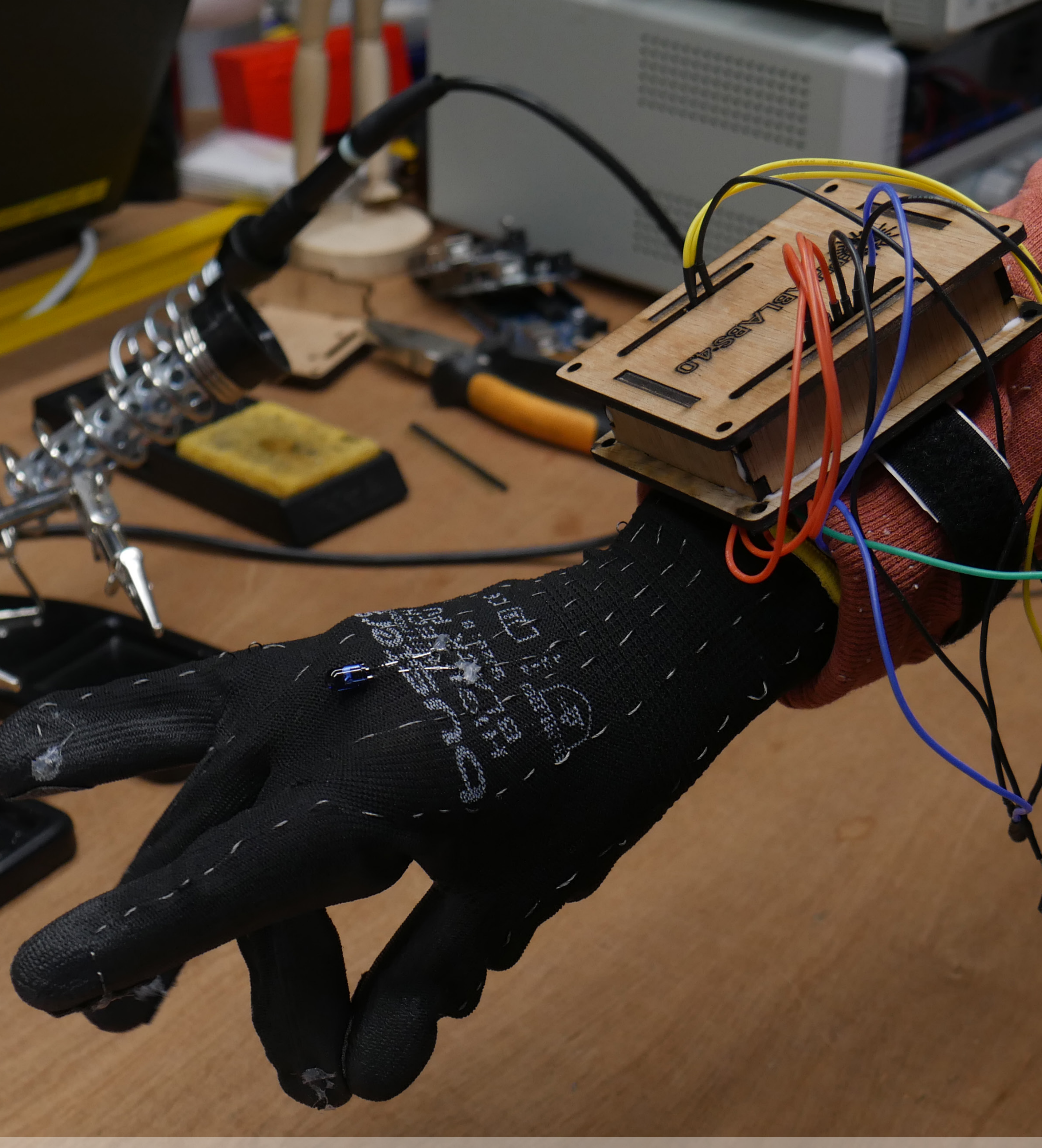

PHABLABS 4.0

PHOTONICS WORKSHOP

PHOTONICS IRglove

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SUMMARY:

The participants will build an IRglove that will serve as a remote control for a certain device. An IR emitter will send the signals to a TV or a radio. A controller and a battery into a bracelet are attached to the glove.

TARGET AUDIENCE:

Students (15-18 years old)

SUGGESTED TIME PLANNING: (Total: 3h)

Timing in minutes	**activity**
0 - 15	Welcome group and explaining of the concept of ‘IR light’ and ‘IR signals’.
15 - 60	Sewing conductive fabric and IR-emitter to the glove.
60 - 150	Controlling and implementing electronics.
150 - 180	Programming the Arduino.

TOOLS:

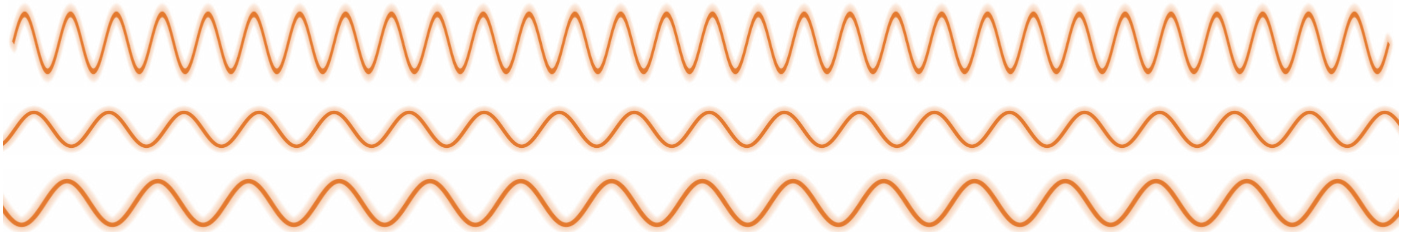
Laser Cutter
Soldering Iron
Computer for programming Arduino
Hot glue gun
Needles

ESTIMATED COST:

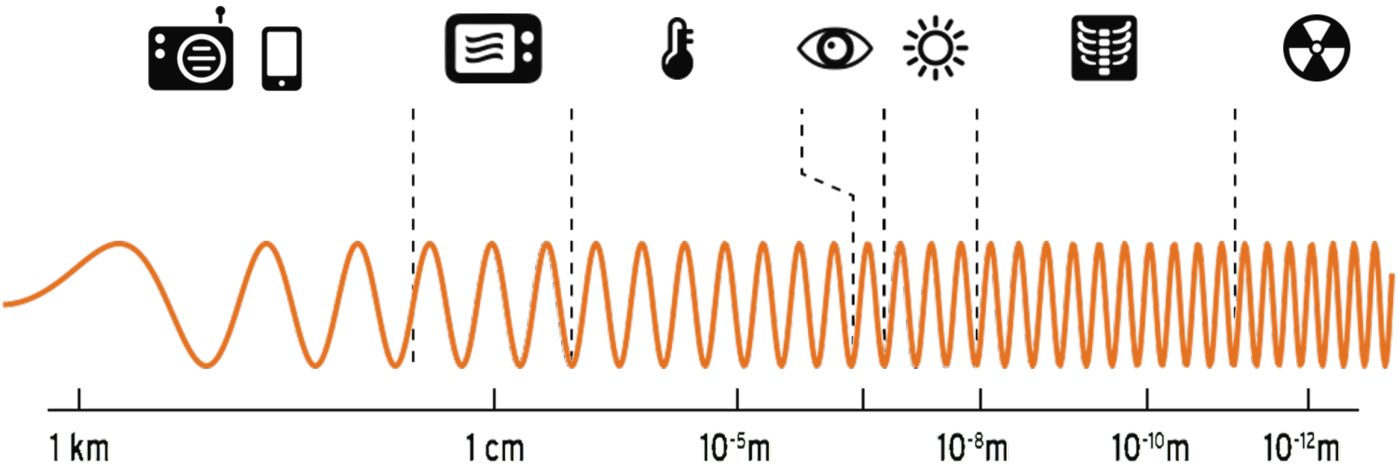
€ 25

Step 1: Infrared?

