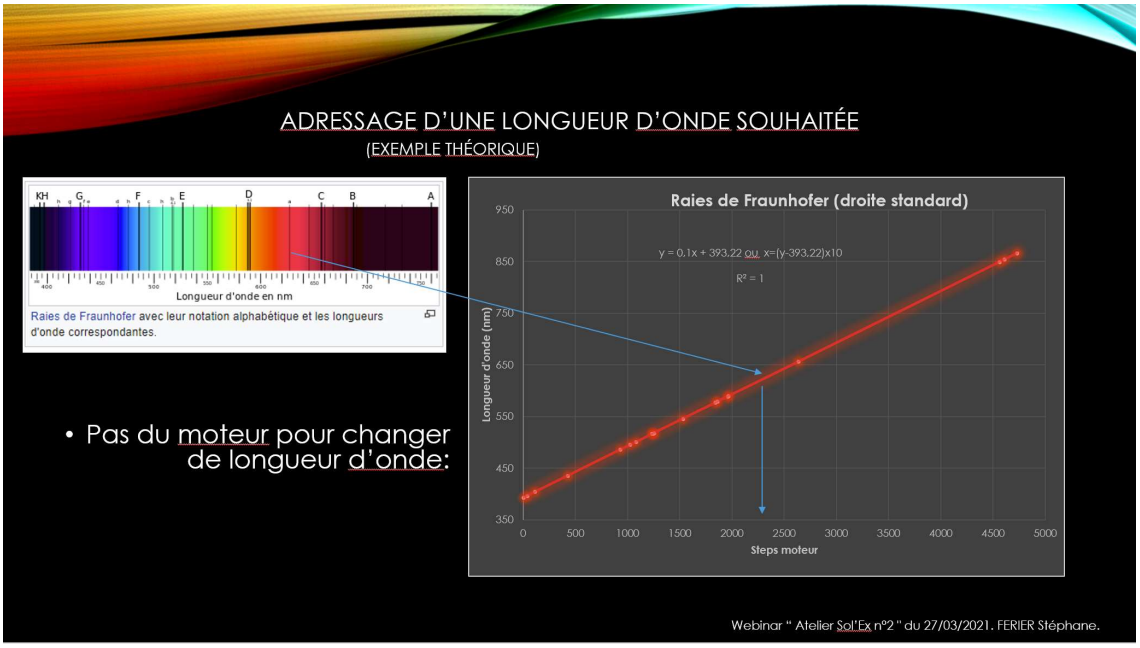
Motorization of Sol'Ex (by Jean Brunet and Stéphane Ferier)

Brief history:

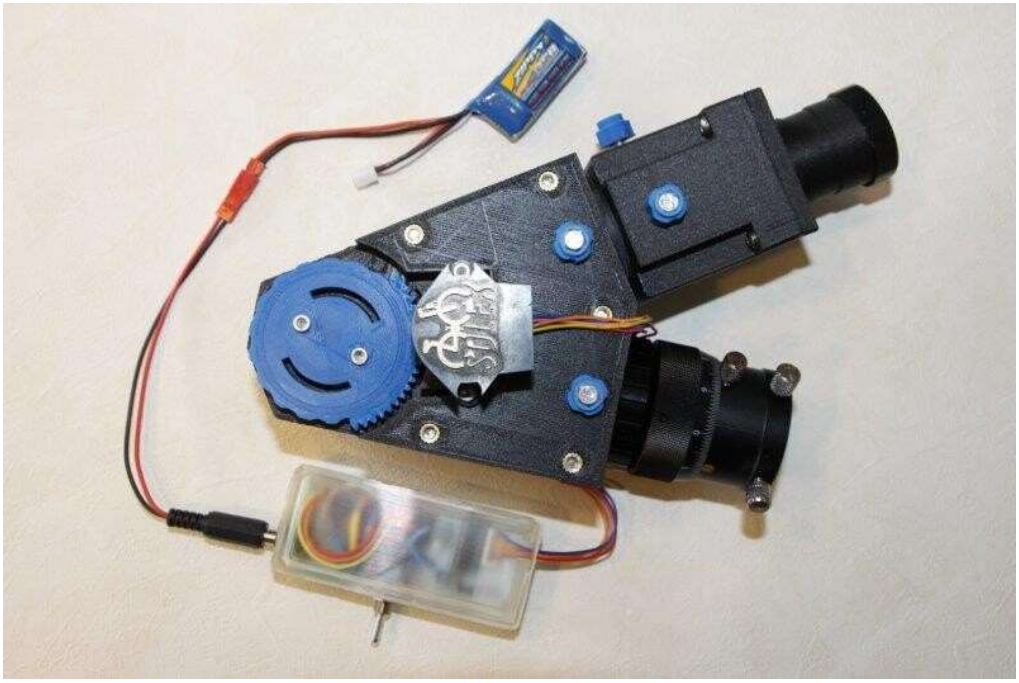
At the beginning of the Sol'Ex adventure, I quickly wanted to motorize the spectroscope, in order to facilitate the user's search for bands of interest.

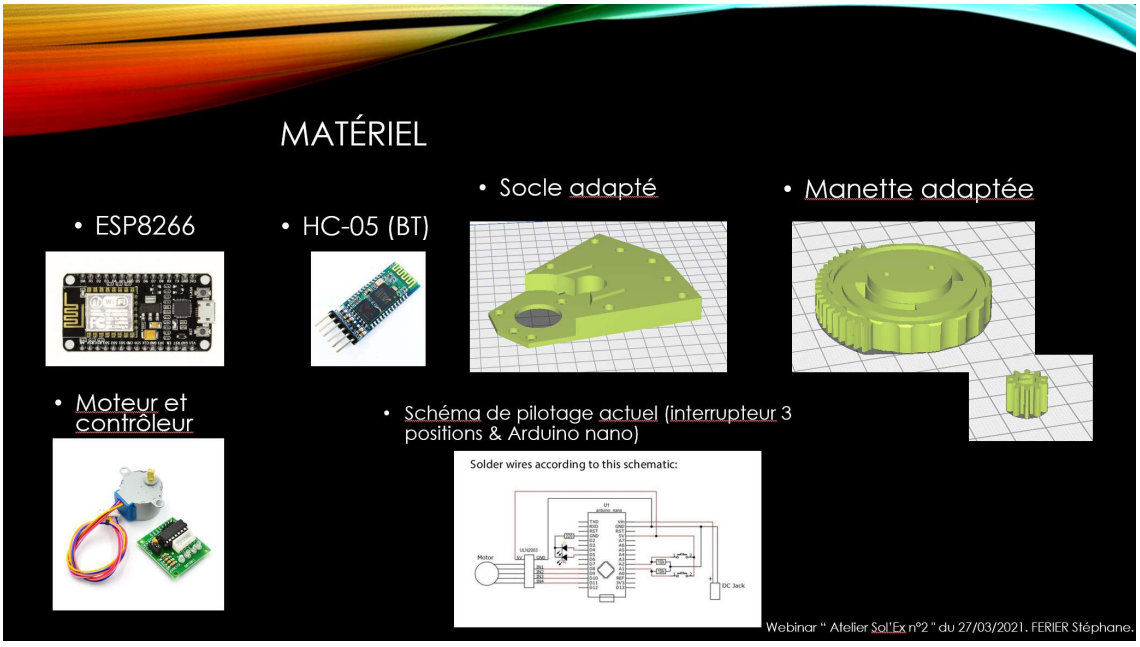
Indeed, the multitude of bands of the solar spectrum does not make it easy to find its way for the beginner in spectroscopy. The simple fact of searching for the Hα line can take precious time, especially when the equipment is to be put back in station if one does not have a fixed astro shelter. Place the mount, orient it correctly to be able to carry out solar monitoring (day stationing) assembly of the scope and Sol'Ex; search for the line of interest ... All this can be time-consuming and discouraging to take out the equipment if the sky is cloudy and offers few "shooting windows"!

