

Open Hardware in Science

a practical approach

Maribor 15.11.2019

Benjamin Paffhausen

CC0 - unless stated otherwise

Structure

aim of the workshop

examples of projects

available tools

resources google youtube reddit

generell flow: input μ C output Power Supply

blink

discussing projects

aim of this workshop

how to approach an hardware project as a scientist

trust in google and engineering

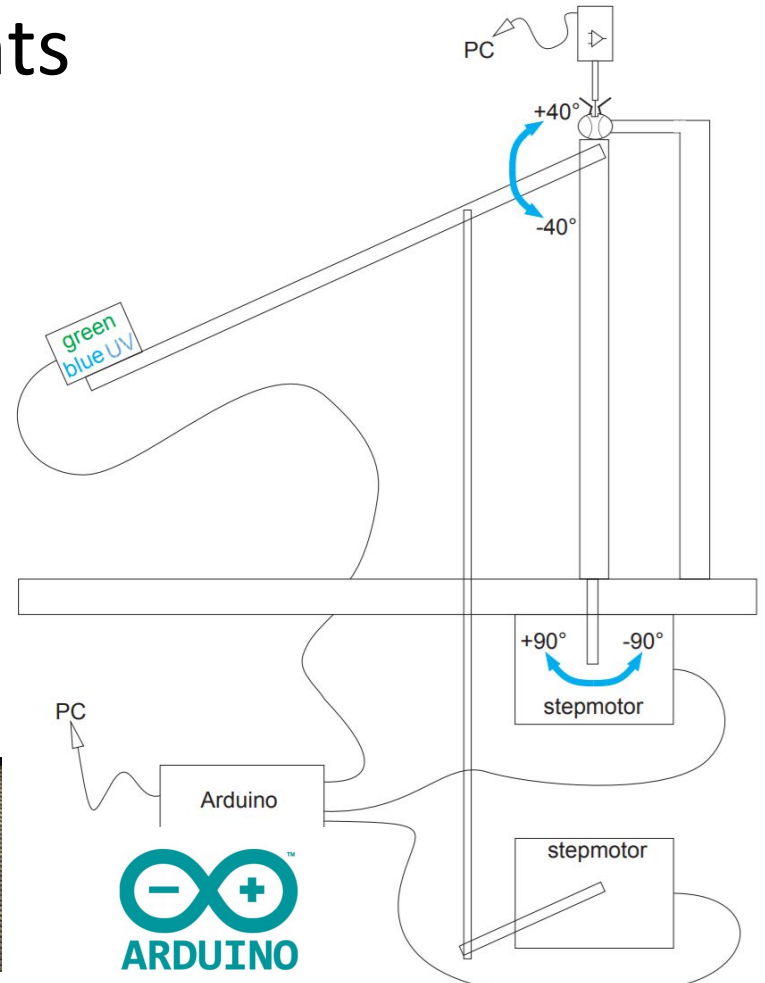
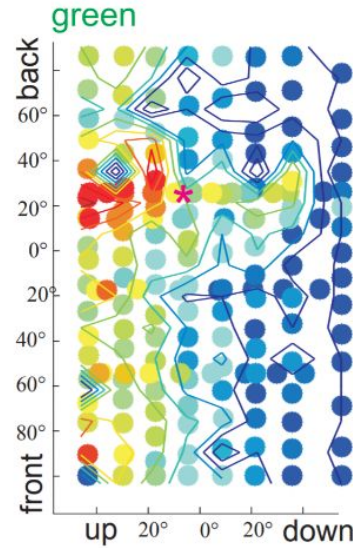
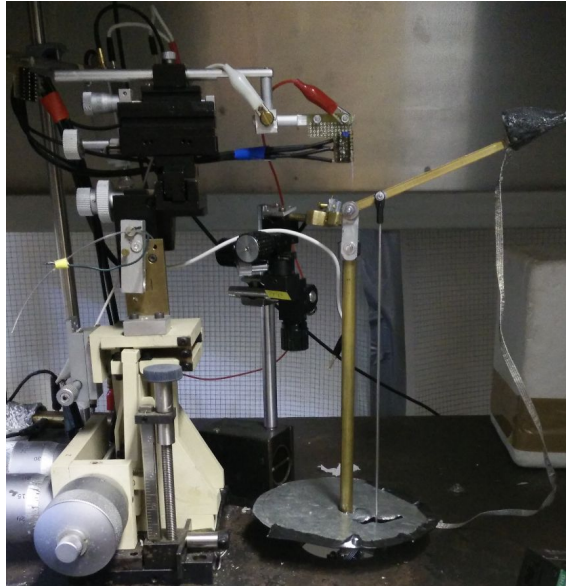
find resources to learn the language and ask for help

motivation: why open hardware is good for you

Examples (mine)

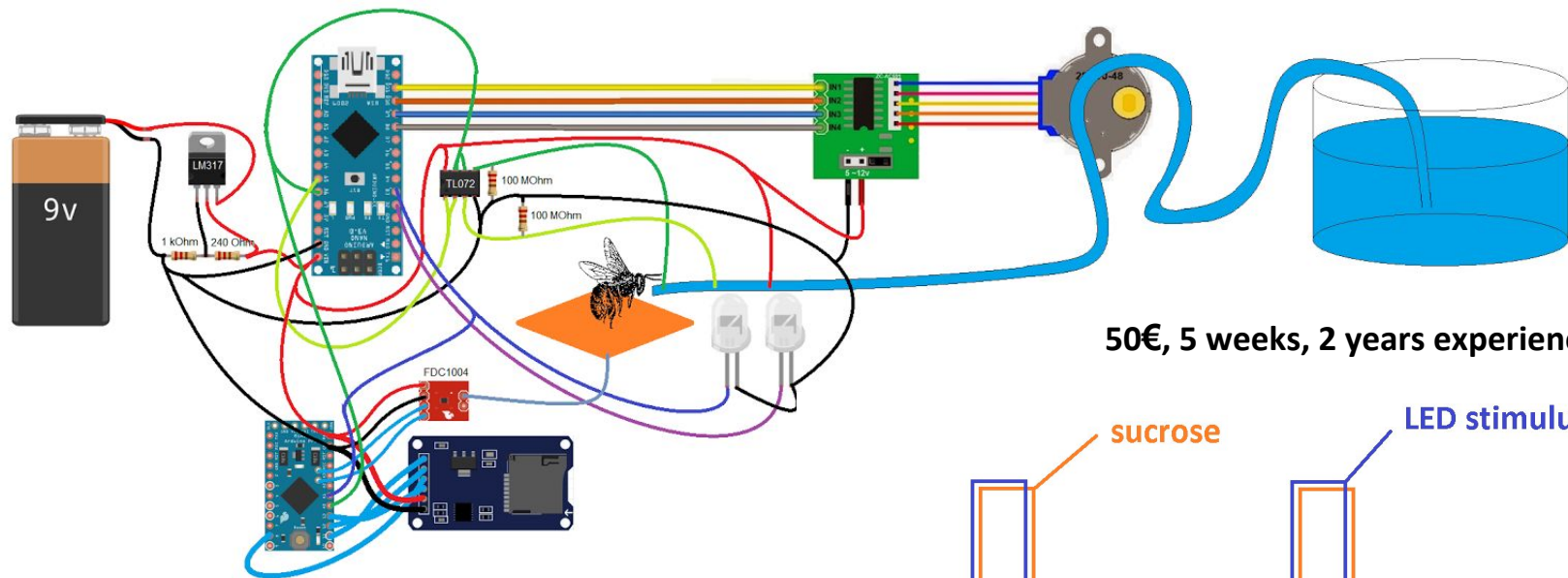
Receptive Field Measurements in Honey Bees

