Artificialis Photosynthesis

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Final Project Paper
Hardware & Physical Computing
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1. Storyline

We as media technology students are aware of all the innovative technologies which are put out in the world. We see the rise and fall of all kinds of products and see their values and implications on our lives. But often we neglect thinking about the consequences of using these (new) technologies. Not only do they affect mental states and create a societal impact, but an often unrecognized problem is also the environmental impact of old technology.

While we live in a society where it's more the norm than the exception to buying new technologies when they come out this consumeristic mentality creates a pile of old technology. Not only do the materials needed to produce these items impact the environment but also the effects they have when they will be thrown away, hoping they would get recycled. This is unfortunately most often not the case.

E-waste is a bigger problem than a lot of people realize, our old electronics get shipped to third-world countries, where they get thrown on a pile and locals will try to extract some elements from it which they can sell on the local markets. These people are living and working on these e-waste junkyards with their families and stock animals. E-waste contains a list of chemicals that are harmful to people and the environment, when electronics are mishandled during disposal, these chemicals end up in the soil, water, and air.

That’s why we focussed on our project by working with recycled materials of old electronic waste (except the Arduino parts). We created an E-waste plant that symbolizes not only photosynthesis but also at the same time shows the impact of e-waste on the environment. We started with a plan to recreate a self-sustainable plant to mimic photosynthesis, while iterating this design we focussed on including e-waste as material for the plant, we used old circuit boards and wires to create the plant.

The object is self-sustainable and can be placed at any location with light, the solars and sensors will detect the light and extract the energy from it, this is visualized by the led lights placed on the plant itself. Where the lights depend on the input from the sensors. The green lights visualize the input from the light source and how much light is detected. They will turn gradually towards red when the light gets less bright. The blue lights show how the input gets transformed into energy, by visualizing the output moving upwards.
While this is happening the battery gets charged due to the solar panels, we created feedback on the battery level by placing red led’s in the soil of the plant.

2. Initial plan

Design

In this section the overall design of our product will be discussed. First, the sketches are shown, then the sketches are explained and lastly the design is explained in terms of its functionality.

Sketches

Below our first sketches of the 'Artificialis Photosynthesis' can be found in Figure 1 and 2. In Figure 1 a sketch of our artificial plant can be encountered and in Figure 2 a close-up of the base with the LED strips are illustrated. The design will be explained in section 1.2.

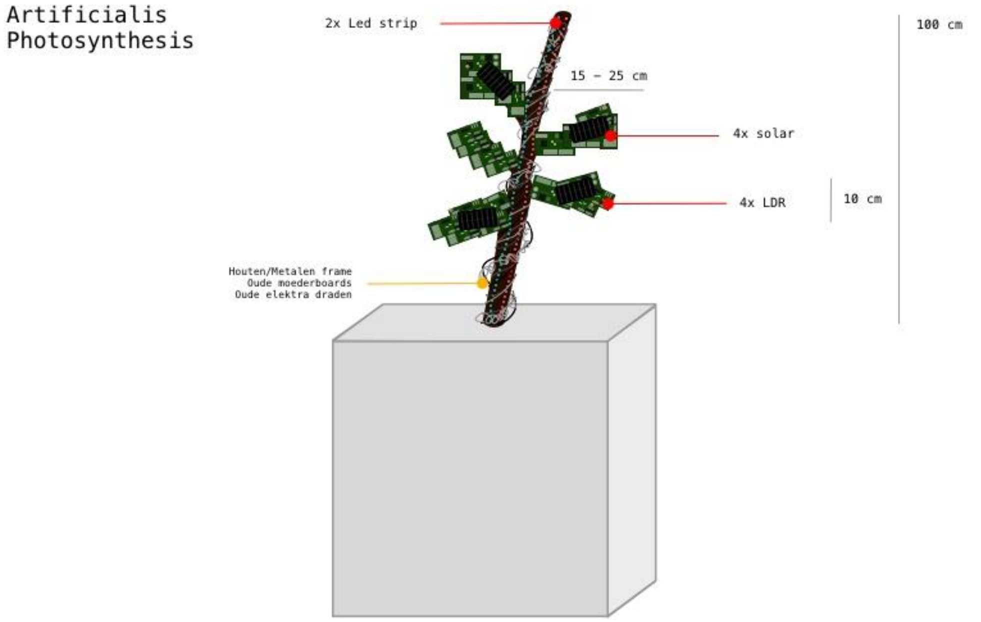

Figure 1. Sketch of 'Artificialis Photosynthesis'

