Building Open Source Scientific Equipment

How researchers are owning their instruments

FOSDEM 2019 – 03/02/2019
CAD and Open Hardware Dev Room
Andre Maia Chagas
Bit.ly/fosdfly

Who am I?

- Biology / Neuroscience
- Advocating Open Science:
  - Open Neuroscience (http://bit.ly/OpenNeuro)
  - Trend In Africa
  - Mozilla & FreiesWissen Fellow
    - Mapping scientific equipment demand (http://bit.ly/BFOSH)

Overview

- Scientific Hardware
- Open Science Hardware
- Flypi an affordable “all in one lab”:
  - Squish things & applications
  - Hardware
  - Software
  - What’s next?
- Open Science Hardware as the new norm

Scientific Hardware

- First developed in 16th century
  - Pretty much the same design since

- “Research grade”
  - Base model 5000€
  - Fluorescence +10000€
  - Optogenetics +5000€

Scientific Hardware

- Hard to customize
- Hard to repair
- Hard to update
- Only accessible in some parts of the globe

Shuts a lot of institutions/groups out of science/education

FlyPi an affordable all in one lab

PLOS BIOLOGY

COMMUNITY PAGE

The €100 lab: A 3D-printable open-source platform for fluorescence microscopy, optogenetics, and accurate temperature control during behaviour of zebrafish, *Drosophila*, and *Caenorhabditis elegans*

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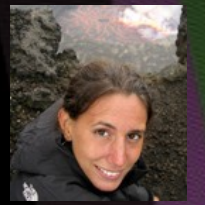
Check for updates

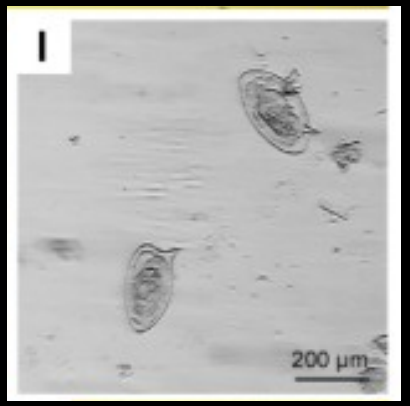
OPEN ACCESS

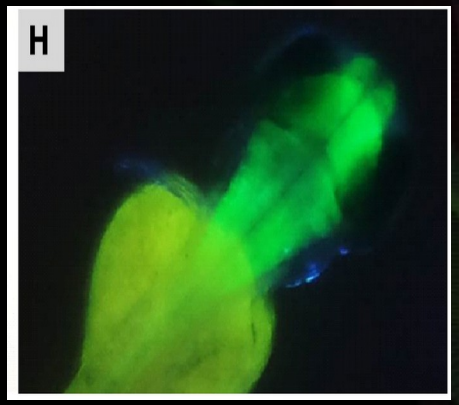
http://bit.ly/flypipos

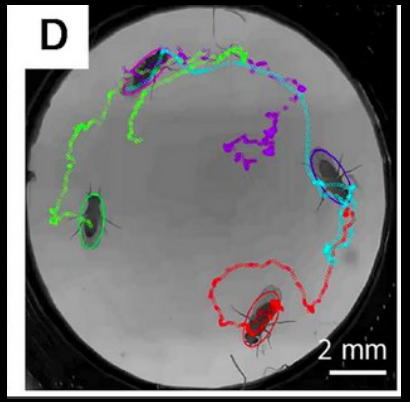
TReND



FlyPi an affordable all in one lab







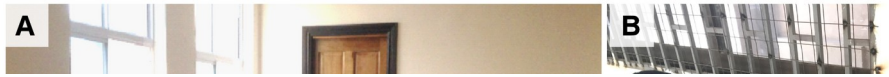
Tracking using C-Trax

http://bit.ly/flypipos


02:06 sec

FlyPi an affordable all in one lab

FlyPi an affordable all in one lab



Contents lists available at ScienceDirect

HardwareX

journal homepage: www.elsevier.com/locate/ohx

Hardware Article

Actifield, an automated open source actimeter for rodents

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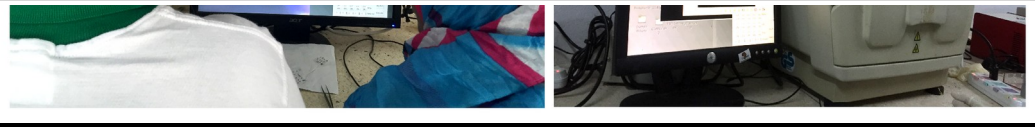
[b] Department of Pharmacognosy, Faculty of Pharmacy & Pharmaceutical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana



