

An overview of open-source hardware for robot learning

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CoRL workshop on Open Hardware in the Era of Robot Learning

27 September 2025

"Off the shelf" has improved a lot

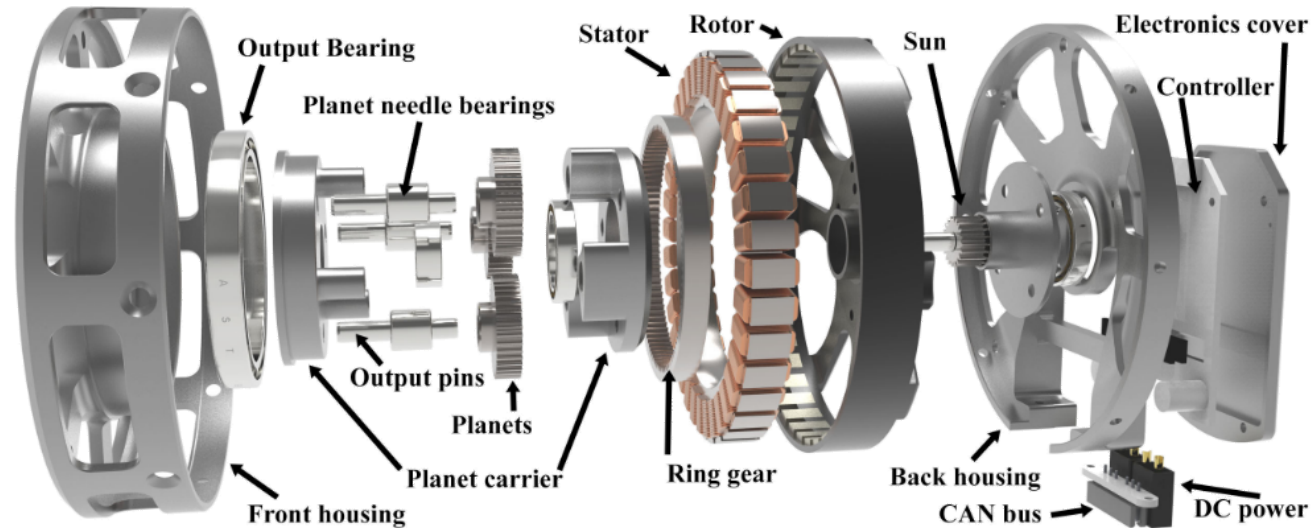
Ten years ago

- Expensive robots, labs only
- Not breaking them was high priority
- Software was open source, not hardware



And then: QDD actuators

Ben Katz's MSc thesis: [A Low Cost Modular Actuator for Dynamic Robots](#) (2018)



See also: [Ben Katz's blog](#), the QDD actuators of the [Berkeley humanoids](#).

Open-source actuators

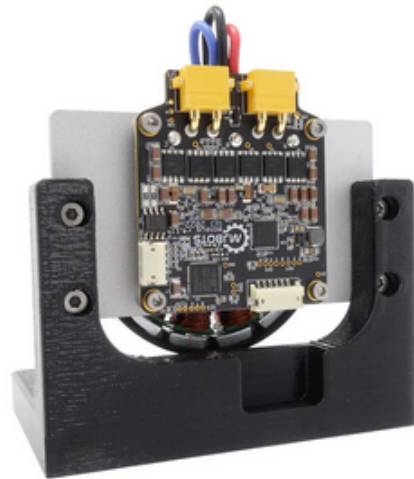


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moteus r4.11 developer kit

\$204.00 USD



moteus-n1 developer kit

\$284.00 USD



moteus-x1 developer kit

\$304.00 USD



qdd100 beta 3 servo

\$559.00 USD

mjbots

- **Open-source** QDD actuators, brushless motor controllers, Raspberry Pi hat, ...
- [Hardware](#): mech. and electrical designs
- [Firmware](#): of the brushless controllers
- [Software](#): C++/Python libraries
- [Discord](#) channel



Thermal modeling for mo - a beginning

🕒 June 19, 2025 📁 Development

One of the things I've been wanting to understand better for quite a while is the performance of motors and motors when used in realistic applications. The thermal limits of one or another determine the eventual sizing of the system, and the most important performance factors. I've covered this before in a post ([customizable pwm rate](#)) but it was far from a general solution. I have a [dynamometer fixture](#), with its ability to accurately measure in real time, an opportunity for finally tackling this. This post will describe a bit of what you should care.

Simple thermal modeling

A thermal model of a system is one that relates the quantities of interest to how they evolve over time. For any given system, you can imagine it as a box with heat going in (the thermal load), heat goes out the other side (cooling) and the temperature changes over time. In practical systems, the cooling heat transfer is a function of the system's temperature and ambient temperature and the width of the heat transfer is a static quantity or an independent variable that is divorced from

Open source

My code is in a public repository.

Is it open source?

The Open Source Definition

The goal of open source is to foster conditions for collaboration.