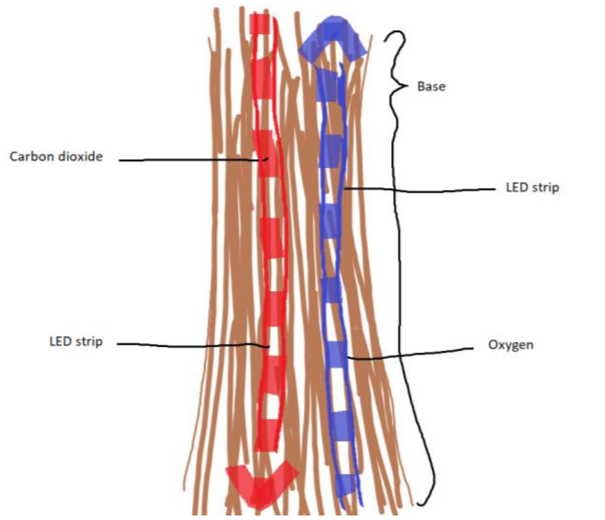

Figure 2. Sketch of the direction of O2 and CO2 LED flow Wikipedia)

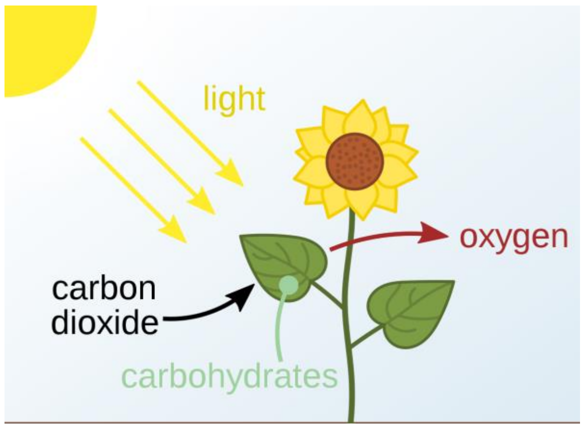

Figure 3. Photosynthesis (picture from

Description

We designed an 'artificial' plant made from electronic waste, as can be seen in Figure 1. This plant will (partly) simulate photosynthesis that is present in real plants (displayed in Figure 3), which is why we called our project 'Artificialis Photosynthesis'. The design itself is still flexible in terms of materials. Nevertheless for now we will use old motherboards for the branches and wires and/ or adapters for the base. The electronic waste material will be gathered from thrift shops, room 406 and our own homes. This will be combined with newly bought solar panels and LDRs functioning as the leaves of the plant. We will also place two LED strips on the base of the plant, to indicate the oxygen and carbon dioxide flows within the plant, as shown in Figure 2. Optional is an LCD Screen which gives feedback on the input sensor.

The 'Artificialis Photosynthesis' has two objectives, which are both educational in their own ways. The first objective is educational in the traditional sense; the user learns how photosynthesis works in plants. This is represented by the input sensors (LDR & Solar) which function as a chloroplast, and by the way oxygen and carbon dioxide flows within the plant (LED).
The secondary objective would be to inform the user/viewer on the importance of plants and how we as humans are piling up our electronic waste. While designing, we got inspired by an article in Trouw which reported this problem of electronic waste. Since sustainability and the environment in general are important virtues to us, we wanted to implement this in our design as well as the thought behind it.

Functional design

We will be using four solar panels to generate enough power to provide the plant of the energy it needs to work. The solar panels will be connected in parallel, whereby the power that is generated will be 5.5v 400mA and is saved on a 3.7 V li-Po battery. All of this will be regulated by the Seed solar charge shield. Each solar panel will be accompanied by a LDR which measures the intensity of light that falls on it. The idea is that the LDR and the LED strip work together. One LED strip will have a blue light for oxygen and the other strip will be red for carbon dioxide. The less light falls upon the LDR, the slower (the speed of consecutive sequence of the LEDs) the flow of oxygen and carbon dioxide. If we have time left, we want to add a LCD screen on the pot of the plant which demonstrates the amount of (sun)light that is present and the amount of power that is generated by the solar panels.

Spatial requirements

The size of the product is comparable to the size of a house plant, which can be put on a desk or in a window frame. Since the 'Artificialis Photosynthesis' needs light to 'live' (to work, be charged), it needs to be positioned in a spot with (a lot of) light, preferably in a window. There is not a restriction on the amount of visitors, since the product is not an interaction between the plant and the visitor. Instead, the plant reacts to the amount of sunlight, and cannot be controlled by the visitor by buttons for instance. This is because the purpose of the work is, as previously described, educational.

Technology

In Table 1. the electronic parts we are going to use for ‘Artificialis Photosynthesis’ are displayed. In Figure 4 the electric circuit diagram of the project can be found.