- 3 weeks, 100€, very first project
- also without the developing scientist

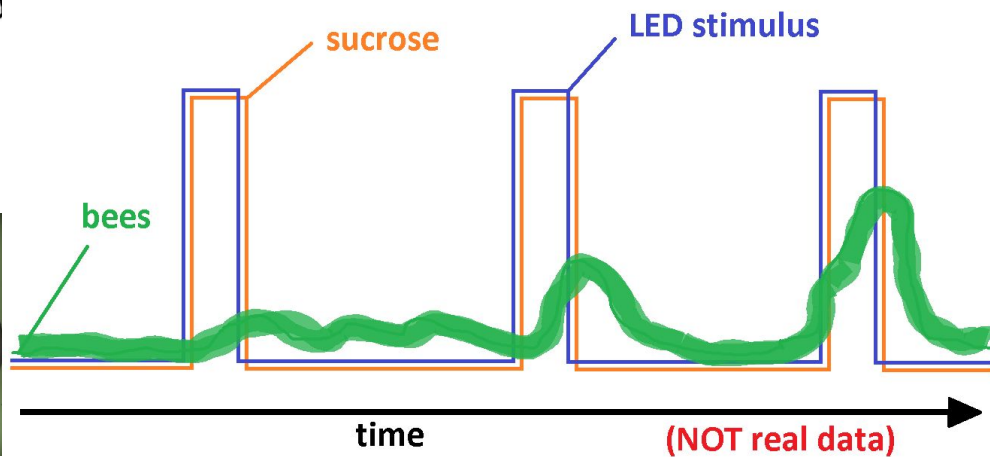
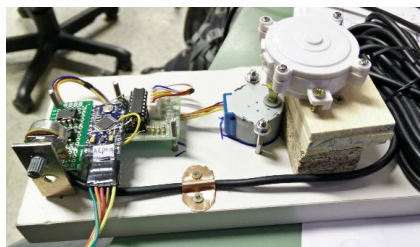


Artificial Flower

<https://neuroscientificmethods.blogspot.cl/2017/03/artificial-flower.html>



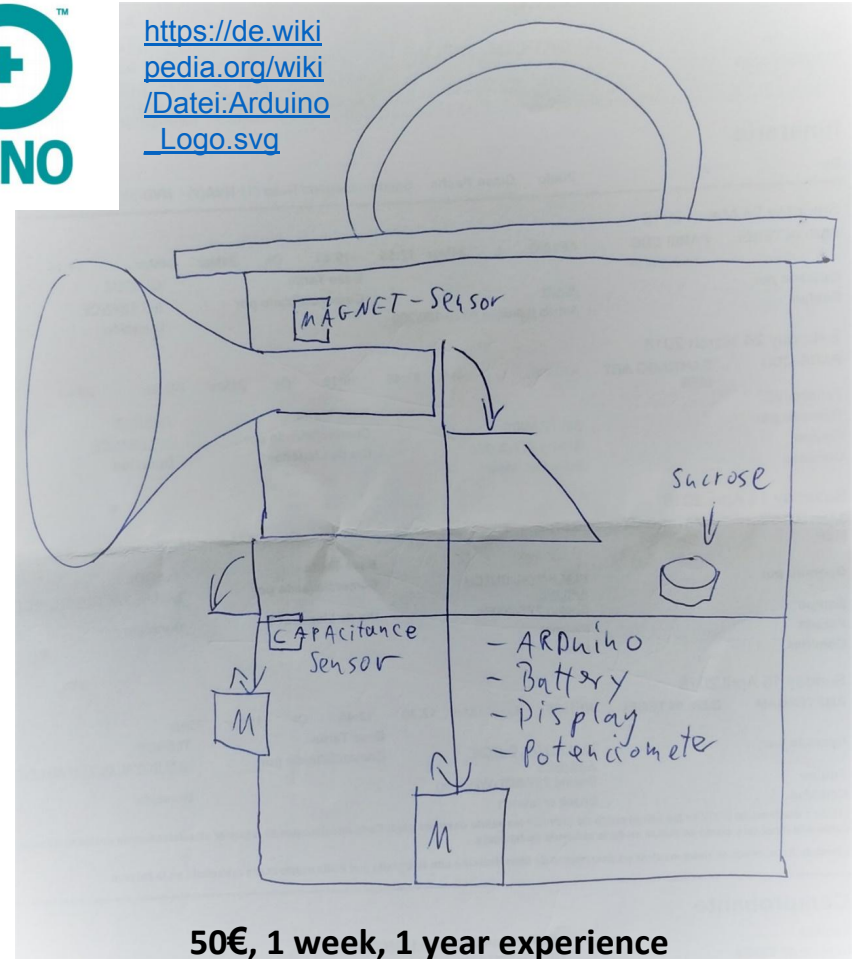
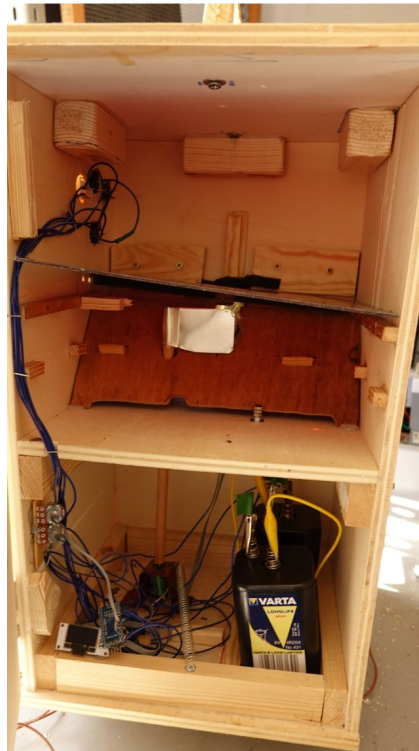
50€, 5 weeks, 2 years experience