The Open Source Definition (1998):

- **Free redistribution (1):** no royalty, software can be sold, ...
- **Source code (2–4):** is included, can be modified, ...
- **No discrimination (5–10):** against persons, fields, joint software, ...

(Says nothing about the capacity of users to run the software.)

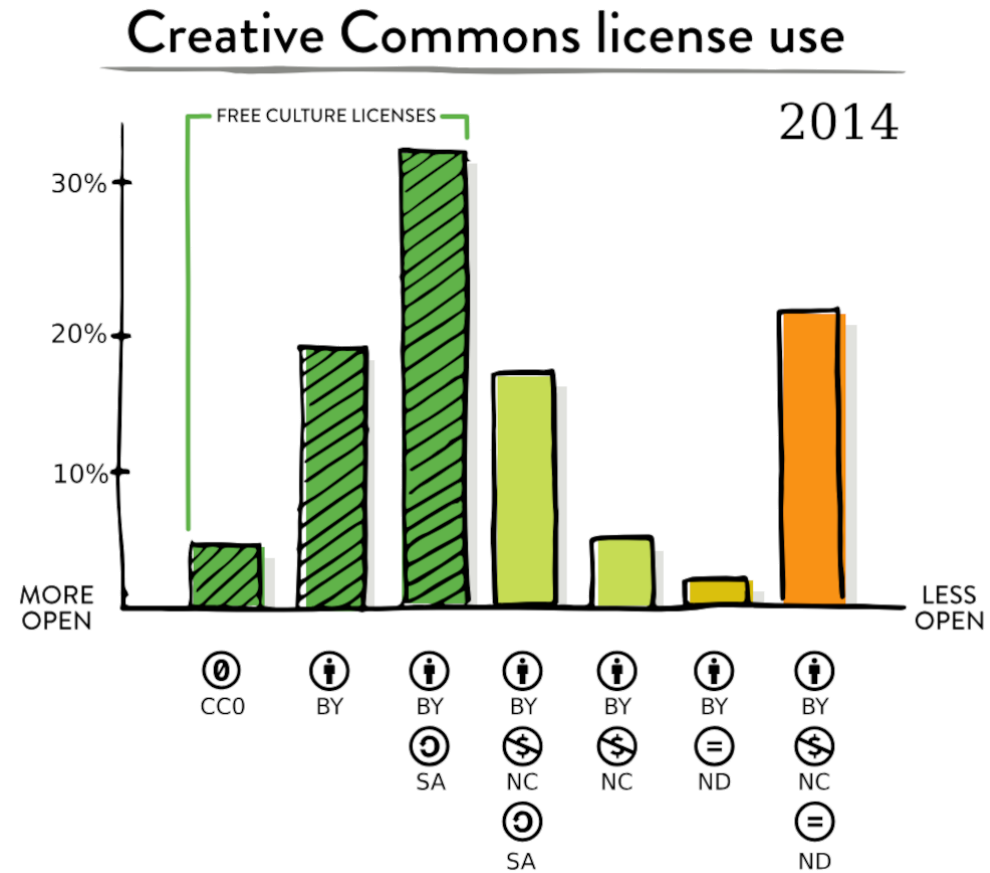
Open source robots

Defining “open source” for robots:

1. **Software:** open source license (copyleft or permissive)
2. **Mechanics:** Creative Commons? CERN Open Hardware License?
3. **Electronics:** Creative Commons? TARP Open Hardware License?
4. **Datasets:** Create Commons? Open Database License?

Copyleft and permissive licenses were written *for software*.

Not all Create Commons licenses are open source:



