Master Thesis and Internships

Applied physics, microrobotics and biomedical topics

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22/04/2020
Design of a capillary gripper for fast pick and place processes

Promoter: Pierre Lambert
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Context: Devices miniaturization and increasingly stringent standards in the micro-component industries (pick and place, micro-assembly, packaging), set new challenges in terms of manufacturing and assembly capabilities. At the sub-millimetre scale, it becomes harder and harder to guaranty a strong but safe gripping, and a precise positioning. In addition, the industry must deal with the large accelerations required for high production rates. The current most common handling strategy is the suction gripping. But the latter starts showing its limits relatively to the previously stated issues. Therefore, alternative handling strategies have been developed for small, fragile, and soft objects [1]. Many of them (microgel, freezing, levitation…) are hardly compatible with high-rate processes.

On the other hand, capillary handling has been proven to be a harmless and strong gripping solution. Due to the self-alignment effect, it also allows a precise positioning of the handled micro-objects, (see video: https://youtu.be/gdqboyUtqwg).

Goal: This project aims at working on the design of a capillary gripper able to deal with the high accelerations of the pick and place machines. For instance, by letting the micro-component “floating” under the gripper, the risk to lose the object is high. Decreasing the liquid volume until having solid friction partially solves the issue (see Figure 1).

This master thesis will have a direct application in the pick and place industry. The student will be free to explore the essential functions of the gripper, by testing different designs and manufacturing solutions. This project is a good opportunity to develop advanced skills in product design, CAD & CAM softwares, and to gain knowledge in micromanufacturing. According to the chosen design, the proof of concept may be manufactured thanks to two high-precision printing machines: Nanoscribe and FemtoPrint (see Fig. 2).

Fig. 1: A capillary gripper (M. Cavaiani’s Master thesis, ULB), presented at MARSS conference 2018,

Fig. 2: Misc. micro-objects manufactured with FemtoPrint (top left) and Nanoscribe [3]

Tasks:
• Literature review / state of the art / understanding of the project and the requirements
• Choice of a technical solution, dimensioning, and CAD design
• Proof of concept: manufacturing of the prototype
• Optimization through characterization experiments (capillary forces, admissible acceleration...)

Instrumented nasal cast for nose-to-brain drug delivery

**Promotors:** Benoit Haut & Pierre Lambert

**Supervisor:** Clément Rigaut - clement.rigaut@ulb.be

**Context:** Nose-to-brain drug delivery is a very promising way to deliver drugs. For this purpose, the airflow generated by a spray device must convey the drug particles through the nose and deposit them in the so-called olfactive area. Since each patient nose anatomy is different, this process must be optimized to become patient specific.

This work would be the follow up of two ongoing master theses. These theses allowed to develop a new nasal cast which is intended to be used for the study of drug deposition. Together with this experimental approach, numerical simulations will be carried on to get precise knowledge about the mechanisms driving nasal drug delivery.

**Goals:** According to the student profile, we can consider two different theses

The numerical part consists of the simulation of a pressure-driven flow in the nasal cavity. This flow must be determined for different boundary condition such as normal breathing, forced inspiration, closing of one nostrils, etc. These simulations aims to provide a deep understanding of the mechanisms implied in the drug deposition.

The experimental part aims to measure the quantity of drug deposited in the olfactory region regarding different parameter such as the delivery procedure or the placement of the spray device in the nose. The goal of this study is to provide insight for the optimisation of drug delivery in the nasal cavity.

**Tasks:**

**Experimental**

- Literature review / state of the art
- Measure of drug deposition as a function of different parameters
- Draw the first guiding lines to optimise nasal drug delivery.

**Computational**

- Literature review / state of the art
- Model the nasal cavity using a CFD software (Ansys-Fluent or OpenFOAM).
- Analyse the flow in the cavity under different breath patterns


[3] Calmet et al. ‘Nasal sprayed particle deposition in a human nasal cavity under different inhalation conditions’, PLOS ONE, 2019
Laser assisted auto assembly (may be coupled to an internship in France, FEMTO-ST)

Promotor: Pierre LAMBERT
Supervisor: Franco PINAN BASUALDO – fpinanba@ulb.ac.be

Context: Lateral capillary forces (cheerios effect) are useful to generate auto assemblies at a fluid-fluid interface [1,2]. Although different techniques exist to tune the auto assemblage, an active way to control the assembly can be necessary to correct defaults or to accelerate it. The proposition is to use the our thermocapillary flow setup [3,4] to assist the auto assembly.

Goals: The specifics of this proposal will be defined according to the student preferences. We envisage 2 options:

- Tuning of the auto assembly through geometry optimization like in [2], but at a smaller scale using FEMTOPrint or Nanoscribe.
- Like previous one, but without going too deep in the geometry optimization and focusing in the use of the laser to correct defaults in the assembly.

During this project, the student will develop the following skills: use of advanced micromanufacturing techniques (Nanoscribe and FEMTOprint), expertise in fluid mechanics and wetting phenomena.

Internship: This project is part of a collaboration between the ULB and the FEMTO-ST Institute (Besançon, France). Therefore, it is possible to link this master thesis proposal with an internship in France in micromanufacturing or microrobotics.

References:

Mechanical programming of smart expansive materials for soft robotics

Promoters: Pierre Lambert (TIPs) – Alain Delchambre (BEAMS)
Supervisor: Gilles Decroly – gilles.decroly@ulb.ac.be

Description: Soft robots could open many new opportunities because of their softness, safety, ability to achieve more complex movements. However, the lack of versatile actuation methods makes difficult the rise of new applications. This work aims at investigating the possibilities to generate complex movements by programming expansive matter. The material studied in the lab uses the large volume variation of micro-bubbles of a fluid upon liquid-gas transition, distributed in a silicone elastomer matrix [1]. The expansion of the material is in this case generated by heating the material. Constraining this deformation could allow to generate complex movements based on simple, modular, and inexpensive designs.

Different solutions can be considered to design complex movements (repartition of the bubbles, inextensible layers, matter patterning...) and for the fabrication method (moulding, 3D printing, laser-cutting...). Several questions and challenges can be addressed in this project: how to generate basic deformation of voxels (bending, twisting, ...)? How to assemble the voxels to generate more complex movements? How to generate the stimulus/heat? How to model the programmed material?

Goal: This project aims to study modular structures of soft materials to generate complex movements. This will require to realise a state of the art comparing the different solutions discussed above. The different solutions and designs identified will be tested, characterized, and compared experimentally. The project is intentionally relatively general. According to the student profile, the emphasis can be put on various points of the project and could open various applications. The development of prototypes demonstrating the programmed matter capabilities will also be part of the project.

Tasks (to be discussed depending of the student profile):
- Literature review / state of the art / understanding of the project
- Design (choice of the configuration, generation of complex movements)
- Modelling
  - FEM if known by candidate, analytical model, ...
- Experimental study and characterization
  - Fabrication of the samples (moulding, 3D printing, laser-cutting, ...)
  - Characterization tests (identification of parameters and output, design of experiment, building test benches, ...)
- Proof of concept
  - Design and optimization of a prototype