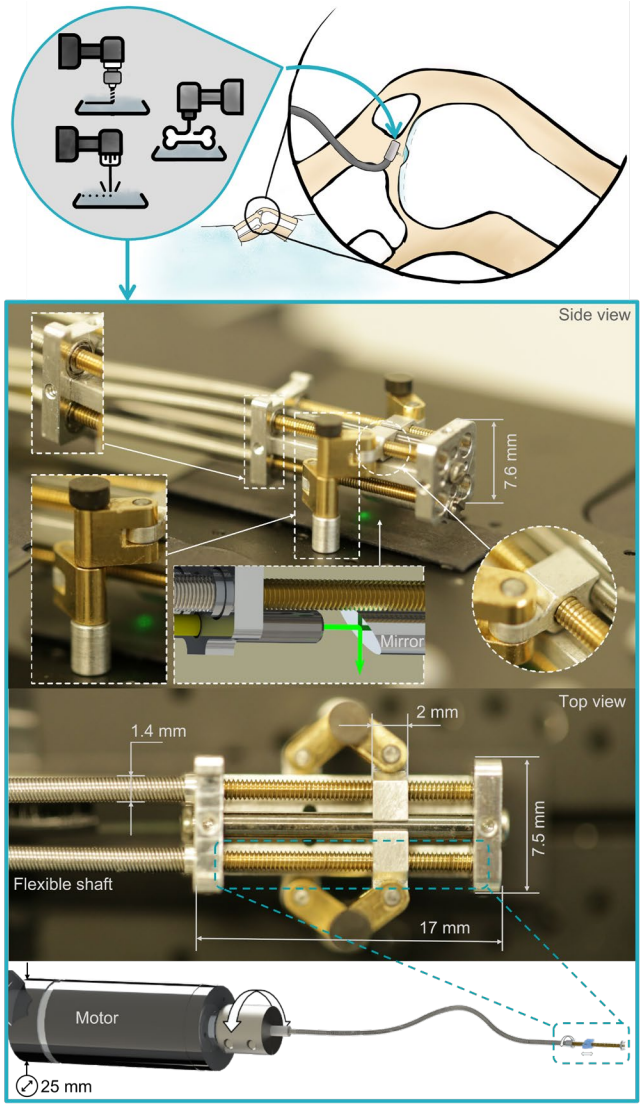
Miniature Robot with Submillimetre Accuracy for Surgical Tool Positioning



Parallel mechanism for 3 DoF positioning of a tool such as a laser (green) with externally placed actuation (Image: Manuela Eugster)

Our goal is to enable high-precision surgical procedures with our innovative approach: A miniature robot consisting of a local attachment to the surgical site and a parallel mechanism that allows manipulating a surgical tool with high accuracy in relation to this attachment.

As medical interventions become less invasive and require smaller devices with higher accuracy, new concepts for robotic manipulation of surgical tool inside the patient's body are needed. We have developed a parallel mechanism that can be integrated at the tip of an endoscope or used as a stand-alone mechanism for high-precision surgery [1]. The applications for this mechanism are diverse and range from ablative procedures using laser technology or mechanical methods such as milling or drilling to additive techniques such as in-situ 3D bio-printing. The current prototype of the parallel mechanism provides motion in 3 planar degrees of freedom. Experiments have shown that the mechanism can achieve a positioning accuracy of 0.176 mm (maximum error) with a mean error of 0.07 mm [2]. The mechanism is designed to operate in confined environments with its longitudinal axis aligned parallel to the surface being treated. The actuation of the mechanism is based on electric motors placed at a distance (outside the patient). Flexible shafts transmit the rotation of the electric motor to the parallel mechanism. This flexible connection inreases stability and robustness of the surgical tool against disturbances. The attachment to the surgical site is application specific and can be realized by simple pins or less invasive concepts such as suction cups or origami pouches.
Applications of this mechanism currently being researched include laser osteotomy [3], cartilage replacement in the knee, and robotic dentistry.

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References:

[1] M. Eugster, P. Weber, G. Rauter, „Medical Endodevice", Patent, US11617495B2, 2017.

[2] M. Eugster, J.-P. Merlet, N. Gerig, P. Cattin, G. Rauter, "Miniature parallel robot with submillimeter positioning accuracy for minimally invasive laser osteotomy", Robotica, 2021.

[3] M. Eugster, C. Duverney, M. Karnam, N. Gerig, P. C. Cattin, and G. Rauter, "Robotic endoscope system for future application in minimally invasive laser osteotomy: First concept evaluation," *IEEE Transactions on Medical Robotics and Bionics*, 2022.