The idea was then to motorize the rotation of the grating, and to be able to record the difference between the order 0 and the Hα line. Make a standard line on the lines of major interest. Subsequently, calculate the number of motor steps to be achieved to be able to reach other lines of interest, taking into account an approximation of linearity in the distribution of lines of interest and motor steps to reach them.



A basic application (left and right movement order) based on the ESP8266 managed by Wifi has been developed, as well as a prototype support to embed the engine.

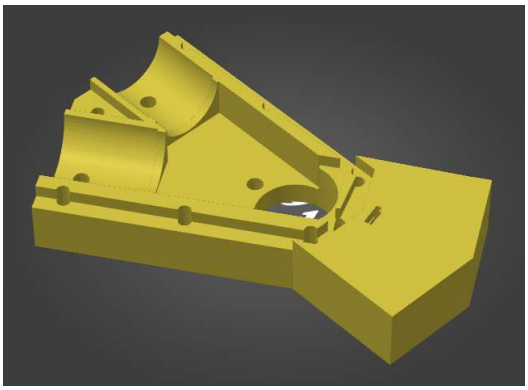
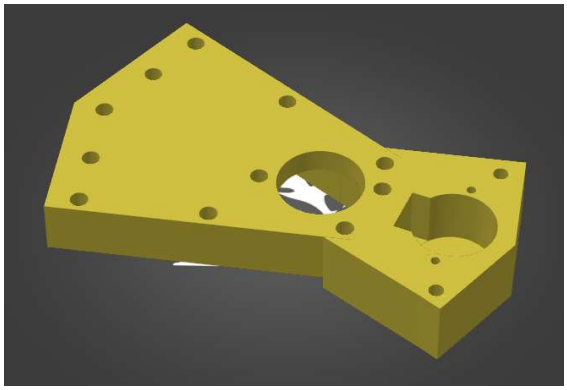




Unfortunately, the engine displacement was unable to cause the network to rotate. I only recently understood by talking with Jean that the problem was most likely due to the driver used which is not optimized to give the impulses that suit this type of stepper motor.

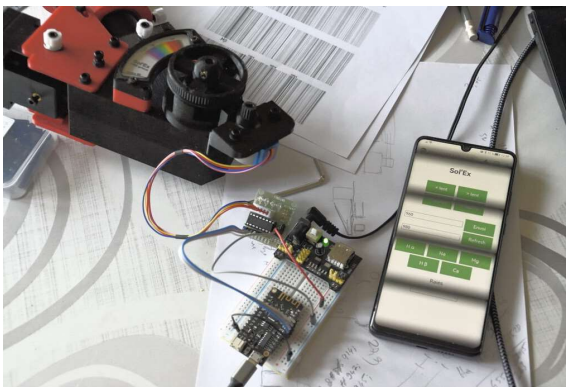
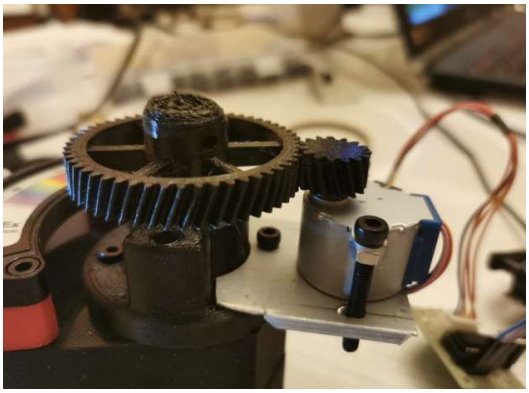
A second prototype is then envisaged, using a belt rather than a tooth-to-tooth drive used for this first test.

In order to make the system as compact as possible, I then redesigned the upper part of the main body of the Sol'Ex to integrate the engine.

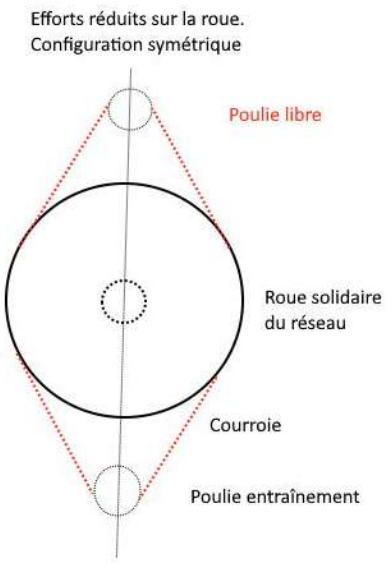



This test, although "cleaner" integrating the engine in the axis of the Sol'Ex did not allow at this time to improve the problem of the drive. (We now know why!!). I was desperate to find a working solution.

