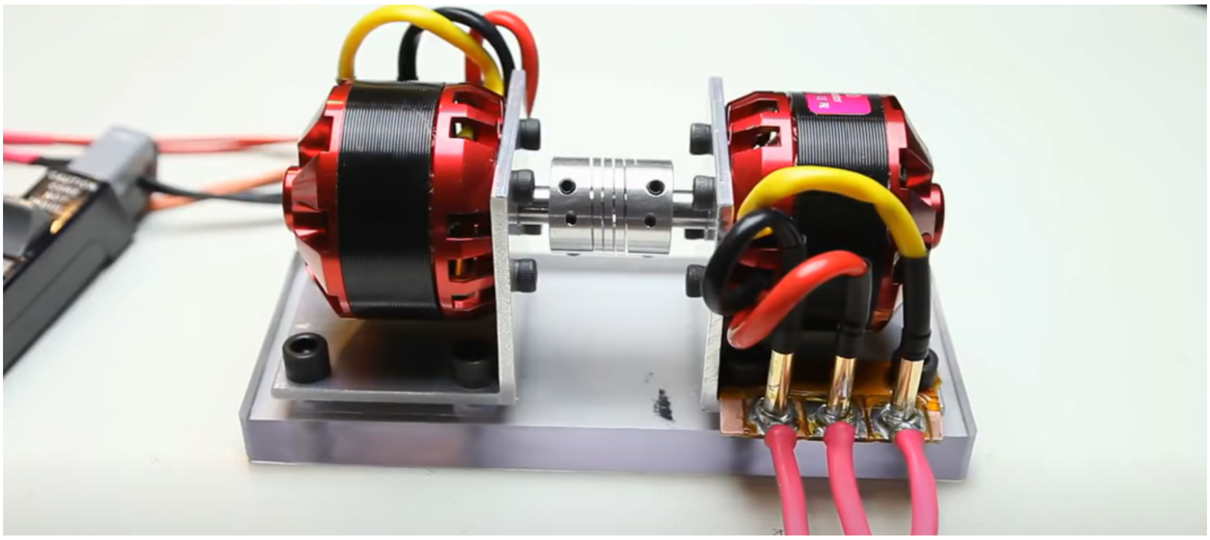
[Forschungspraxis/Internship] BLDC actuator back-drivability hacking



[1]Picture only for representation purposes, source: [Dummy load for BLDC controller testing]

Brushless motors are growing in popularity for Robotics applications. In particular, due to their high power density, these motors can be used with smaller gear ratios to deliver the torque and speed requirements. For example, the key to MIT mini cheetah's success was BLDC adaptation within the Proprioceptive Actuator concept [1].

Evaluation of actuator abilities requires capabilities to sense torques, speed, power input, and output (mechanical and electrical) [3]. For this purpose, alongside the motor being tested, the testbed requires a dynamometer (measuring torques and speeds) as well as an absorber (an element that will be consuming the power - regulating the effort required for the tested motor rotation). An example of a build can be found in [2] and [4]. Challenge is that commercial solutions are not usually tailored for high currents and are not focused on in-depth testing, specific to various setups. The goal would be to identify several criterias for the actuator backdrivability alongside the design of corresponding test cases for their evaluation.

Task will be to understand physical properties of BLDC actuators, and be able to mathematically describe them. One should design test scenarios and program the control for them (that includes programming absorber side - how the loading will look like, alongside the motor being tested). Collect, visualise and analyse data from experiments (plotting power, efficiency, etc.). Make conclusions about the relation between physical properties of different actuators (high level design choices like inrunner or outrunner, number of poles, control algorithm, etc.) and collected results. It's worth mentioning that you will not start from scratch and will be supported by inhouse developed solutions for BLDC control, available testbed, etc.

[1] Dummy Load for BLDC controller testing https://youtu.be/n16nrkDgMSA?si=UvVKYjV67vnbA-1a

What you will gain:

- Hands-on experience and in-depth understanding of Brushless Motors, and their control
- Visualising and analysing the data
- Best practices for Embedded software development
- Experience building, prototyping, 3d Printing
- Working with DataSheets and Documentations of various Devices
- Hacking electronic signals (via oscilloscope, etc.)
- Insights in our System Development and access to our community

Requirements from candidates:

- Knowledge of C, Matlab
- Working skills in Ubuntu operating system
- Understanding how Motors work
- Basics in Electronics and Mechanics
- Proficiency in English C1, reading academic papers
- Plus are:
    - Familiarity with GIT
    - Embedded software development
    - Robotics

Work is expected to be a collaboration between two students, tackling various configurations of BLDC motors (for example adding a spring in series, etc.). We are welcoming initiative and always aiming to support new ideas. This internship is a great opportunity to get familiar with our work and gain a lot of hands-on knowledge.

To apply, you can send your CV, and short motivation to the Supervisors (with the Senior Supervisor in cc)

Supervisors

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[1] P. M. Wensing, A. Wang, S. Seok, D. Otten, J. Lang and S. Kim, "Proprioceptive Actuator Design in the MIT Cheetah: Impact Mitigation and High-Bandwidth Physical Interaction for Dynamic Legged Robots," in *IEEE Transactions on Robotics*, vol. 33, no. 3, pp. 509-522, June 2017, doi: 10.1109/TRO.2016.2640183.
[2] Small Motor Dynamometer: The Beginnings
https://build-its-inprogress.blogspot.com/search/label/Motor%20Dyno?updated-max=2016-08-29T18:57:00-04:00&max-results=20&start=8&by-date=false
[3] Motor Dyno Efficiency Mapping
https://build-its-inprogress.blogspot.com/2017/05/motor-dyno-efficiency-mapping.html
[4] Gear test rig for health monitoring and quasi static- and dynamic testing; design, construction and first results https://elib.dlr.de/90564/