The Open Dynamic Robot Initiative Project

Journée 2RM Robotique Mobile 2021

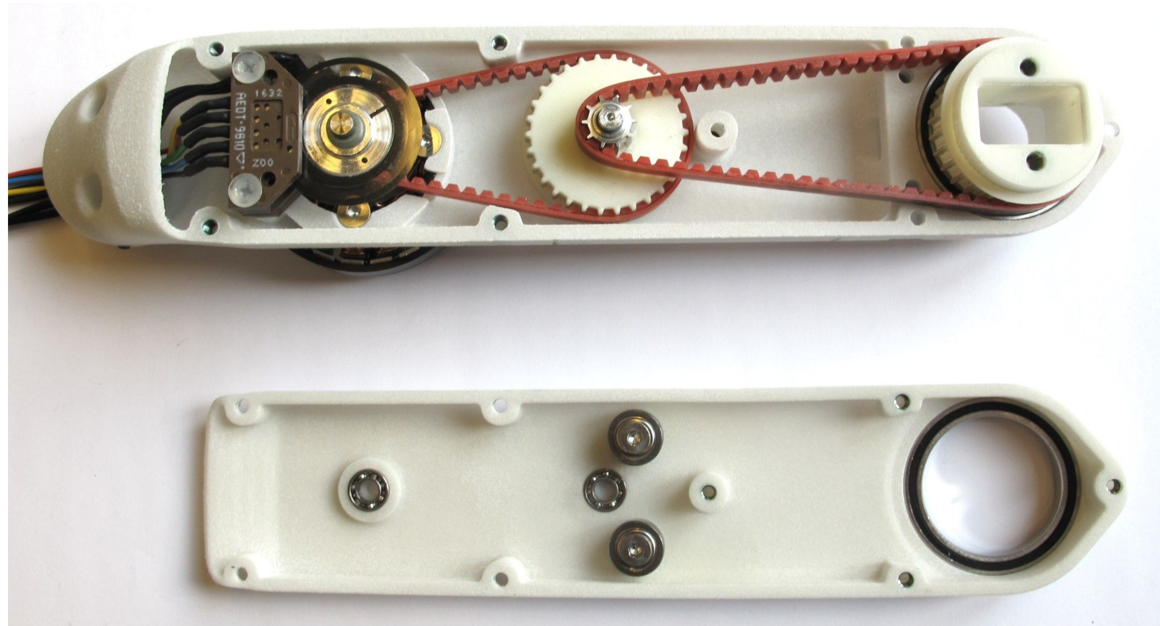
Thomas FLAYOLS
LAAS Gepetto - Oct. 19th, 2021

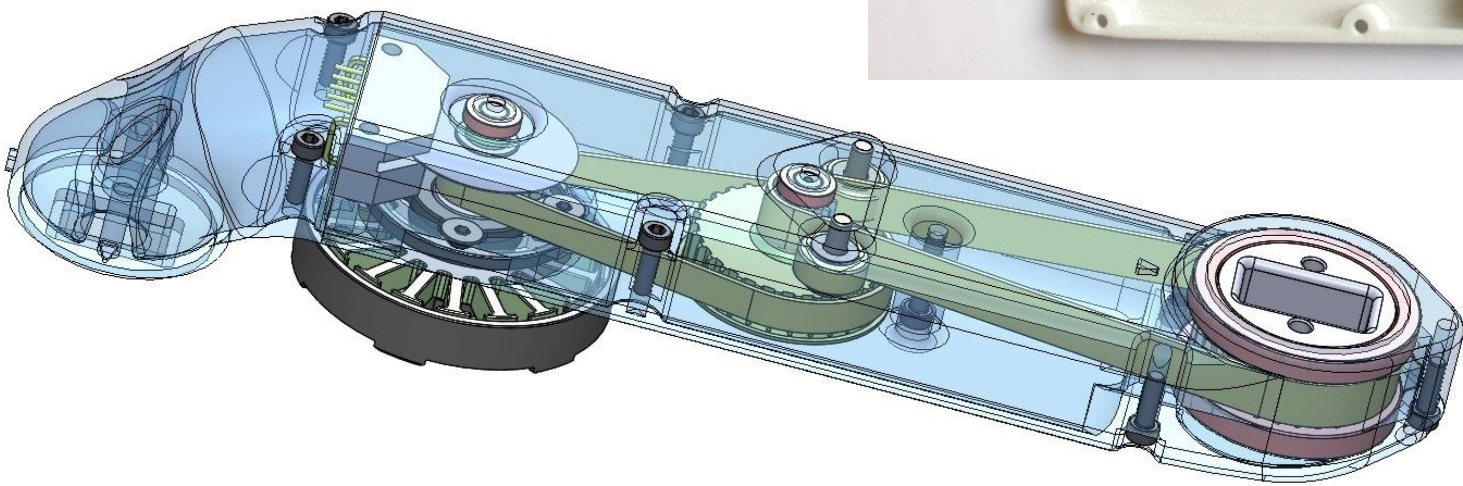
What is the ODRI project ?

- A collaborative project between MPI Tübingen, NYU and LAAS
- Transparent actuation modules with low gearbox ratio + brushless motor
- Easy-to-build robots, heavily documented
- Dynamic, light and cheap
- Free and open-source design

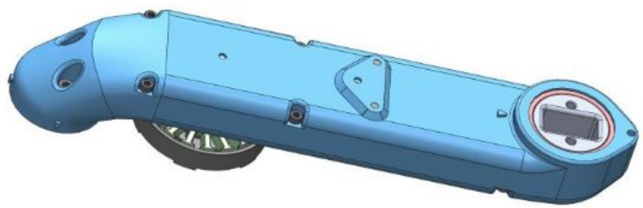
Actuation module

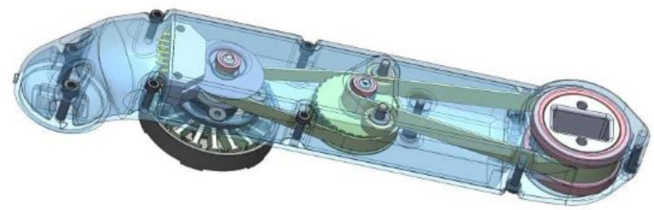
Length	160mm
Mass	150g
Torque	2.5Nm at 12A
Gear r.	9:1

