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## Intelligence on six legs

The robot looks like a giant stick insect: Inspired by the insect, Hector (HExapod Cognitive auTonomously Operating Robot) has elastic joints and an extremely lightweight exoskeleton. In the six legs, maxon DC motors provide the robot with a flexible gait.

When Hector carefully negotiates an obstacle course, it has an elegance that hardly any other robot can rival. The Biomechatronics research group of Bielefeld University, led by Prof. Dr. Axel Schneider, developed this six-legged walking robot using a stick insect as a model. For the design, the insect's measurements were increased by a factor of about 20. The total length of the robot is roughly 90 cm – a giant stick insect. The project's goal is to better understand the gait of these insects and make the underlying coordination principles usable for technical systems. The research team also wants to investigate fundamental concepts for controlling elastically actuated robotic systems.

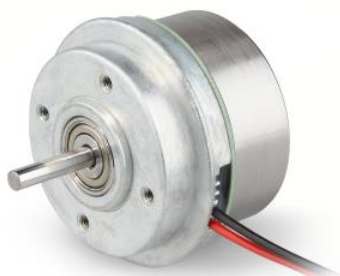
The extremely light exoskeleton consists of carbon-fiber reinforced plastic (CFRP). All drive parts and the connections between the leg segments were designed and fabricated in-house in Bielefeld. They are made of aluminum alloy. The unique features of this robot, which weighs 12 kg, are the multitude of sensors with which it is equipped and its biologically inspired, decentralized control principle. With its specially designed drives and sensors, it can adapt to the ground conditions while walking. Hector is currently capable of negotiating slightly uneven terrain and overcomes smaller obstacles, such as steps, without difficulty.

One leg – three maxon motors

Each leg of the walking robot has three joints, so that the movements of 18 joints have to be controlled simultaneously. Each joint is equipped with a brushless maxon EC 45 flat motor. These 50 W drives are custom units without a lateral connection board. The 18 leg joints are controlled using biologically inspired algorithms. For this purpose, the drive electronics and their controls are embedded in the drives. To make the drives elastic, special elastomer couplings, custom-designed for this purpose, were integrated directly into the drives. The research team needed a motor to deliver high torque while being small and lightweight. "The motors also had to be as short as possible, because the resulting length of the overall drive limits the leg's range of motion, among other things. This is why we chose the EC 45 flat 50 W," explains research team member Jan Paskarbeit, who designed and built Hector.

### Basic intelligence

Hector's intelligence is still vastly inferior to that of insects. However, it already has to process complex sensor data for the leg coordination. Hector is able to walk independently and responds to obstacles. "You can't deny that even an insect is intelligent, in a very basic way. Similarly, Hector also displays simple intelligent behavior. One of many important properties of intelligent behavior is, for example, the ability to plan ahead. Initial versions of a more advanced robot control are currently being tested on the system, with the purpose of giving the robot simple planning capabilities – making it more intelligent, so to speak," says Paskarbeit. Until 2017, the walking robot will be equipped with additional abilities over the course of a collaborative project hosted by the Bielefeld-based Center of Excellence for Cognitive Interaction Technology.



#### maxon EC 45 flat (50 W)

The brushless EC 45 flat motor drive delivers 50 W of power, at a diameter of 45 mm. The drive delivers high torque and needs very little installation space.



#### Drive unit with integrated electronics

Each leg of the walking robot Hector has three joints, so that the movements of 18 joints have to be controlled simultaneously. Each leg is powered by three of these elastic units with integrated electronics.

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**Video of Hector, the walking robot:**

<https://www.youtube.com/watch?v=9pbqSrXLKGI>



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