Benchmarking Coaxial Rotor Systems to Optimize Performance in Autonomous Applications - A Tutorial

1 Type

Half Day Tutorial

2 Organizers

- Dr. Minas Liarokapis, Senior Lecturer / Director of New Dexterity Research Group (www.newdexterity.org)
  The University of Auckland
  Email: minas.liarokapis@auckland.ac.nz
  Phone number: +64 2102623799
- Joao Buzzatto, PhD Student
  The University of Auckland
  Email: jsan819@aucklanduni.ac.nz

3 Tutorial URL

https://newdexterity.org/CoaxialRotorSystemsBenchmarkingCASE2022/

4 Tutorial Content

The tutorial will consists of 4 parts, focusing on:

- **Background of Coaxial Rotor Systems**
  It will begin with a brief presentation about coaxial rotors and the methods and resources used in the tutorial to improve their efficiency. In sequence, there will be a comprehensive description of the benchmarking platform used to collect data and support the efficiency improving method.
- **Benchmarking Platform Operation**
  Will focus on how to operate the benchmarking platform, general visual interface operation, sensors calibration and setting up of motors, and how to program and perform automated testings.
- **Data Treatment and Control Allocation Determination**
  Using provided code, the participants will learn how to treat the experimental data collected, how to interpret the results, and how to derive a control allocation policy that improves coaxial rotor efficiency.
- **Verification of Control Allocation and Implementation on Multirotor UAVs**
  Finally, the participants will learn how the control allocation method they derived can be verified on the benchmarking platform, and how it can be implemented on a coaxial UAV running the PX4 firmware.

5 Motivation

In the UAV field, the efforts to develop drones with more payload and flight time capacity are constant. Coaxial multirotor drones offer high payload capacity in a relatively small vehicle footprint [1]. However, compared to regular 'flat' multirotors, they exhibit a much lower efficiency. The content covered in this proposed tutorial is based on a very recent work of the authors where they developed a control allocation method in which experimental results showed an increase in efficiency of up to 11% compared to the current state-of-the-art [2]. Additionally, the tutorial also covers the operation of an open-source benchmarking platform developed by the authors with the purpose of testing and optimizing the performance of coaxial rotor systems. Therefore, the tutorial will provide the participants with all the tools needed to perform experiments, develop, and implement control allocation methods to improve the efficiency of coaxial rotor systems in autonomous applications.

6 Proposed Agenda

The tutorial agenda will be as follows:

- **Background of Coaxial Rotor Systems, 9:00 am - 9:45 am**
  A presentation / demonstration session focusing on the related work on coaxial rotors, the control allocation method used to improve their efficiency, and a comprehensive description of the open-source benchmarking platform that will be used to collect data and support the efficiency improving method.
- **Short Break, 9:45 am - 10:00 am**
- **Benchmarking Platform Operation, 10:00 am - 10:45 am**
  A presentation / demonstration session focusing on how to operate the benchmarking platform, including visual interface operation, sensors calibration and setting up of motors, and how to program and perform automated experimental trials.
- **Short Break, 10:45 am - 11:00 am**
- **Data Treatment and Control Allocation Determination, 11:00 am - 11:45 am**
  A presentation session with separate breakout rooms for each group of participants to work individually. The participants will be provided with a Matlab code to learn how to treat the data collected from the experiments and how to interpret the data. Next, they will be provided with another code that uses the results from the previous one to determine a control allocation policy that improves the coaxial rotor efficiency.
- **Lunch Break, 11:45 am - 12:30 pm**
- **Control Allocation Verification, Implementation on UAV, and QA, 12:30 pm - 1:00 pm**
  In the last part of the tutorial, there will be another presentation showing the verification test of the control allocation method on the benchmarking platform and a demonstration of how it can be implemented on a real vehicle. A QA session will also be included.

7 Related Events and Soliciting Participation

We are not aware of any related events. An email will be sent to the participants of the conference, inviting them. Additionally, the invitation will also be sent to the Robotics World Wide emailing list.

8 Dissemination, Archiving, and Equipment Needed

The presentations will be recorded on Zoom and posted on Youtube. The code will be available on Github. Each participant will need a computer with Zoom and MATLAB.

References

[1] Joao Buzzatto, Pedro H Mendes, Navin Perera, Karl Stol, and Minas Liarokapis. The new dexterity omnirotor platform: Design, modeling, and control of a modular, versatile, all-terrain vehicle. In *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 6336–6343. IEEE.

[2] Joao Buzzatto and Minas Liarokapis. A benchmarking platform and a control allocation method for improving the efficiency of coaxial rotor systems. *IEEE Robotics and Automation Letters*, 7(2):5302–5309, 2022.