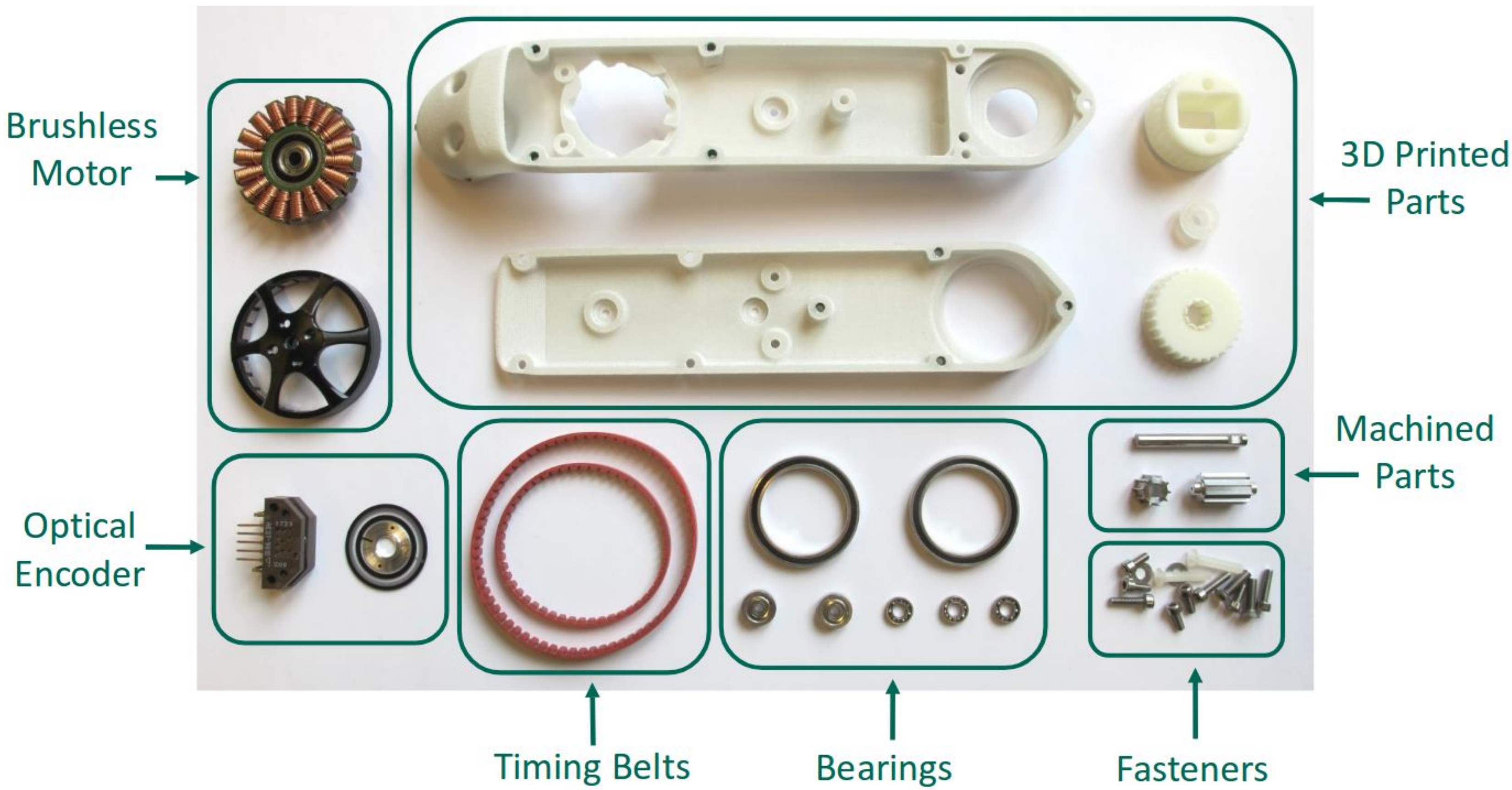




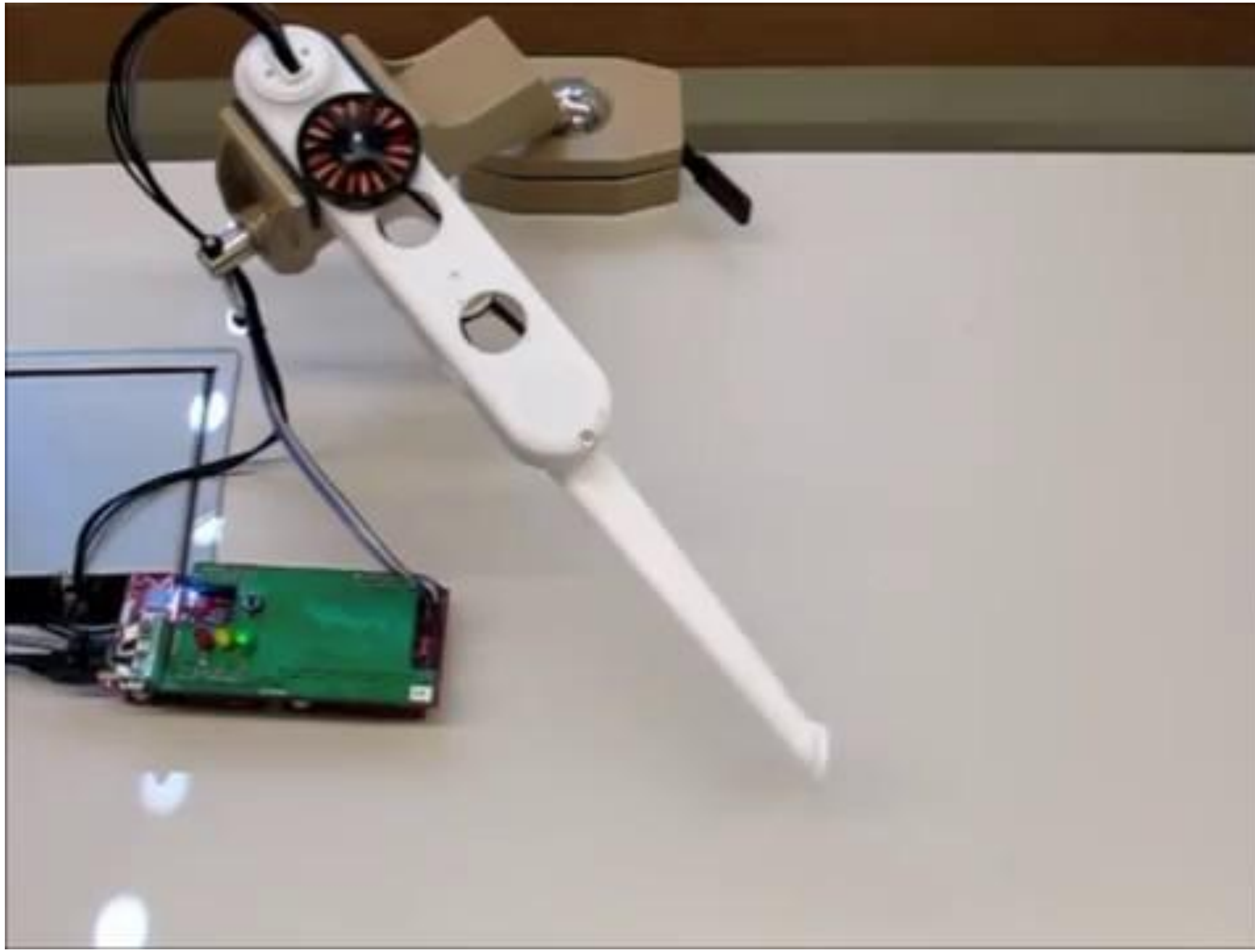
Actuation module



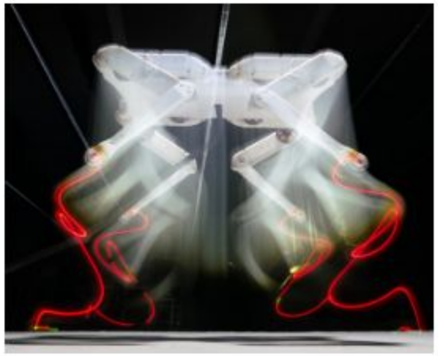
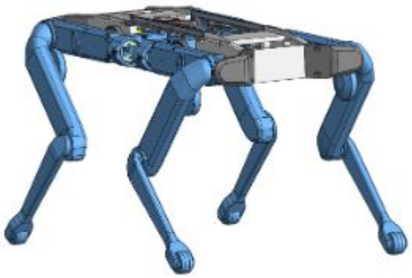
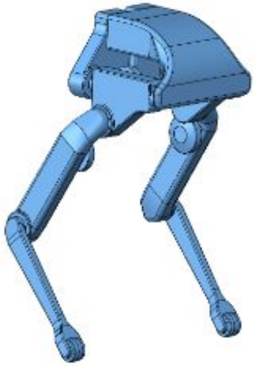


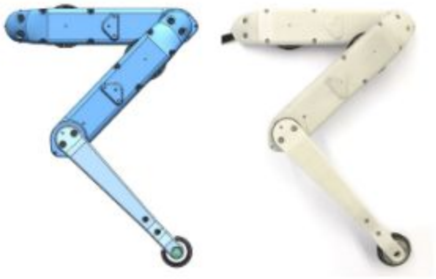
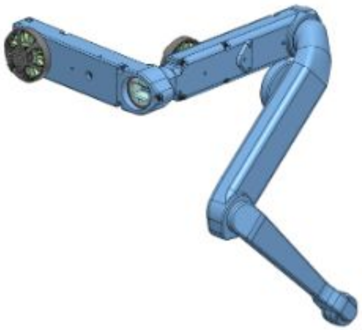
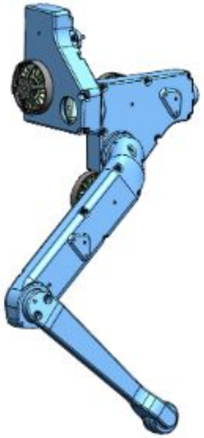


Actuation module

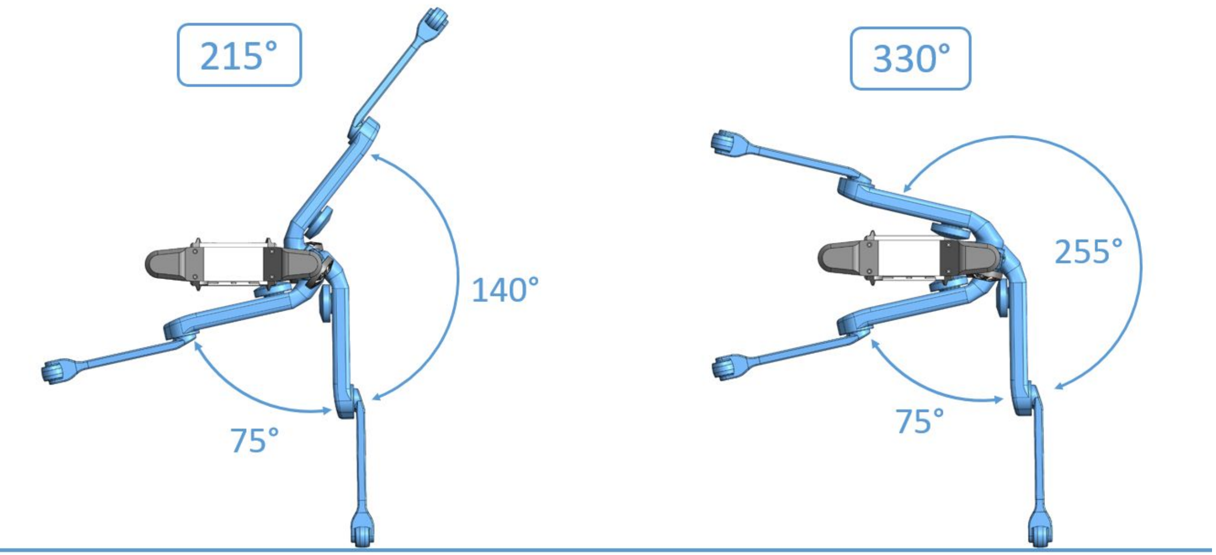


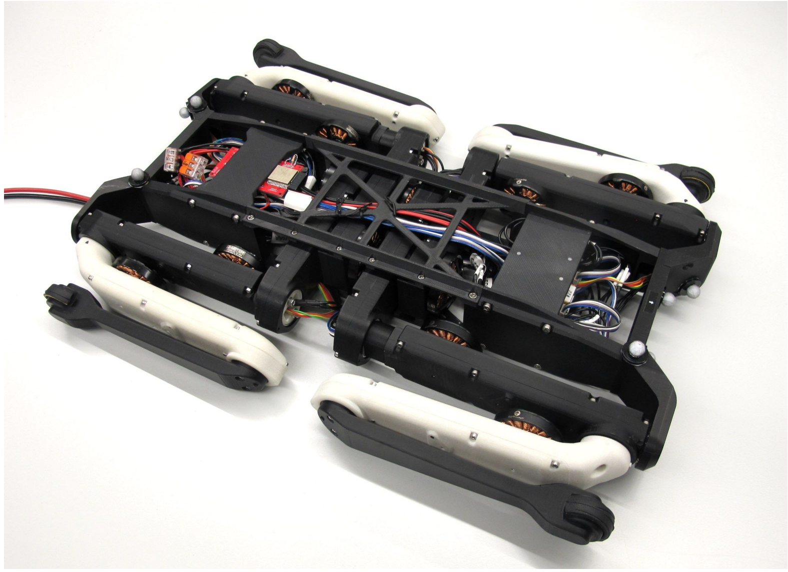
The Robots

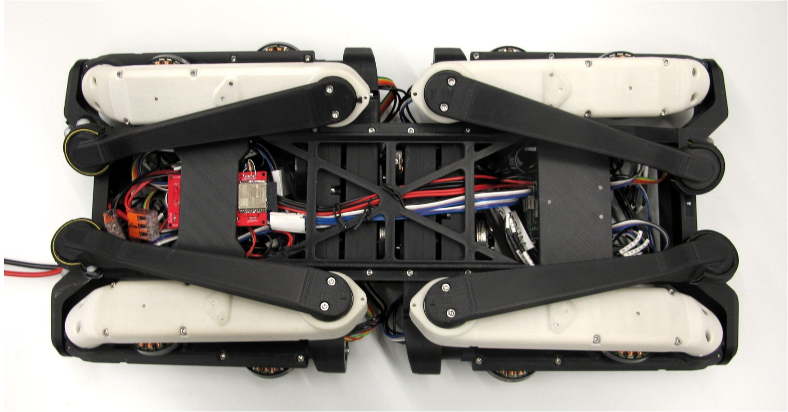
Quadruped 8dof	Quadruped 12dof	Biped 6dof	TriFingerEdu
			