Light is an **electromagnetic wave.** And one of the most important property of an electromagnetic is the **wavelength.** Forms of electromagnetic radiation like radio waves, light waves or infrared (heat) waves make characteristic patterns as they travel through space. Each wave has a certain shape and length. The distance between peaks (high points) is called wavelength. The difference in wavelength is the way we tell different kinds of electromagnetic energy apart.



Wavelength is commonly designated by the Greek letter lambda (λ).
The **electromagnetic spectrum** is the collective term for all known frequencies and their linked wavelengths of the known photons (electromagnetic radiation).



Radio Waves: 10^4 km > λ > 1m
Radio waves are used for transmission of data, via modulation. For example: television, mobile phones, wireless networking and amateur radio all use radio waves.

Microwaves: 1m > λ > 1mm
Microwaves are absorbed by molecules that have a dipole moment in liquids. In a microwave oven, this effect is used to heat food.

Infrared waves: 1mm > λ > 780nm
Far-infrared: (1mm - 10 µm): used in astronomy
Mid-infrared: (10 µm - 2.5 µm): Hot objects can radiate strongly in this range.
Near-infrared: (2.5 µm - 780 nm): used in image sensors for infrared photography

Visible light: 780 nm > λ > 380 nm
Visible light includes all colours we can see with the human eye. The range of colours lies between red (700 nm) and blue (400 nm).

Ultraviolet waves: 380 nm > λ > 10 nm
The sun emits significant UV radiation that could potentially destroy most life on land .

X-rays: 10 nm > λ > 1pm
X-rays can interact with matter. One notable use is diagnostic X-ray imaging in medicine.

Gamma Rays: λ < 1pm
These are the most energetic photons. They are used in medicine in radiation cancer therapy.

This workshop is using infrared technology.

Some properties of the infrared light:

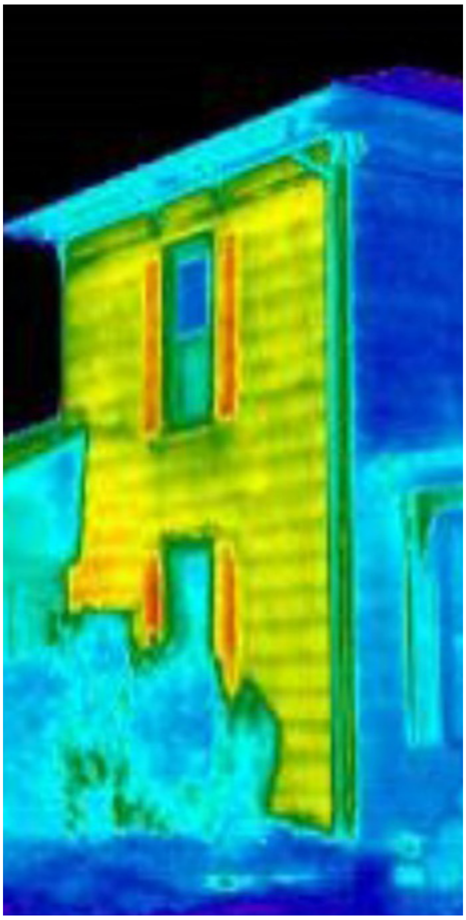
Infrared light is an electromagnetic wave that is **not visible for the human eye**. But did you know that snakes can? Boid and crotaline snakes have a very special property: they can detect infrared by an infrared registering membrane, located in tiny pits around the mouth. This infrared light corresponds to very small temperature changes. They use the temperature sensor to estimate the location of, and distance to, prey animals.

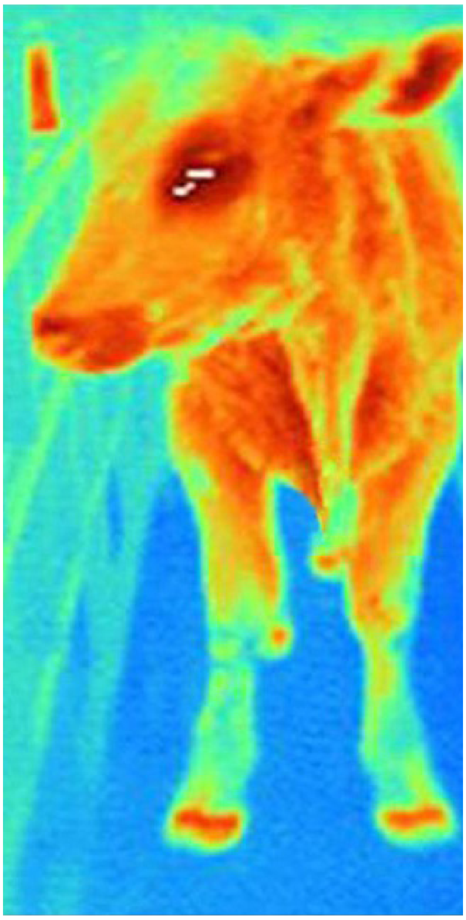
Infrared light is **detectable through the skin** because of their heat mode. Everything with a temperature above minus 268 degrees Celsius emits IR radiation, wherein the wavelength is dependent on their temperature. The sun gives off half of its total energy as IR, and much of its visible light is absorbed and re-emitted as IR.