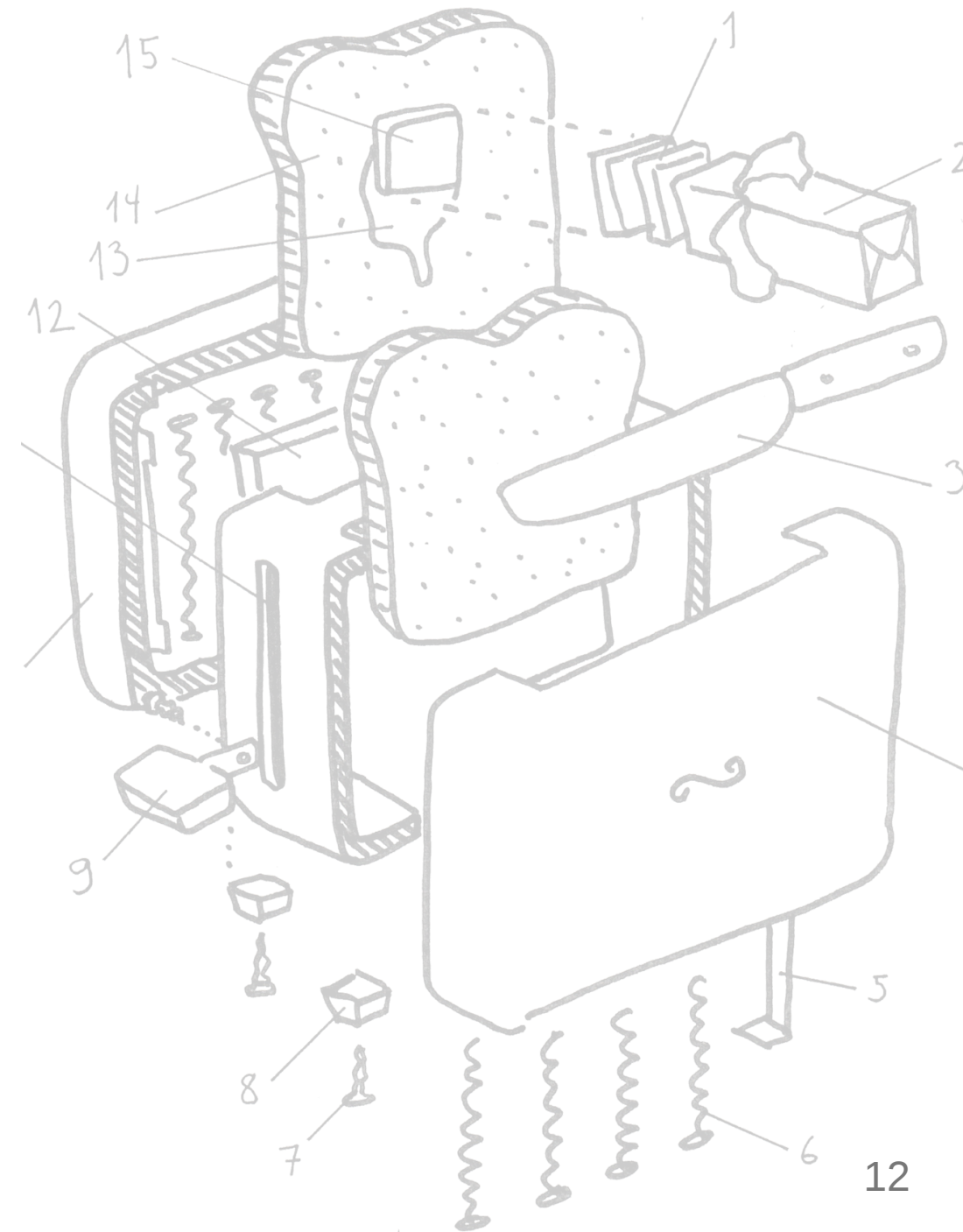
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Open source hardware

There is an [OSHW Definition](#):

- "Hardware": anything physical with public source files
- Definition applies to electronics and mechanical designs
- Requires sharing the files to build *and* modify the hardware

See also: [OSHW certification program](#).



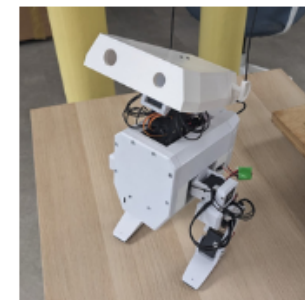
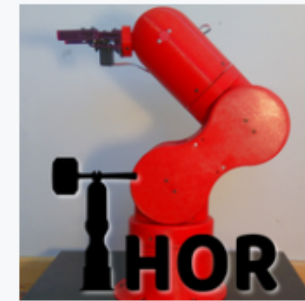
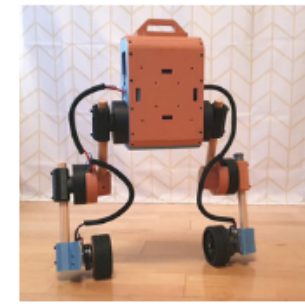
Open source robots

Awesome Open Source Robots

Curated collaborative list, for instance:

