Flexible Medical-Robotic Instruments
Integration and Control of Shape-Memory-Alloy-Actuators in Parallel-Kinematic Configuration
— 20th February 2021 —

Context

Flexible medical instruments in minimally invasive surgery might be of great help to surgeons while operating next to or within critical compartments of the human body (e.g., crucial blood vessels). The design and control of such instruments is challenging. “Smart materials”, such as so called “Shape Memory Alloys” (SMAs) could be very useful to face these challenges due to their ability to memorise an arbitrary shape when heated. While the handling of SMAs regarding their fabrication and application (e.g., heat transfer, shape restoration) is quite demanding, their potential for creative new approaches in steering and actuation are of great interest for ongoing research in the field of medical robotics.

Figure 1: Team of surgeons in the operation theatre. Source: © Solvay 2020.

Figure 2: Utilisation of a flexible instrument to approach a lesion in the human brain avoiding damage to non-involved tissue. Source: MTU Aero Engines (modified).

Objective

Deploy the “one-way-memory-effect” of SMA actors in a three-actor configuration and control it to achieve reliable positioning in the x-y-plane.

Task Summary

- Read about SMA actuation.
- Propose three suitable austenite actor-shapes.
- Fabricate the actors via heat treatment.
- Assemble the demonstrator to achieve symmetric three-actor configuration, as shown in Figure 3.
- Implement a control strategy for visual servoing.
- Evaluate the demonstrator’s accuracy.

Figure 3: Schematic of the demonstrator featuring three SMA actuation module attached to an elastic structure.

Figure 4: Proposed segmented actor design using preformed SMA wires for 3 DOF tip motion by Khadir et al. (2019).

Requirements

Qualified candidates (computer science, engineering, physics, material science) shall be interested in:

- Interdisciplinary challenges
- Control
- Material sciences

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