Individually Marked Bee Feeder

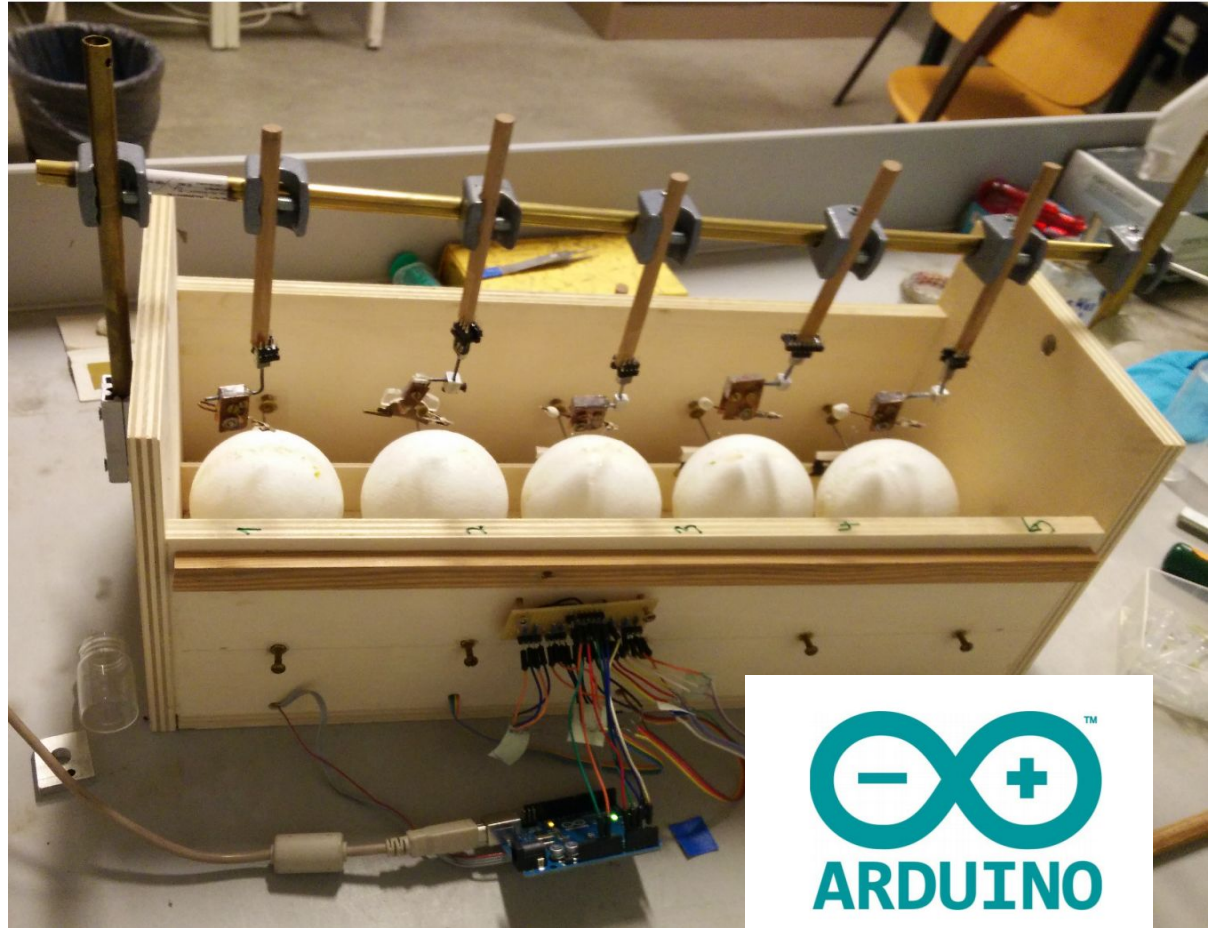


https://de.wikipedia.org/wiki/Datei:Arduino_Logo.svg



50€, 1 week, 1 year experience

Motor Activity Measurements



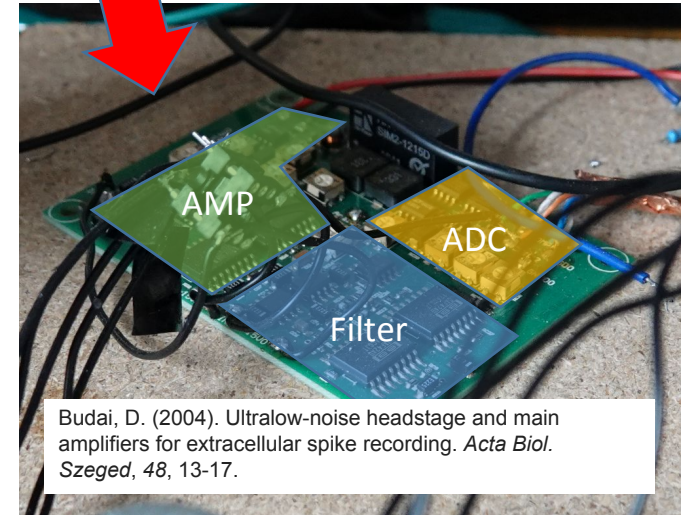
Lightweight Extracellular Amp

12 kg ~ 10.000 €



45 g ~ 500 €

+ Raspberry Pi (50 g, 45€)

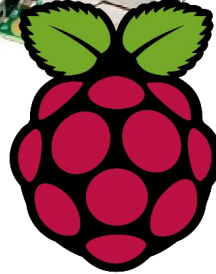


Budai, D. (2004). Ultralow-noise headstage and main amplifiers for extracellular spike recording. *Acta Biol. Szeged*, 48, 13-17.