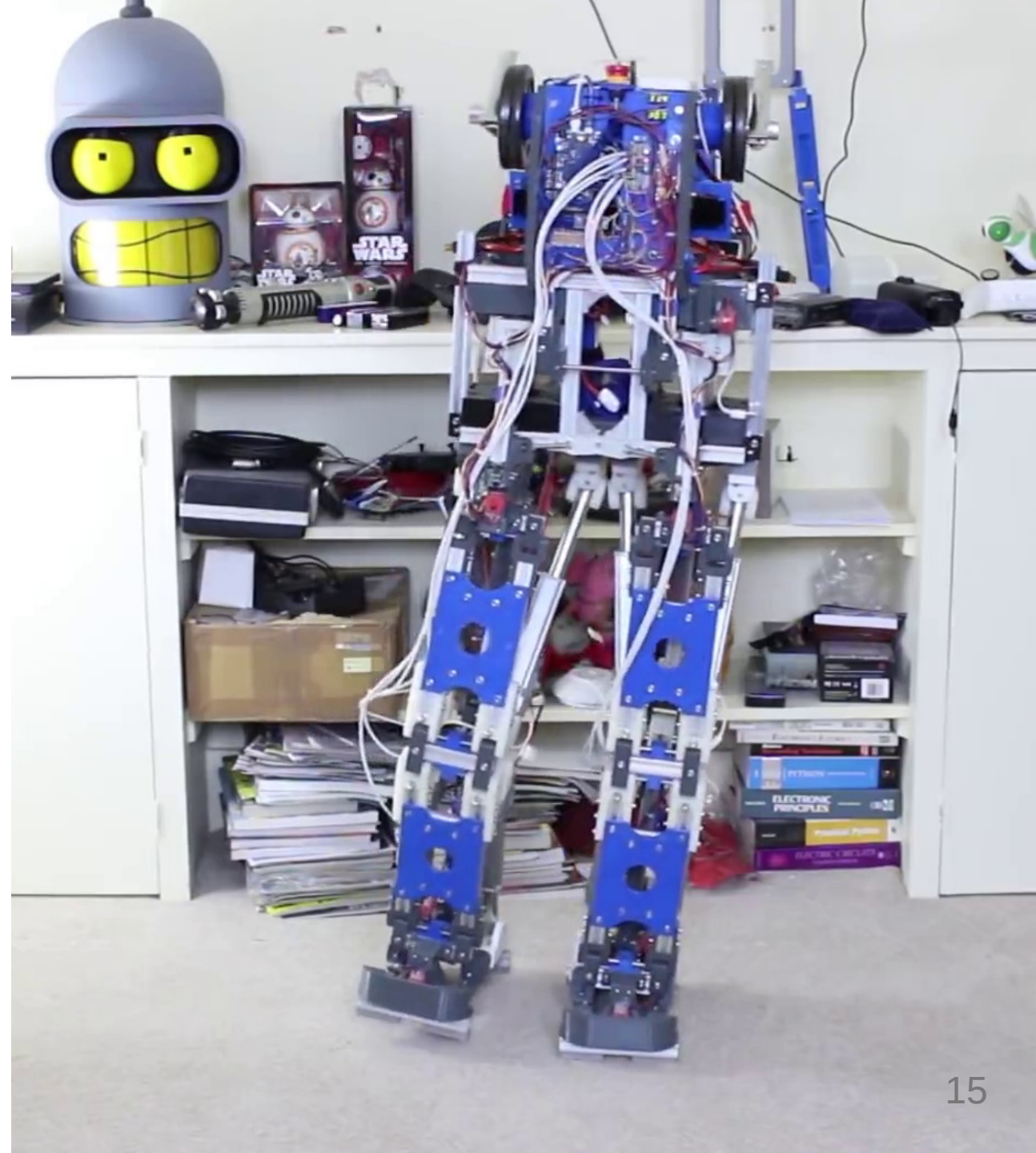
Bipeds

Project	Maker	Hardware	HW License	Software	SW License
Bolt	Open Dynamic Robot Initiative	Instructions	BSD-3-Clause	GitHub	BSD-3-Clause
Duke Humanoid	Duke University	Wiki	MIT	GitHub	MIT
Kayra	Ramin Assadollahi	GitHub	BSD-3-Clause	GitHub	BSD-3-Clause
MABEL	Raspibotics	GitHub	GPL-3.0	GitHub	GPL-3.0
Open Duck Mini	Antoine Pirrone	GitHub	Apache-2.0	GitHub	Apache-2.0
TipTap	Darren V Levine	GitHub	MIT	GitHub	MIT
Upkie	Stéphane Caron	Wiki	Apache-2.0	GitHub	Apache-2.0



Robot X

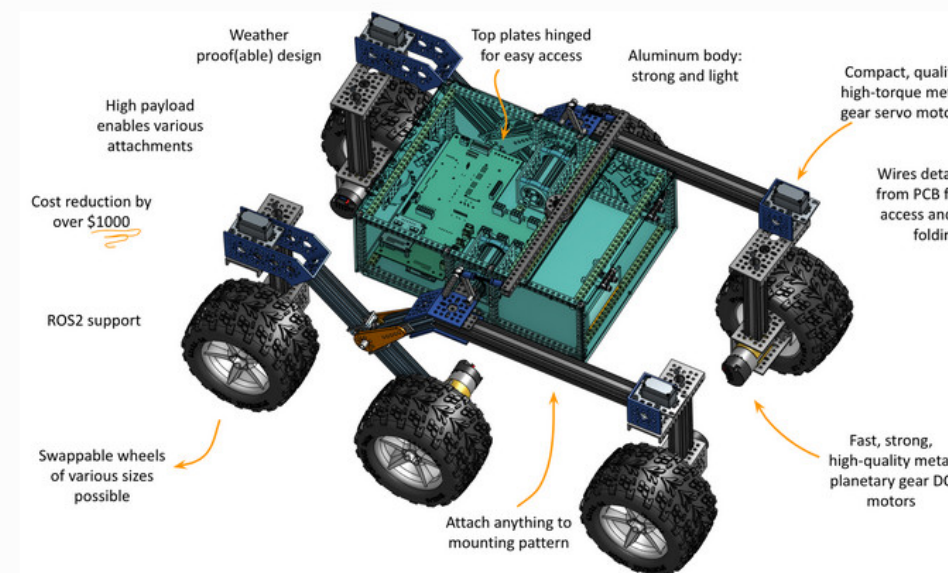
- Maker: James Bruton
- **Released: 2018**
- HW: GPL-3.0 / SW: LGPL-3.0
- Documentation: None
- Reproduced: ?
- Learning: no
- Active: no