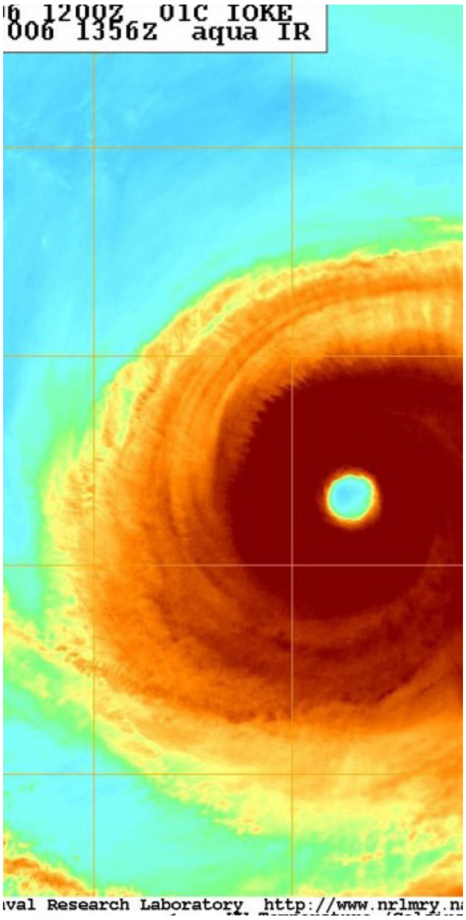
The temperature of an object depends on the average speed of movement of all the atoms and molecules in the object. More important is that infrared radiation doe not have a negative influence on our health.

Applications of infrared

Infrared light has a lot of applications.
An infrared camera can detect the heat of objects or bodies. It is used for example to detect heat losses in a house. Using the infrared camera helps to find out which part needs to be isolated better. A camera is also used in veterinary medicine. Animals can not tell where they are in pain, but such a camera can indicate at which place the body is much warmer. An inflammation feels warm. NightVision have infrared sensors. These are used to find missing persons, or security cameras for during the night. And during the ebola crisis, people were screened on fever in the airport with an infrared camera.





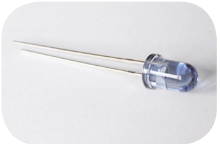


Weather satellites provide by means of infrared radiation day and night the cloud cover. Infrared is used in astronomy to observe the Universe at infrared wavelengths. This allows us to see cold objects as well.
Infrared lamps are also used for various applications. They are used eg for hatching eggs in incubators or to keep food warm, as a heat source in terrariums.
But also in infrared saunas or for the correction of muscle and joint pain in physiotherapy.

A TV remote control uses IR waves to change channels. In the remote, an IR light-emitting diode (LED) or laser sends out binary coded signals as rapid on/off pulses. A detector in the TV converts these light pulses to electrical signals that instruct a microprocessor to change the channel, adjust the volume or perform other actions. IR lasers can be used for point-to-point communications over distances of a few hundred meters or yards. In this workshop an IRglove will be made, so you are able to change channels by touching two fingers.

Step 2: Parts list

Photonics Parts:

IR emitter
1 piece/prototype


Receiver
1 piece/prototype

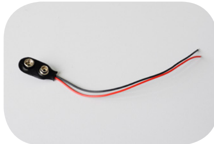
Other Parts:

9V battery
1 piece/prototype

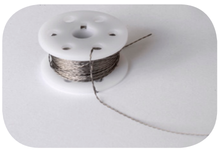
Glove
1 piece/prototype

Velcro

Electronic Parts:

9V battery connector with plugin
1 piece/prototype



Conductive thread


Arduino
1 piece/prototype

Transistor
1 piece/prototype


Resistor 330 Ohm & Resistor 10 Ohm
1 piece/prototype

Breadboard
1 piece/prototype

A complete toolkit is available on the www.phablabs.eu website.
Or via email: phablabs4.0@gmail.com

Step 3: Sewing conductive fabric

The following step explains the order of the steps that should be taken. Go through each step with the participants.

Sew with **conductive thread** on the thumb. (The length of the thread should be minimum twice the length from the fingertop to the wrist.) Don't trim the beginning of the thread.



Then sew the thread along the top of the glove all the way down to the wrist. Sew it at least once around the border of the glove. Leave minimum 5 cm of thread hanging loose at the wrist. Do this for all 5 fingers. Make sure the wires of the different fingers do not touch each other, otherwise you will cause a short circuit.



To win some time, you can ask the participants to only sew the thumb and two other fingers. Then they will have a glove that will be able to emit two different signals.

Step 4: IR-emitter

The buttons are ready now. But for sending the signal, we need an infrared emitter. This IR-emitter should be placed prominent on the glove. The easiest place is on top of the knuckels of the hand.

Weave the legs of the IR-emitter through the fabric of the glove. Do this on the back of the hand,

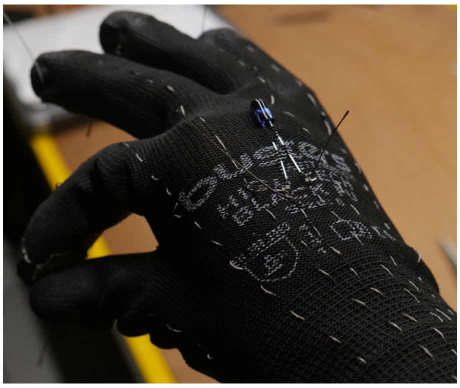


at the level of the knuckels.
Bend the legs of the IR-emitter with a pair of pliers to create barbed hooks. Make sure you still see



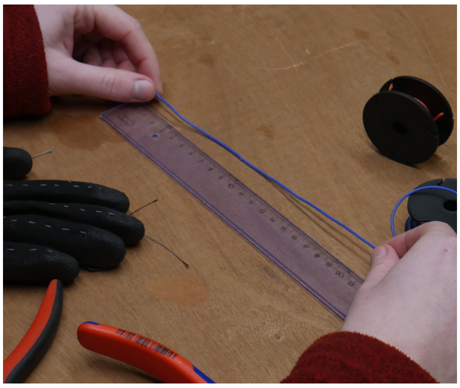
the difference between the long and the short leg.
Attach a conductive thread at the end of a leg with a knot and weave it around a little bit. Sew with the conductive thread from the legs to the wrist. Leave at least 5 cm of thread at the wrist. Do this



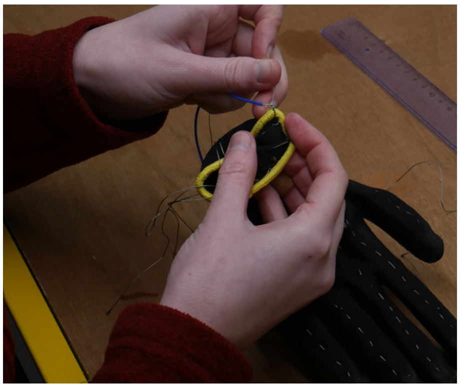
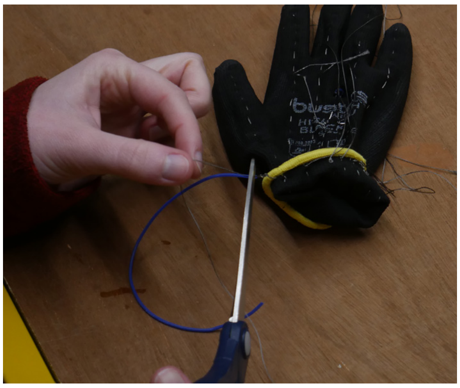