Part	**Model**	**Number**
Seeed Studio Zonnepaneel - 5.5V 100mA - 55x70mm - met JST-PH connector	SEEED-313070004	4
GL5528 LDR lichtgevoelige weerstand	GL5528	4
Seeed Studio Solar Charger Shield V2.2	SEEED-106990020	1
Li-Po Accu 3.7V 2000mAh - JST-PH	LP103450	1
WS2813 Digitale 5050 RGB LED Strip - 60 LEDs 1m	WS2813STRIP1M60	2
JST-PH 2.0mm Connector met Kabel - 2 Pins	JSTPH2.0CABLE2P10CM	1
JST-XH Female Connector met Kabel - 2 Pins	JSTXH-FEM-CABLE2P30CM	4
470Ω resisto	470Ω	4
DuPont Jumper wire Male-Female 100cm 10 wires	DUPOMF100	1
1000uF 25V Elektrolytische Condensator	1000UF25VELEK	1

Table 1. Electronic parts of ‘Artificialis Photosynthesis’

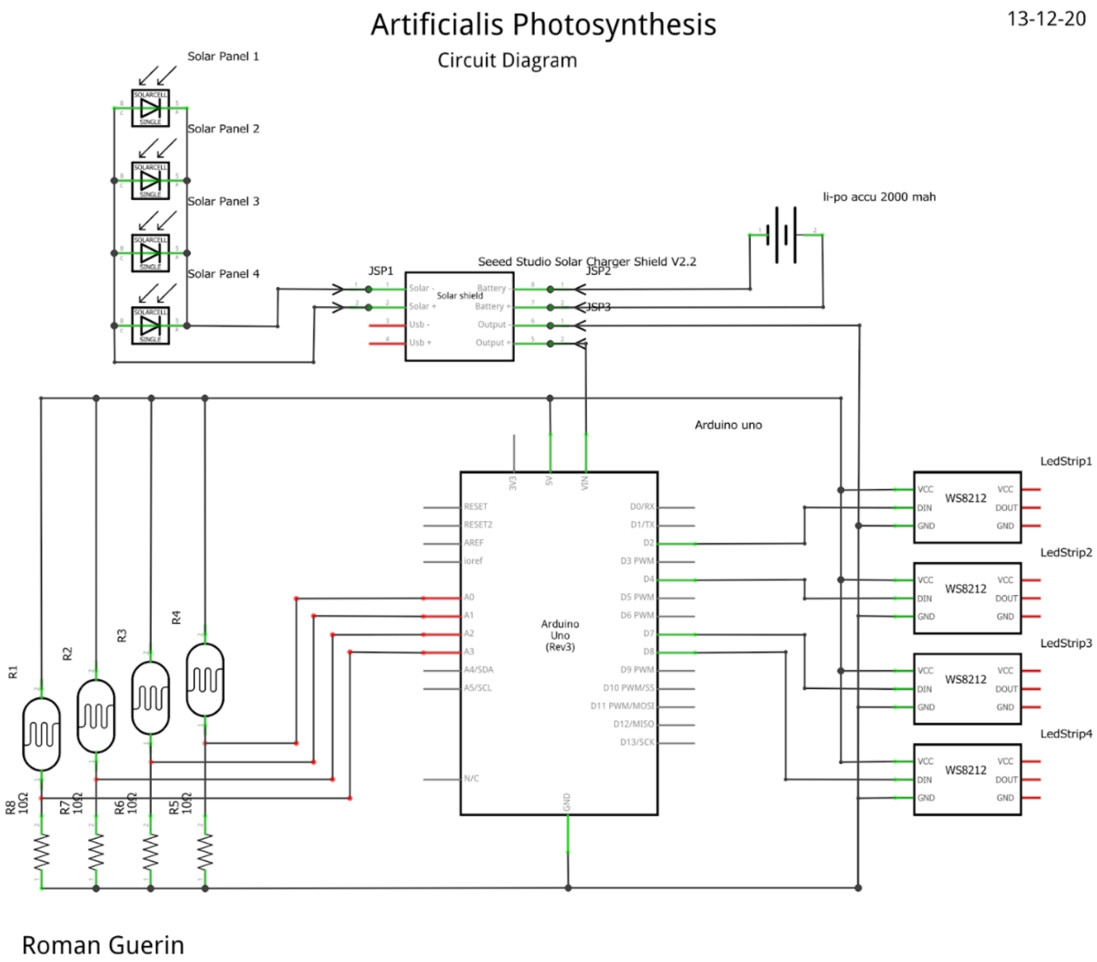

Figure 4. (Previous) circuit diagram of 'Artificialis Photosynthesis'

