Robots for Microscopes. imina technologies

APPLICATION NOTE

Robots cooperation for particles manipulation under microscope

Introduction

Robotic manipulation of micron scale biological samples is a challenging operation which requires high dexterity and precision. In fact, both the manipulators and the end-effectors have to be flexible enough to cope with the samples shape and size variations while simultaneously preserving them from any damage (e.g. perforation).

This application note reports on the work that is carried out at the Hamlyn Center for Robotic Surgery of Imperial College London and aims at tackling these challenges [1]. A compliant end-effector was created and a multi-robots cooperation developed to semi-automate manipulation tasks. This solution may find application in single cell surgery, cell measurements, cell enucleation and tissue engineering.

Experimental setup

The micro-robotics system consists in an upright optical microscope (Zeiss Axio Zoom.V16), micromanipulators (Imina Technologies miBot™) equipped with custom compliant end-effectors, and a computer software application [Figure 1]. Spherical particles (50 µm in diameter) are chosen as specimen to manipulate as they are close in size and shape to biological cells.

Robots cooperation by visual servoing

The same way as we would do with our own hands, objects manipulation is greatly improved when at least two robots are cooperating. In this work, the visual servoing technique is used to detect in real-time the position of the end-effectors and the particles in the microscope video stream. After an initial calibration the system is able to automatically predict the robots' motion directions, to recognize their orientation and to modulate their speed based on the distance to destination [Figure 4]. Thus, instead of being forced to control independently two manipulators, the human operator can for instance decide to mirror the movements of the left manipulator with those of the right one, greatly

In collaboration with:

Imperial College London
United Kingdom
www.imperial.ac.uk

Imina Technologies products in use:

- Vacuum compatible miBot™ BT-11-VP
- Compact stage (4-Bot)
- Software Development Kit (SDK)

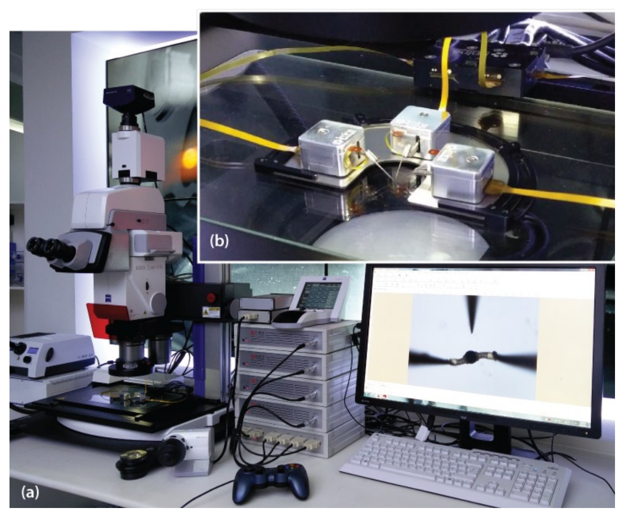

Figure 1: (a) Experimental setup for compliant objects manipulation. (b) Three miBot™ micro-robots free to move over a centimeter range workspace (Imperial College).

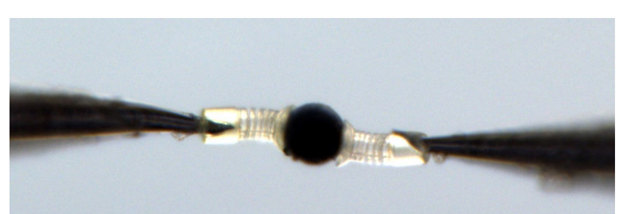

Figure 2: Manipulator probes with compliant end-effectors co-operating to move a micrometer spherical particle. Their passive springs bend and compress to adapt to the particle shape.

simplifying the transport of particles in three dimensions. Imina Technologies' software development kit (SDK) was used to program the closed-loop robot control based the visual feedback.