BT & GPRS Temperature Logger for Bee Hives



+

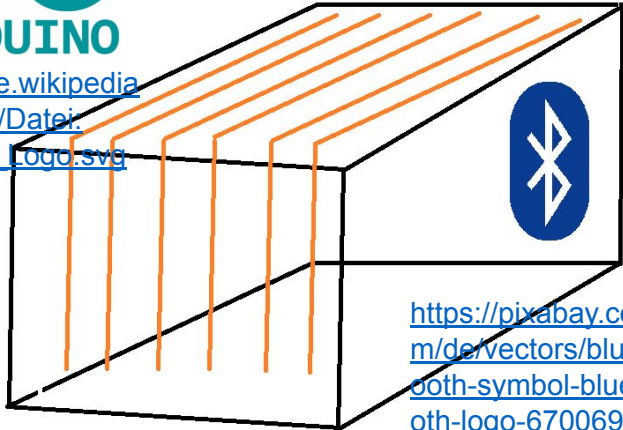


https://de.wikipedia.org/wiki/Datei:Raspberry_Pi_Logo.svg



ARDUINO

https://de.wikipedia.org/wiki/Datei:Arduino_Logo.svg



<https://pixabay.com/de/vectors/bluetooth-symbol-blutooth-logo-670069/>

LOG.CSV

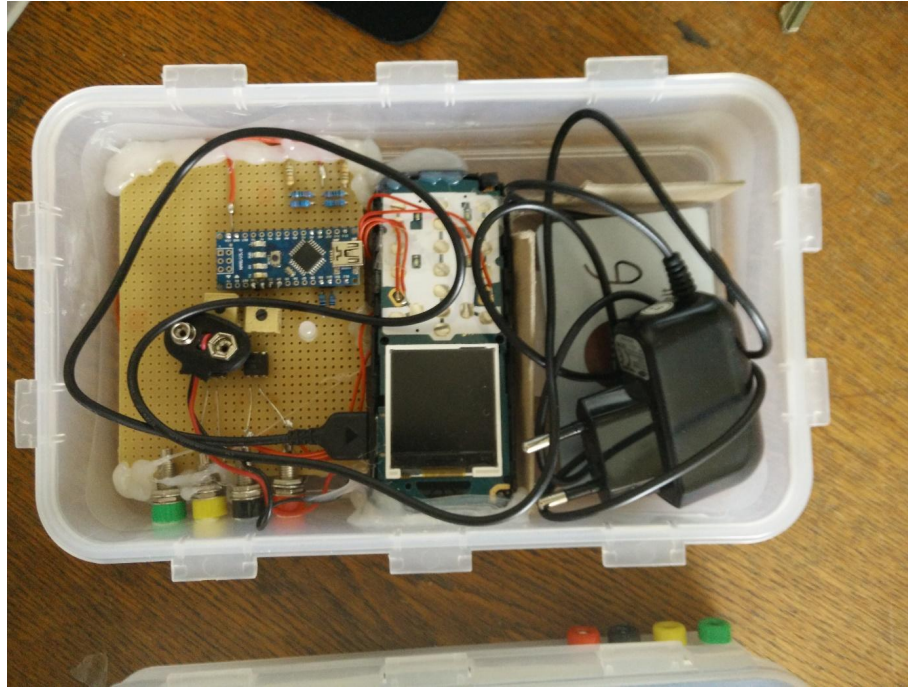
2018-04-01-12-00-35.5-34.9-35.6-35.2-...

...

...

...

