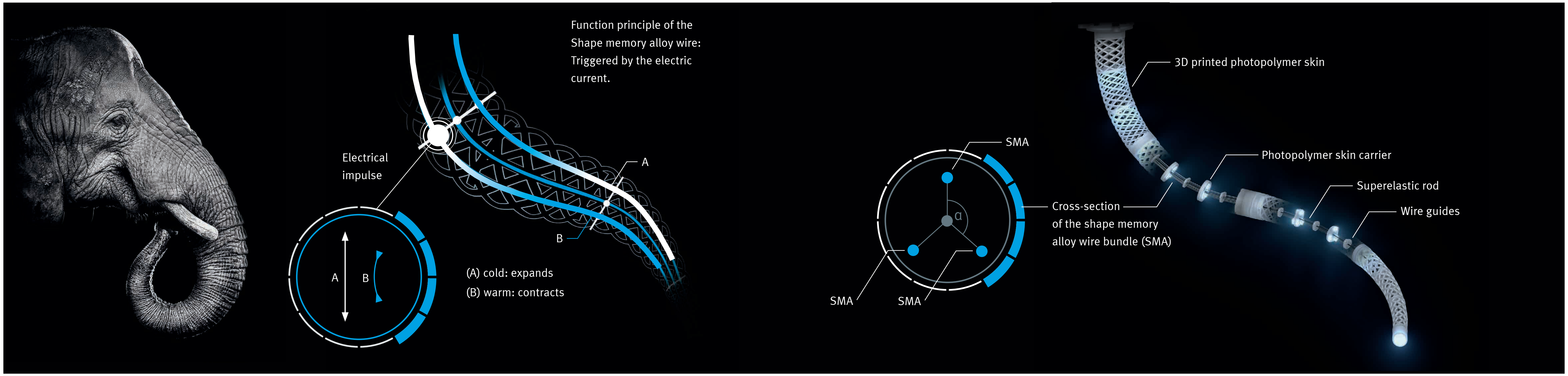


For years now, the Bionic Learning Network – an alliance between Festo and universities, institutes and development firms – has been developing research platforms whose basic technical principles are derived from nature. One such recurring theme is the unique movements and functions of the elephant's trunk.

**Pneumatic predecessors from the Bionic Learning Network**
With the Bionic Handling Assistant (2010), the BionicMotionRobot (2017) and the BionicSoftArm (2019), a series of pneumatic lightweight robot arms has emerged over time. Thanks to their flexible bellows structures, they can effortlessly implement the flowing movement sequences of the natural archetype they are modelled after.

Depending on the desired action, the bellows can bend freely and stiffen as required. Their inherent flexibility and low dead weight allow for a direct and safe collaboration between humans and machines.

In due course, the bionic concepts became more compact, smaller in size and quicker to put into operation. The modular design of the BionicSoftArm, for example, allows easy adaptation to a wide variety of applications and needs.

**Electrically driven miniature**
For the delicate Bionic E-Trunk, our developers, together with the Centre for Mechatronics and Automation Technology in Saarbrücken, Germany, have taken the idea of miniaturisation further and implemented the natural forms of movement for the first time as an electrically driven miniature.

The Bionic E-Trunk is made up of two 140-millimetre-long segments with a tapered diameter. Its core comprises a structure made of 3D-printed material and a super-elastic rod for longitudinal stabilisation. Thin wires made of a special metallic material, a so-called shape memory alloy, are arranged around this centre, which resembles a spinal column.

**Artificial muscles with shape memory alloy**
The shape memory alloy exists in two different structures depending on the temperature: If it is heated – for example with the help of electricity – the wires shorten. When they cool down, they 'remember' their former shape and return to their original position. This allows the Bionic E-Trunk to be bent individually and in a controlled manner in any spatial direction. The thinner the wires are, the faster they heat up, cool down again, and thus react more directly to their control.

**Controlled, delicate movements**
When building the concept, the developers chose a similar arrangement to the pneumatically driven trunk projects of the past. Three wire bundles, each consisting of two or four individual wires, are arranged per segment. It can thus be steered in a defined direction depending on the separate activation of the wires. In interaction with each other, these artificial muscles in the elements provide the fluid and flexible movements of the Bionic E-Trunk.

Thanks to its low dead weight of only twelve grams, the trunk can be moved easily with the actuators made of shape memory alloys. Compared to other drive principles, these have the highest force-to-weight ratio.

**Conceivable applications and potential uses**
When combined with a micro gripper, the Bionic E-Trunk could be used to handle small objects. In addition, the concept would enable a dosing process in the life science sector. For this purpose, a flexible hose could be attached to the side of the structure. This could be used to remove liquids from vessels and transfer them to other containers. It would also be conceivable to emit targeted air streams to clean constricted areas.

While the pneumatic predecessors were used exclusively to demonstrate the form-fitting gripping of objects, the Bionic E-Trunk can be used to implement other functions of the elephant's trunk, namely, the intake and delivery of liquids or air.

## Technical data

- Total length: .................................................... 280 mm
- Diameter: ..................................... tapering from 16 mm to 6 mm
- Total weight: .................................................... 12 g
- Material of the outer structure:............ Agilus 30 (photopolymer)
- Inffed accuracy without additional closed-loop control technology:............................................ approx. 5 mm radius
- Dynamic without additional closed-loop control technology: ............................................................ ca. 0,3 Hz
- Maximum power: ................................................ 30 W,
- ............ with simultaneous control of two directions per segment

- Action radius: .................................................... 200 mm
- Maximum bending angle of the segment:
  - Segment 1:.......................................................... 75°
  - Segment 2:.......................................................... 90°

- Diameter of the wires:
  - Segment 1:.......................................................... 150 µm
  - Segment 2:.......................................................... 130 µm

- Maximum force of the wires:
  - Segment 1:.............................. 4 × 150 µm per direction = 16 N
  - Segment 2:................................ 2 × 130 µm per direction = 6 N

## Project participants

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