JPL Open Source Rover

- Jet Propulsion Laboratory
- Released: 2018
- HW & SW: Apache-2.0
- **Documentation: yes**
- Reproduced: ?
- Learning: no
- Active: yes

spec	value
top speed	~1.6m/s (~slow running, subject to motor selection)
nb motors	10
structural material	aluminum
total cost	~\$1600 (about the cost of a TurtleBot 3 Waffle)



The OSR mostly uses parts from [GoBilda](#) for the mechanical assembly. For GoBilda's (international) shipping options, see [here](#).

Other open-source, cheaper alternatives exist but are slower, less strong, and are more fragile. [Additional Projects](#).

Features

This rover is designed to function similarly to the 6 wheel rover designs on Mars and employs a number of the major driving mechanics that the mars rovers use to traverse rocky surfaces:

- **Rocker-Bogie:** The Rocker-Bogie suspension system allows all 6 wheels to continually be in contact with the ground while climbing over obstacles
- **Differential Pivot:** Allows weight to be mechanically offloaded from one side of the rover to the other while climbing
- **6-Wheel Ackerman Steering:** Driving and steering/turning mechanism that governs where

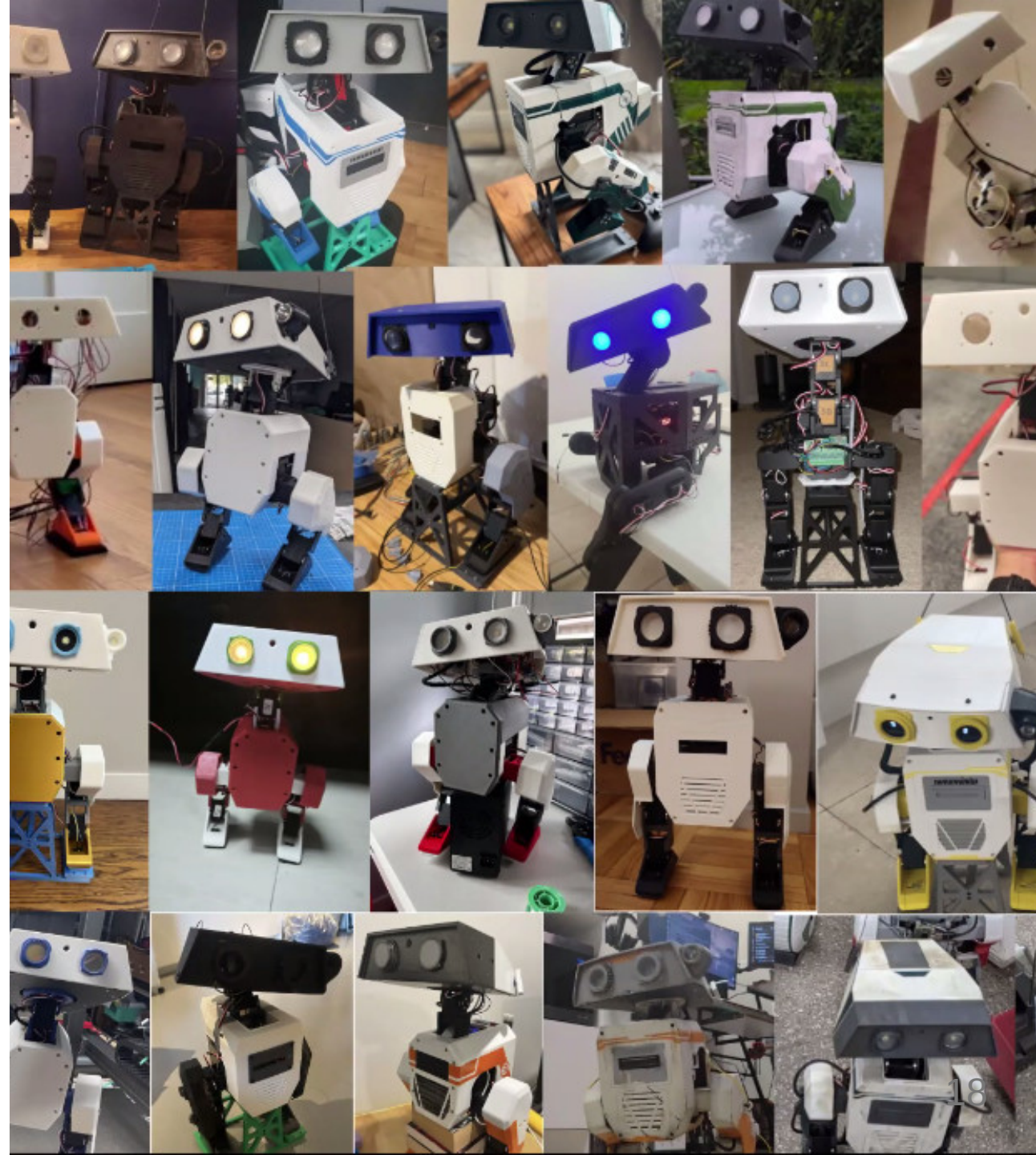
Upkie wheeled bipeds

- Maker: was me for v1 (⚠️ full bias)
- Released: 2022
- HW & SW: Apache-2.0
- Documentation: yes
- Reproduced: 5+
- Learning: yes
- Active: yes