2dof Leg	3dof Leg	Biped Leg	FingerEdu
			

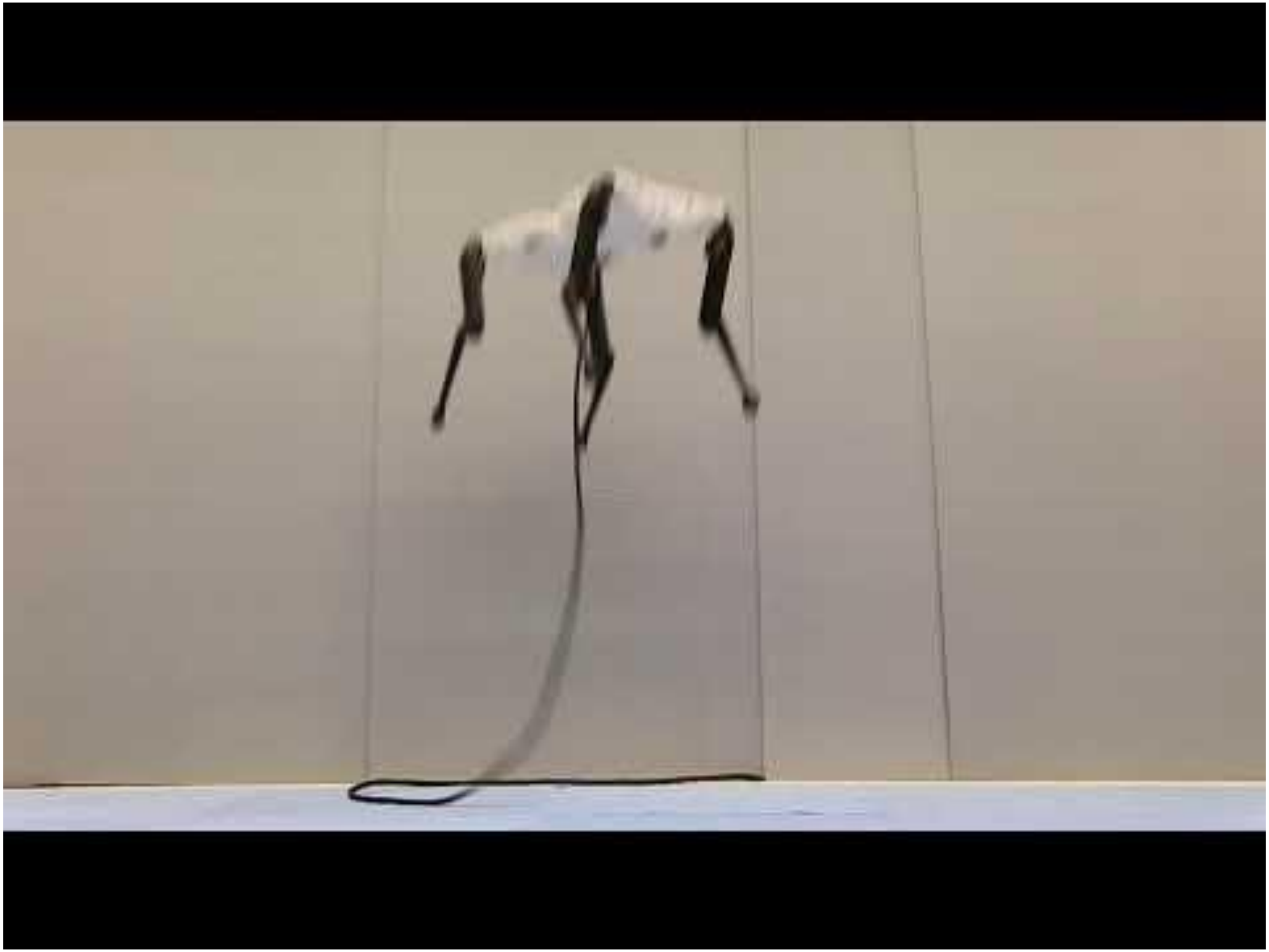
Solo 12





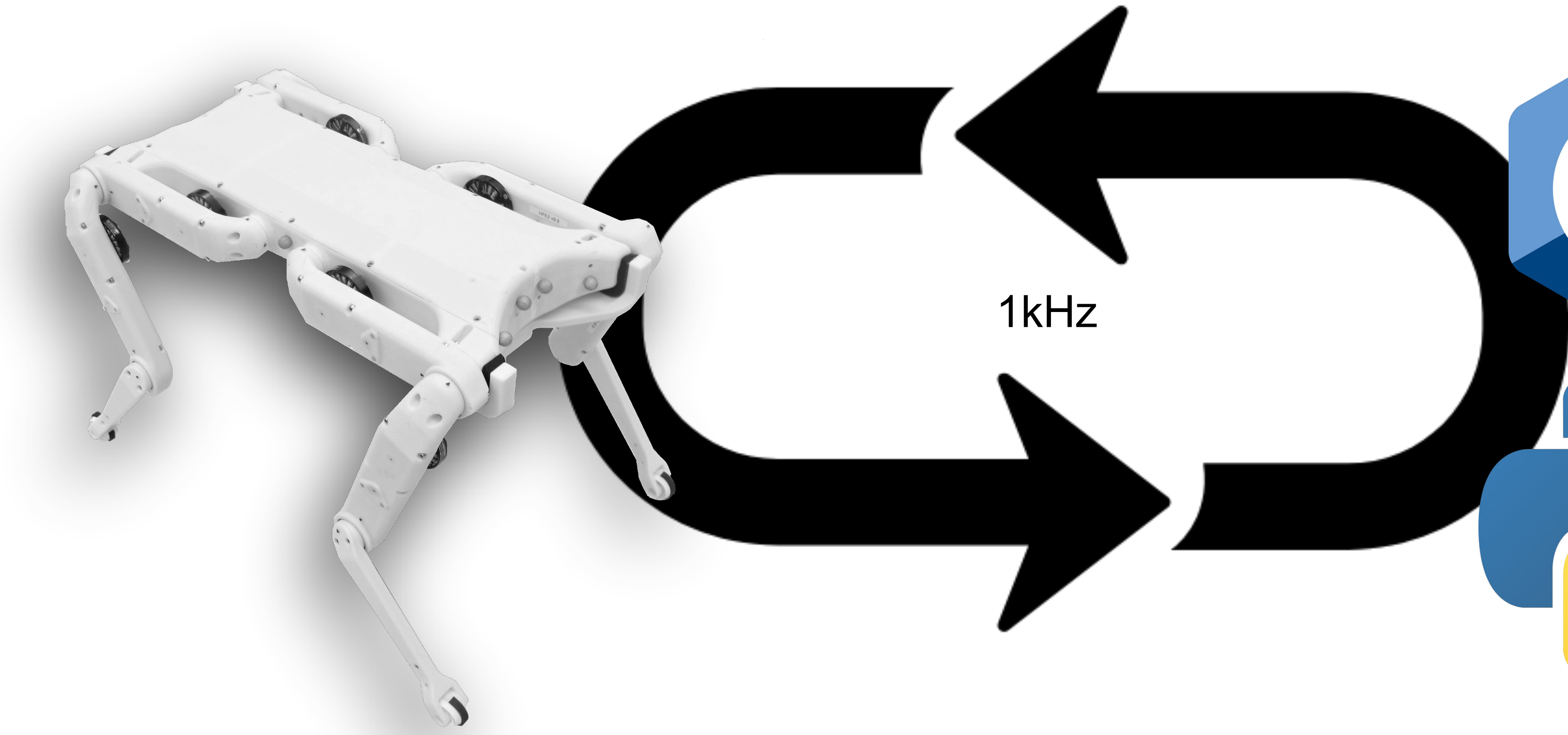


Solo 12

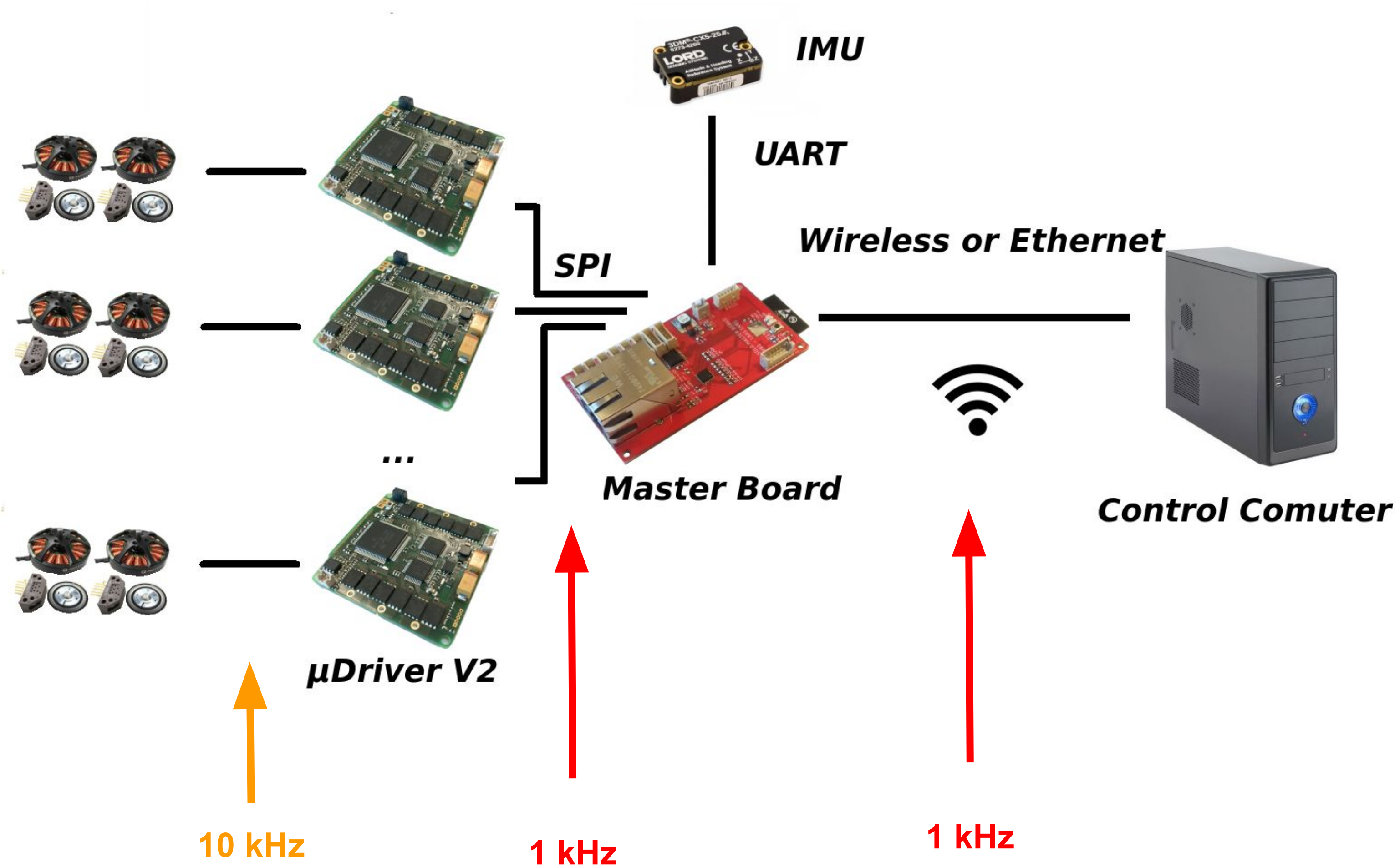


Custom electronic and communication link

Simple SDK to control the robot from a distant computer



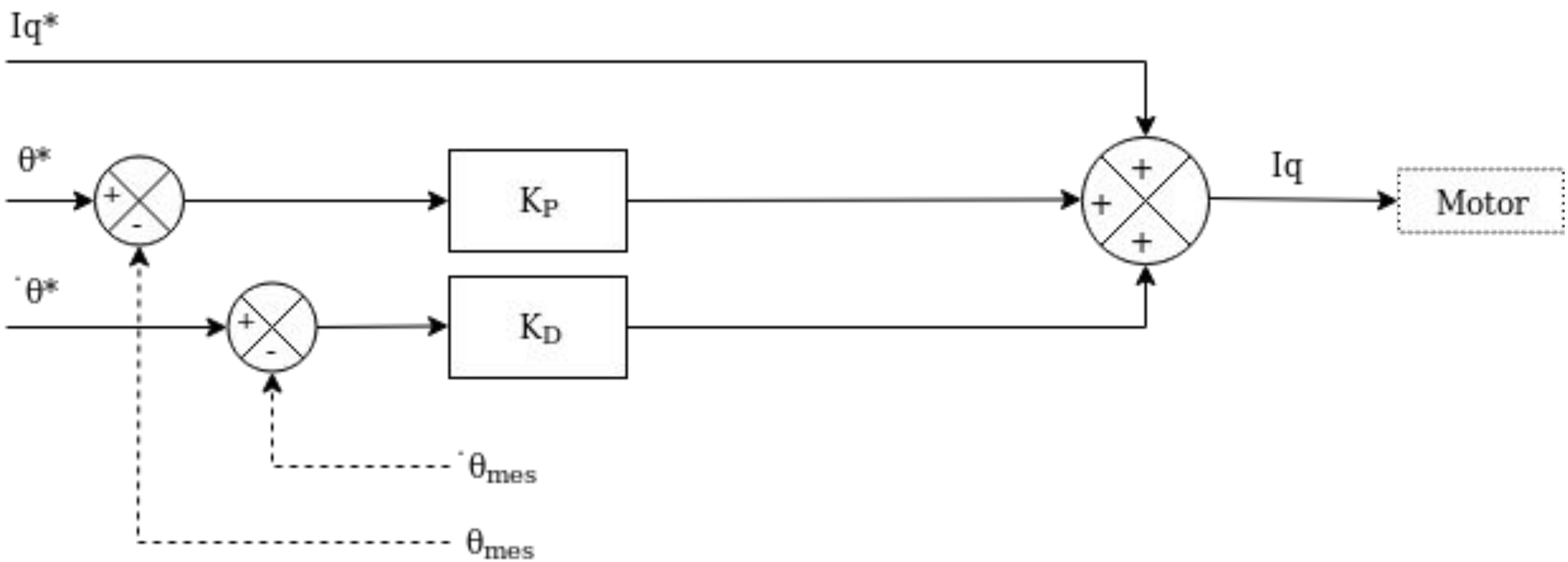
Control architecture



Custom electronic and communication link

uDriver

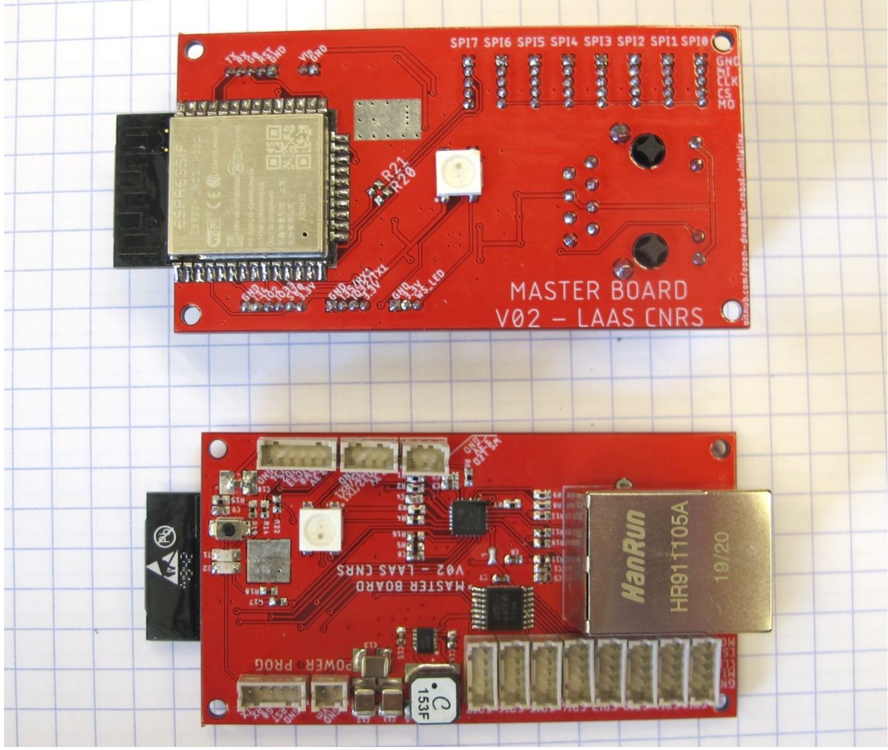
Running at 10 kHz :