Compliant end-effectors

Although the visual servoing framework achieved good accuracy, little margin for error is allowed when trying to manipulate spherical particles with sharp probe tips. Moreover, probe tips offer no alternative but to push the particles to move them. In fact, the need for a compliant end-effector increases with the need to perform more flexible motion in several dimensions. For that reason, a custom end-effector was designed with two primary features: a cupped shape to fit the object to manipulate, and a flexible spring to provide compliance in contact. The passive end-effector can thereby compensate by bending or compressing and still maintaining contact with the object if a small overshoot occurs [Figure 2]. Direct laser writing was used to fabricate the compliant micrometer scale (20 µm in diameter and 75 µm in length) end-effector at the tip of the manipulator probes [Figure 3].

Conclusions

Dexterity and accuracy are key features in the design of a robust robotic system dedicated to the manipulation of particles under microscope. This note reports on the successful use of the miBot™, Imina Technologies' mobile micro-robots, to create such system. These high precision devices move with nanometer resolution over several millimeters travel ranges, providing the motion smoothness required by this task. Moreover, contrary to stationary manipulators, the miBot's mobile motion technology makes positioning and orientation of the end-effector flexible to adjust to various sample shapes and dimensions. To ease the handling and transport of micro-particles, compliant end-effectors were printed on the manipulator probes and a computer software was programmed to assist the human operator with semi-automated robot cooperation tasks.

[1] Maura Power and Guang-Zhong Yang, Direct Laser Written Passive Micromanipulator End-Effector for Compliant Object Manipulation, 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). http://dx.doi.org/10.1109/IROS.2015.7353462

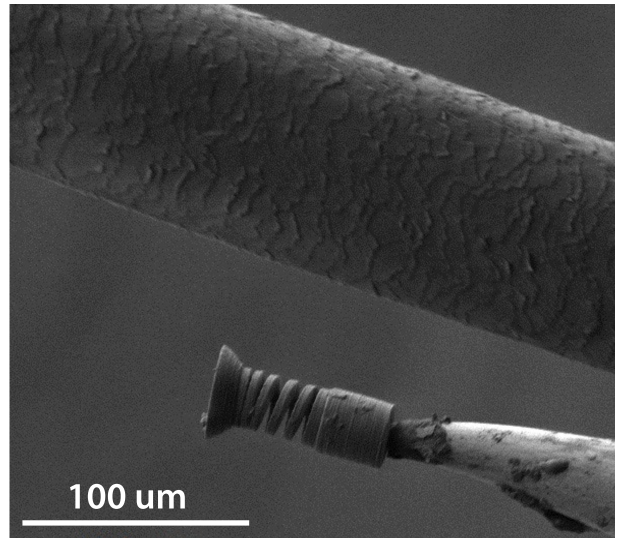

Figure 3: SEM image of the compliant end-effector printed on the manipulator probe tip (bottom) and a human hair (top).

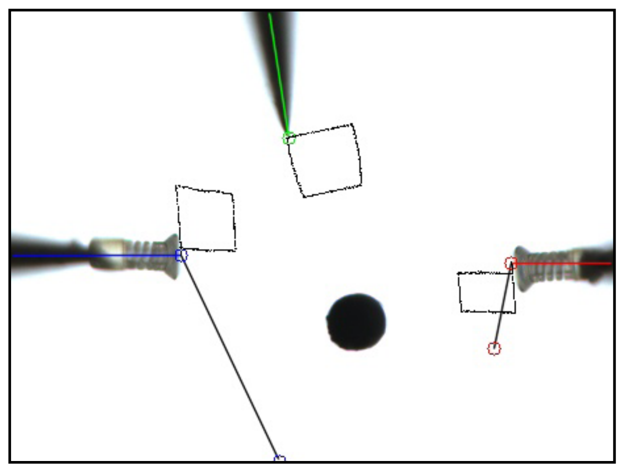

Figure 4: Micro-robots position and trajectory controled by visual servoing.

imina technologies

Imina Technologies SA
EPFL Innovation Park, Bât. E
CH-1015 Lausanne
Switzerland

Phone +41 22 534 90 78
Email info@imina.ch
Web www.imina.ch