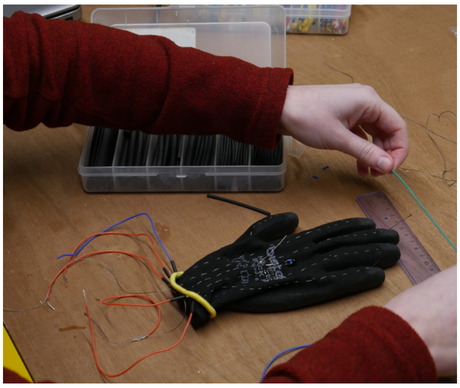
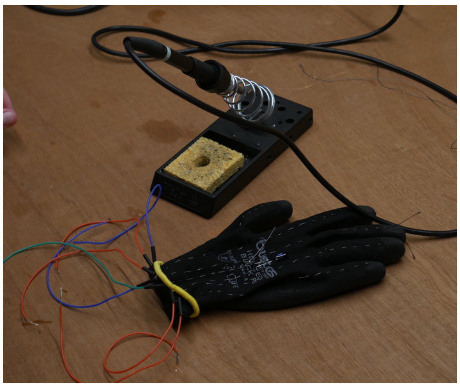
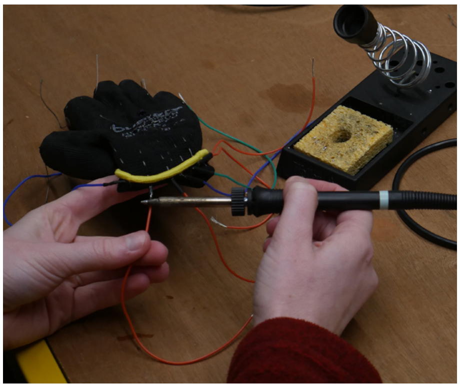
for both legs of the IR emitter.

Foresee 7 electric wires of about 20cm. 1 for the thumb, 4 for the other fingers, 1 for the longest leg of the IR emitter and 1 for the short leg of the IR emitter. Strip all wires at both ends. Choose the colours of the wires, so you can keep them apart.

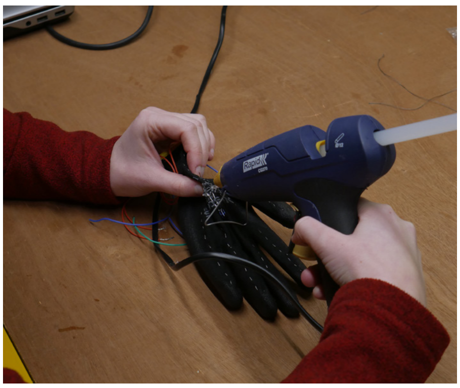
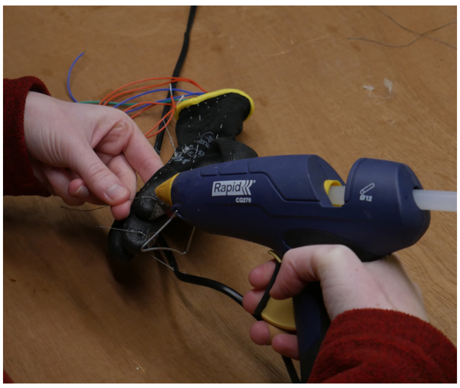
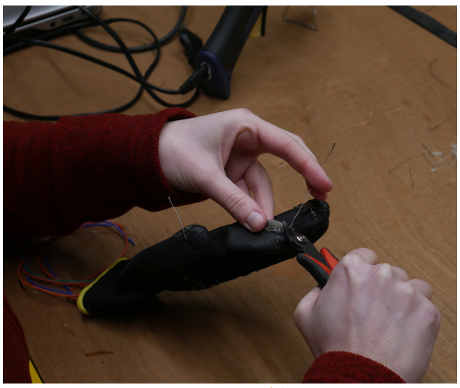




Knot the thread, coming from the thumb, fixing to the wire of the thumb. Trim the excess thread. Cover this connection with a heat shrink sleeve. Do this for all 5 finger connections. Heat up the sleeves to shrink them around the connections. Solder the remaining wires to the legs of the IR emitter.