FlyPi an affordable all in one lab

Hardware
- 3D printed frame
- Raspberry Pi
- PiCamera
- Arduino Nano
- Custom PCB (KICad)
- Optional: 12V battery

- All released under CERN OHL 1.2

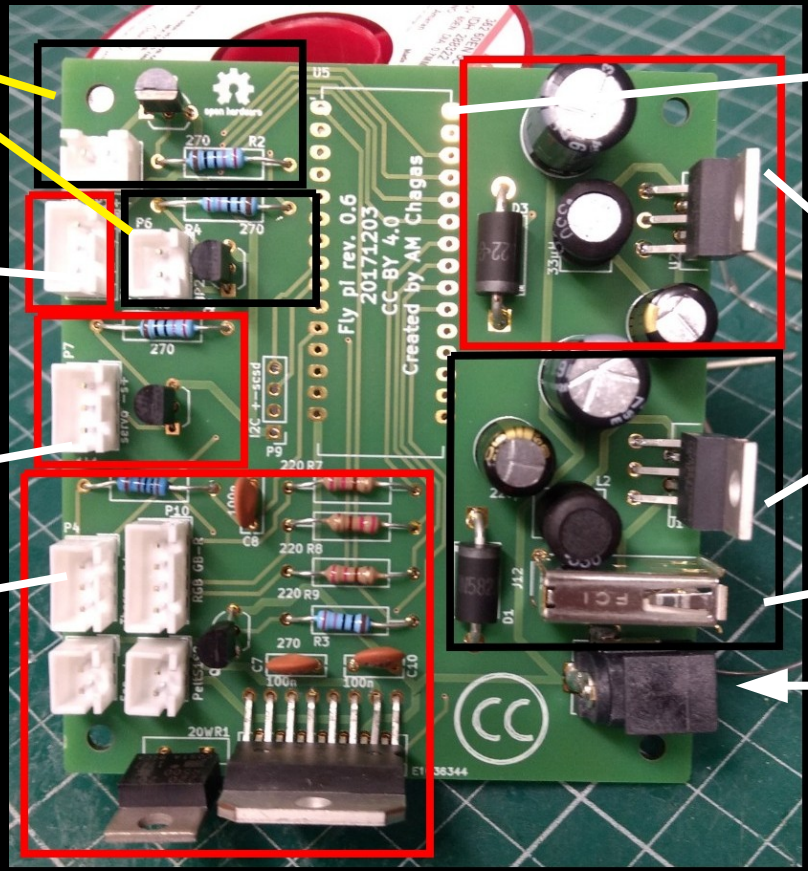
FlyPi an affordable all in one lab

“General ports”
NPN transistor
5V 1A (Fluorescence)

LED Ring
Adafruit Neopixel 12
(Microscopy & optogenetics)

Continuous servo motor port (Focusing)

H bridge (L298N) for Peltier element (12V), and temperature sensor (AD22100) for feedback