Open Duck Mini

- Maker: Antoine Pirrone
- Released: 2024
- HW & SW: Apache-2.0
- Documentation: WIP?
- **Reproduced: yes**
- Learning: yes
- Active: yes



ToddlerBot

- Maker: Haochen Shi
- Released: 2025
- HW: CC-BY-NC ❌ / SW: MIT
- Documentation: yes
- Reproduced: yes
- **Learning: yes**
- Active: yes



RL Walk

RL Walk

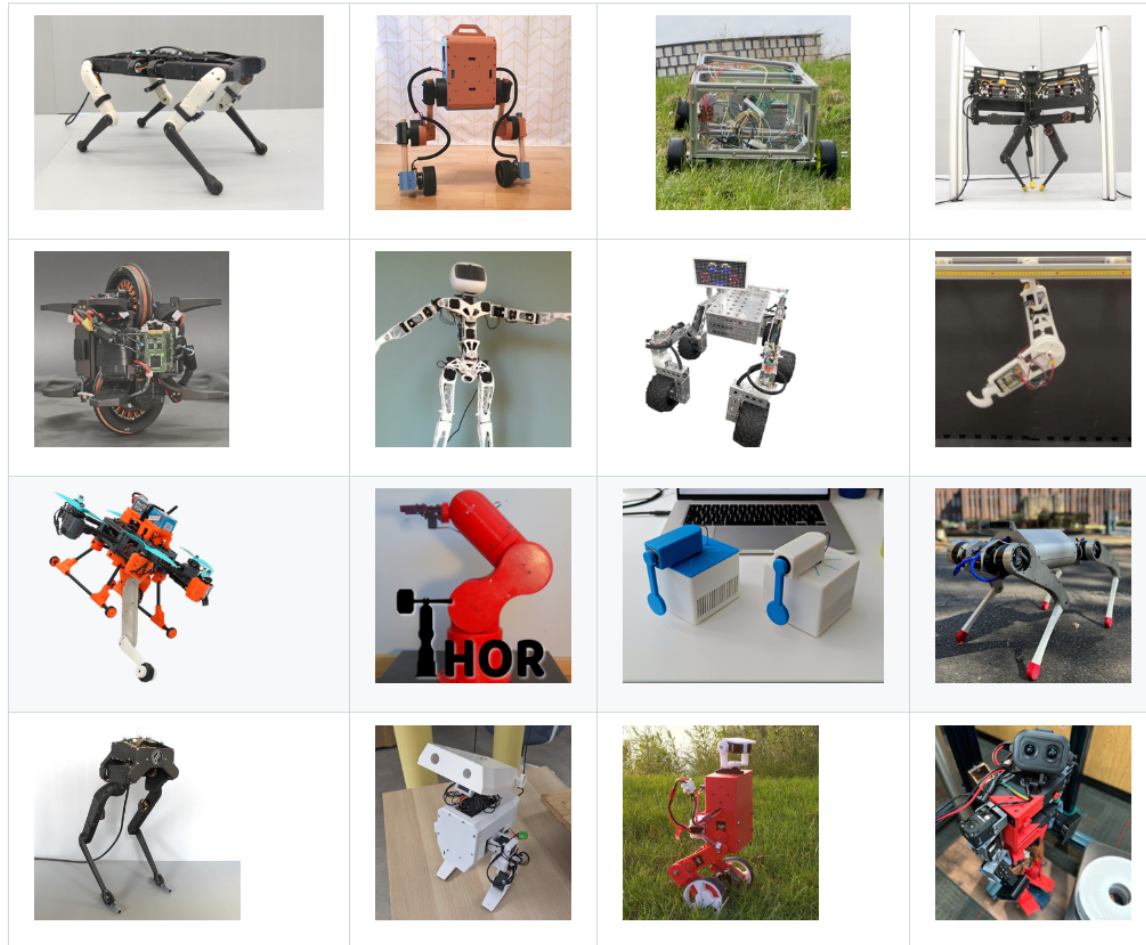
DP + RL Push Wagon

DP Mar

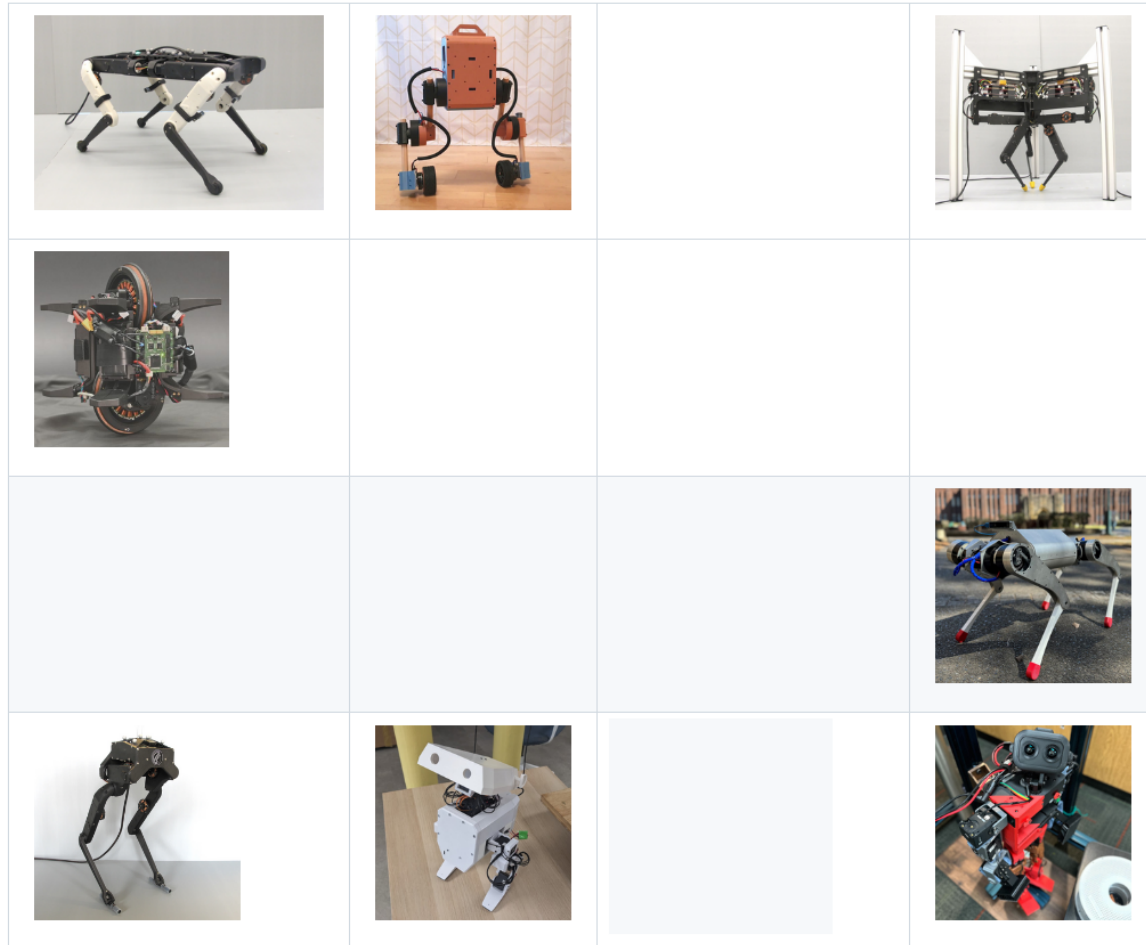
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Machine learning has come