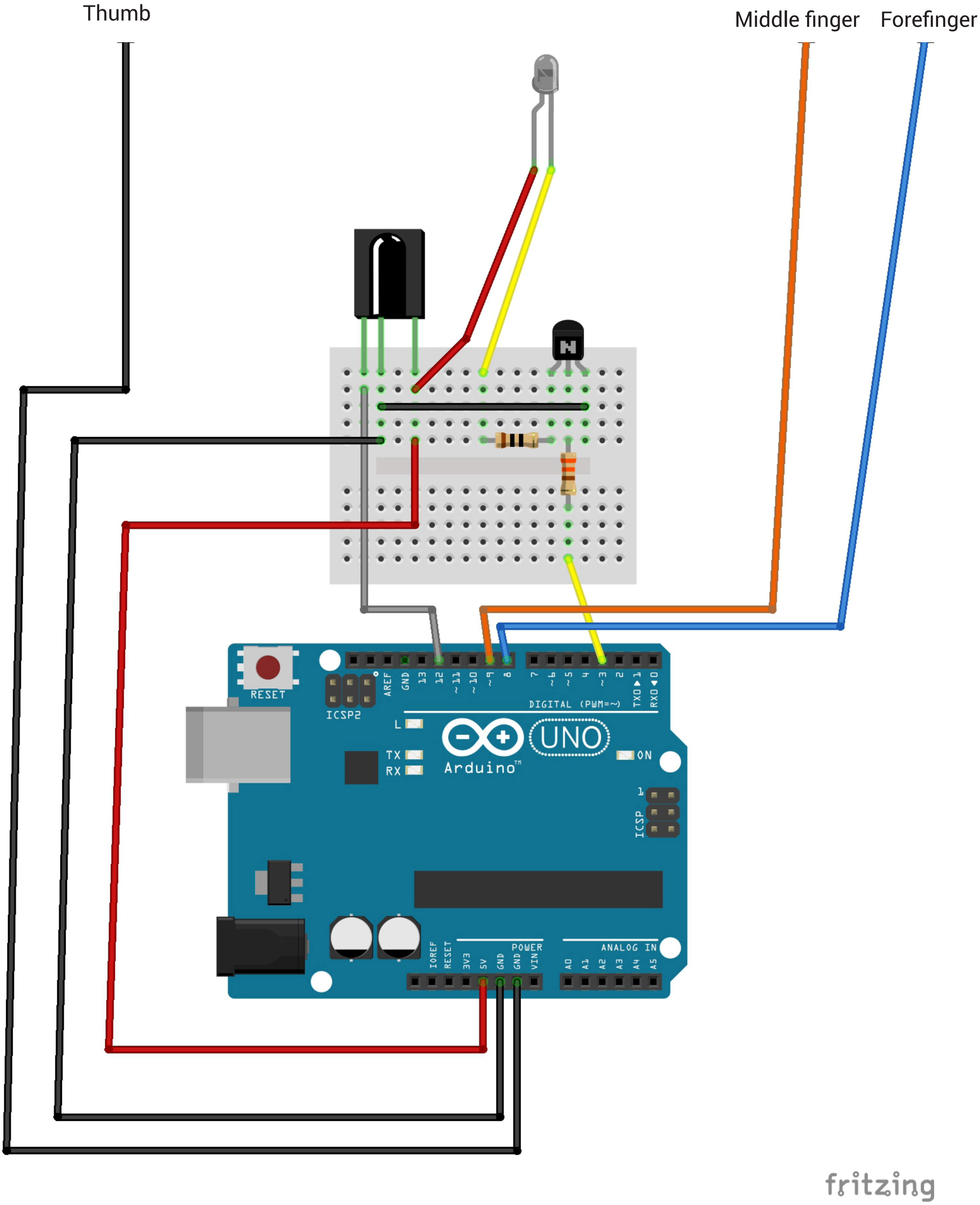



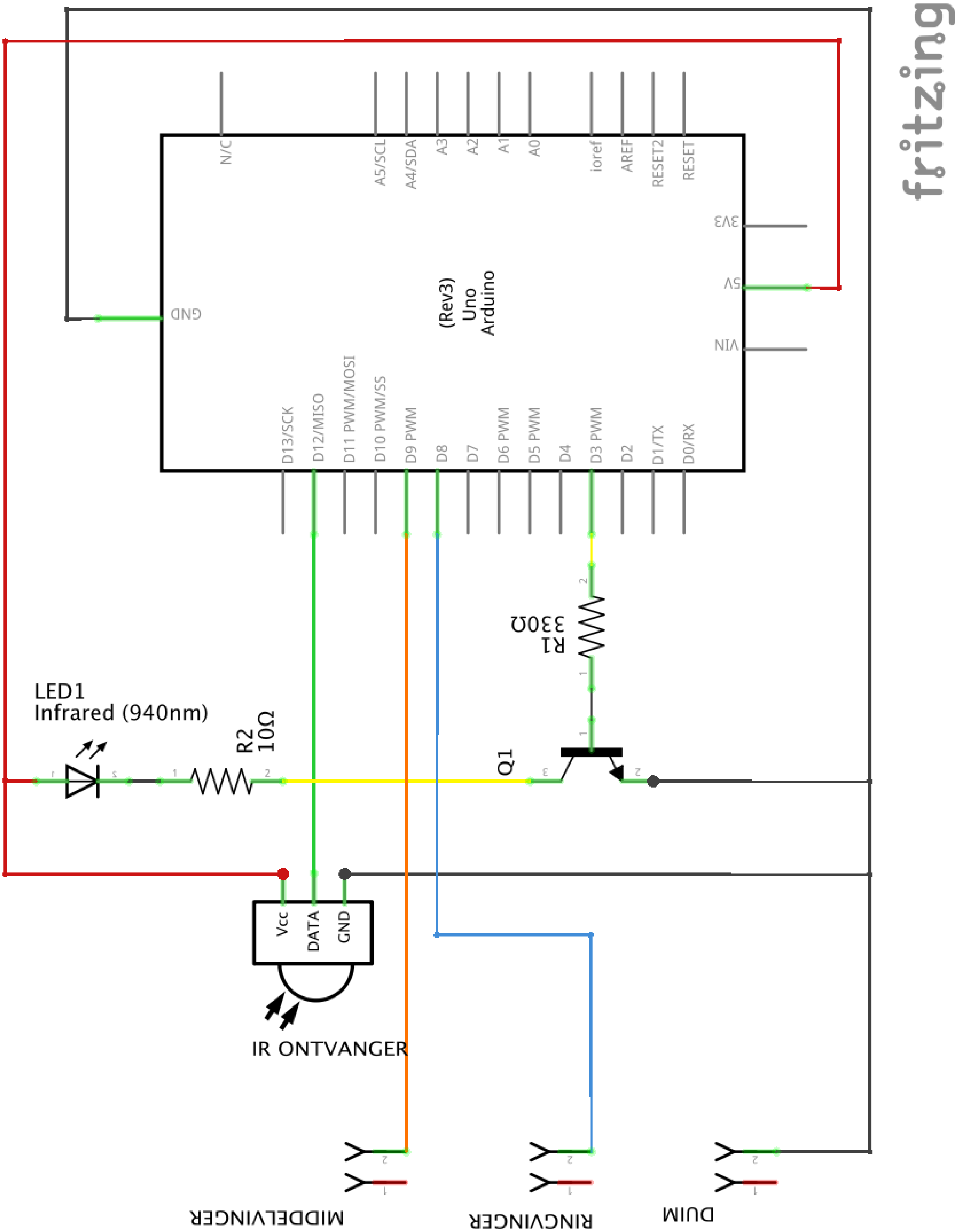




Secure every connection on the glove (e.g.the starting point of the thread at the conductive fabric) with hot glue.
Now you can trim the excess wire at the finger tops.

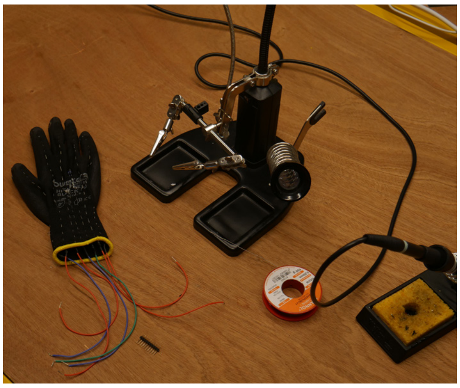




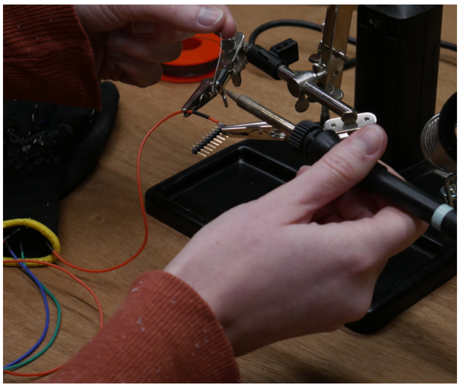
Step 6: Electrical scheme

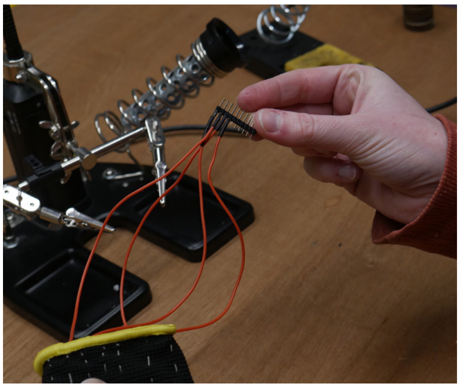



fritzing
Arduino
Uno
(Rev3)
N/C
A5/SCL
A4/SDA
A3
A2
A1
A0
ioref
AREF
RESET2
RESET
3V3
5V
VIN
GND
D13/SCK
D12/MISO
D11 PWM/MOSI
D10 PWM/SS
D9 PWM
D8
D7
D6 PWM
D5 PWM
D4
D3 PWM
D2
D1/TX
D0/RX
R1
330Ω
Q1
LED1
Infrared (940nm)
R2
10Ω
Vcc
DATA
GND
IR ONTVANGER
MIDDELVINGER
RINGVINGER
DUIM