From his side, the idea of motorization had also germinated in the mind of Jean Brunet! His first prototype was shared with us for Saint Nicolas (... and yes, I'm Belgian, and at home, it's gift day 😉)

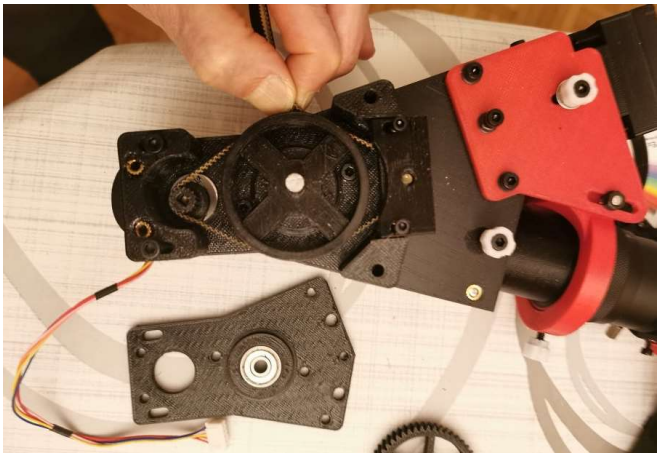
That's when we started talking about the topic offline, because in our conversations, he came up with a brilliant idea to my eyes, to go back to an additional box, using ball bearings and a drive axis.



The physical constraints of tension on the axis of the grating support took advantage of this to disappear ... In addition, Jean had also made a perfectly functional software and directly bringing "pre-programmed keys" to align the major lines! Subsequently, the free pulley of the diagram above bringing nothing special was removed.

My happiness was made ...

Here is its case in test version:



All that remained was to optimize the parts for easier realization, using pulleys and a belt, easily found by internet.

During this time, Jean was refining the electronic part by making a test PCB, and a box adapted to its electronic assembly. By my side, I updated the software for use with commercial wheel of 60 teeth.

We offer in appendices the fruit of our joint work, including a simple mechanical assembly, and two possible options for the electronic part, based on either a PCB to be engraved, or a prototyping plate as illustrated in this image.

The programming of the engine is also explained in detail below.

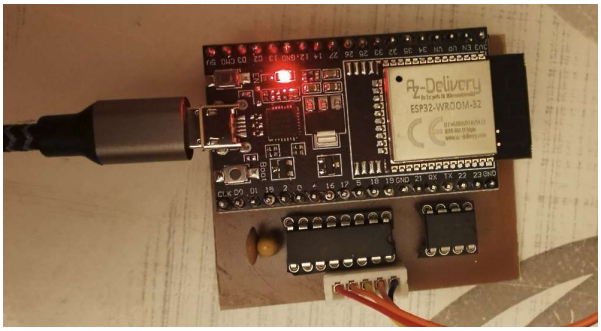
Regarding the equipment to be purchased, everything is also found further down in this document, including links to find the parts to order.

3D printing, electronic editing : Preamble.

As said a little above, annexed to this document, you will find the . STL files necessary that will allow you to print the lower and upper frames, as well as the new grating support suitable for mounting.

Next point of attention: it is not given to everyone to know how to print a PCB (support board for electronic components).

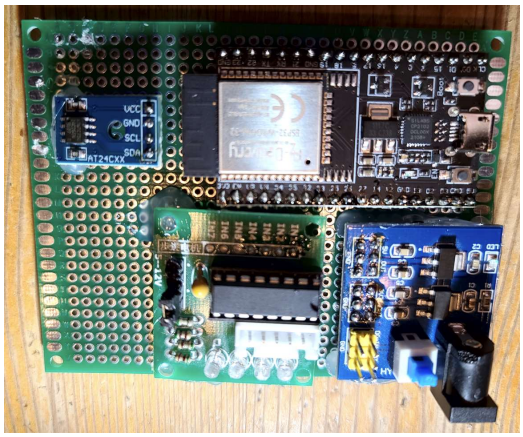
You will therefore find two possible options: either the plan to print your PCB and mount the electronic components, as well as a box, or the diagram to mount the components directly on a prototyping plate. Power is supplied through the USB port of the ESP. It is the only way to consider to power the engine.



In the "prototyping" kit, the electronic part will be placed on a prototyping plate. As you can arrange the components to your willing, there are no STL files for the case here.

A PPT file lists the connections to be made between the components. The advantage here is that without the skills to make the PCB, you can still realize the motorization of your Sol'Ex.

Another advantage of the power supply offered here is that you can ideally supply 12V (from 8 to 12V in reality, but I recommend 12V), and that the module has an integrated "on / off" button. The realization of a box can then use this additional function. Be careful that to work properly, the ESP must be powered by USB (in both options).



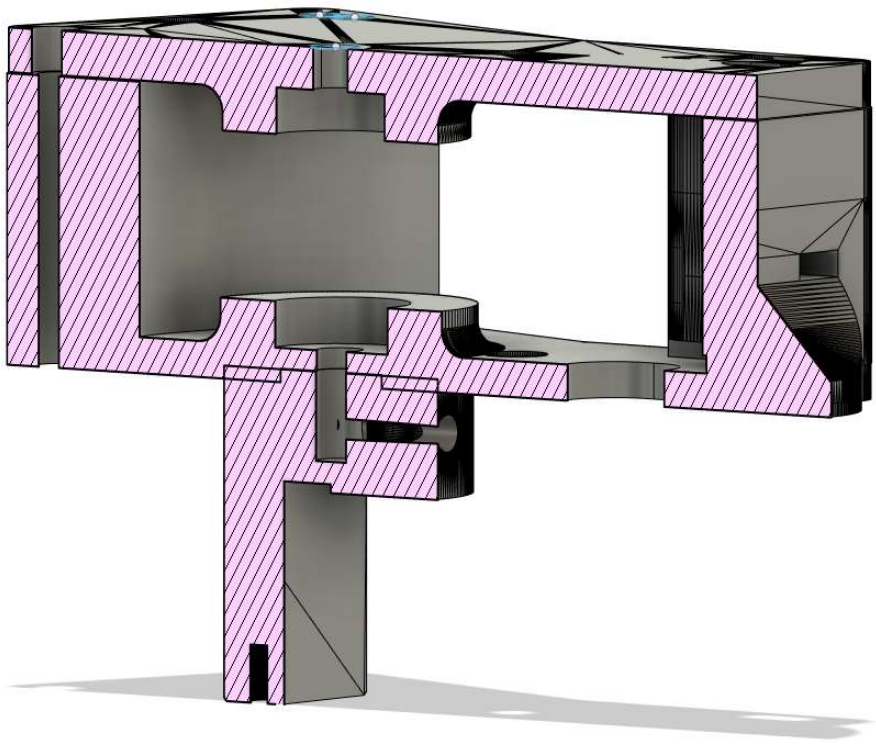
For the printing of 3D parts, there is always PETG, but I preferred to use PLA+ or PLA + Carbon from Sunlu. This material is harder once cooled. The PLA+ is printed at 225°c, on a bed at 80°c. To improve adhesion when printing, use 3D lacquer on your printing glass. You can also test with hair spray, but it adheres less than the one intended for 3D.