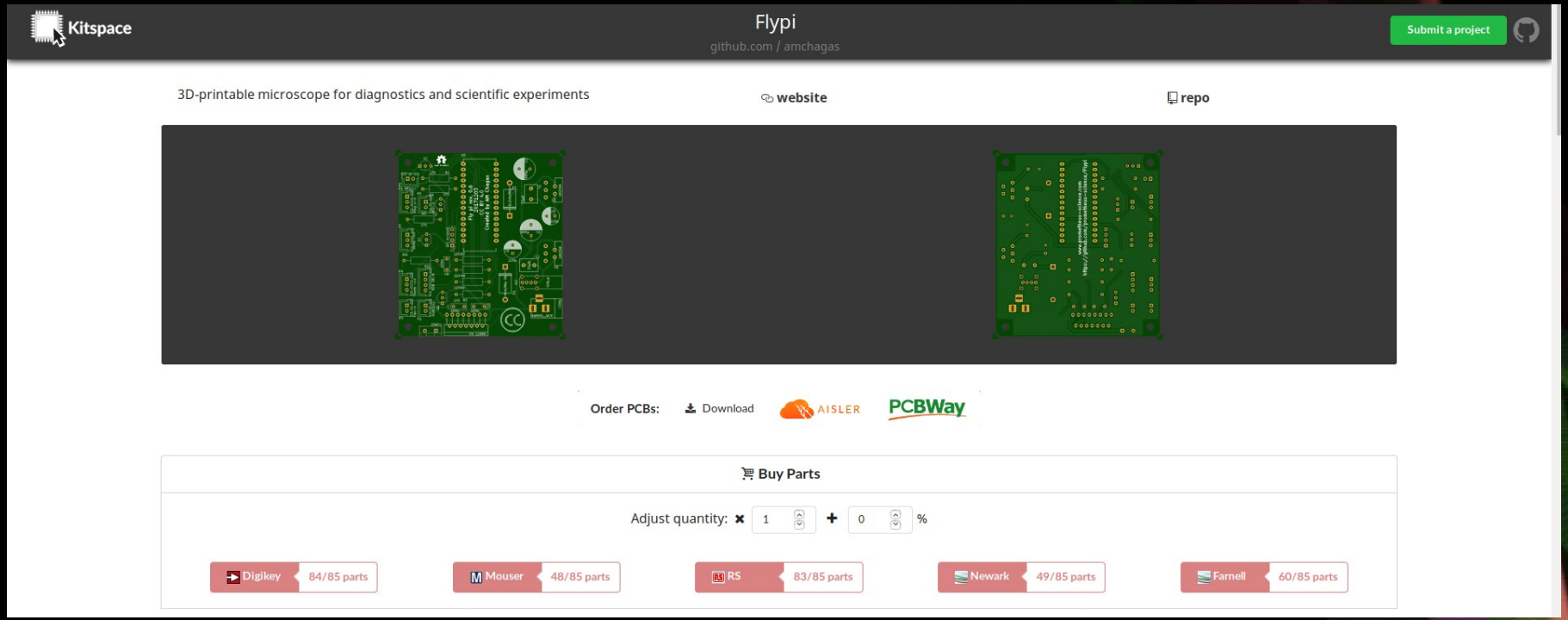
Arduino Nano

12 to 5V converters
(LM2596)

USB A (power to Pi)

12V in

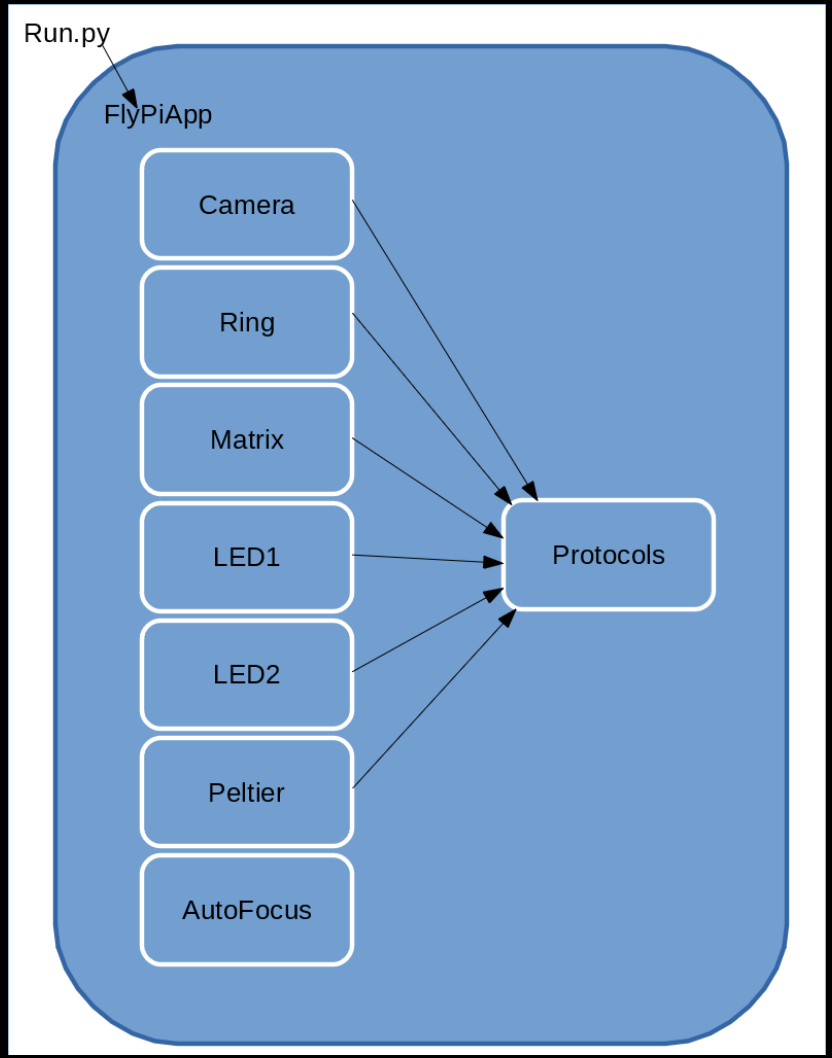
Get FlyPi components @ Kitspace!



