INSTITUT PASCAL (UMR 6602 - UCA/CNRS) - Group M3G

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Design of a variable stiffness overtube for robotic colonoscopy

This request concerns a half-grant thesis. The other co-financer is the Saint Joseph Hospital of Marseille, Digestive Endoscopy Unit. This establishment has training and research centers to promote phase 1, 2, and 3 clinical studies.

Summary of the thesis topic:

Hospital practitioners are continuously looking for new instruments to minimize surgical interventions' invasiveness while facilitating operative procedures. Laparotomy has been largely supplanted by less invasive laparoscopy. Therapeutic flexible endoscopy through the natural route (colonoscopy/fibroscopy), which is even less invasive because it does not involve any skin invasion, is in full expansion. Flexible endoscopy replaces laparotomy and laparoscopy in many indications (superficial digestive cancers). But one of the major limiting factors of flexible endoscopy is the formation of loops by the endoscope during colonoscopies. This results in 5 to 10% of failures and up to 20 to 30% of cases with positioning difficulties in treating superficial colon tumors or cancers. For these patients, major surgery is most often indicated.

When the endoscope is pushed, the loops indeed enlarge, and the progression in the colon is blocked or even reversed. This results in a loss of mobility and precision, making it impossible to resect tumors entirely and access certain areas to be treated (e.g., cecum and right colon). The loops also increase the pain felt by the patient due to the stretching of the digestive structures. ***The principle of a variable stiffness overtube surrounding the endoscope is promising, and we wish to develop during the thesis such a system with a sufficiently large variation in stiffness to overcome the problem of thrust following the formation of loops****.*

Coming from the field of soft robotics, variable stiffness can be obtained by using internal mechanisms and smart materials [1]. The system then uses high deformability to achieve the requirement of motion guidance by passive conformation to the environment, and high stiffness during shape locking and force exertion. The thesis will consist in designing an overtube based on these principles and respecting the specifications given by the hospital partner. The requirements will include space constraints, activation mode, and structural integration quality.

The milestones of the thesis will be:

- *Evaluation of current technologies with respect to these constraints.*
- *Selection, modeling, design, and optimization of an adapted solution.*
- *Definition of the manufacturing process (preferably based on 3D printing), and experimentation.*

[1] M. Manti, V. Cacucciolo, et M. Cianchetti, "Stiffening in soft robotics: a review of the state of the art," IEEE Robotics & Automation Magazine, vol. 23, no 3, p. 93-106, 2016, doi: 10.1109/MRA.2016.2582718.