Parts to be printed in 3D:

The mechanical part is composed of:

- A new network support adapted to insert a 5mm long axis of 40mm (or 50mm if you want to use Xavier's vernier above the motorization), which will be used for axis rotation. In order to fix the axis in the grating holder, a Ruthex M3 nut and a headless screw are used. It is also possible to glue the axis in the grating holder, but be careful that the metal axis must be perfectly vertical!
- The lower frame that will receive a ball bearing and pulleys/drive belt;
- The upper frame which will also receive a ball bearing.

3D section of the different parts to be printed:



Assembly of the motorization kit:

As we have already made our Sol'Ex, the most difficult is far behind us! It will therefore be necessary here to carefully replace the initial network port by that of the kit.

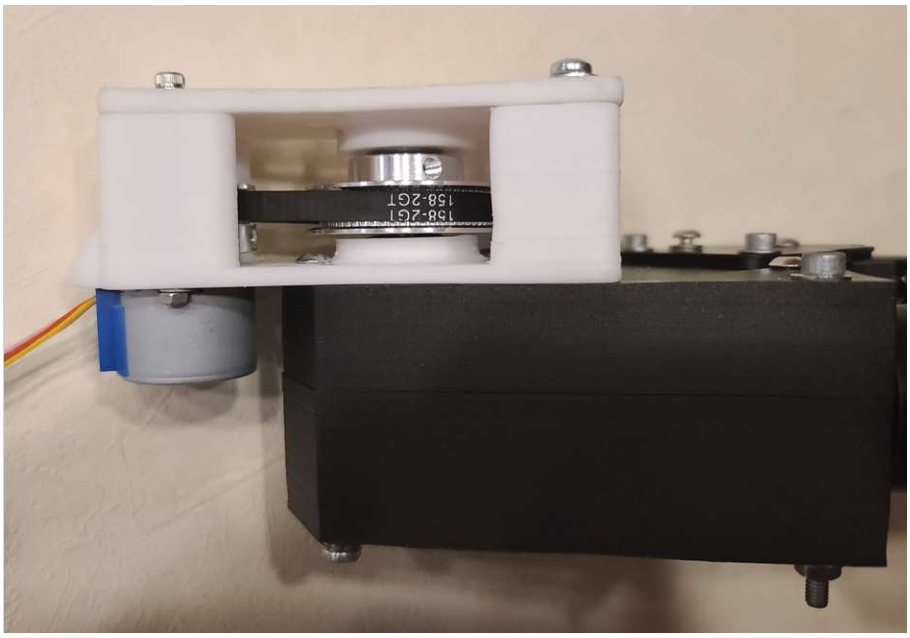
The first thing to do, before setting up the grating, is to fix the axis in the grating support. You can glue it with a two-component glue, or use a 3mm Ruthex and a headless screw, to be inserted into the hole perpendicular to the axis of rotation of the network holder.

The grating will then be placed on the grating holder, then all inserted into the body of the Sol'Ex.

Then, the lower frame is placed around the axis and it is secured to the Sol'Ex by the screws that were used to fix Christian's grating wheel.

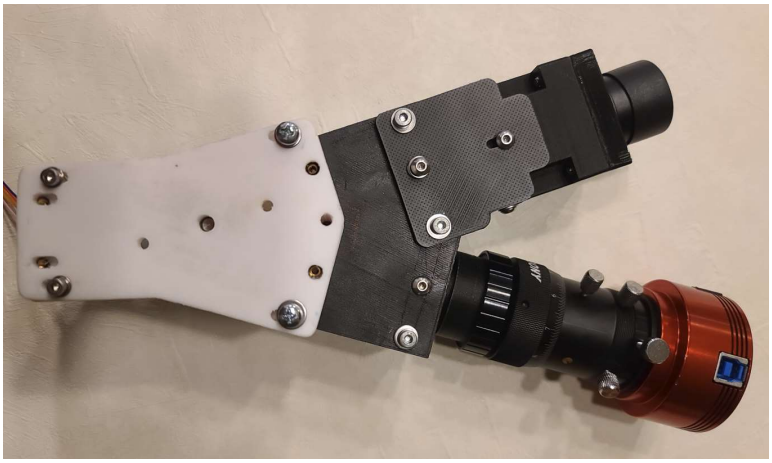
The main pulley is then placed on the axis. Here too, it has headless screws to make the axle and pulley solid. Remember to identify the orientation of

the zero order of the network by a line on the frame and pulley. We then arrange the pulley that adapts to the engine, as well as the belt before fixing and slightly tightening the belt by fixing the motor on the lower frame. It attaches to the outside of the mount.



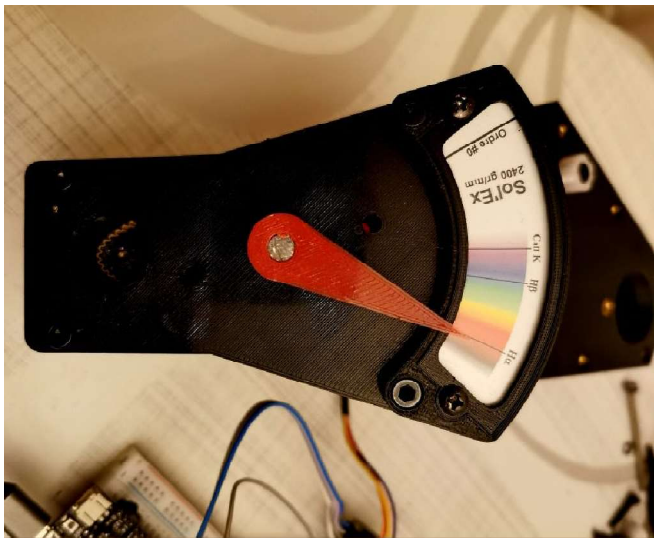
As can be seen in this image, the motor holding screws pass throughtwo frames. We also see here the headless screw housings of the pulley.

The closed ensemble looks like this:



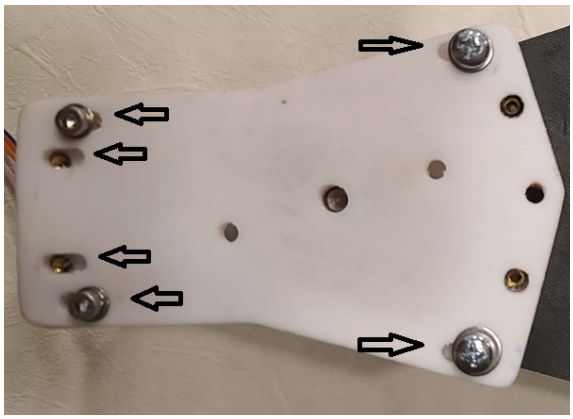
Two long M4 screws complete the assembly and solidify the whole thing a little more. Xavier's vernier can also be added, in order to keep a visual reference on the position of the network. In this case, the axis of rotation

will have to protrude from the assembly, in order to be able to attach a needle that is available in the RAR kit.



