PhD Position

Topic

Microrobotic systems for diagnosis and gastrointestinal therapies.

Context

Since the appearance of the first endoscopic capsules for the observation of the gastrointestinal (GI) tract, a lot of work has been done to increase the performance of these devices by giving them new functions [1]. Initially as mere inert capsules, these systems have evolved gradually into real micro-robots with new functions as locomotion and in situ intervention (drug delivery, biopsies, sample extraction, etc.). However, the fabricated prototypes are generally designed by miniaturization of mechanical principles initially thought for conventional-size robots, which leads to major difficulties in clinical operations. The recent development of 3D printing processes using biocompatible materials and progresses in microrobotics and micro-mechanisms based on flexible structures allow considering the development of new approaches for the design of micro-robots transiting through or staying inside the digestive tract with a major objective: clinical application on a large scale and at low cost.

For this purpose, the LIRMM (Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier - UMR CNRS 5506) and ICube (Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie - UMR 7357) propose this PhD position. These two laboratories are recognized in the field of medical robotics and in the design of robots, and offer this thesis in the LABEX CAMI context (Computer Assisted Medical Interventions). The aim is to develop a new generation of microrobots exploiting the possibilities of biocompatible additive manufacturing (3D printing) to design and implement micro-robots based on flexible structures for applications in diagnostic and gastrointestinal therapies, designed in partnership with the laboratory TIMC-IMAG (Techniques de l'Ingénierie Médicale et de la Complexité – Informatique, Mathématiques et Applications de Grenoble, UMR CNRS 5525).

Ph.D. Objectives

The objectives are to study and develop new robotic solutions at the centimeter scale to propose devices with mobility capabilities, in order to perform motion in the GI tract, and also to perform tasks such as delivery of active substance, sample collection, and more generally to contribute to the diagnostic and treatment of digestive pathologies.

Technological developments will be mainly based on the use of 3D printing techniques for the manufacturing of biocompatible flexible structures. Current additive manufacturing techniques offer

a large freedom in the design and they constitute a solid basis for building miniaturized devices with a bottom-up strategy, instead of a classical top-down process. In this latter case, robotic solutions are elaborated from well-known solutions at the macro scale. This can be a strong limitation with assembly or friction issues that are not encountered with solutions developed initially at the micro scale, on which we will rely. In other words, we intend to use design principles issued from micro and nano robotics to develop at a meso scale robotic devices that can be exploited in the GI tract environment and that are able to generate sufficient forces and displacements.

For this Ph.D. work, the student will benefit from the expertise of the advisors in the field of compliant mechanisms, robotic systems, microrobotics and in medical robotics. A whole set of experimental facilities will be available within the DEXTER group at LIRMM and AVR group at ICube, as well as apparatuses from TIMC-IMAG. The three groups also have close interactions with the medical environment.

Work program

The Ph.D. work will take place in Montpellier and Strasbourg, two very attractive cities, at LIRMM and ICube, two outstanding research environments for the development of such medical microrobots. Mobility during the 3-year program will be needed in order to develop the Ph.D. project.

In a general way, the foreseen work program can be described in the following way:

- State of art on GI robotics
- Study of the GI environment and selection of relevant tasks for the applicative context
- Assessment of biocompatible 3D printing processes
- Elaboration of mechanical concepts based on compliant mechanisms for the design of meso robots
- Design, integration and evaluation of new flexible structures
- Design, integration and evaluation of new microrobots
- Experimental assessment in lab conditions
- Preclinical trials, depending on the performances obtained during lab evaluation

The time spent in Montpellier and Strasbourg will be defined after discussion with the Ph.D. applicant, the goal being to optimize the interactions with scientific experts and the use of experimental facilities on the two sites. During the 3 years, Montpellier-Strasbourg-Montpellier or Strasbourg-Montpellier sequences can for instance be considered.

Applicant profile

The Ph.D. applicant needs to have a mechanical engineering or mechatronics background. He/she will hold a M.Sc in one of these fields, or an equivalent diploma (engineer degree). Skills in the medical robotics/compliant mechanisms would be a plus.

Expected beginning

Beginning of the Ph.D. thesis is expected in october 2016 for 36 months.

Advisors

Yassine HADDAB
Professor, University of Montpellier
LIRMM - UMR 5506 - CC 477
161 rue Ada, F-34095 Montpellier Cedex 5
e-mail: yassine.haddab@lirmm.fr
Tél. : +33 4 67 41 85 57

Pierre RENAUD
Professor, INSA Strasbourg
AVR – Icube
IRCAD, 1 Place de l'hôpital, F-67091 Strasbourg
Email: pierre.renaud@insa-strasbourg.fr
Tél. : +33 3 88 11 91 47

Lennart RUBBERT
Assistant Professor, INSA Strasbourg
AVR-ICube
IRCAD, 1 Place de l'hôpital, 67091 Strasbourg
Email : lennart.rubbert@insa-strasbourg.fr
Tél. : 03 88 14 47 00

Bibliography

[1] Gastone Ciuti et al. Capsule Endoscopy: From Current Achievements to Open Challenges. IEEE REVIEWS IN BIOMEDICAL ENGINEERING, VOL. 4, 2011.

[2] Simon Henein. Conception de guidages flexibles. Presses Polytechniques Universitaires Romandes 2001.