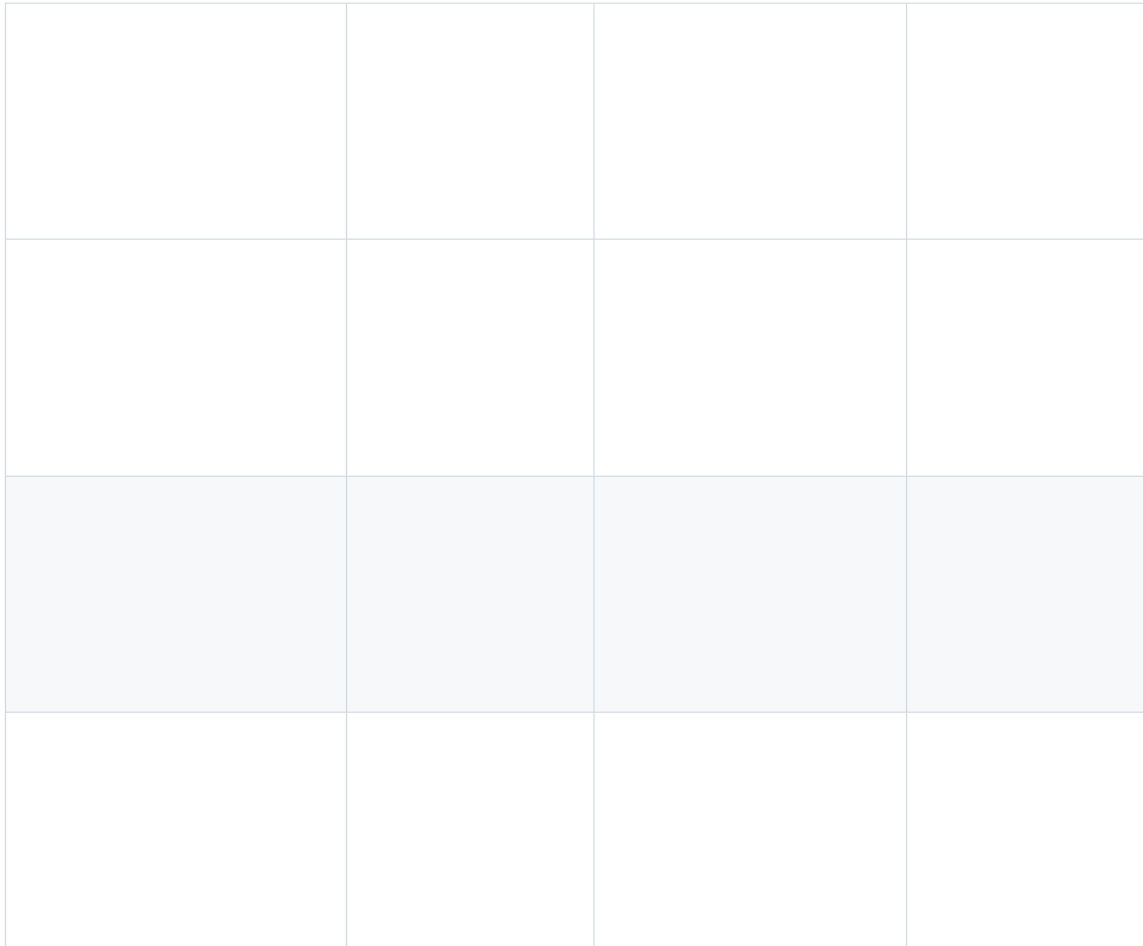
Open source robots



Open source robots trained by RL with sim2real



Open source robots trained from real data



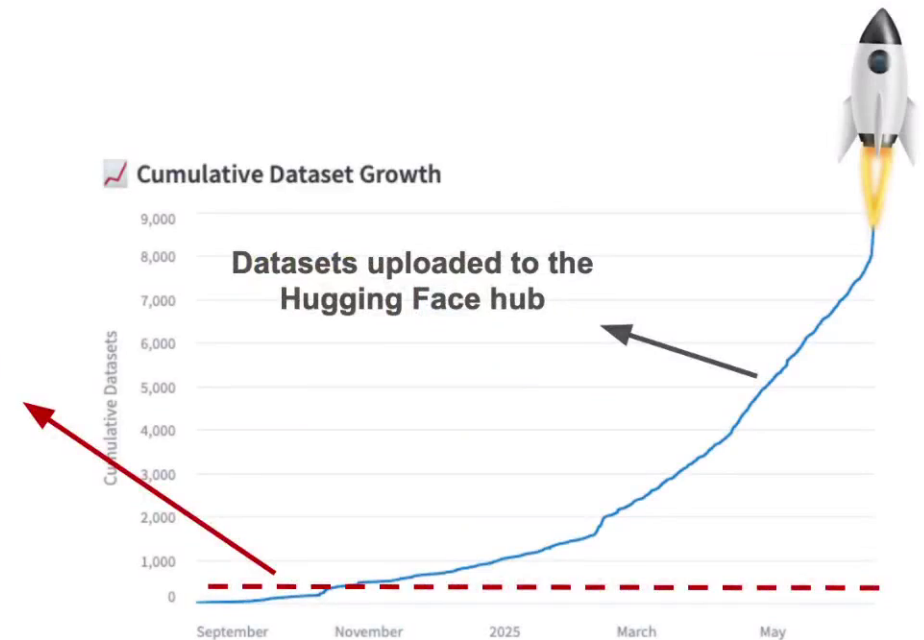
What format to share

- RT-1, Open X Embodiment, ...
- Data format: RLDS? [LeRobot](#)?
- Collecting data: user consent?
- License for sharing data?

⇒ Collective motivation to do so.

See also: AIRoA open dataset.

Right: *SmolVLA: A vision-language-action model for affordable and efficient robotics*, Shukor et al., 2025.



Why make robots open source?

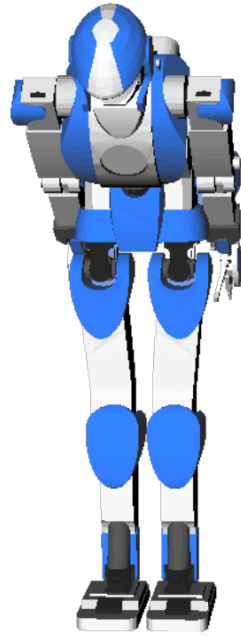
Making open source robots

Pros:

- **Individuals:** visibility, collaboration
- **Laboratories:** own full prototyping stack
- **Companies:** cool factor, collect data?

Cons:

- **Individuals:** projects come and go
- **Laboratories:** risk of divesting from research
- **Companies:** engineering investment, public image



Thank you!