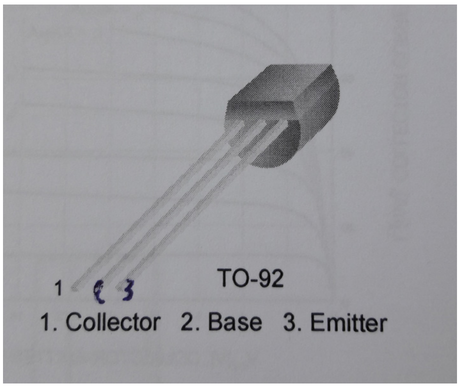
Secure the wires coming from the fingers easily in the Arduino. The four wires starting from the four fingers exept the thumb can be attached to four pins next to each other. Foresee heat shrink sleeves to cover the connections. These pins will be connected to the 8, 9, 10, 11 pins of the Arduino.

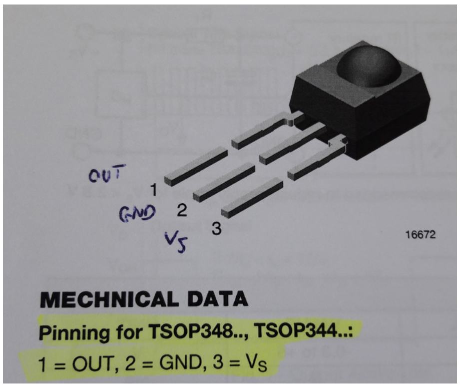


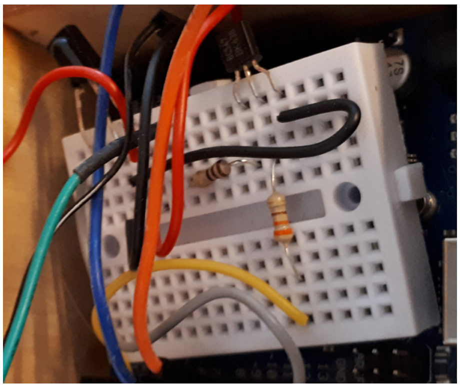




Put the IR receiver, the transistor and the resistors in the breadboard as shown in the electric scheme. A transistor is mainly intended to amplify or to switch electronic signals. In general, there are three connections (electrodes). The signal to be amplified is fed to the emitter, E, the amplified signal can be extracted from the collector, C, and the third connection is common for the two signals, the base, B. The Collector of the transistor should be connected to a resistor of 330 Ohm in series. The resistor should then be connected to the IR emitter in series. Connect the collector pin of the IR emitter (short leg) to the resistor.





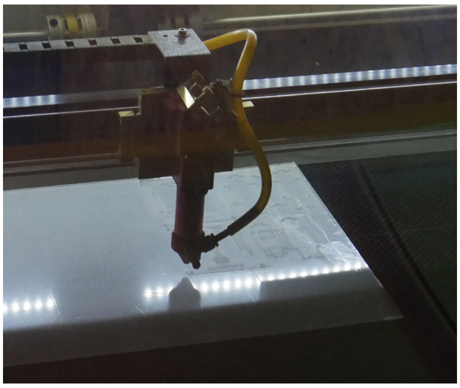
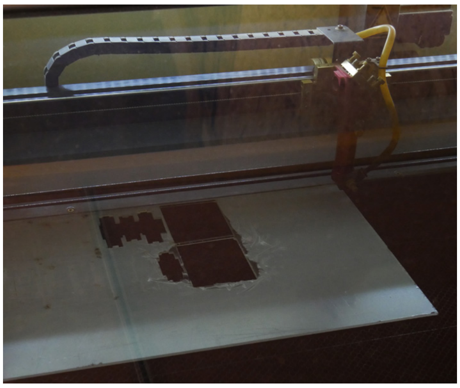
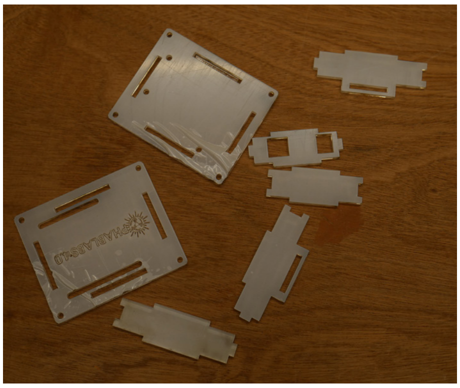


Simply connect then the Base of the tranistor to a resistor of 330 Ohm. Attach then the other side of the resistor to a cable which we will connect to the D3 pin of the Arduino.
The Emitter pin of the transistor should be connected to the ground. The next step is to connect the IR receiver correctly. An IR receiver has a flat side and a convex side. When the convex side is facing up, the middel leg needs to be connected to the GND, the left leg is the output, OUT and the right leg is Vs. Connect a wire to the OUT leg of the IR receiver, which will be connected to the D2 pin of the Arduino.
Put a wire to the GND leg of the IR receiver, which will be connected to the GND pin of the Arduino.
Put a wire to the Vs leg of the IR receiver, which will be connected to th 5V pin of the Arduino.
Connect all components as shown in the electric scheme.

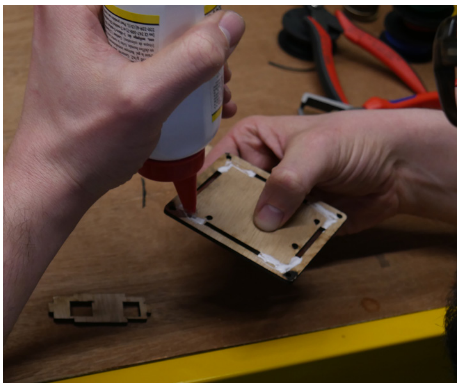
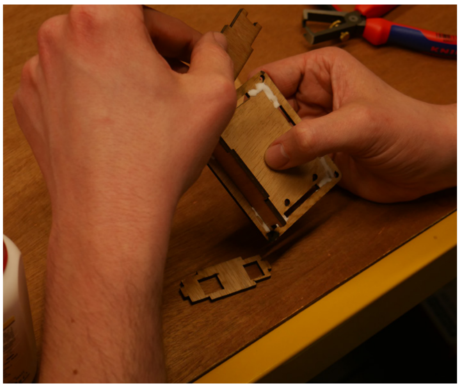
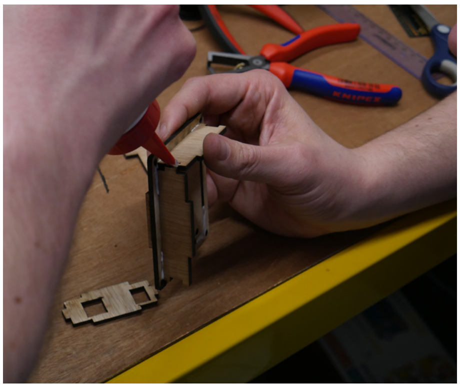
Step 7: Case Arduino

The case will be made with the laser cutter. You can now choose to let the participants make their own design of the wooden box with the programme makercase.com. Or you can give them the .stl file to cut out the case. Help the participants sending their design to the laser cutter.