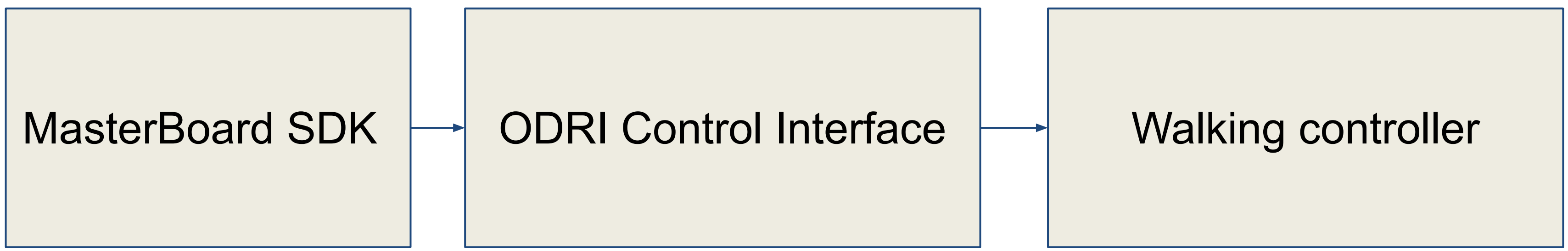
Custom electronic and communication link

Master Board

- Open source/hardware
- Synchronous RT com with up to 16 actuators, IMU, ...
- Wired or Wireless com with RT control PC
- 1Khz control loop
- Onboard safety procedures
- room for user code..



Control stack



Low-level driver

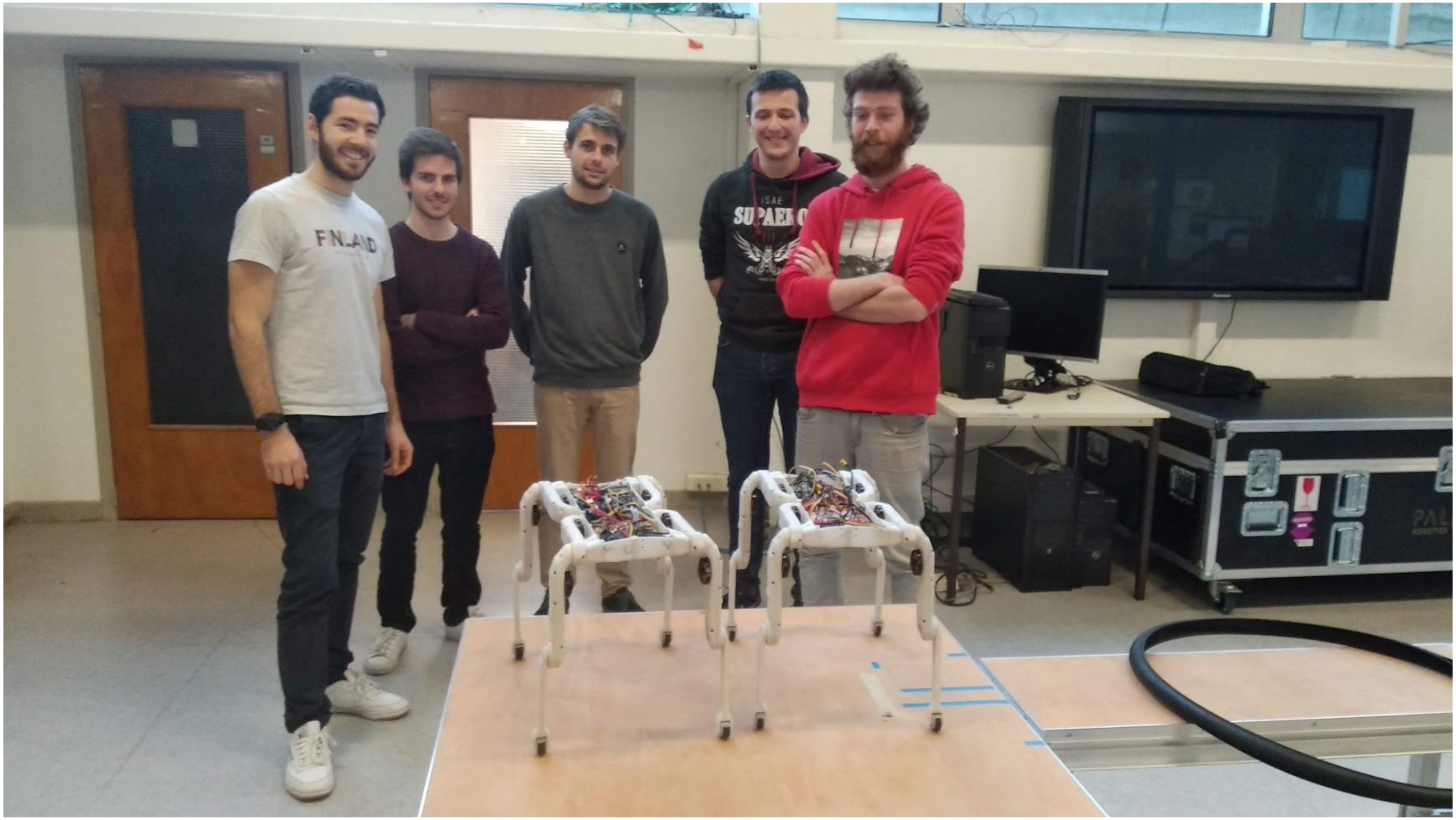
Robot level (URDF order, joint level data, Calibration procedures)

User controller, high level Inverse Kinematics/Dynamic, MPC...

