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[Development of a Multi-Level Stiffness Soft Robotics Module with Force Haptic Feedback for Endoscopic Applications](#)

[Naghibi, Hamid](#)

University of Twente

[Gifari, Muhammad Wildan](#)

University of Twente

[Hoitzing, Willem](#)

University of Twente

[Lageveen, Jornt W.](#)

University of Twente

[van As, Dave M.M.](#)

University of Twente

[Stramigioli, Stefano](#)

University of Twente

[Abayazid, Momen](#)

University of Twente

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Abstract: Despite the recent advances in soft endoscopes, they could not yet fully fulfill the requirements for minimally invasive and natural orifice transluminal endoscopic surgeries. Maneuverability, bendability, different structural stiffness required for different endoscopic surgical interventions, the space needed for surgical manipulators and patient's safety are among the main factors which can contribute to implementing the new soft robotics endoscope in practice. In this study, based on finite element analysis on an existing endoscopic segment, a new improved endoscopic module was developed. A novel approach for stiffening of the endoscopic module was proposed. The actuation and stiffening components were combined to introduce a multi-level stiffening mechanism to the endoscope, and also to provide a free lumen for manipulators. To increase patient's safety, a force sensing module was developed to estimate the magnitude and direction of the force from tissues to the endoscope. The developed endoscopic system was integrated to a haptic control system. The 3D kinematics control and haptic feedback control of the endoscopic module were validated.