FlyPi an affordable all in one lab

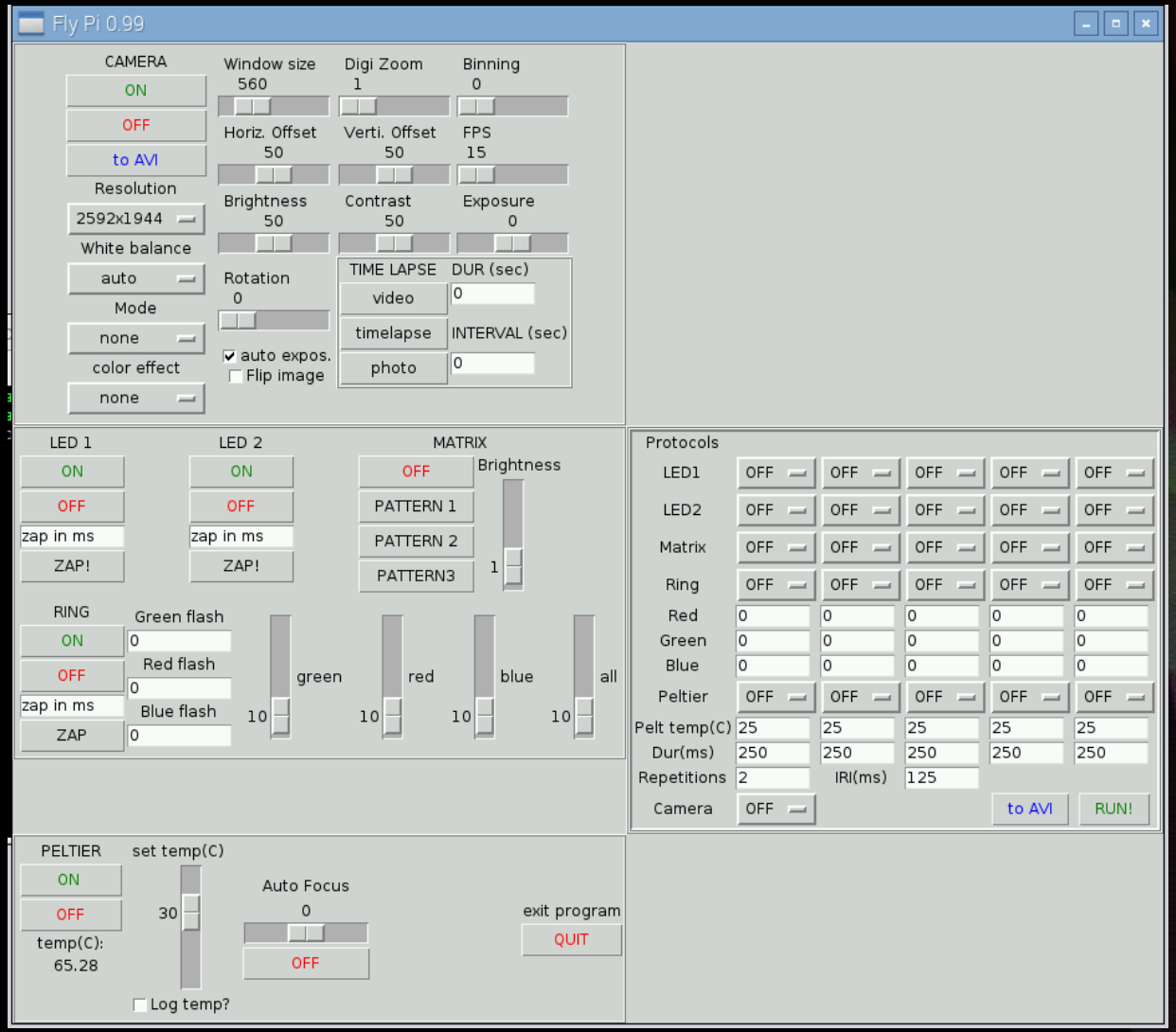
Software
- Raspian
- Python3
    - Pycamera
    - Tkinter
    - PySerial
- Arduino Sketch
    - Serial com
    - Precise time control (microsec) of devices