Research project lead at LAAS

Assembly + Simple gait optimisation with Genetic Algorithm - ISAE student project

Etienne Arlaud, Thibault Noël, Thomas Corbères, Marion Valette, Ethan Cherki, Jean-lou Quetin



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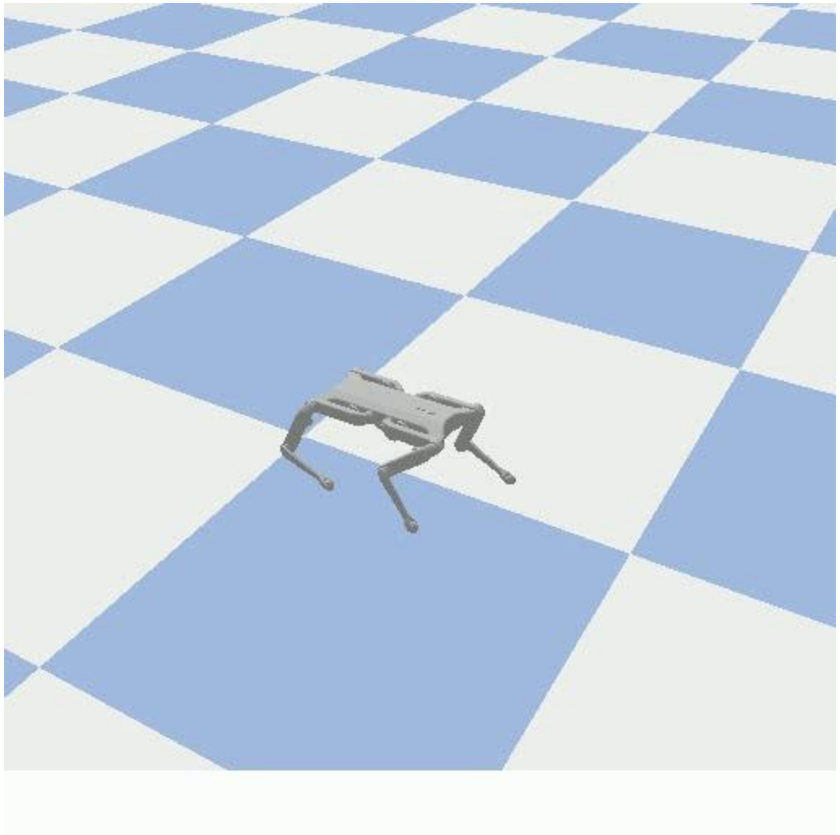
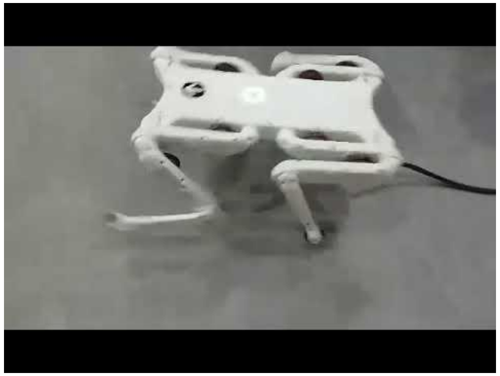
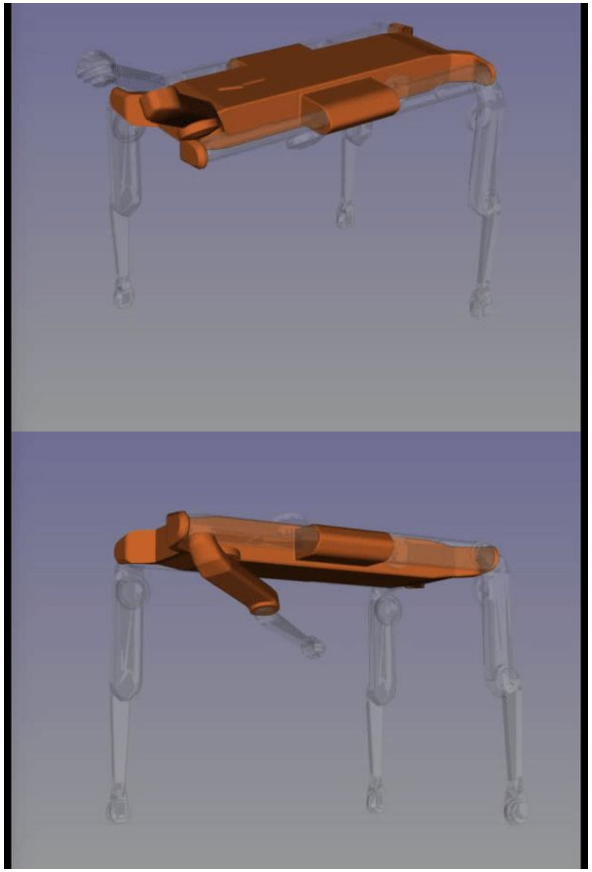
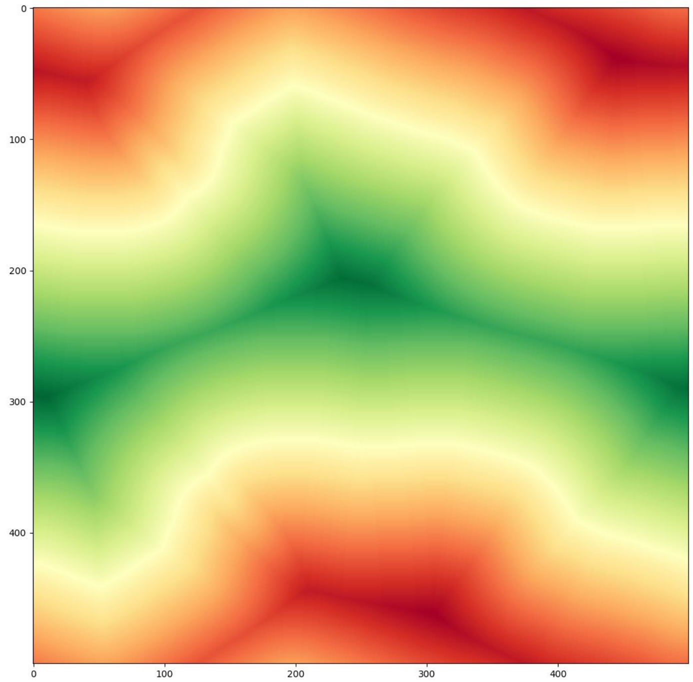




Research project lead at LAAS

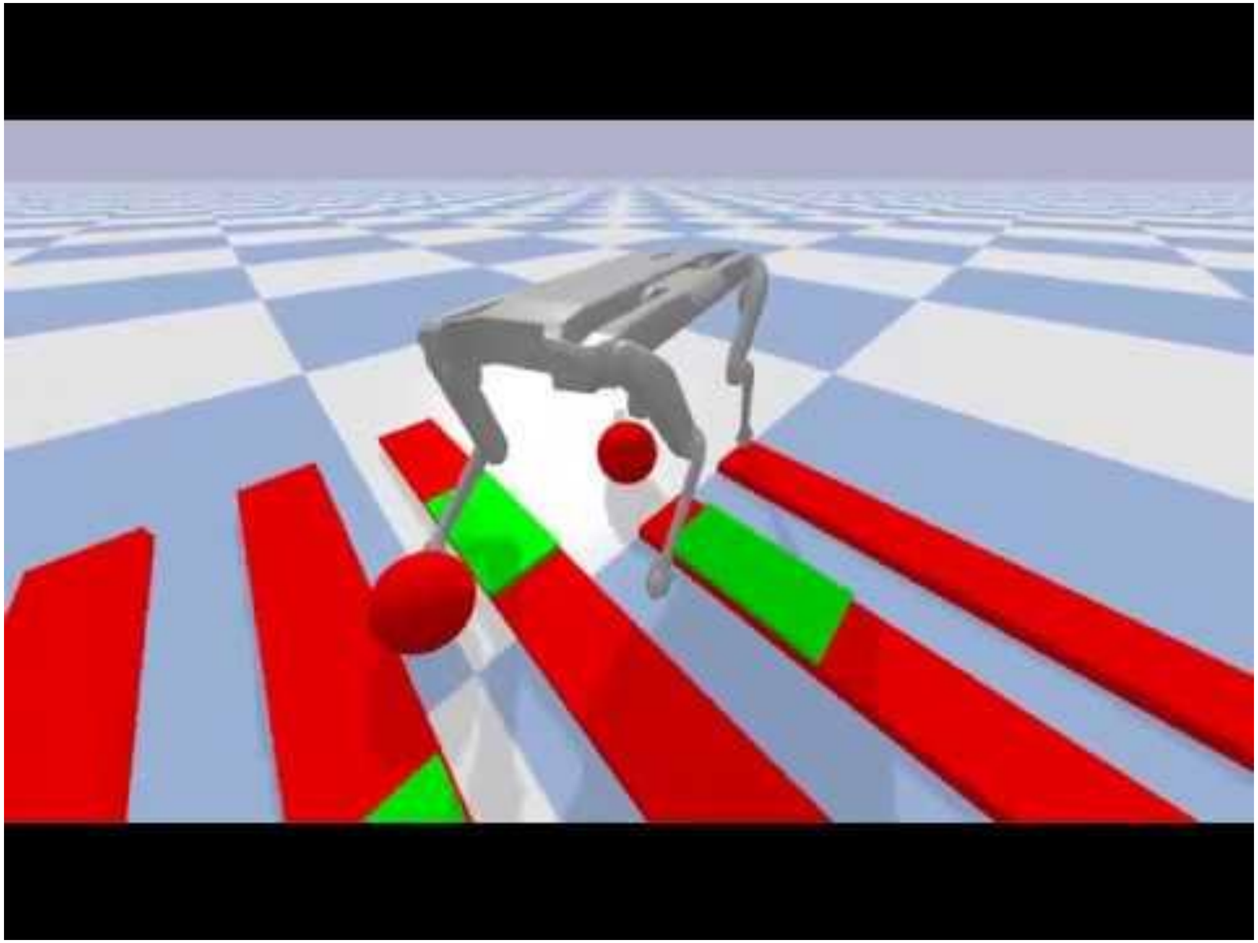
Self collision detection and avoidance - Thibault Noel

