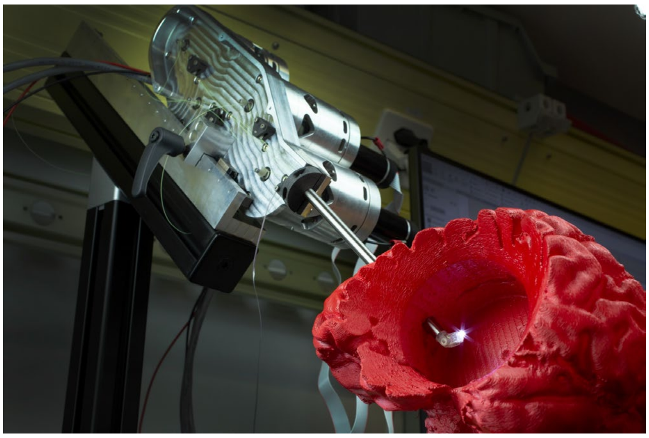
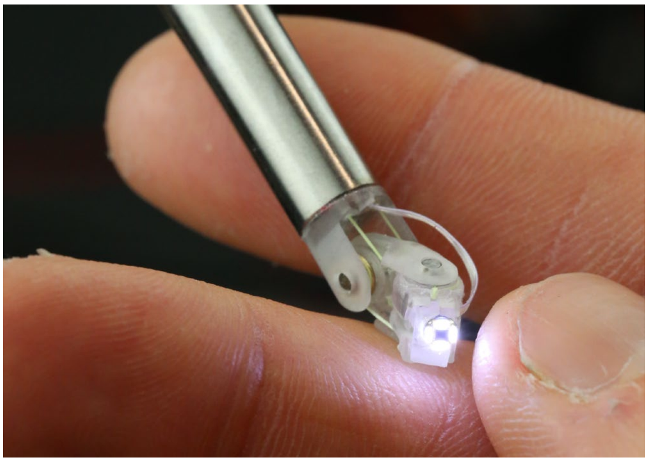
Bio-Inspired Actuation for Safer Robotic Endo-scopes



Our bio-inspired actuation enables endoscopic surgeries in places that are surrounded by sensitive tissue, such as neurosurgical applications (Photo: Lorin Fasel)



Elastic elements in the transmission reduce the forces between the endoscope tip and its surroundings. (Photo: Lorin Fasel)

We aim to make robotic endoscopes safer by using a bio-inspired actuation approach: Integrating elastic elements in the transmission reduces endoscope-tissue contact forces and makes it possible for the surgeon to not only see but "feel" the interaction with the tissue.
Project Lead: Lorin Fasel (BIROMED-Lab)

Endoscopic surgeries are beneficial for patients, but manual endoscope manipulation is difficult for the surgeons. Robotic endoscopes are a promising solution to simplify endoscope manipulation: While the robot performs endoscope steering, the surgeon could focus more on the tasks that cannot be automated.
But how do we ensure that those automated robot movements are performed in a safe way? Instead of relying only on software control, we are also designing the mechanics of the robotic endoscope to be inherently safe. In contrast to traditional robots, which are designed to be as stiff as possible, we deliberately integrate elastic elements in the transmission. This approach is inspired by nature: Musculoskeletal systems, for example human fingers, are essentially rigid links (bones) that are actuated by motors (muscles) via elastic elements (tendons). The elastic elements reduce contact forces between the endoscope tip and tissue, thus minimizing tissue damage in case of unintended collisions (1). Furthermore, the deflection of the elastic elements can be measured to get an estimate of the forces applied to the endoscope tip (1,2). This force information can be returned to the surgeon as "haptic feedback" to not only see but feel interactions with the tissue. For more autonomous tasks, the force estimate can be used as sensor feedback to actively control and/or limit the contact forces of the endoscope tip with the tissue (2).

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References:

(1) L. Fasel, N. Gerig, P. C. Cattin, and G. Rauter, "Control evaluation of antagonistic series elastic actuation for a robotic endoscope joint," *J. Bionic Eng.*, vol. 19, pp. 965–974, Feb. 2022.

(2) L. Fasel, N. Gerig, P. C. Cattin, and G. Rauter, "The SEA-Scope: Torque-limited endoscopic joint control for telemanipulation or visual servoing through tendon force control with series elastic actuation," in *2021 International Symposium on Medical Robotics (ISMR)*.