Adjusting the axis tilt:

In some cases, it may be that the image sent back by the grating to the camera is not well centered ... This misalignment can be corrected by adding small tape behind the grating, in order to incline it as needed ... But rest assured, I didn't need it.



The mechanical part is over!!

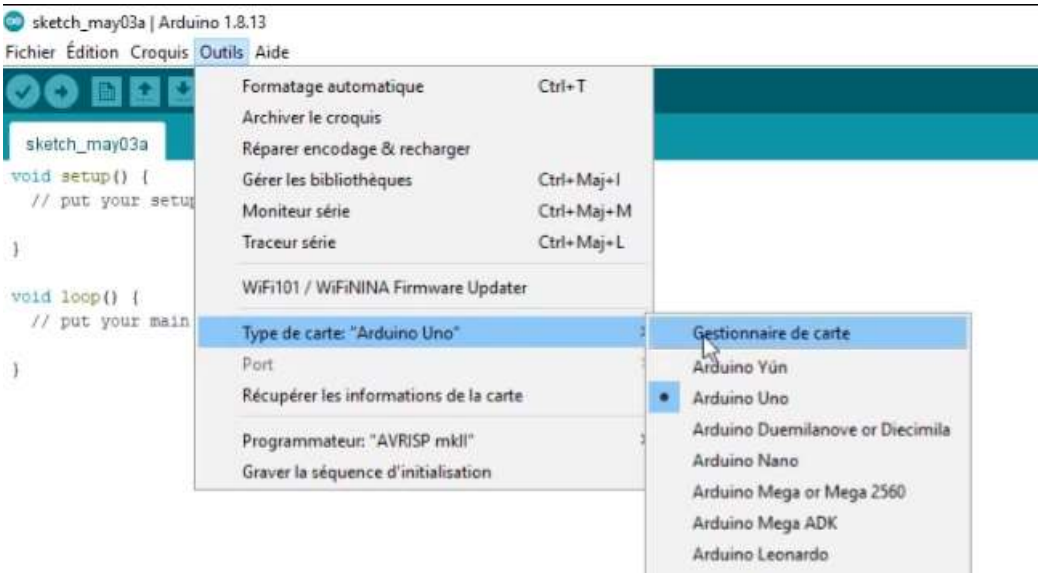
Loading the software into the ESP:

This part may seem complicated, but it is not!

We will assume that you have a PC at your disposal, but a MAC can also do the trick, because ARDUINO software is available for both platforms. It can be downloaded for free here: https://www.arduino.cc/en/software

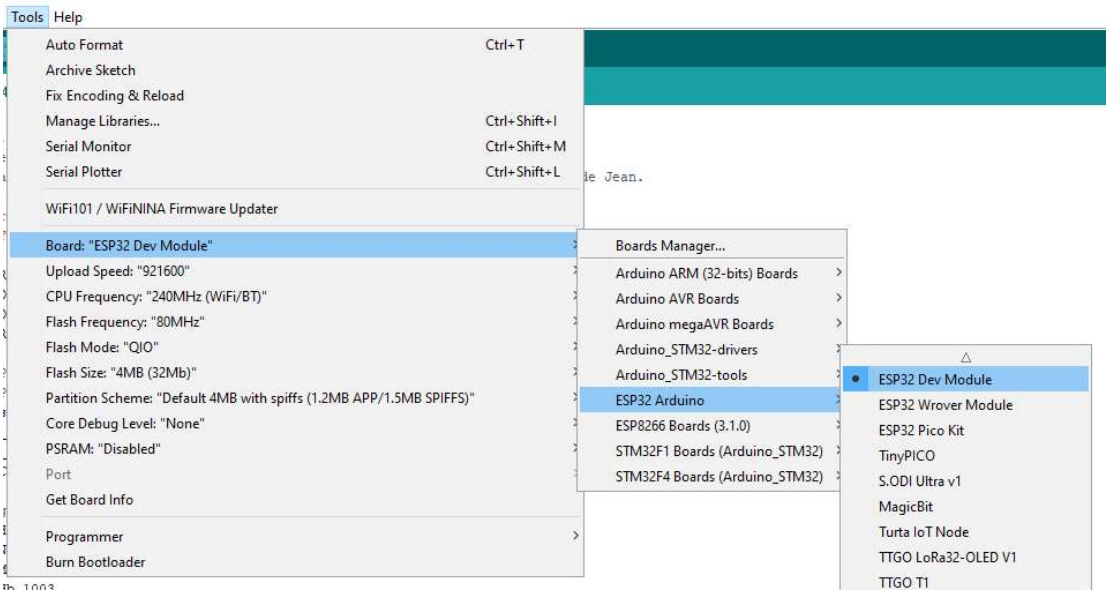
Once the program is installed, you can start running it. Now we need to add the ESP card management module that interests us like this:

Open "Tool/Card Type/Card Manager"



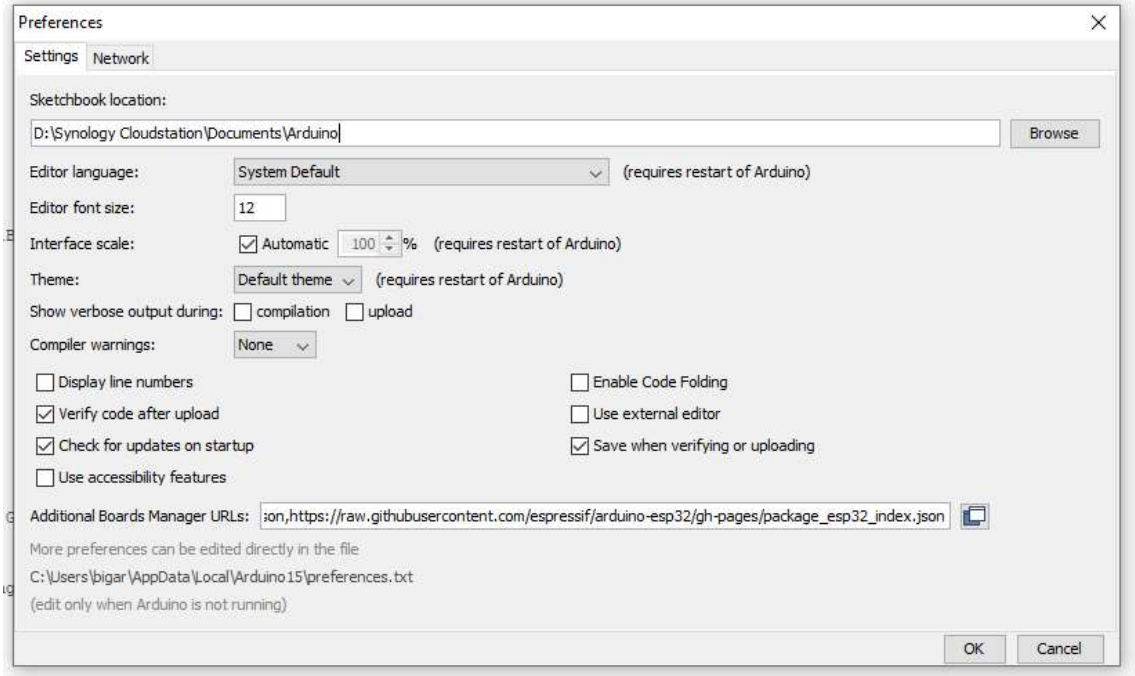
Type "ESP32", you can install version 1.0.6