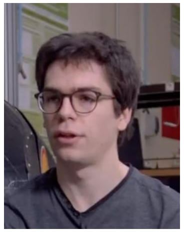




Research project lead at LAAS

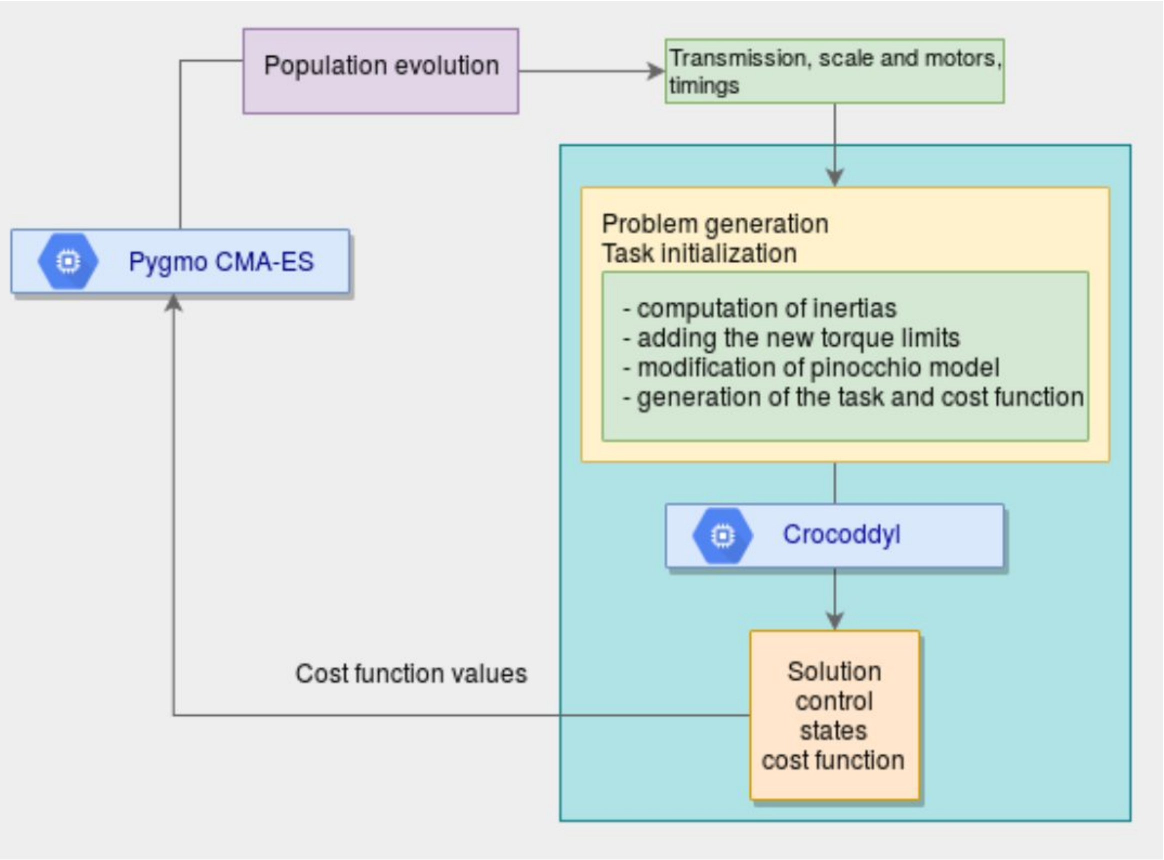
Reactive walking controller - Pierre-Alexandre Leziart & Thomas Cobrère





Research project lead at LAAS

Co-design - Gabriele Fadini



Research project lead at LAAS / IRI

CosySLAM - César Debeunne

CosySLAM: tracking contact features
using visual-inertial object-level SLAM for locomotion

César Debeunne[†], Médéric Fourmy[†+], Yann Labbé[△],
Pierre-Alexandre Léziart[†], Guilhem Saurel[†], Joan Solà[†*] and Nicolas Mansard[†+]

***Abstract*— A legged robot is equipped with several sensors observing different classes of information, in order to provide various estimates on its states and its environment. While state estimation and mapping in this domain have traditionally been investigated through multiple local filters, recent progresses have been made toward tightly-coupled estimation. Multiple observations are then merged into an a-posteriori maximum estimating several quantities that otherwise were separately estimated. With this paper, our goal is to move one step further, by leveraging on object-based simultaneous localization and mapping. We use a pose estimator to localize the relative placement of the robot with respect to large elements of the environments, e.g. stair steps. These measurements are merged with other typical observations of legged robots, e.g. inertial measurements, to provide an estimation of the robot state (position, orientation and velocity of the basis) along with an accurate estimation of the environment pieces. It then provides a consistent estimation of these two quantities, which is an important property as both would be needed to control the**

Fig. 1: Experimental setup: a Realsense D435i is mounted on the Solo robot which localizes itself with respect to stairs. A motion capture system provides ground truth of the robot pose.

Research project lead at LAAS / IRI

State estimation - Mederic Fourmy

Contact forces pre-integration for the whole body estimation of legged robots

Mederic Fourmy†, Thomas Flayols†, Nicolas Mansard† and Joan Solà†*

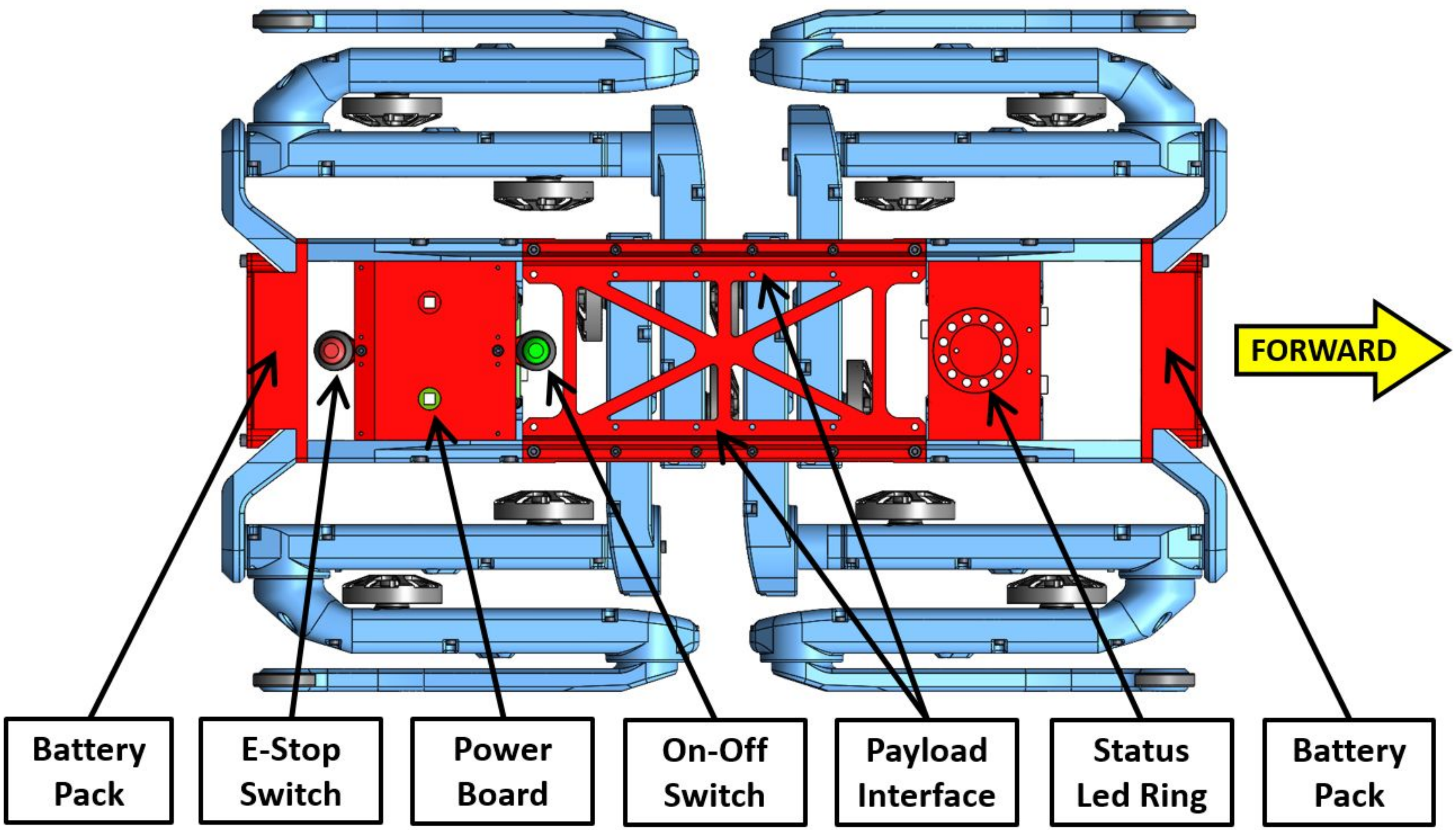
Abstract— **State estimation, in particular estimation of the base position, orientation and velocity, plays a big role in the efficiency of legged robot stabilization. The estimation of the base state is particularly important because of its strong correlation with the underactuated dynamics, i.e. the evolution of center of mass and angular momentum. Yet this estimation is typically done in two phases, first estimating the base state, then reconstructing the center of mass from the robot model. The underactuated dynamics is indeed not properly observed, and any bias in the model would not be corrected from the sensors. While it has already been observed that force measurements make such a bias observable, these are often only used for a binary estimation of the contact state. In this paper, we propose to simultaneously estimate the base and the underactuation state by using all measurements simultaneously. To this end, we propose several contributions to implement a complete state estimator using factor graphs. Contact forces altering the underactuated dynamics are pre-integrated using a novel adaptation of the IMU pre-integration method, which constitutes the principal contribution. IMU pre-integration is also used to measure the positional motion of the base. Encoder**