Swarm Experiments: Optical Barrier with GPRS



https://de.wikipedia.org/wiki/Datei:Arduino_Logo.svg

Influence of Algae on Isolation Walls Measurements

5x light

intensity

direction

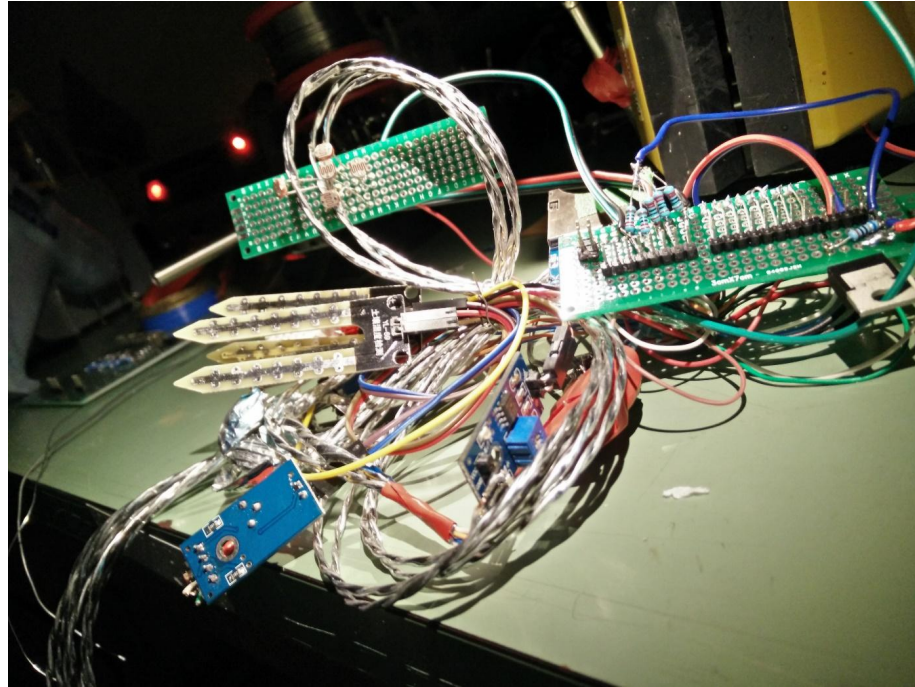
2x moisture

4x humidity

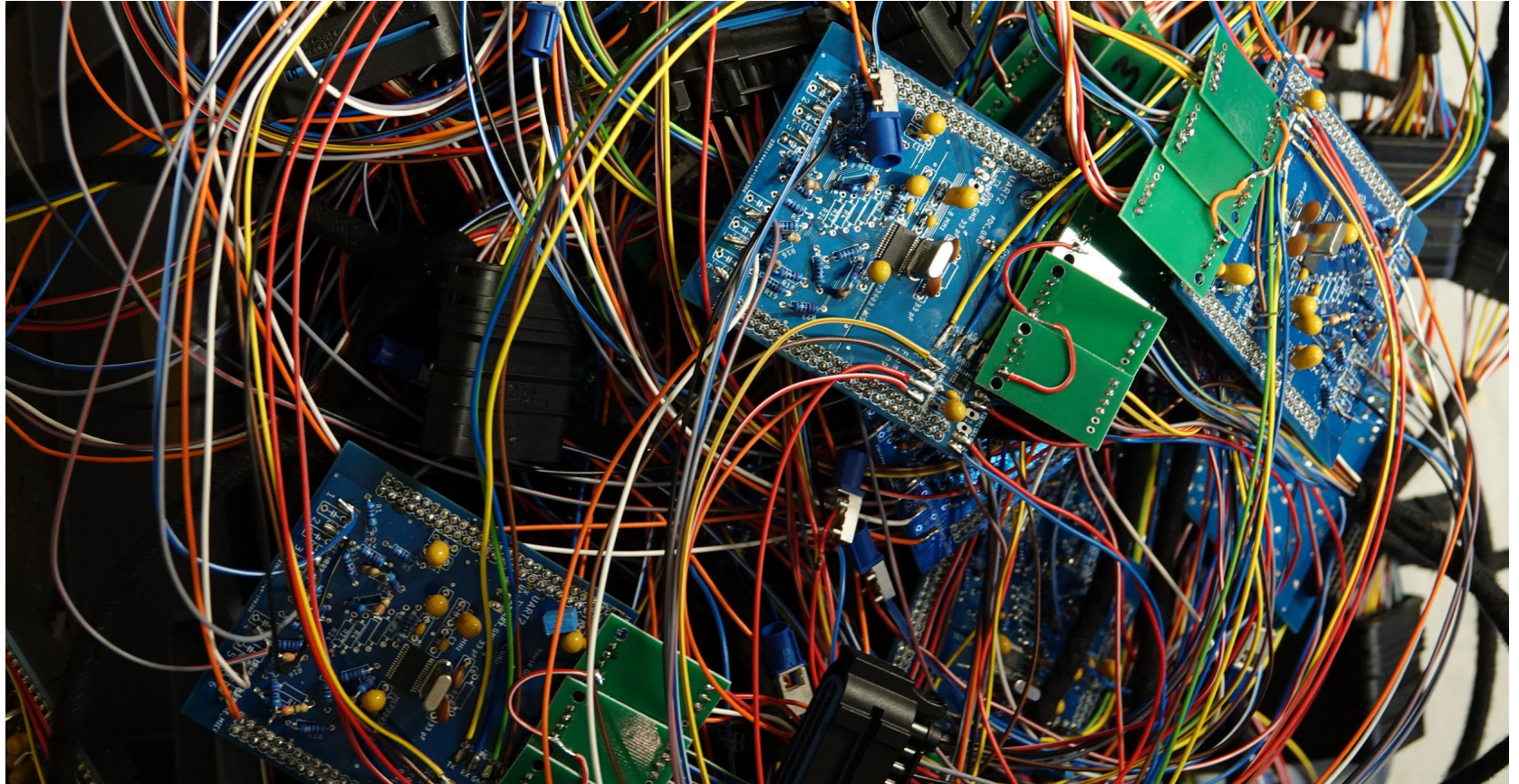
22x temperature

8x dew point

by Meike Stechel



Honey Bee Hive as Environment Indicator



Cunningham's Law

https://meta.wikimedia.org/wiki/Cunningham%27s_Law

"the best way to get the right answer on the internet is not to ask a question; it's to post the wrong answer."

https://www.reddit.com/r/PrintedCircuitBoard/comments/815542/pcb_with_24_bit_adc_how_is_my_decoupling_proto/

https://www.reddit.com/r/PrintedCircuitBoard/comments/81f3sf/pcb_with_24_bit_adc_2_design_all_your_suggestions/

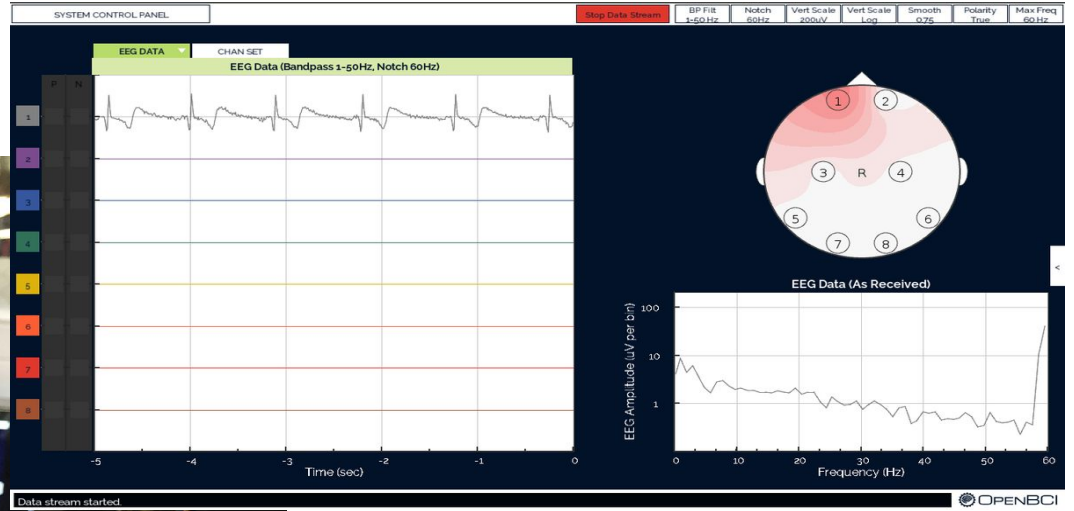
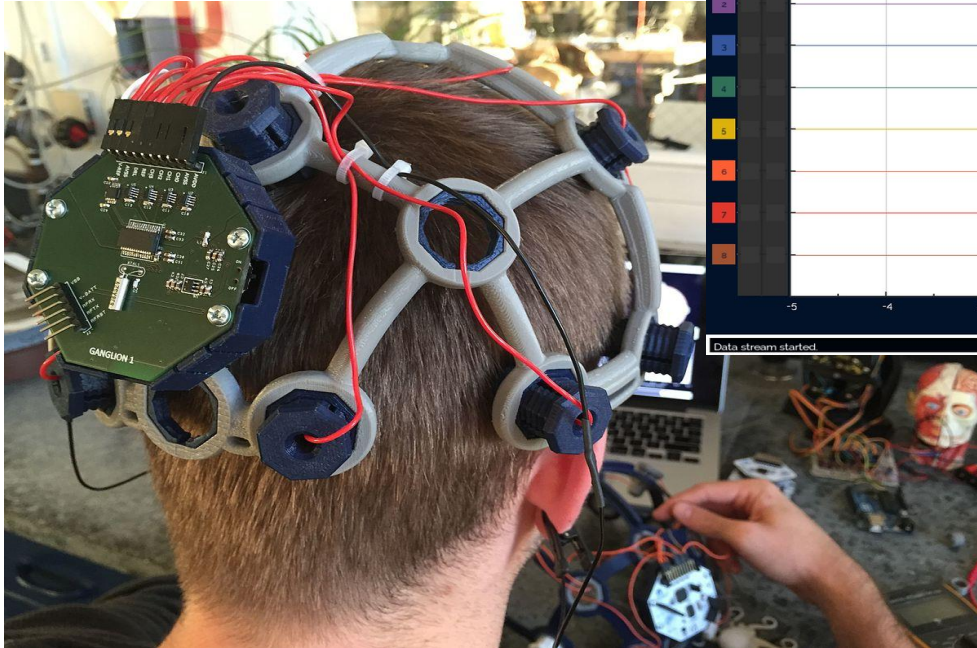
blink

```
// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000); // wait for a second
  digitalWrite(LED_BUILTIN, LOW); // turn the LED off by making the voltage LOW
  delay(1000); // wait for a second
}
```

