PhD Proposal 2017

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Collaboration with other partner during this PhD: **In France:**	**In China:**

Title: Design of an underactuated compliant gripper for high-speed robots
Scientific field: Automation and Robotics
Key words: robotics, mechanical design, grippers, dynamics, underactuation

Details for the subject:

Background, Context:

High speed robots are very appealing in industrial context because they allow for increasing the production rate at lower cost. However, even if they can reach high velocities and high accelerations, their accuracy is usually quite poor. Moreover, the dynamic phenomena (vibration, high tracking error) limit their efficiency and leads to a decrease of the cycle time: for instance, high vibrations at the end of the trajectory must be dissipated before being able to pick or place an object.

In the Lab, we have a prototype of high-speed robot for pick-and-place operations, named IRSBot-2 (Fig. 1). This robot is able to reach 20G of accelerations, speeds of 6m/s, while its absolute accuracy is of 100 microns in statics. However, the dynamic accuracy is poor, and the robot has rotational vibration effects at 50Hz (amplitude of the vibration of several degrees at high-speed).

Fig. 1. IRSBot-2

We propose in this thesis to work on the design and control of grippers for the IRSBot-2 for catching objects at high-speed. The main idea is to design new grippers able to catch a small object with accuracy and at high speed (in order to avoid losing cycle time), even if the effector of the robot is vibrating or not at the correct location, i.e. the gripper must be adaptive enough in order to compensate the vibrations and the tracking errors at the end of the high-speed robot trajectory.

Industrial robots generaly use suction cups or pneumatic parallel jaw gripper, since pneumatic air permits very high flow rate and thus short cycle time (less that 10 ms). A few attempts have been made by the constructors to design flexible grippers using pneumatics [1][2] but these are not fast enough for high-speed pick-and-place applications.

In [3] the authors present the 100G capturing robot and a hand designed for high speed catching of a ball in flight. The closure time is about 25ms. This hand is underactuated which permits to reduce the number of actuators.

Underactuation, when applied to grasping mechanisms, permits to reduce the number of actuators while reducing the gripper mass, but maintaining a high number of degrees of freedom and the capability of the grasping mechanism to adapt to objects with various shapes.

Research subject, work plan:

There is a large diversity of mechanical devices which enable a hand to adapt to the geometry of an object. A classification of such mechanisms is proposed in [4][5]. The work will start with an exhaustive literature review on the design of underactuated grippers. Three main classes of underactuated grippers (Fig. 2) can be found and should be investigated:

(i) *underactuation by compliant mechanisms:* Various hands or grippers have been designed using compliant mechanisms (springs, soft linkages, ...) to distribute forces among phalanxes [6]-[9]

(ii) *Underactuation by differential mechanisms:* Another method to distribute forces among phalanxes consists in using differential mechanisms such as “4-bar linkages”, “pulley-cable”, ... [10]–[13]

(iii) *Underactuation by self-locking mechanisms:* this last method consists in introducing non-backdrivable mechanisms in the transmission of the closing sequence [2][14]

Then, the student will synthesize several design concepts for the gripper by taking into account the following specifications: the gripper must be lightweight (in order to reduce mass on the end-effector of the high-speed robot), it must have as less actuators as possible and it must compensate for the poor dynamic accuracy of the robot. The bandwidth of the mechanical system must also be compatible with the dynamics of the robot cycle (opening and closing of the gripper necessary in a few milliseconds). Gripper architectures actuated with piezo actuators will be investigated as well as fully underactuated systems. The last part of the work will be to validate the results by simulations (ADAMS + Simulink) and then via experimentations on the IRSBot-2 robot.

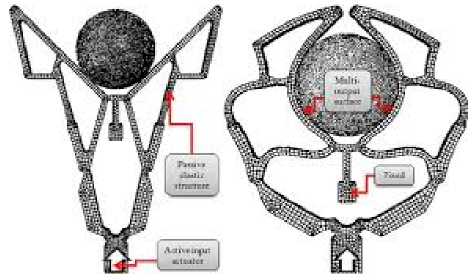

Fig. 2. Example of compliant underactuated gripper

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