Fig. 1: LAAS-Gepetto robot Solo12 from the Open Dynamic Robot Initiative

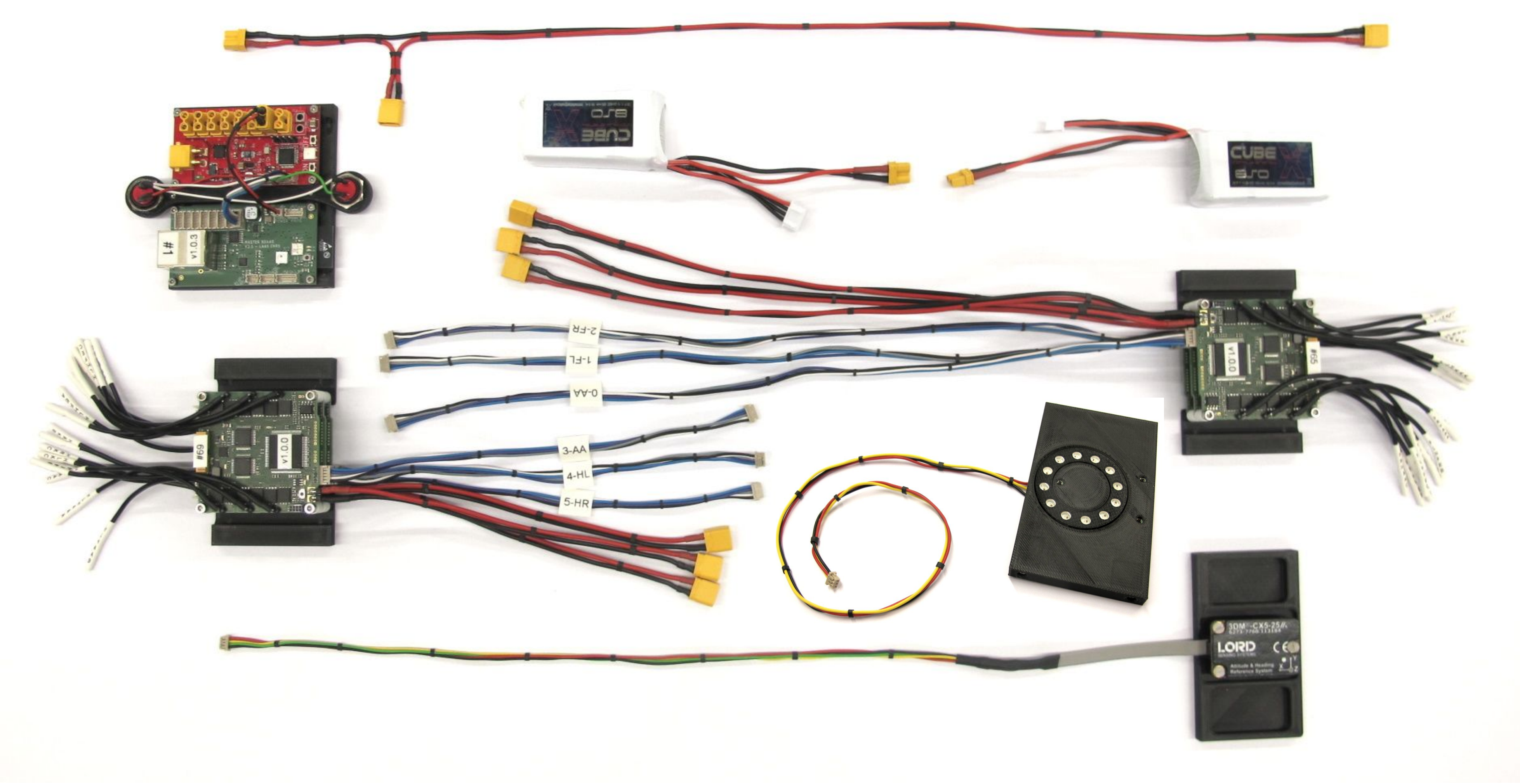
estimator to obtain the centroidal quantities. While [6] uses simplified models such as the LIPM, [7] applies the full dynamical model to develop Kalman Filters using kinematic measurements fused with sensor wrenches while permitting the estimation of an external force or kinematic model

- Power board
- Battery
- LED ring
- Wireless closed loop remote control
- New motor driver design
- Computer payload
- Depth Camera
- Packaging of the walking controller

New dev:


FORWARD
Battery Pack
E-Stop Switch
Power Board
On-Off Switch
Payload Interface
Status Led Ring
Battery Pack

New dev: Electronic side



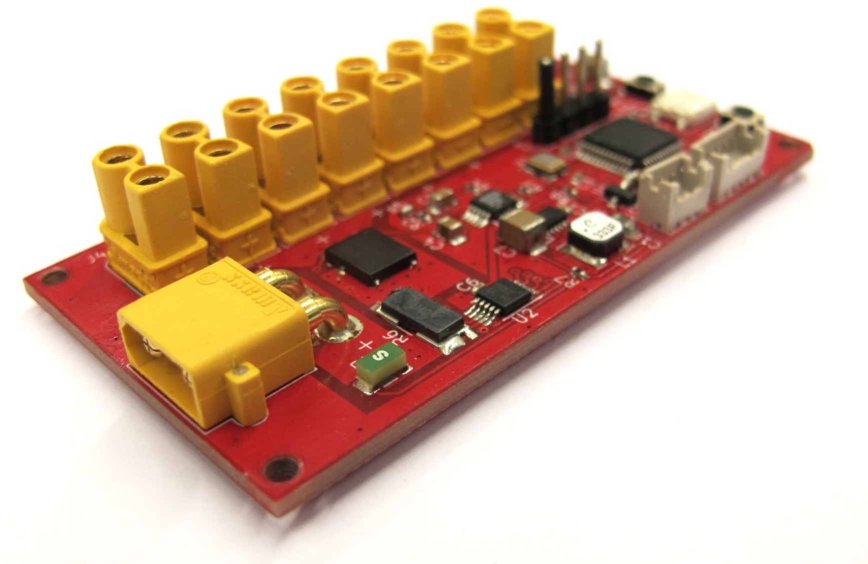
New dev: Power Board

Main features

- 40A 32V DC load switching - External push buttons
- Inrush current limiting
- Monitor voltage, Current and Energy - (16bits resolution, 1kHz sampling)
- Measure negative current (regeneration)
- Under voltage, Over current shutdown with settable thresholds
- Telemetry, load switching via SPI
- Zero consumption during shutdown
- Open Hardware

What it doesn't do:

- Individual cell monitoring
- Reverse polarity protection
- Battery temperature monitoring



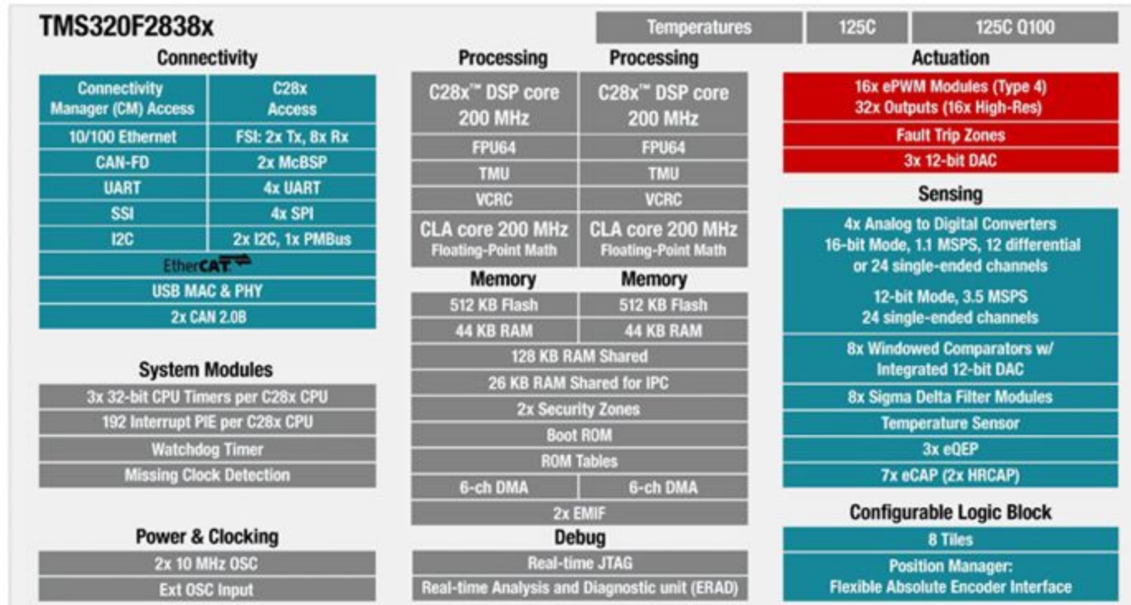
New dev: Power Board

2X Lithium Polymer Batteries
SLS X-Cube 850mAh

- 3S1P / 11,1V / 30C continous / 60C burst
- weight: 68g
- dimensions: 60mm x 30mm x 21mm

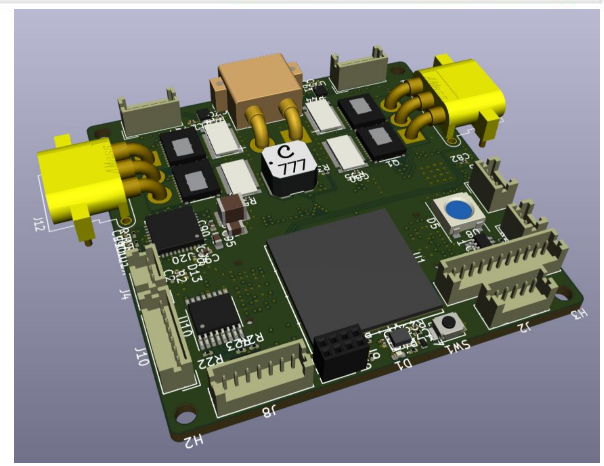
Custom electronic and communication link

uDriver:



A major update is on its way!

