The potential of novel design and fabrication processes for the transfer of plant kinematics into technical systems

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Abstract

Growing experience in the design, simulation, and fabrication of fibrous structures has led to a deeper understanding of handling composite materials and customizing target-oriented fiber-reinforced polymers (FRP). As a result of this development, however, our perspective on the implementation range for composite material has changed. It shifted from designing rigid structures to the design of soft structures. Particularly pliable surfaces can tap the material's unique potential that lies in its elasticity in order to gain a functional or structural advantage.

While the concept of elasticity has hardly been used in technical systems, pliable surfaces and functionalized deformation principles are rampant in nature. Since we lack a catalogue of technical reference structures, an interdisciplinary research collaboration was formed to screen systematically for inspirational concepts in nature. In particular, the elastic deformation principles and actuation systems that can be found in plant movements were examined further. Their internal actuation often depends on active movements (plant metabolism) or passive movements, which are both in the focus of various research groups. In the study presented here, the authors follow the concept of external actuation by mechanical force, which can initiate a multitude of morphologically predetermined organ deformations. Such non-autonomous motions proved to be very suitable for investigation, abstraction, and translation into technical systems, here exemplified by the Flectofin® principle.

The successful transfer from the biological role model to the technical artifact became possible by adapting the fabrication process to allow for both, manufacturing a monolithic global structure as well as differentiating its material set-up locally. By implementing further optimization steps, e.g. contour geometry optimization via reverse biomimetics, the hinge-less flapping system of the Flectofin® has reached demonstrator status and can be compared to kindred plant movements.