- own code released under CC BY 4.0



Under the hood:
- Each hardware module is controlled with via Python class

GUI


Fly Pi 0.99
CAMERA
ON
OFF
to AVI
Resolution
2592x1944
White balance
auto
Mode
none
color effect
none
Window size
560
Digi Zoom
1
Binning
0
Horiz. Offset
50
Verti. Offset
50
FPS
15
Brightness
50
Contrast
50
Exposure
0
Rotation
0
auto expos.
Flip image
TIME LAPSE
DUR (sec)
video
0
timelapse
INTERVAL (sec)
photo
0
LED 1
ON
OFF
zap in ms
ZAP!
LED 2
ON
OFF
zap in ms
ZAP!
MATRIX
OFF
PATTERN 1
PATTERN 2
PATTERN3
Brightness
1
RING
ON
OFF
zap in ms
ZAP
Green flash
0
Red flash
0
Blue flash
0
green
10
red
10
blue
10
all
10
Protocols
LED1
LED2
Matrix
Ring
Red
Green
Blue
Peltier
Pelt temp(C)
Dur(ms)
Repetitions
IRI(ms)
Camera
to AVI
RUN!
PELTIER
ON
OFF
temp(C):
65.28
set temp(C)
30
Log temp?
Auto Focus
0
OFF
exit program
QUIT

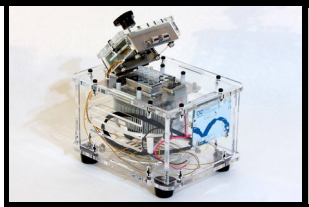
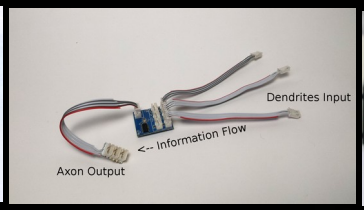
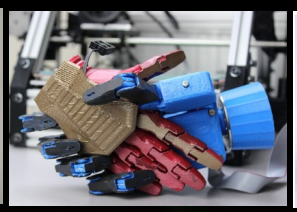
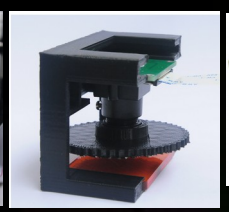
What’s next? (GH Issues)

- FlyPi (http://bit.ly/flypirepo)
  - PCB modularity (several blocks)
  - Move GUI to PyQT
  - Camera feed into file/buffer for SSH transmission
  - Improve camera resolution (software? hardware?)
  - Increase fluorescence options
    - New filters and leds
  - Improve user manuals (http://bit.ly/flypiman)
  - Experimental protocols
  - Prometheus Science: provide Flypi and other OSH science tools as kits/complete sets

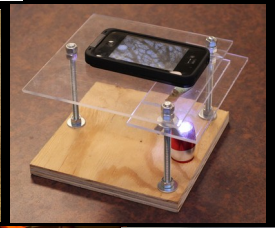
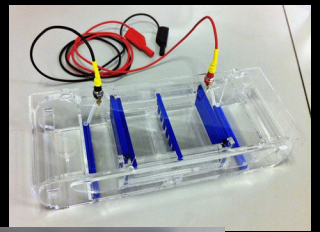
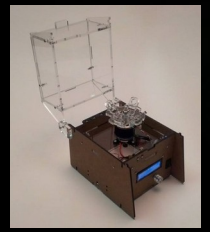
Open Science Hardware: New norm?