- State-of-the-art hardware
- Open source/hardware
- Scalable solution (power, size)
- Fast communication link



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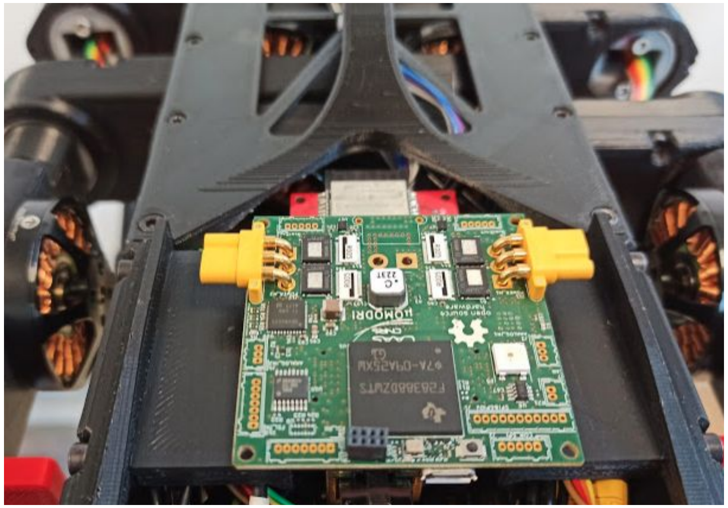
PAL ROBOTICS

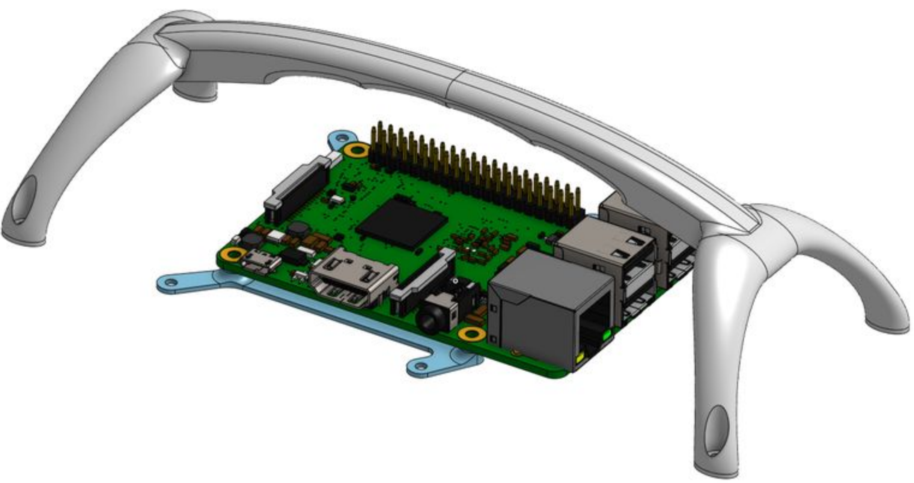
New dev: Major update of µDriver motor controller

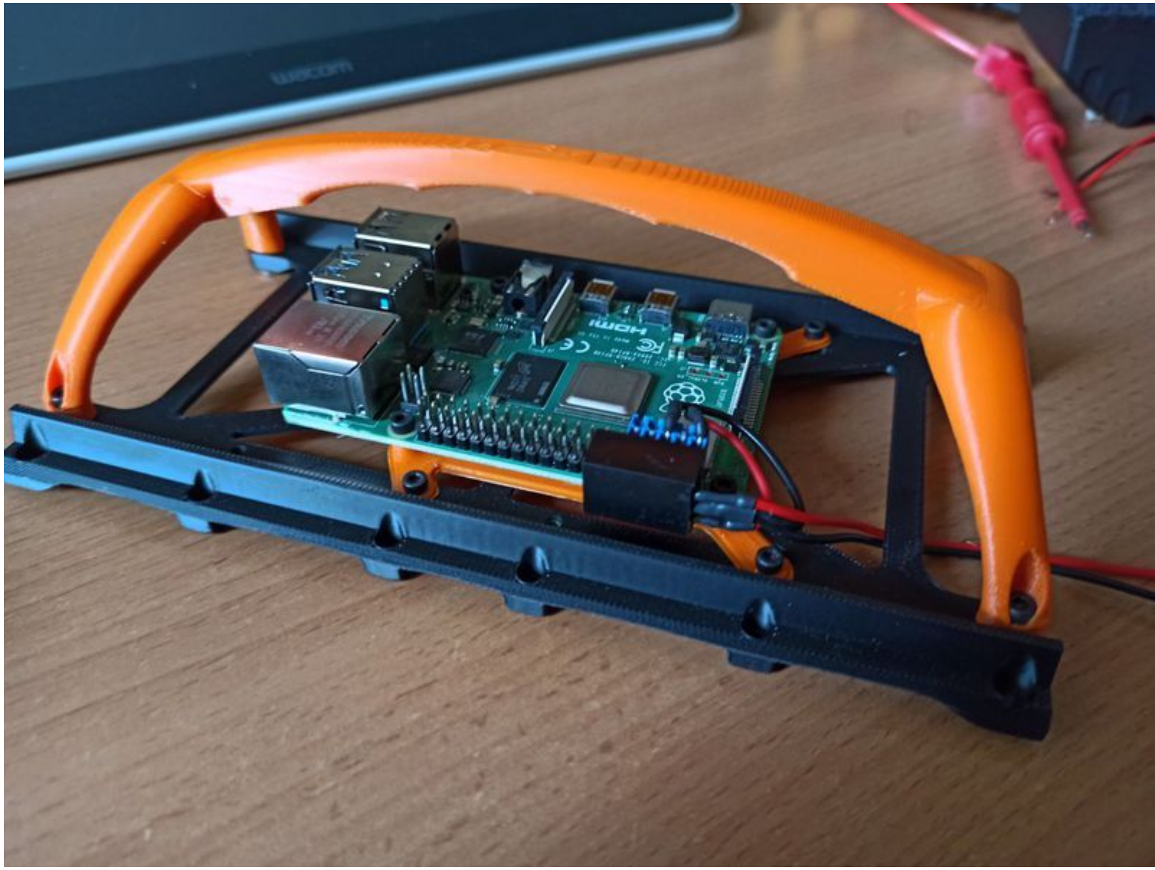


- Open Source and Open Hardware
- Collaborative design: LAAS + PAL Robotics
- Flexible design:
  - Different hardware implementation possible
  - Shared firmware
- Extensive communication interfaces:
  - EtherCat, SPI, FSI, UART, CAN-FD, CANv2 …
- Powerful MCU with room for custom algorithms:
  - 3 Cores: FOC, Communication and user control algorithms
- Compact (dual axis design) 50x50mm
- Main people involved at LAAS: Jerome Manhes, Thomas Flayols.

Computer Payload

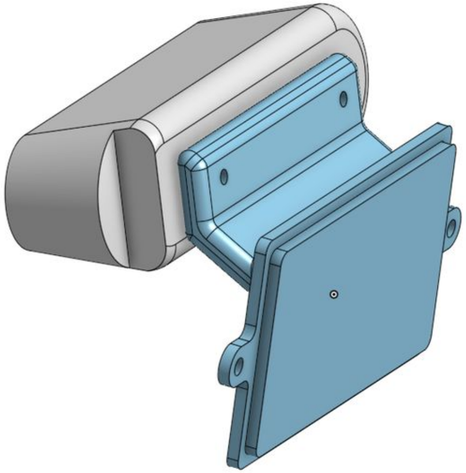
Raspbery Pi 4, Jetson...

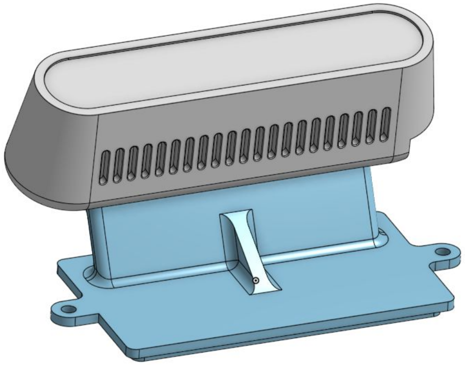




Vision payload

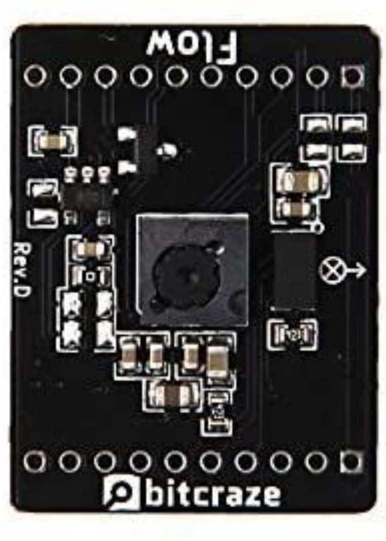
Intel RealSense D435i





Ideas for the future

- Integrate lower grade IMU (Bosh BMI-088)
- Add ground optical flow camera on the robot's belly
- Pan-Tilt RGB camera



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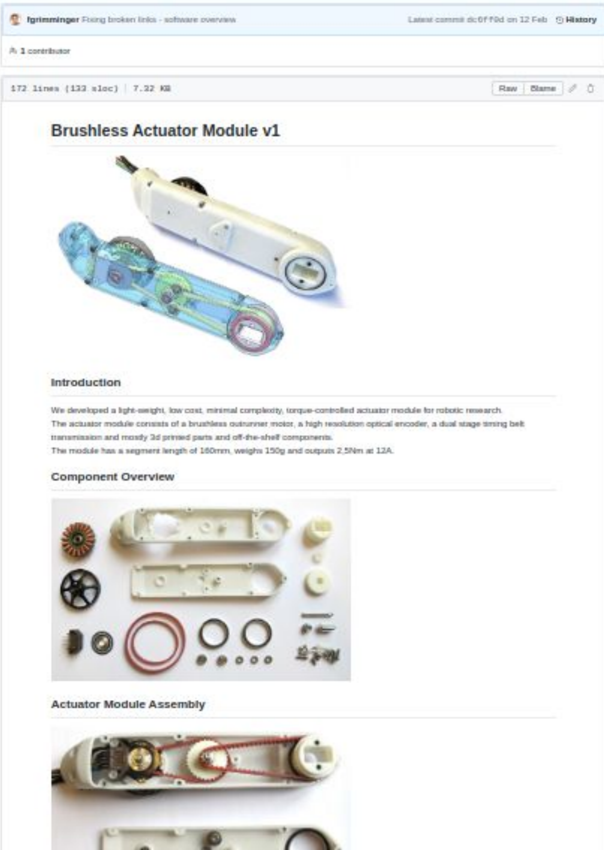
Conclusion

Website https://open-dynamic-robot-initiative.github.io/

Youtube channel https://www.youtube.com/channel/UCx32JW2oIrax47Gjq8zNI-w

GitHub https://github.com/open-dynamic-robot-initiative/

Paper F. Grimminger et al., "An Open Torque-Controlled Modular Robot Architecture for Legged Locomotion Research," in IEEE Robotics and Automation Letters, vol. 5, no. 2, April 2020



Merci !

Solo12 at SIANE 2021 until Thursday