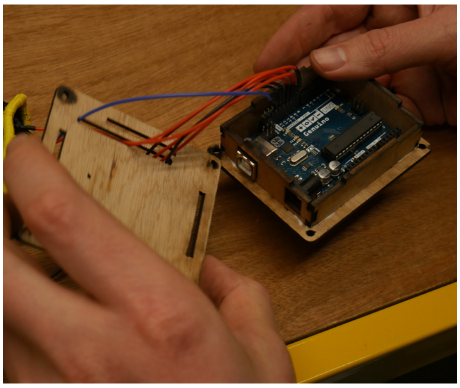
Make your wooden case for the Arduino with the laser cutter. **.stl file can be found on website**. Or you can design your own case with makercase.com.

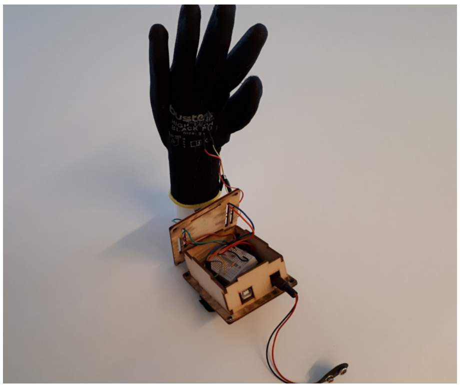




Glue the side parts and the bottom together.

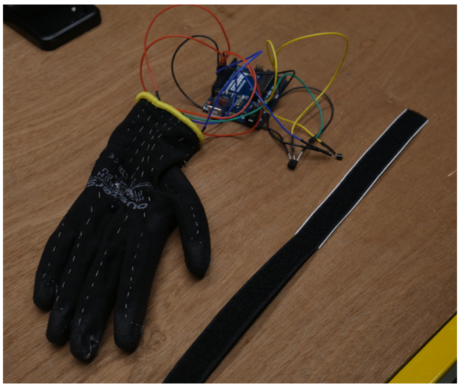
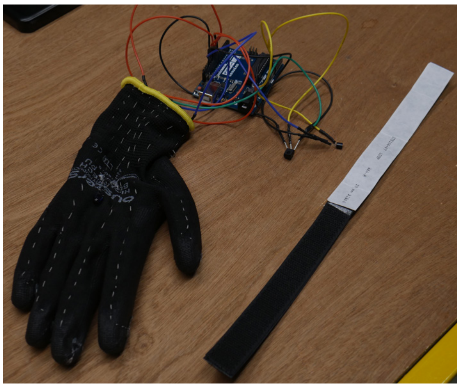
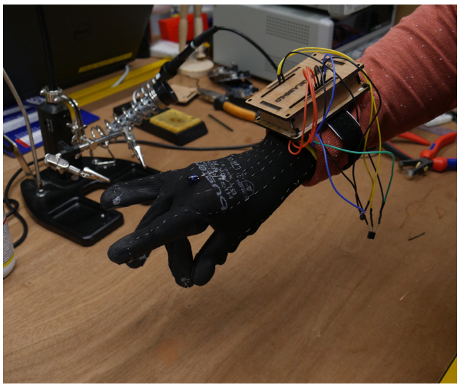




Insert the Arduino and the breadboard on top of it in the case. Put the connection pins through the foreseen holes in the cover of the box. Put the pins in the right inputs/outputs of the Arduino. Click the cover on top of the box.





Cut a piece of Velcro with the length equal to the outline of your wrist. Glue the two parts of the Velcro on top of each other. Put the Velcro bracelet through the foreseen holes in the bottom of the wooden box. Put on the glove and the wrist bracelet.

The battery can be left outside the box, which makes it easier to replace.
Put a piece of velcro at the back of the 9V battery and the reverse part of the velcro on the outside of the box.

Step 8: Programming the Arduino

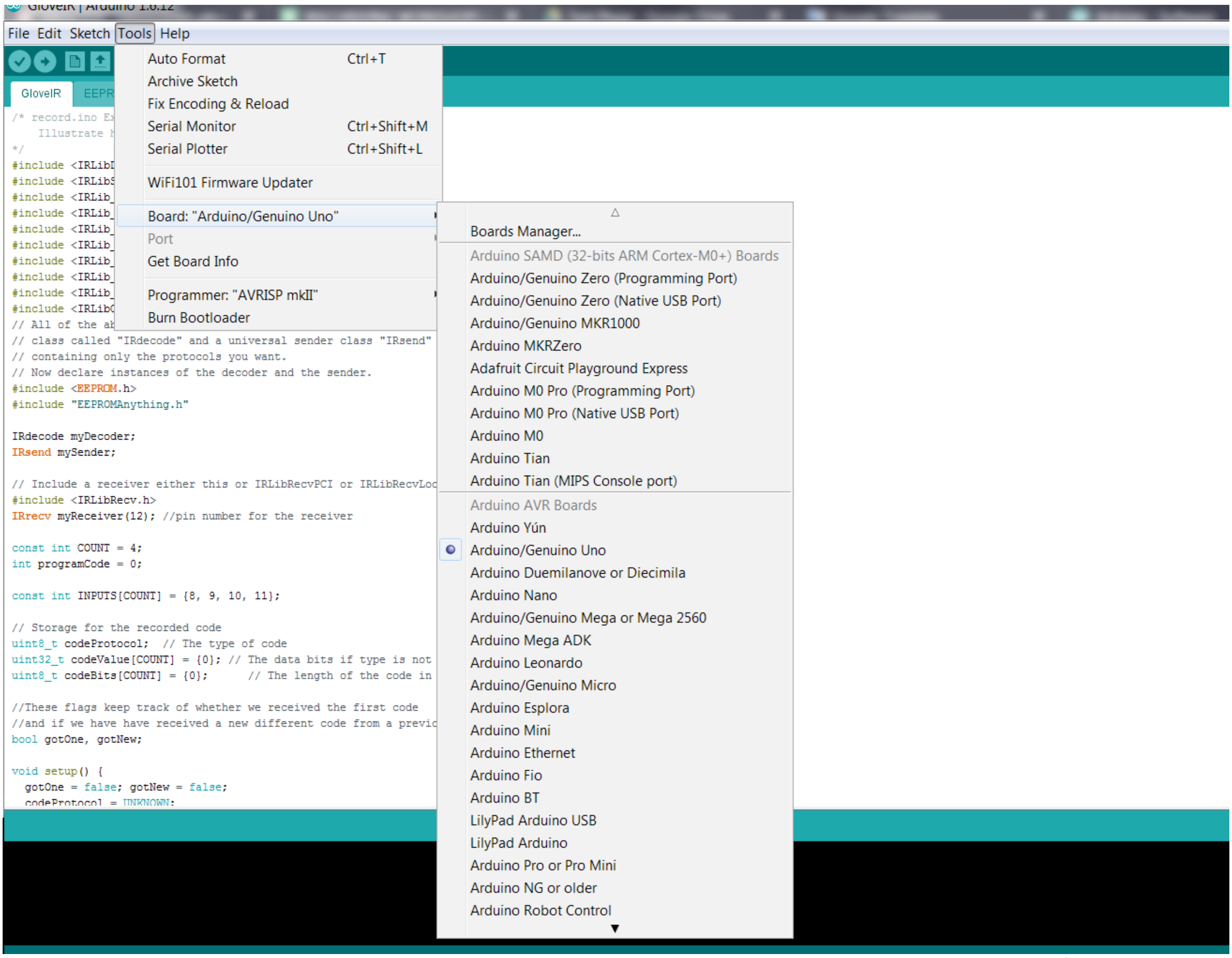
Note: programming doesn't work with the arduino version 1.8.7 due to an internal error - arduino version 1.8.5. needs to be used for the programming part.