Examples by Others

OpenBCI



<https://openbci.com/>



The Egg



The Device

The Egg is a WiFi-enabled device that uses sensors to record changes in the levels of specified air contaminants. Each Egg can detect at least one air contaminant – NO₂, CO₂, CO, O₃, SO₂, particulates, and volatile organic compounds (VOC). It tracks any changes and automatically uploads the data to the cloud where it can be accessed through our web portal, mobile app, or by manual download by connecting the Egg to a computer.

- Seven air contaminant sensors to choose from
- Accurate, precise air quality measurement
- Durable and portable for field trips and off-site study
- All models equipped to measure temperature, relative humidity, and barometric pressure

From Wikipedia, the free encyclopedia

OpenROV (**open-source remotely operated vehicle**) is a low-cost **telerobotic submarine**/underwater **drone** built with the goal of making underwater exploration and education affordable.^{[1][3][7]}

Contents [hide]

- [Telerobotic submarine](#)
- [Community](#)
- [Hall City Cave](#)
- [Developers](#)
- [References](#)
- [External links](#)
- [Bibliography](#)

Telerobotic submarine [edit]

OpenROV is a remotely operated mini-submarine that weighs ~2.6 kg and has dimensions 15 cm x 20 cm x 30 cm.^{[5][6]} This submarine is powered by 26650 Li-Ion batteries and can be assembled from common materials, with the most expensive piece being the **BeagleBone Black Linux** computer (~\$89). The submarine is controlled from a **laptop** computer connected to the submarine via a **tether** and is equipped with on-board **LEDs** and a camera.^[1] OpenROV is an **open-source hardware** project. By providing the list of the submarine parts and instructions on how to assemble them, the developers aim to democratize underwater exploration.^[4]

Community [edit]

OpenROV



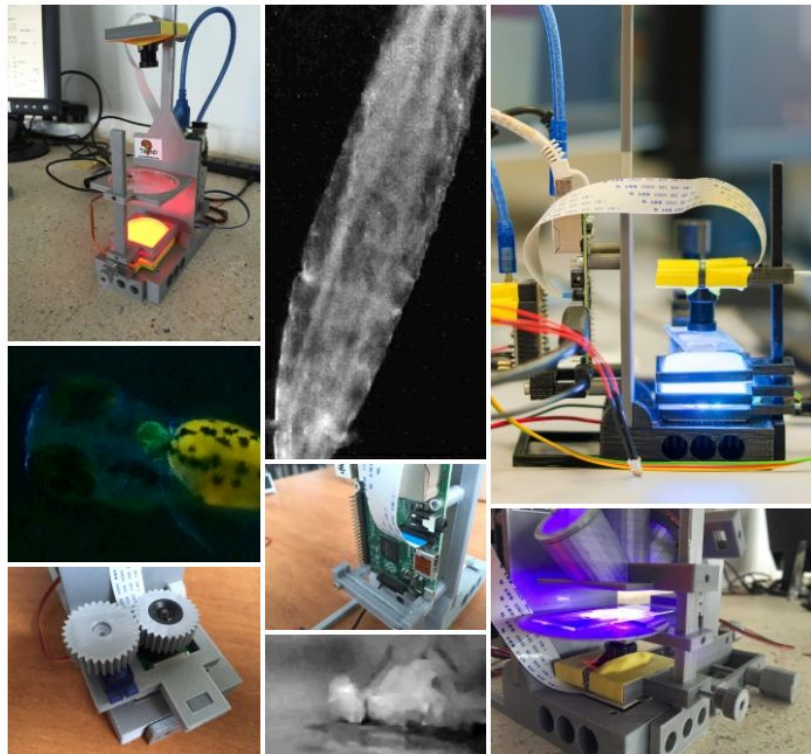
OpenROV submarine from Xeopesca at A Estrada.

Developer	Matteo Borri, David Lang, Eric Stackpole and DIY community . ^{[1][2][3]}
Manufacturer	OpenROV and DIY community . ^[4]
Type	Telerobotics submarine underwater drone
Release date	circa 2012, current version: 2.8 (26 Jun. 2017) ^[5]
Units sold	118 (2012) ^[6]
Operating system	Linux ^[5]
System-on-	TI AM335x (BeagleBone Black on-board

FlyPi

A 3-D printable open source platform for fluorescence microscopy, optogenetics and accurate temperature control.

By A Maia Chagas, LL Prieto Godino, A Arrenberg and T Baden



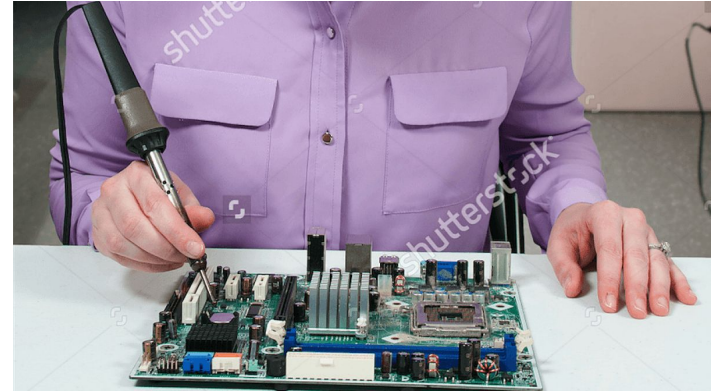
<https://open-labware.net/projects/flypi/>

Tools

soldering / reflow PCB design software

voltmeter / oscilloscope

<https://makezine.com/2016/03/08/beautiful-woman-soldering-stock-photo-wrong/>



<http://flyingfolk.com/LCD-Digital-Multimeter-Messgeraet-Typ-D-T-832-Voltmeter-mit-Messkabel>

