Contact-based incremental nonlinear control for aerial manipulators

Background

Aerial manipulators are aerial robots that can manipulate the object and physically interact with the environment. In other words, they are also “flying hands” rather than “flying cameras”. An emerging application of aerial manipulators is using them for ultrasonic testing (UT) of infrastructure, such as wind turbine blades to detect their interior flaws. While existing solutions can achieve point detection, it still remains a challenge to smoothly **slide on a rough surface** because of the unknown frictions.

In this project, you will explore the Incremental Nonlinear Control (INC) algorithms to address this task. The INC family approach utilises instantaneous sensor measurements to estimate the friction of the surface and use the information to guarantee stability and improve accuracy during the operation. You will develop and test the INC-based algorithm in the simulation, and eventually validate them in real-world experiments.

Research question

- How to design an incremental nonlinear controller to control and stabilize an aerial manipulator in a contact-based task?
- How to improve the incremental nonlinear controller to address unknown disturbances from the friction and the aerodynamic effects?

(The aerial manipulator stands for a multi-rotor drone with a rigidly attached manipulator)

What we expect from you:

- Highly motivative.
- Experience in programming languages such as Python and C++.
- Knowledge in robotic dynamics and nonlinear control.
- Experience with Matlab \ Simulink is a bonus.
- Experience with real-world experiments with drones is a bonus.

What you can learn from this project:

- Hands-on experience with the modelling and control of multi-UAV (aerial robot) systems.
- Access to our optimization-based control framework of drone systems in C++ and Matlab \ Simulink.
- Hands-on experience in hardware development of aerial robots.
- Chance to publish in high-ranking robotic and ML conferences/journals.

Reference

[1] Tzoumanikas, Dimos, et al. "Aerial manipulation using hybrid force and position NMPC applied to aerial writing." *arXiv preprint arXiv:2006.02116* (2020).

[2] Ollero, Anibal, et al. "Past, present, and future of aerial robotic manipulators." *IEEE Transactions on Robotics* 38.1 (2021): 626-645

[3]Sun, Sihao, et al. "A comparative study of nonlinear mpc and differential-flatness-based control for quadrotor agile flight." *IEEE Transactions on Robotics* 38.6 (2022): 3357-3373

Contact:

If you are interested in conducting this cool project, please contact Dr. Sihao Sun via

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When applying, please provide a short motivation, an up-to-date CV, a transcript of your current degree program and an intended start date.

Short bio of the supervisor:
Dr. Sihao Sun is a new member of CoR funded by the NWO talent program “Veni” grant. He has intensive experience in the control, planning, estimation and machine learning of aerial robotic systems by working with Prof. Davide Scaramuzza, Prof. Antonio Franchi, and Prof. Guido de Croon. He’s the winner of the Best Paper Award of Robotics and Automation Letters (RAL) and the NASA Tech Brief award. He has supervised over 20 MSc students, and three of them won CumLaude respectively in TU Delft and ETH / Zurich.