Steps for the use of Arduino:

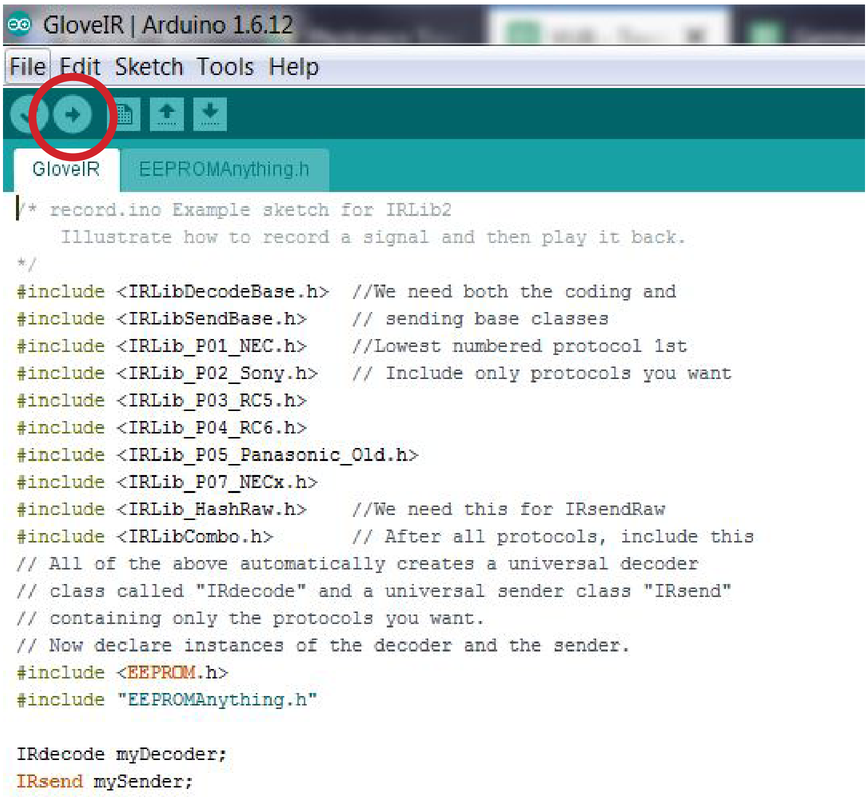
1. Download the program 'Arduino' on your computer. Arduino is open source and freely downloadable via this link: https://www.arduino.cc/en/Main/Software
With the Arduino Uno and this programme, you can build a lot of systems.

2. To use the programme for the IRglove, you first need to install the IR Library.
-Visit the IRLib2 page on GitHub.
-Select "download ZIP", or simply click on this link.
-Unpack the ZIP-file after download.
-The file "IRLib2-master" contains 5 seperate files. This is because this library is a collection of 5 libraries which work together.
-Make a copy of all 5 files to your Arduino-library file next to your other Arduino-libraries. Mostly you will find this in your file: home/Documents/Arduino/Libraries. Libraries can't be installed next to the Arduino-application itself.
-Restart the Arduino IDE programme.

3. Connect the Arduino to the computer. Select the correct board: "Arduino/Genuino Uno". And then select the correct "Port".

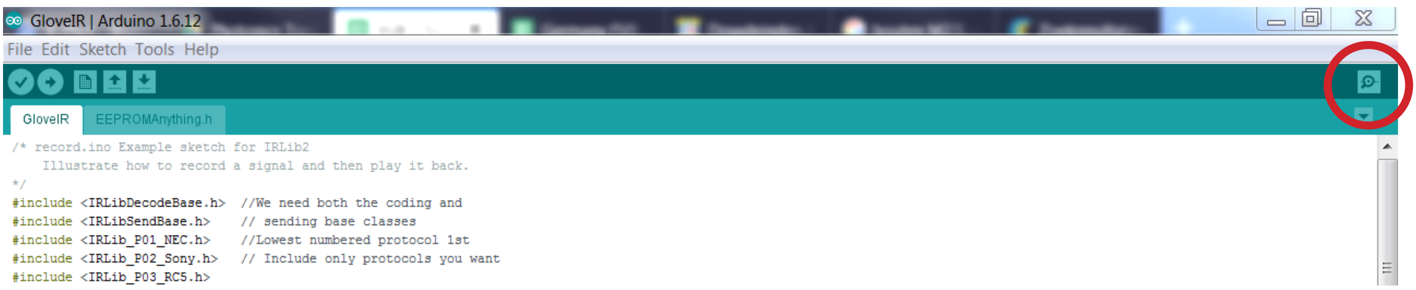


4. Upload the program "GloveIR" to the Arduino. 2 tabs will open: GloveIR and EEPROMAnything.h



5. Pick a device with remote control (working with IR) which you would like to control with your IR glove.

You can put 4 commands in your Arduino. Open the Serial monitor of the Arduino programme by clicking on the magnifying glass in the right upper corner.



Type first number '0' and then push on a button on your remote control while you point out to the IR receiver. You will receive a message when the signal is loaded to the programme. For the next finger you do the same with number '1'. Number '2' and '3' are for the other fingers.

Now these commands are recognised by the Arduino.
Be carefull! Make sure the Arduino is powered all the time, otherwise he will lose the commands. Attach a battery to your Arduino before disconnecting the Arduino from your computer.
Point out the glove to the device and try to put it louder, on mute... by pushing your fingers to your thumb.

PHABLABS 4.0 is a European project where **two major trends** are combined into one powerful and ambitious innovation pathway for digitization of European industry:
On the one hand the growing awareness of **photonics** as an important innovation driver and a **key enabling technology** towards a better society, and on the other hand the **exploding network of vibrant Fab Labs** where next-generation **practical skills-based learning** using KETs is core but where photonics is currently lacking.

www.PHABLABS.eu

This workshop was set up by the *Brussels Photonics Team, Vrije Universiteit Brussels* in close collaboration with *Fablabfactory*.