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Press release

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# Robotics taking wings thanks to butterflies - Study develops method for movement without electronics and batteries

**Researchers at the Technical University of Darmstadt and the Helmholtz Centre Dresden-Rossendorf have developed a revolutionary technology: flexible robot wings that are moved by magnetic fields. Inspired by the efficiency and adaptability of the wings of the monarch butterfly, they enable precise movements without electronics or batteries. This bio-inspired development could fundamentally change environmental monitoring, rescue operations and biomedical applications.**

Monarch butterflies are known for their outstanding endurance and adaptability. Every year, they cover thousands of kilometres on their migrations between Canada and Mexico. The key to this feat lies in their unique wings, which allow the insects to fly energy-efficiently through a combination of active movement and passive bending. These properties served as inspiration for the development of the magnetically driven robotic wings.

The team, led by Professor Oliver Gutfleisch (Institute of Materials Science at TU Darmstadt) and Dr Denys Makarov (Helmholtz-Zentrum Dresden-Rossendorf), built wings from a flexible plastic in which magnetic particles were embedded. External magnetic fields cause these particles to move, causing the wings to bend and imitate the movements of butterfly flight.

The development process was challenging: twelve different wing designs were initially produced using 3D printing. Some designs contained vein structures that were modelled on the natural wing veins of monarch butterflies. The aim was to use a combination of finite element analyses and experiments to find out how these patterns affect the manoeuvrability and efficiency of the wings.

The results were recently published in the journal “Advanced Intelligent Systems”. They show that larger wings with vein structures are particularly adaptable, enduring and easier to bend. “The biggest challenge was to print ultra-thin, flexible structures that are also robust enough to withstand the loads,” explains Kilian Schäfer, one of the lead authors of the study.

Various fields of application
There are many potential applications for the magnetic wings. In the environmental sector, for example, “winged” robots could be used to monitor pollinator populations or for air quality studies. As the wings enable a small and energy-efficient design, such robots would be ideal for travelling to disaster areas, for example, where they could be used to search for and rescue people.

The study focussed on developing flexible magnetic wings that function without electronic components. However, the new approach can also be applied to other shape-changing robots. For example, the newly developed technology opens up possibilities for medicine: lightweight robots with precisely controllable movements could be used in minimally invasive surgery, for example for operations on sensitive tissue. In addition, the principles of bio-inspired robotics could

be used in the development of artificial muscles or intelligent materials that can change their shape as required.

Further research is needed before the new technology can be used. “The current wings still require external magnetic fields, but future developments could integrate miniaturised magnetic field generators to enable autonomous movements,” explains Muhammad Bilal Khan, also lead author of the study. The team wants to investigate how modifications to the magnetic field enable complex control of movements and flight routes.

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