AGILE ROBOTIC MICRO-ASSEMBLY BASED ON SMART GRIPPING

Context of the PhD Thesis

AS2M (Automation and MicroMechatronics) department of FEMTO-ST research Institute is specialized in the design, fabrication, modelling and control of microrobotic systems for many application fields such as medical, telecommunications, instrumentation or biology. Several robotic micro-assembly platforms (assembly of components with size between 1 µm to 1 mm, see Fig. 1) have notably been developed contributing to a worldwide expertise in this field.

In this context, a national project (ANR) has just been obtained and will be starting at the end of 2016. This project entitled COLAMIR is based on the collaboration between two research institutes and two companies. The general objective consists in providing news ways of manufacturing innovative micro-products by succeeding complex and highly accurate robotic micro-assembly tasks. Many microscale specificities will notably have to be considered (erratic behaviour of manipulated objects due to the predominance of surface forces, extremely high dynamics, lacks of efficient measurements, behaviour of robots highly non-linear and time varying). To reach the project objective despite these specificities, the proposed approach relies on the collaboration between human worker and robots that have complementary skills:

- Robots can today be equipped with integrated micro-force sensors (Fig. 2) providing the robot much better tactile capabilities than for human worker. This is all the more true and important during contact transitions (between contact to non-contact scenario and vice-versa) which are a key source of instabilities and inaccuracies when not properly controlled
- Micro-robots have much better dynamic capabilities than human workers enabling the grasping of microscale components with very high accuracy
- Reversely, human worker is able to define complex strategies depending of multiple parameters much better than robots at the microscale.
- Human worker can very efficiently adapt a strategy regarding very limited set of data or observation even in widely varying environments or many influent parameters. This is all the more important that many kind of assembly tasks can be performed and that the behaviour of assemblies cannot be predicted accurately in all cases with enough confidence.

COLAMIR project expects to synergize these complementary skills by developing technical demonstrators and studying the way human and robot have to collaborate regarding different scenarios. Control strategies will then be derived and implemented onto an industrial demonstrator.

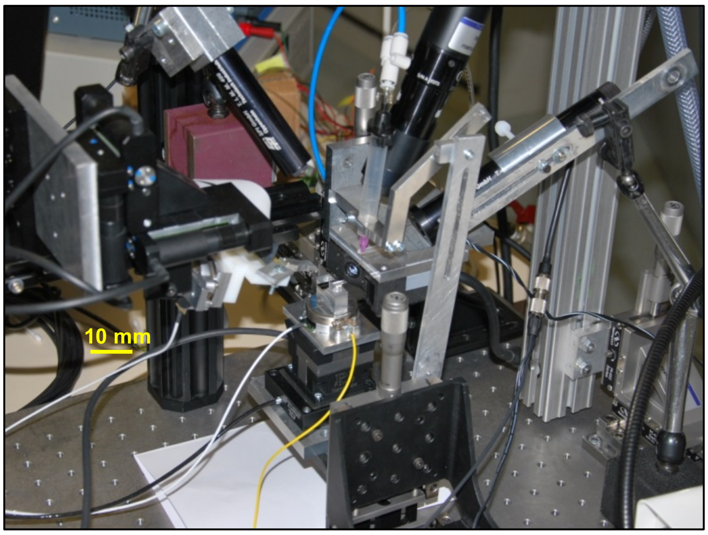

Fig.1 Example of micro-assembly platform equipped with 15 Degrees-of-freedom [Clévy et al. 2015[1]]

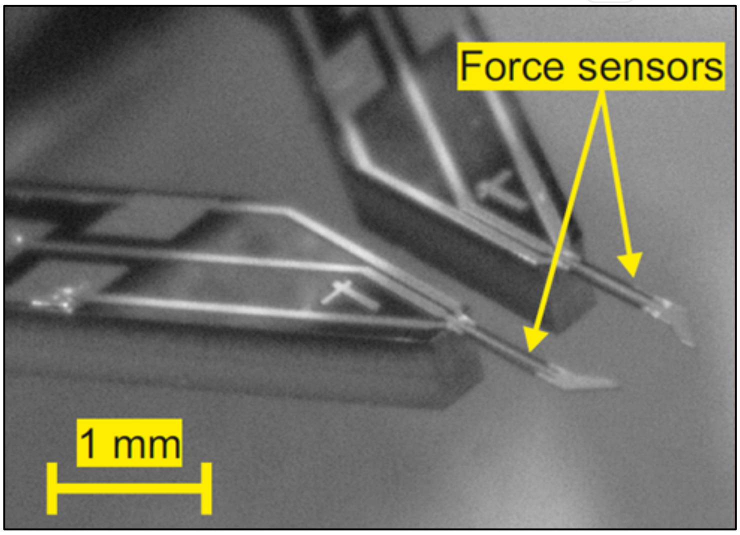

Fig. 2. Microgripper instrumented with two force sensors recently developed at FEMTO-ST [Komati et al. 2016[2]]

