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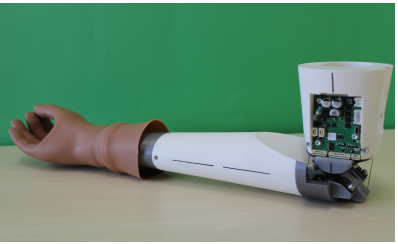
BICEP: A Bio-Inspired Compliant Elbow Prosthesis

Compensating for the loss of upper extremities is still a technological and clinical challenge, especially for subjects with high-level amputation. Traditional prostheses often lack natural movement and can lead to complications like instability and limited range of motion. Compliant prostheses aim to mimic the natural biomechanics of the elbow joint offering improved function, durability and patient satisfaction.Researchers from Technical University of Munich (TUM) have developed a compliant elbow prosthesis that offers significant advantages for the user.



Active Flexion-Extension and Shock Absorption in the Sagittal and Transversal plane

BICEP enables rotation along its flexion-extension axis while maintaining flexibility in out-of-plane directions.The soft cross-axis flexural pivots exhibit compliant behavior in the sagittal and transversal planes enabling a pleasant interaction with the environment and ensuring safe absorption of impacts.

REFERENCES:

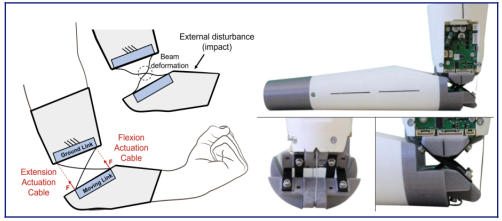
Video of BICEP

01 Lifting capacities up to 2500g and max. speed of 157 ps across a 135 range of motion

02 Compliant behavior in both the sagittal and transversal planes

03 Capability to absorb sideway perturbations in different configurations.

04 Design is easy to scale and can be adapted to different sizes and requirements



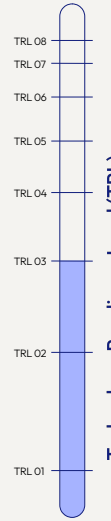
Left: Schematic of cross-axis flexural pivot configuration. Deflection under normal flexion and beam deformation under impact through external disturbances are presented. Right: BICEP prototype. The system employs cross-axis flexural pivots for the joint design and two tendons that act as an agonist-antagonist actuation mechanism.

CHALLENGE

Commercially available elbow prostheses consist of a single rigid DoF rotational joint. These commercial systems can cover the physiologic range of motion (RoM), but their rigid and simplified design ends up strongly decreasing usability and robustness. In addition, these systems often adopt conventional rigid sockets to interface with the user, which often limits shoulder movements in the residual limb, e.g. external rotation.

INNOVATION

The actuation architecture of BICEP is inspired by the biological elbow joint structure and consists of 2 rigid prosthesis parts (corresponding to the upper and lower arm), which are connected by crossed flexible ligaments (Dyneema wires) intended to imitate the tendons. One replicates the bicep tendon and is used for flexion movements, while the extension movements are actuated by a tendon which replicates the tricep tendon. The two tendons system act as an agonist-antagonist mechanism, controlled by a motor which is widely used in robotic joint actuations.



01 Basic principles observed · **02** Technology concept formulated · **03** Experimental proof of concept · **04** Technology validated in lab · **05** Technology validated in relevant environment · **06** Technology demonstrated in relevant environment · **07** System prototype demonstrated in operational environment · **08** System complete and qualified

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