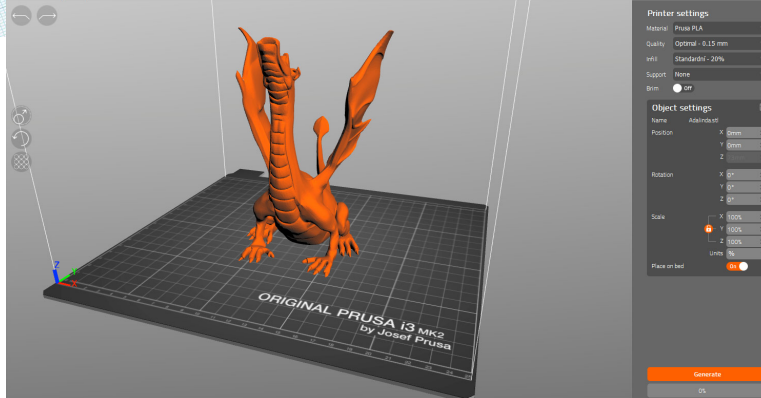
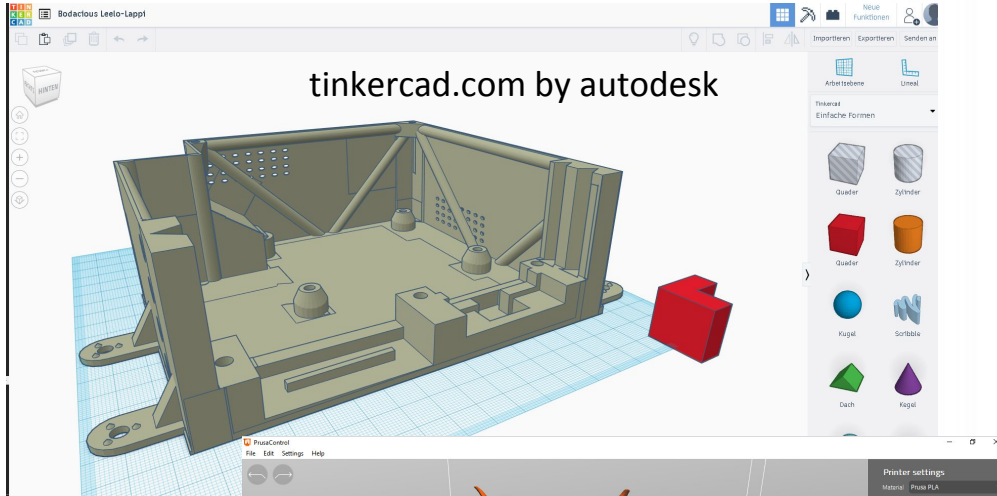


<https://www.amazon.com/KEYSIGHT-DSOX1102G-Oscilloscope-Analog-Channels/dp/B06XCC3LN4>

3D Printing

<https://www.prusa3d.de/>

prusa i3 mk3
800€



<https://www.thingiverse.com/>

<https://www.tinkercad.com/things/c54Ugnq4iWA-bodacious-leelo-lappi/edit>

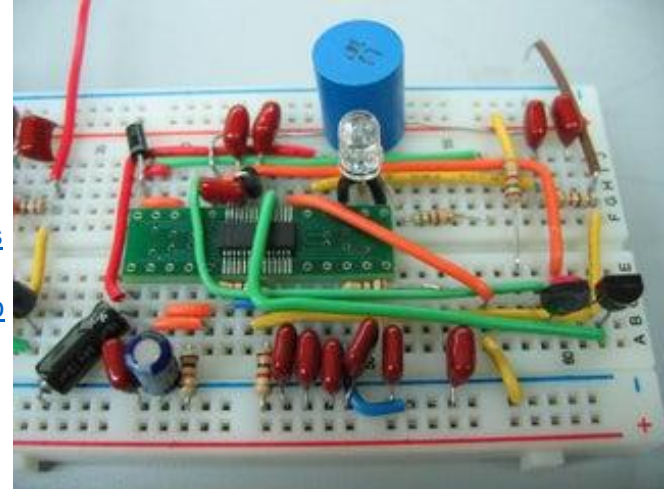
Parts

modules



<https://www.faranux.com/product/photosensitive-sensor-module-detection-photo-resistor-ldr-light-sensor-module-com43/>

through hole technology THT

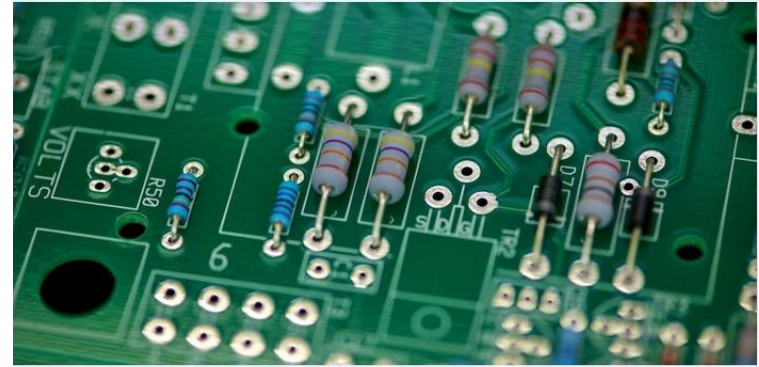


<https://www.instructables.com/id/How-to-use-a-breadboard/>

surface mounted device SMD



© Can Stock Photo - csp30163484



<https://enzfpcb.wordpress.com/2017/02/17/surface-mounting-smt-and-through-hole-mounting-tht/>

Datasheets

example LM35 temperature sensor

<http://www.ti.com/lit/ds/symlink/lm35.pdf>

power supply

range

output (digital/analog)

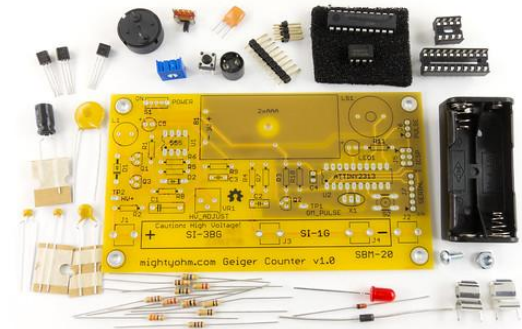
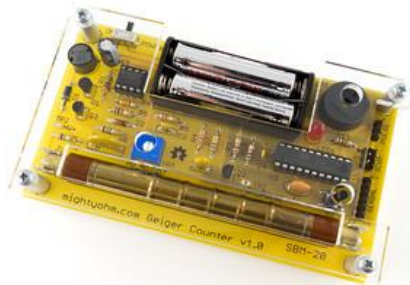
accuracy

Ordering Parts

modules: ebay, aliexpress, amazon (3 reasons administration hates me...)