Then select ESP32 Dev Module:

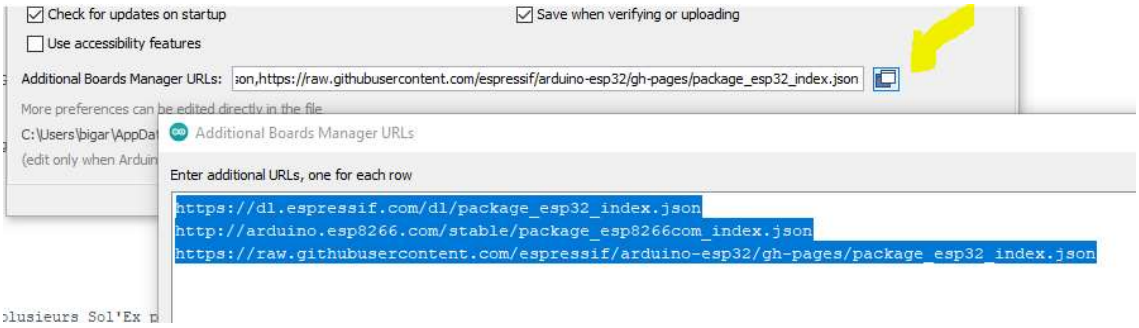


You drop the "Arduino" folder that is in your RAR file into the "Documents" folder.

In the "File/Preferences" menu of the Arduino application, specify the path of the folder where you want to deposit the working files. In my case, I chose "Documents/Arduino":



While we are in this window, take the opportunity to add in "Additional Board URL Manager" the following lines, which can be used for other Arduino applications:



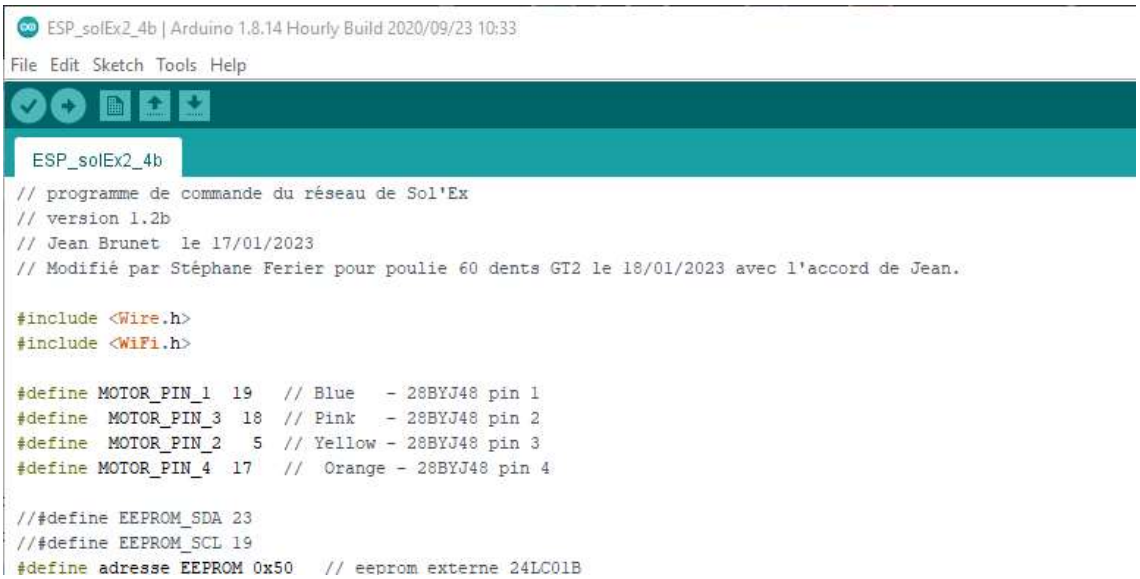
https://dl.espressif.com/dl/package_esp32_index.json

http://arduino.esp8266.com/stable/package_esp8266com_index.json

https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json

You can close this window.

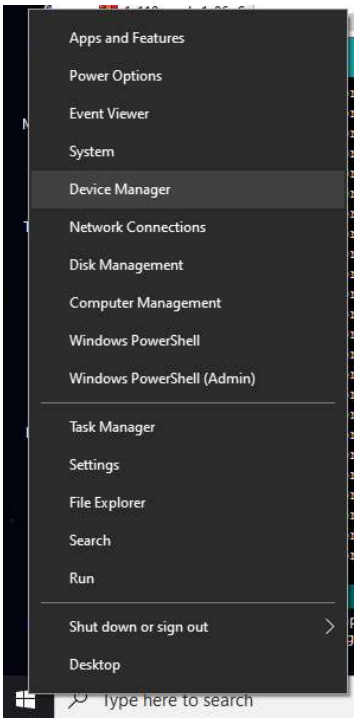
Now load the file "ESP_SolEx . INO" located in the "Documents/Arduino/" folder



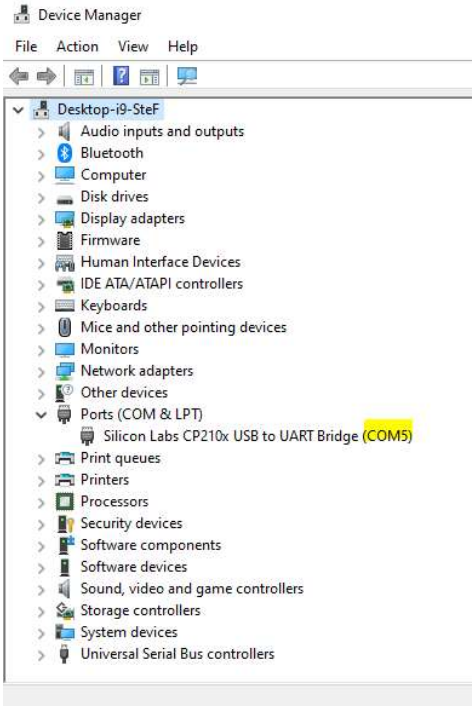
Connect the ESP32 via a USB cable to your computer, a red LED should light up continuously on the ESP.

