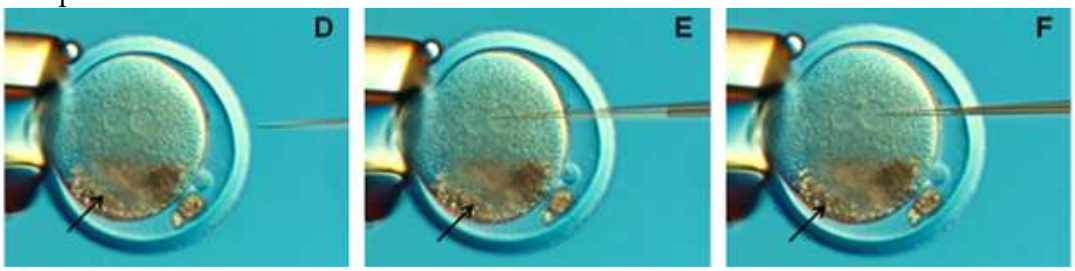
THESIS PROPOSAL

TITLE: ROBOTIC TELEOPERATION SYSTEM FOR BIOBOLICAL CELL NANOMANIPULATION

CONTACT: Applications should be sent to :
Supervisor: Antoine FERREIRA, Professor
Laboratoire PRISME – INSA Centre Val de Loire – 88 Boulevard Lahitolle, 18000 Bourges, France.
Email : antoine.ferreira@insa-cvl.fr WhatsApp : +33671616365

Micromanipulation is considered a challenging task which requires high precision motion and measurement at the micro scale. When micromanipulation is concerned with living organisms important considerations need to be addressed. These include the physical or chemical properties of micro-organisms, living conditions, responses to the environment and achieving suitably delicate manipulation. Bio-micromanipulation can include micro surgery or cell injection operations, or to determine interaction forces as the basis to investigate behavior and properties of living micro-organisms. In order to achieve suitable bio-micromanipulation appropriate processes and/or sensory systems need to be investigated. This thesis aims to look into the force interaction and sensing addressing two distinctive challenges in the field of bio-micromanipulation.



DESCRIPTION OF WORK

As an important embodiment of biomanipulation, injection of foreign materials (e.g., DNA, RNAi, sperm, protein, and drug compounds) into individual cells has significant implications in genetics, transgenics, assisted reproduction, and drug discovery. This thesis will develop a microrobotic system for fully automated zebrafish embryo injection, which overcomes the problems inherent in manual operation, such as human fatigue and large variations in success rates due to poor reproducibility. Based on computer vision and motion control, the microrobotic system performs injection at a speed. The actual dual tele-biomanipulation system is shown in Figure 2. We have been developing dexterous two finger micro hands and a total micro manipulation system. Our aim is to handle and to manipulate micro object whose size ranges from one to hundreds micrometers. We have improved and refined our hand focusing on extension of workspace, simple finger setting-up procedure, force sensing capability as well as calibration, automated picking-and-placing, etc. The micro manipulation system consists of microscope with high speed CCD camera, fine force sensor, user interface devices, and low level motion controllers. Each probe will be able to scan the surface in order to localize precisely the object before its manipulation but also to measure the nature and the intensity of the interaction

between the tip and the object in order to tune the grabbing force to avoid sample damage. The force control is based on the measurement of the frequency or phase shift of the tuning fork oscillating signal due to the tip-surface interaction. This mode is called dynamic mode in Atomic Force Microscope (AFM). Once the object is localized and the two probes positioned closed to it, the grabbing action will be carried out thanks to a high fidelity multi-sensorial interface based on a force feedback system involving accurate human manipulation capabilities (see Figure 2).

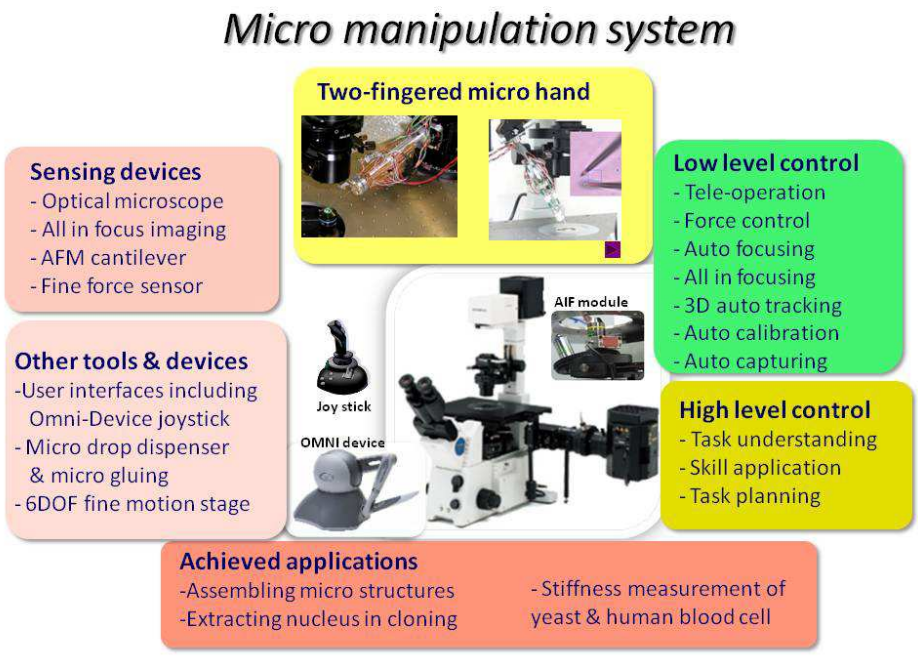


Figure 2: Overall view of the biological micromanipulation system..

The main objectives of this thesis work will be to propose new control strategies for a two-probe nanomanipulation system. By nano-robotic manipulation, it is meant that biological cells are localized, positioned, injected, characterized and placed by controlling external forces with sensorial feedback. The candidate will investigate several control tasks leading to :

· Dynamics modeling of two-probe handing tasks
· Robust control strategies for piezoelectric-stack actuated nano-manipulators,
· Force/position nano-handling control using AFM tip nano-probes;
· Multisensorial (vision, force, X-ray) integration and data fusion ,
. Robotic cell injection experiments

(1) W. Wang, X. Liu, D. Gelinas, B. Ciruna, and Y. Sun, "A fully automated robotic system for microinjection of zebrafish embryos," PLoS One, vol. 2, 2007.
(2) H.B. Huang, D.Sun, J.K. Mills, and S.H. Cheng, "Robotic cell injection system with position and force control: toward automatic batch biomanipulation," Robotics, IEEE Transactions on, vol.25, no.3, pp. 727–737, 2009.
(3) Y. Xie, D. Sun, C. Liu, H. Y. Tse, and S. H. Cheng, "A Force Control Approach to a Robot-assisted Cell Microinjection System," The International Journal of Robotics Research, November 13, 2009 2009.(4) Y. Xie, D. Sun,C.
(4) Liu, H. Y. Tse, and S. H. Cheng, "Force sensing and manipulation strategy in robot-assisted microinjection on zebrafish embryos," IEEE/ASME Trans. on Mechatronics, vol. 16, no. 6, pp. 1002-1010, December 2011