THT, SMD, consumables: digikey, mouser, conrad (in UNIKAT)

kits supplied by the manufacturer (4. reason..)

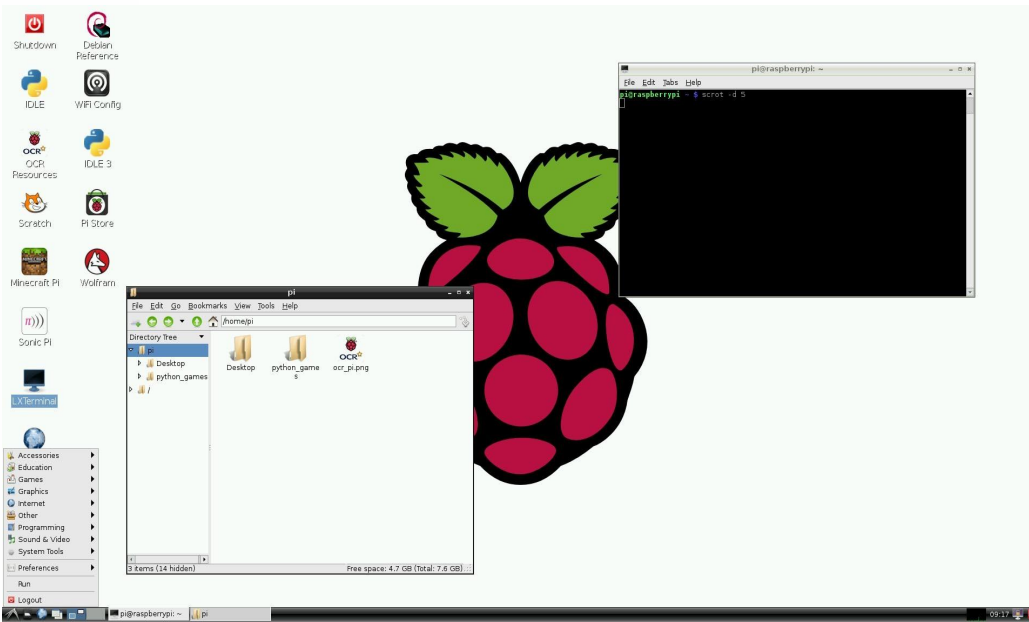


Tools - Arduino



<https://www.reichelt.de/arduino-uno-rev-3-dip-variante-atmega328-usb-arduino-uno-dip-p154902.html>

Tools - Raspberry Pi



Resources

first step - understand your desired device and its elementary parts, what are inputs, outputs, data flow and requirements (no cable, solar...)

search for existing projects for each part (**google**)

learn the language (moving thingy - motor? DC, stepper, servo...):

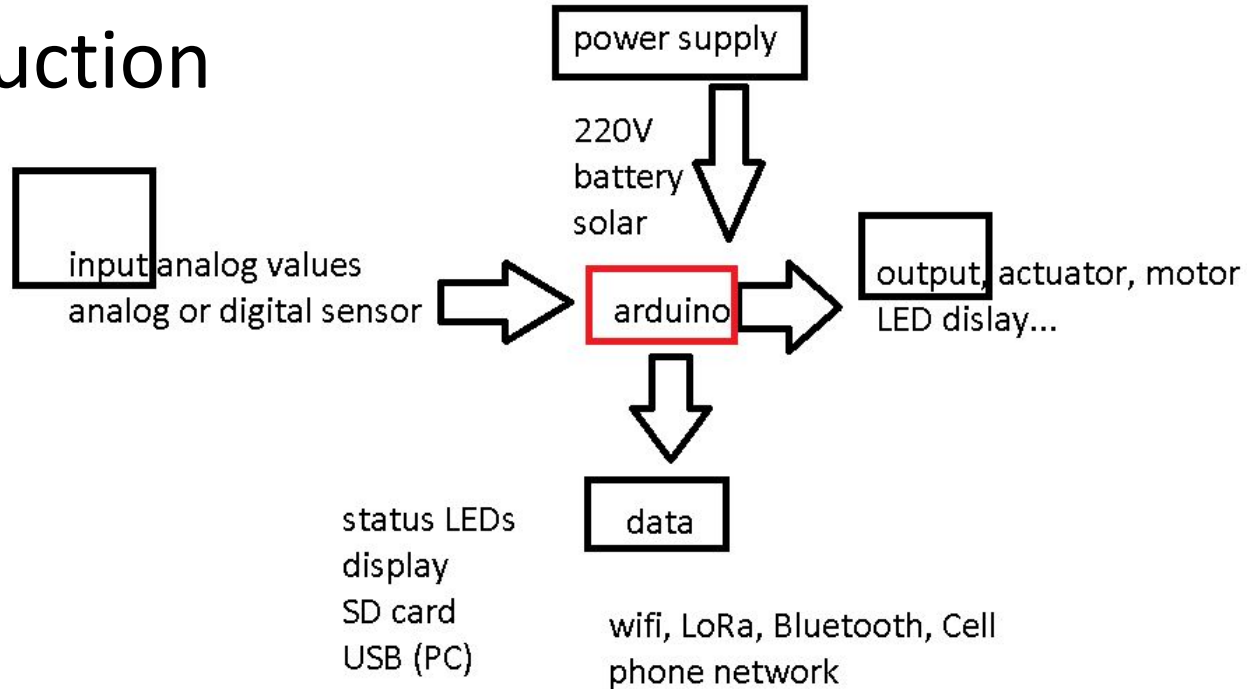
youTube tutorials / introduction videos

talk to pros when you are stuck: **reddit** (askEngeneering)

meet people in real live (**meetups.com/nearby** makerspaces)

<https://www.meetup.com/de-DE/topics/makerspaces/de/berlin/>

Deconstruction



build each one independently; firstly each project exactly as found
then adopt, combine and test / compare to a commercial device

Why?

no alternative

it's FUN

fast

more specific

cheaper - more

better understand data

better communication with engineers and programmers

publish the project

learn programming the easy way

an edge for your CV

Useful Links

<https://hackaday.com/> - get inspired

<https://forum.openhardware.science/> - huge community around the globe, common goal: make open hardware in science ubiquitous

https://open-neuroscience.github.io/_pages/learning/youtube_as_a_resource_for_open_science_hardware/ list of good youtubers (I like) to get started

<https://neuroscientificmethods.blogspot.com/> my blog