- FlyPi is one of many projects out there!
  - GOSH Community
    - Make Open Science Hardware ubiquitous by 2025





Dendrites Input
<-- Information Flow
Axon Output



CYCLOPS
LED DRIVER

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2
3
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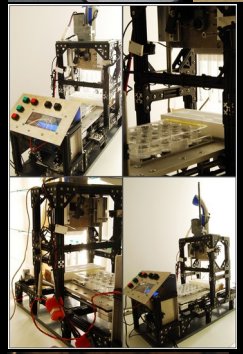
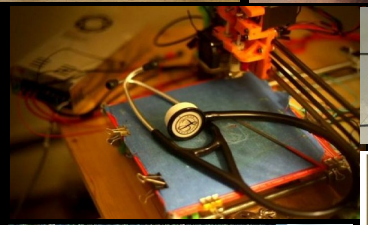
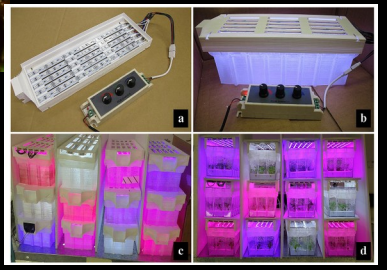
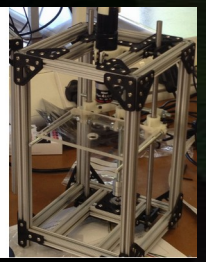



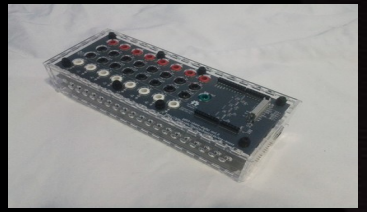
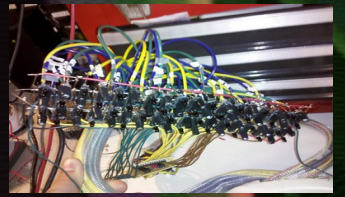


a
b
c
d

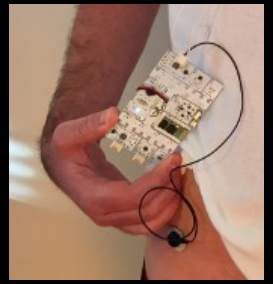
D

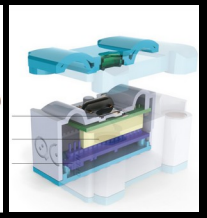


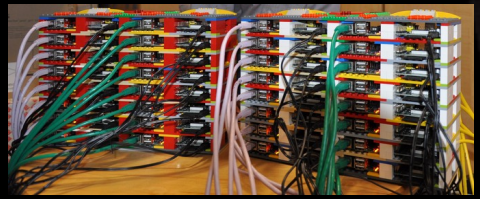

INDUSTRIAL
Professional Alarming Device

CO2
SENSOR

EEG-SMT


OpenPCR
OpenPCR





OS Hardware: Living in the “Cambrian explosion”

- Wikipedia >70 projects (only commercial level/big projects)
- In these slides at least another 36
- Many, MANY more in repositories online

- OS tools to create hardware are getting better and easier
  - Software
  - Fast prototyping
- Lower price for manufacturing
- Internet infrastructure
  - Sharing videos, tutorials, documentation
- Some companies applying OS business models are >5 years old.

OS in research and education

- “Tradional systems:
  - Expensive (fluoresc. Scope >5000€)
  - One supplier commitment
  - Hard to fix/customize/upgrade
  - One per lab/classroom
  - Costly calibrations
  - Bugs hard to spot
  - Fixed, one size (has to) fit all
- OS systems
  - Affordable (fluoresc. Scope <250€)
  - Buy parts from anywhere
  - Know your tools from inside out
  - Many per lab/classroom
  - Calibrate before every experiment
  - Bugs are easier to spot
  - Adaptable to local realities

Build following demand

- Projects normally start with a local need:
  - one lab, in one department, inside one institution…

- What if we could map the needs researchers have?
  - And build OS Hardware based on that demand?
    - Online survey http://bit.ly/BFOSH Please share!
    - Landing page: https://fosh-following-demand.github.io/en/home
    - Repos: https://github.com/FOSH-following-demand

Thanks!

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Companies/non-profits provinding OS Hardware and services around them