BionicWheelBot

Walk and roll like a flic-flac spider

FESTO

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01

As a global driving force in automation technology, Festo is always on the lookout for new drive concepts and amazing forms of movement. Nature is often a source of inspiration in this respect. Festo therefore teamed up with the discoverer of the Moroccan flic-flac spider, Professor Ingo Rechenberg, as part of its Bionic Learning Network.

The bionics engineer from Berlin discovered the spider in the Erg Chebbi desert on the edge of the Sahara in 2008, and since then has been working on transferring its movement patterns to the technical field. The flic-flac spider can walk like other spiders. It can also propel itself into the air, however, with a combined sequence of somersaulting and rolling on the ground.

Perfectly adapted to its habitat
It is, therefore, ideally adapted to its surroundings: on even ground, it is twice as fast in so-called rolling mode than when walking. However, where it is uneven, it is faster walking normally. As such, in the desert, where both types of terrain can be found, it is able to move safely and efficiently.

Technical implementation of the unique movement patterns
Having examined the spider thoroughly, Rechenberg and his team designed a few preliminary models of the BionicWheelBot. The kinematics and drive concept of the artificial spider were then developed together with Festo.

Ingenious kinematics based on the natural role model
Like its biological model, the BionicWheelBot has eight legs, which help it to both walk and roll. They are controlled by a total of 15 small motors, which fit in the knee joints and body. There are also 14 automatic-locking worm gear units that ensure that the spider only has to use energy when moving its legs – not, however, to keep its body upright when standing still.

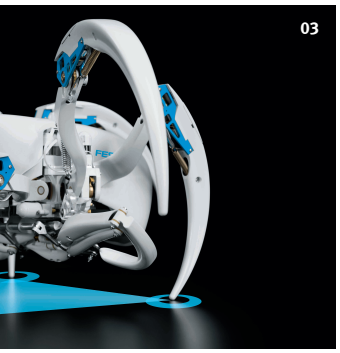
In rolling mode, the BionicWheelBot does a somersault with its whole body, just like the real flic-flac spider. Thanks to the integrated inertial sensor, it always knows what position it is in and when it has to push off again. It, too, is therefore much faster when rolling than walking and can even overcome inclines of up to five per cent uphill.

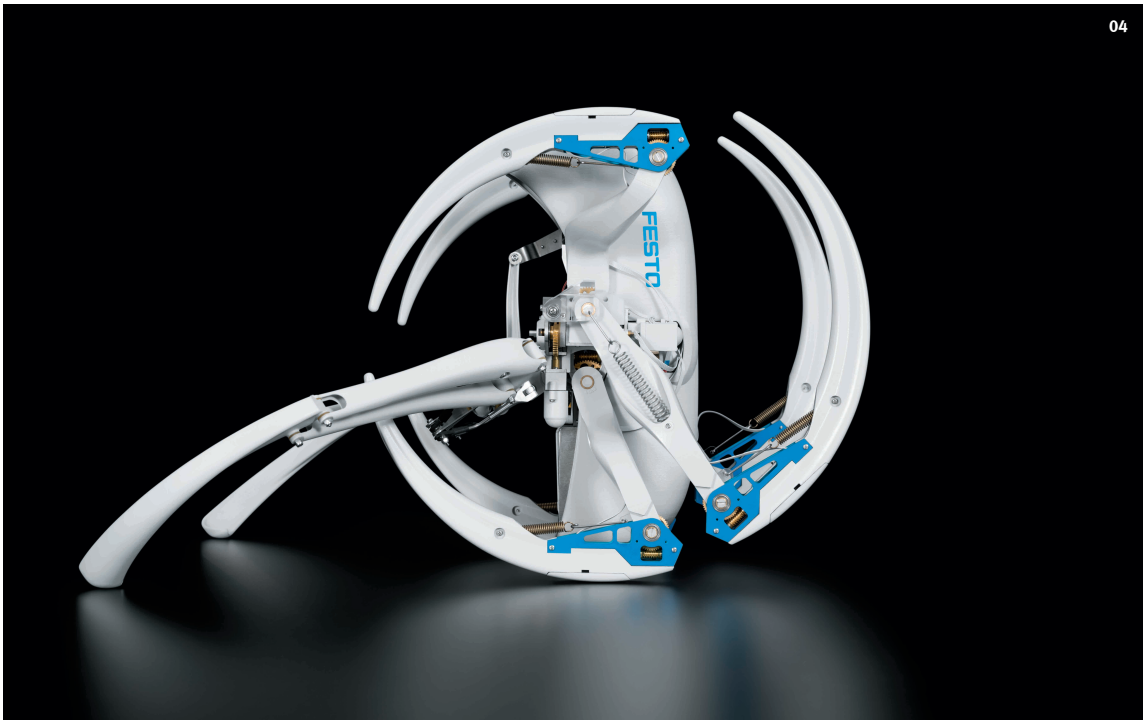
01: Mechatronic complete system: Ingenious kinematics based on a natural role model

02: Cebrennus rechenbergi: named after the professor who discovered it, Ingo Rechenberg

03: Tripod gait: sure walking even on rough terrain

04: Powerful rolling: driven by the push-off legs, the BionicWheelBot rolls on the legs folded into wheels





Walking with tripod gait
Just like the real flic-flac spider, the BionicWheelBot propels itself with a tripod gait. That means the artificial spider uses six of its eight legs to walk, leaving the two so-called push-off legs folded up. For every step, three legs remain on the ground, whilst the other three are lifted, moved forward and then put back down on the ground.

With the same sequence, the BionicWheelBot then moves the other three legs forward that were just on the ground.

Power boost from sophisticated mechanical system
In order for the artificial spider to move its long legs quickly and efficiently, the drives must apply comparatively high forces. They are supported by a spring mechanism for this.

A spring is fitted in every knee and shoulder joint, which is pre-loaded when the relevant leg is lifted. The force temporarily stored at this time then supports the corresponding motor in the counter-movement when lifting the body.

Secure footing and sure turning on the spot
Walking with three legs whilst leaving three legs on the ground makes sense from a mechanical point of view. Three points determine a level, so the BionicWheelBot has a secure footing even when walking, regardless of the condition of the ground.

Based on this, the bionic spider can also turn on the spot. It stands on its two longest legs, pushes its body upwards, and then turns in the required direction before continuing to walk as normal.

Transformation from walking to rolling mode
In order to start rolling, the BionicWheelBot bends three legs each on the left and right of its body to make a wheel. To do so, it firstly brings the rear legs in parallel into position, and then pulls the others up after them. The two legs folded up whilst walking then extend, push the rolled-up spider off the ground, and continuously push it forward whilst rolling. This prevents the BionicWheelBot from grinding to a halt in the sand and ensures that it can move itself forward even on rough terrain like its natural role model in the desert.

Technical data

- Body length: ..... Max. 570 mm
- Body height: ..... Max. 238 mm
- Body width:..... Max. 796 mm
- Leg length:..... Max. 344 mm
- Gauge: ..... 164 mm
- Wheel diameter: ..... 267 mm
- Degrees of freedom: 15

- Material, body and legs: .....Polyamide, 3D-printed
- Battery: ..... Lithium polymer, 7.4 volts, 1000 mAh
- Radio module: ..... 866 MHz
- Radio remote control: ..... By tablet
- Processor:..... STM32F4
- Actuator technology: ..... 14 × automatic-locking worm gear units
  ..... 1× servo motor
- Sensor technology:..... 1× BNO055 Absolute Orientation Sensor

Project participants

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Project coordination:
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