Check which "Com port" the ESP is connected to your PC/MAC:

Right click on the Windows window; Device Manager:

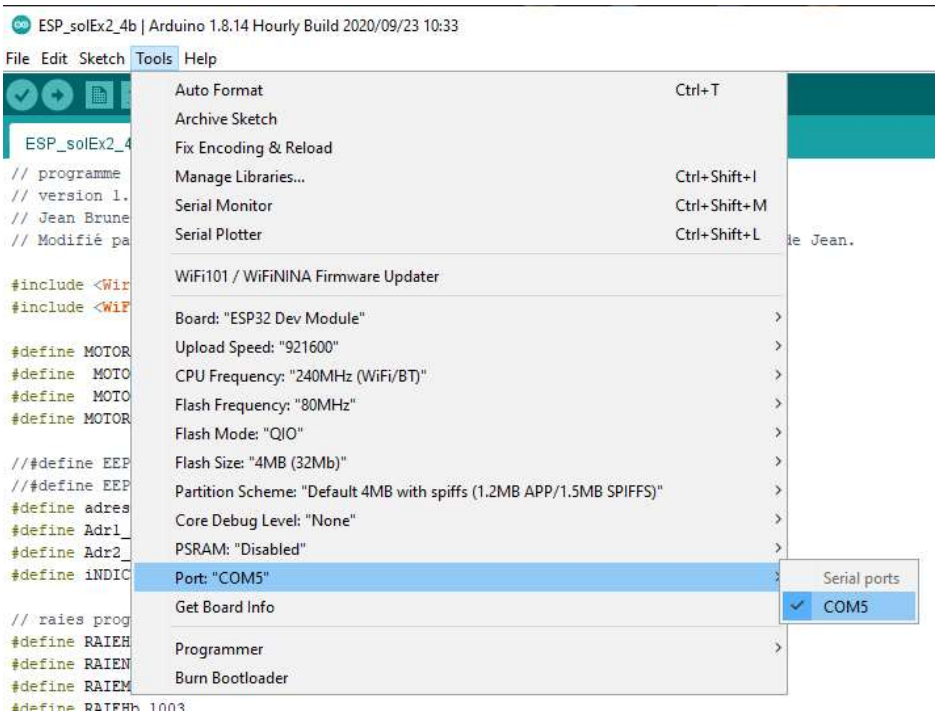


then:



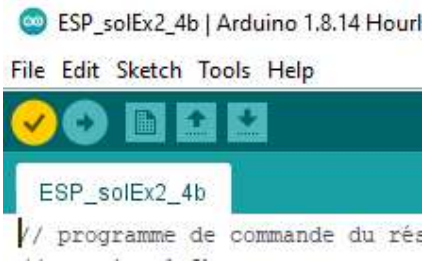
In my case, it is the port "Com5" that is assigned to the ESP.

Then check the connection equivalence here:

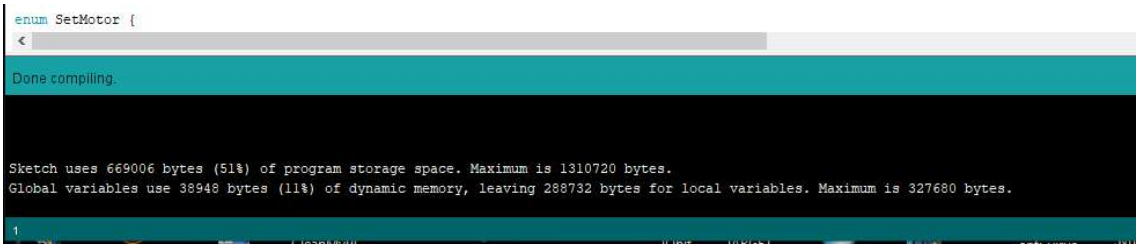


You are now ready to upload the program to the ESP.

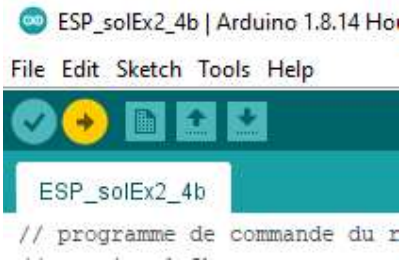
We check that everything is ready by clicking on the "v" button here:



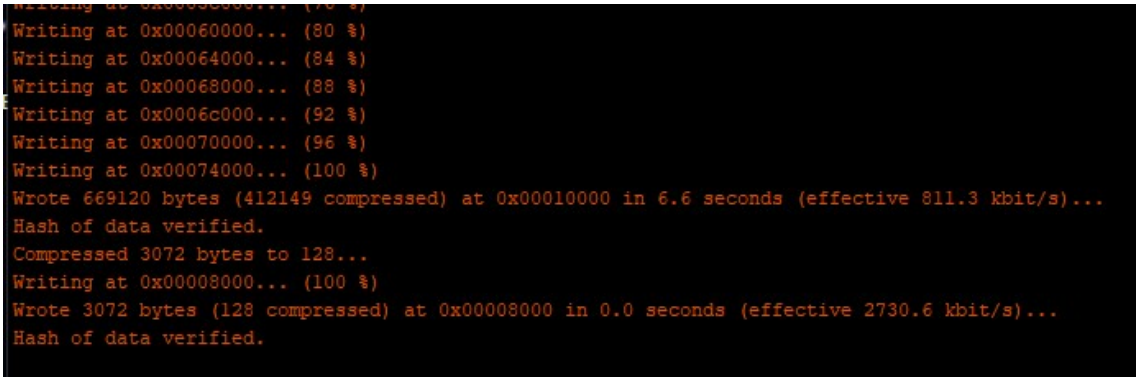
The console should tell you this:



In this case, the upload can be done by clicking on the arrow:



The console informs us of the upload status, and concludes with:



Congratulations, you have programmed your ESP. We will be able to test all this ...