Objectives of the PhD thesis

The proposed PhD thesis includes several complementary objectives and will cover a large spectrum from modelling and control to the experimental validation. The core objective of the PhD thesis will be to achieve complex robotic micro-assembly tasks with high accuracy (typically down to 1 µm the along several degrees of freedom). Succeeding in achieving such objectives will require to take into account and find innovative solutions to several key locks that can be of technical nature (very small free place to integrate sensors, highly non-linear actuators, varying behaviours) or of physical based nature (high dynamics, predominance of surface forces, scale effects, very large uncertainties).

The first objective of the thesis will consist in achieving complex multi-degrees-of-freedom (dof) assembly tasks such as insertion in automated mode. A 4 dof piezoelectric microgripper instrumented with integrated force sensors will be notably used. The measurement of contact forces in the gripping plane (to grasp a component notably) and out of the gripping plane (for insertion for example) will enable a multi-dof based force control approach. A multi-physical dynamic and non-linear modelling of the whole gripper will be investigated to provide accurate position control at the same time than force control. Thus, a hybrid force-position control will be associated to original assembly strategies. A specific attention will be paid to contact/non-contact transitions (high dynamics, surface force predominance) which will be a key lock to be addressed.

The second core objective of the PhD thesis will be to guarantee the positioning accuracy of two components after their assembling. At first, a methodology will be developed to quantify this positioning accuracy. Experimental investigations will then be conducted to analyse the main sources of positioning errors and to propose a relevant strategy to achieve an accurate positioning. A key lock will notably to control the relative position of components during their solidarization: techniques such as gluing or soldering induce important position drift. The approach

[1] C. Clévy, I. Lungu, K. Rabenorosoa and P. Lutz, *Positioning Accuracy Characterization of Assembled Microscale Components for Micro-Optical Benches*, Assembly Automation (AA), 34(1), pp. 68-77, January 2014

[2] B. Komati, J. Agnus, C. Clévy and P. Lutz, *Prototyping of a highly performant and integrated piezoresistive force sensor for microscale applications*. Journal of Micromechanics and Microengineering, 24(3), pp. 1-19, March 2014

INSTITUT FEMTO-ST – DÉPARTEMENT AUTOMATIQUE & SYSTÈMES MICRO MÉCATRONIQUES
24 rue Alain Savary 25000 BESANÇON - **www.femto-st.fr**

proposed will notably rely on controlling interaction forces during solidarization through the combination of force-position behavioural modelling with robot control.

These works will be integrated into the industrial demonstrator of the project, then the recruited PhD student will have to study collaborative control modes i.e. defining with other partners, how every task can be "optimally" achieved from a control point of view.

Finally, forces to be controlled during the whole assembly process will cover a very wide range: contact forces to be controlled to succeed accurate gripping are in the µN range whereas forces to be controlled during the solidarization are in the mN range. Due to this specificity, the PhD thesis topic will also be opened to active based compliant approaches.

Technical means available for the thesis:

Computers, softwares (Matlab, Solidworks, Catia, Comsol Multiphysics), experimental set-up for research scale validation of results, funds for additional experimental needs and participation to international conferences.

Requested skills

Profiles based on/or merging competencies of robotics, automatic control mechatronics, and/or instrumentation will be considered with a great attention. The proposed thesis is for curious, inventive, dynamic applicants having a strong scientific background and a sense of collaborative works. Experience of research and experimentation will be appreciated extra points. Knowledge about microscale and microrobotics would be appreciated but not compulsory.

Advisory team of the PhD:

Cédric Clévy (Associate professor – CODE team, AS2M department, FEMTO-ST Institute)
Philippe Lutz (Full professor and advisor of the PhD– CODE team, AS2M department, FEMTO-ST Institute)

Funding:

3 years duration doctoral contract, The PhD thesis will start in September or October 2017.
Doctoral school SPIM (Engineering Sciences and Microtechnologies)

Application:

Please send your application documents to Cédric Clévy (cclevy@femto-st.fr) including a detailed CV and a motivation letter dedicated to the proposed position. You may add additional documents such as the marks and ranks you obtained during your master degree or engineering school.

Cédric CLEVY – Associate Professor HDR
FEMTO-ST Institute,
Automatic Control and Micromechatronic Systems department (AS2M)
24 rue Alain Savary, 25000 Besançon, FRANCE
Email : cclevy@femto-st.fr
https://sites.google.com/site/cedricclevy/home