Experimental validation of two semi-implicit homogeneous discretized di erentiators on a cable-driven parallel robot

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bstract

A cable-driven parallel robot (CDPR) consists of a moving-platform that is connected to a rigid frame by means of cables and actuators, the latter being generally mounted on the ground. Most of the existing robots are powered by electric motors. These robots are very attractive for handling tasks [1, 2] because of their low inertia, a higher payload to weight ratio and a large workspace compared to conventional manipulator robots with articulated rigid limbs. Their possible application fields can be industrial, or dedicated to search-and-rescue operations. However, for tasks such as motion planning realized with CDPRs, haptic control is still improvable. To deal with various restrictions on cable tensions, cable elasticity, collisions and obstacle avoidance, over-actuation of the moving platform is actually a challenging scientific problem [3], [4].

As a consequence the control of CDPRs is challenging. One key point for their control design is the access, for each electric motor, to the angular variable and its time derivative of each actuator output shaft. These data are useful to design the robot control in tracking position or in haptic control [5]. Usually, the measurement of the angular variable of the output shaft of each actuator is made thanks to an encoder sensor or a resolver-to-digital converter. However, due to weight restrictions, reliability, financial cost and so on, a tachymeter is not usually available. A solution to get the value (or the estimation) of the angular velocities can be based on numerical di erentiators. The expected characteristics of a di erentiator are accuracy and low sensitivity to noise (the reader can refer to [6] for more details and state-of-the-art of di erentiation solutions under sampling).
A CDPR, named CRAFT and located at LS2N, Centrale Nantes campus, is equipped with eight actuators and a moving-platform. Each motor has an encoder sensor measuring the angular velocity of its output shaft allowing to evaluate the performances of the di erentiation solutions. The moving-platform has six degrees of freedom. This moving platform is thus over-actuated [7].

The performance of two new numerical di erentiation schemes providing an estimation of the angular velocities is compared experimentally to the finite-time di erence method. The first strategy is based on a semi-implicit discretized homogeneous first-order di erentiator [8] in the framework of velocity estimation regarding the angular variable of the actuator output shaft. The second strategy is based on a semi-implicit discretized homogeneous second-order di erentiator [9] in the framework of velocity/acceleration estimation regarding the angular position. Those two di erentiators combine an explicit di erentiation part with an implicit di erentiation one based on two *projectors* in order to reduce the e ects of chattering phenomena as well as noise and disturbances. It should be noted that better performance was obtained with the two proposed di erentiators compared to the finite-time di erence method in terms of tracking errors and noise rejection.

Future work will focus on the design of a new control scheme for haptic control of CRAFT.

Keywords cable-driven parallel robot, discretized di erentiator, chattering, output shaft position and velocity, experimental data.

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