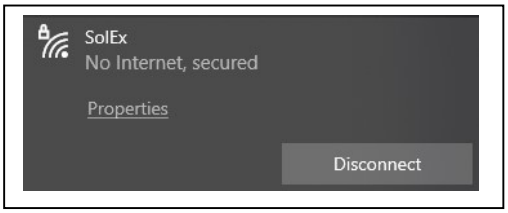
Motor position adjustment / zero order:

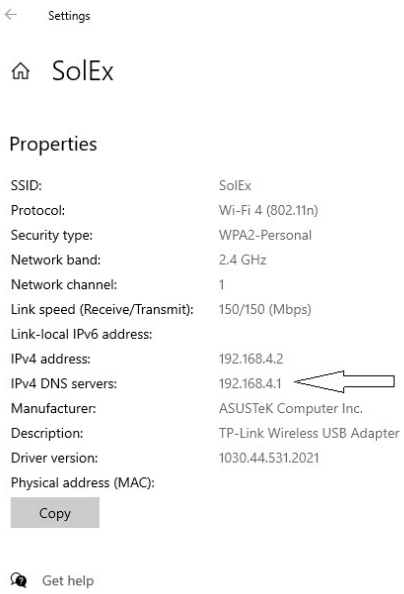
Let's feed our assembly ...

The interface is called after connecting by WiFi to the Sol'Ex server. The default password is: solex1234

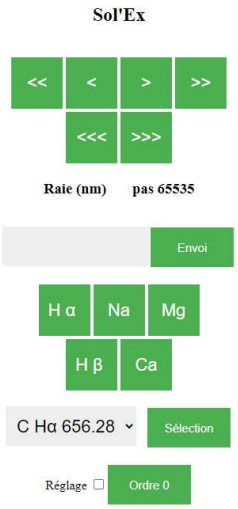
To call the interface, enter the following http address: 192.168.4.1

If this address is already used by your network, you will find the one defined by your DNS server for Sol'Ex here: (open SolEx "Properties" in your WiFi network connections)

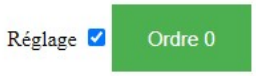




The interface appears as follows:



Check the "setting" box, then click the green/blue "Order 0" box:



This has the effect of emptying the "Line (nm)" field and setting the number of steps to zero.

Raie (nm) pas 0

Then use the arrows to return the grating to the "order 0" position

... And precisely adjust the order 0 in the center of the window of your Camera, in the area you will use when scanning the sun.

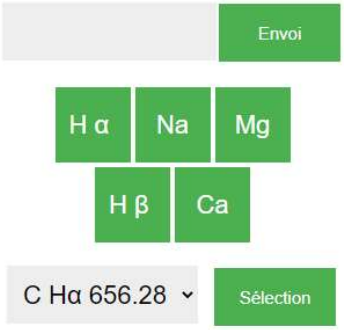
When this is done, uncheck the "Setting" box to test the programmed wavelengths.

3 selection zones are possible to rotate the grating to the target wavelength:

Preprogrammed boxes (Hα, Na, Mg, Hß, Ca);

The multiple choice area and the "Selection" button (30 lines of interest are encoded);

The free field and the "Send" button.



Depending on your choice, the motor rotates the grating until it reaches the wavelength of your choice. The display then indicates the centered wavelength and the number of motor steps of this position.

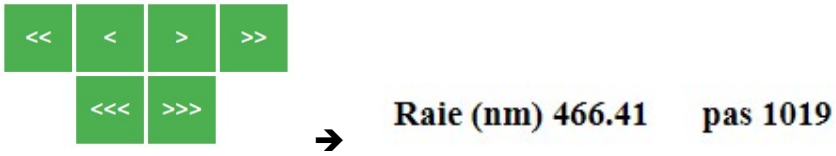
Raie (nm) 587.63 pas 1356

You then have the choice to change the wavelength of interest using one of the 3 selection modes: the pre-programmed boxes or fields, or the use of the outbox:

By pressing "Send", the engine will decrease or increase the number of steps from the current position to your new target in increments of several engine steps, until it approaches your target (but does not position itself accurately)

Raie (nm) 478.05 pas 1049 ➔ Raie (nm) 464.84 pas 1015

To refine the position, you can then use the arrow buttons until you reach your target more accurately:



The arrow 

increments by 2 motor steps; 10 steps; 

25 steps.

If you stop the engine by turning off its power, the last position is stored in the EEPROM, so that if you have not manually changed the position of the grating, when the system is turned back on, the information is picked up where it was interrupted.

However, it may be useful (or desired) to check this position. In this case, pressing the "Order 0" button will return the grating to order zero. Be careful not to check the setting box in this case.

Note: The programs recorded in the "ESP_SolEx.INO" file that you uploaded to the ESP32 are valid without modification for the sole use of a 2400 lines / mm grating, in combination with the gear wheels recommended in the proposed system:

- 60-GT2 main pulley, 16-GT2 motor pulley and GT-2 belt

  Have fun!

Jean and Stéphane.

Material used:

Mechanical part:

PLA+ (Sunlu) for parts to be printed (bed at 80°c; print head at 225°c);

5 Ruthex M3 & 2 Ruthex M4 ; washers for M3 and M4

2 x M4 50mm screws; 4 screws M3 15mm and 2 screws M3 40mm + nuts

1 M3 headless screw (to fix the axis in the network holder

1 axis 5mm diameter, length 40mm: https://www.amazon.fr/dp/B07P45W61W

2 x 625ZZ ball bearings: https://www.amazon.fr/dp/B079DKGWS9

1 motor 28BYJ-48 5V (see below for reference)

1 pulley 60 teeth https://www.amazon.fr/dp/B07N65GCL6

1 pulley 16 teeth https://www.amazon.fr/DollaTek-aluminium-al%C3%A9sage-largeur-Imprimante/dp/B07DK3DCMS

1 belt 158 teeth https://www.amazon.fr/dp/B07D923SDS

Electronic part:

ESP32-WROOM-32 Dev kit C4: https://www.amazon.fr/dp/B08BTS62L7

ULN2003 & 28BYJ-48 5V motor: https://www.amazon.fr/HUABAN-moteurs-28BYJ-48-module-ULN2003/dp/B08B4J33HX/ref=sr_1_6

USB connector for power: https://www.amazon.fr/dp/B0BQMWCSFL

EEPROM : https://www.amazon.fr/dp/B07RHMPRK1

Power module: https://www.amazon.fr/DollaTek-dalimentation-Conversion-Tension-Multi-Sortie/dp/B07DK4NTH3

Prototyping board 7x9cm: https://www.amazon.fr/HeyNana-prototype-perfor%C3%A9e-circuit-Prototype/dp/B0924S5RD6

USB cableto program the ESP;

12V or USB power supply depending on the chosen assembly.