3. Who did what?

The project consists of four major parts: design, creation ('building'), hardware and technology. The design is created by Tobias and Lieke, as was the creation of the plant, since these elements are intertwined with each other. Roman was fully in charge of the technical and technological parts of *Artificialis Photosynthesis.*
First, Lieke made the base of the plant together with her father (Figure 5 in Section 5) over Christmas break. After this we had weekly group meetings to work on the project together. Tobias and Lieke worked these weeks on building the structure of the plant; think about designing and crafting the leaves, branches and roots. Roman worked on the hardware, and with that the circuit diagram, and the arduino code. In the final phase we integrated these above mentioned four components, design, creation, hardware and technology. Lastly, Tobias shot and edited the video. Roman provided him with the final shots that were missing. Lieke was in charge of the final documentation.

4. Problems and solutions

4.1 Hardware

The first problem would be connecting four solar panels to one solar shield. However, putting them together in parallel with diodes provides the current going to the right input (see Figure 4). The second problem would be the power management for providing all the LEDs with enough stable power. A 1000uf capacitor was needed to stabilize the power draws of the LED strips. Since we chose to solder all the wiring on a shield board together, instead ofusing a breadboard, the management of this had to be very precise and well-thought out. If you look at Figure 15, you will see the difference in what we thought we needed versus what we really needed (Figure 4).

4.2 Software

Arduino has some software limitations as it can only do one task at the time. Therefore you will need to do some tricks to let the code do four different tasks at the same time. First trick is that the loop will check first the input of the LDR before giving the color to the ledstrip. Because if you do not do that the reaction will be very slow. The second trick was putting the colors in an array of 10 different colors and not in rgb. With the array the colors go from green-yellow-orange-red without errors. This works because we needed only these colors and made the code more stable. Third and last trick was giving the integer of maxlight a +10 otherwise the LDRs would sometimes overcompensate there values and giving errors to the overall code.

4.3 Design

First, since the materials we used are quite heavy (circuit boards and copper wire) we needed to find a way to properly structure and support the different parts of the plant. We have tried multiple ways to support the heavy leaves, but lots of them did not work and were quite messy. Finally, we were inspired by nature itself by braiding three copper wires into a nicely looking 'branch', which was strong enough to support the leaves.
Another problem we encountered was attaching the separate parts together firmly. The problem with the old circuit boards was that they were still fully packed and it was hard to get rid of the elements on it. Because of this, it was hard to attach the supporting branches to the leaves. Lots of glue and the use of cleaning sponges finally did the trick.

5. Result

The final product, Artificialis Photosynthesis, can be seen in the video and Figures 6 to 14. The base of the plant consists of two parts: the 'pedestal' and the pole. The pedestal is made of a piece of wood and old carpet. The pole is a wooden broomstick with pieces of an iron hanging system (duraline storage f-rail) screwed against it. Inside the pedestal, the contours of the pole were sawn out so that the pole would stand firm in it. Four 'carriers' (*F-drager* in Dutch) are attached to the pole and are hammered into the pedestal, which forms the steady base for the rest of the plant. The base is shown in Figure 5.

Furthermore, the plant consists of five main branches with leaves, from which four have solar panels and LDRs. The leaves are made of old, used circuit boards. On top of the leaves a solar panel is attached. Thereby copper wire is used to create veins, as can be seen in Figure 6. The leaves are supported by braided copper wire, which are placed in the elongated holes of the hanging system. The four LED strips are attached with tie wraps to the branches, as shown in Figure 7. Each LED strip reacts to the input of the LDR of that specific leaf. The LDR is attached to the bottom of the leaf, as shown in Figure 10. The wires of the solar panels, LDRs and LED strips are wrapped around the base and the carriers in such a way that it represents the roots of real life plants and/or trees (Figure 8). At the bottom the battery is placed where the electricity from the solar panels is stored (Figure 11). All in all to make it work together an custom arduino shield is soldered together to connect all the sensors and make the plant work (Figure 12).

Artificialis Photosynthesis mimics photosynthesis in real life plants. When light falls on top of the leaves, the solar panel starts converting the sunlight into energy, just as chloroplasts. Carbon dioxide is taken from the environment and is converted to oxygen, which will be emitted to the environment. The LED strip represents these two different streams: oxygen and carbon dioxide. Oxygen is represented by an upgoing blue flow of light and carbon dioxide by a green downward going flow of multiple lights. When the LDR receives less light than the initial state (the state in which the plant started out), the colour of the carbon dioxide stream will go from green to yellow, to orange, to red, depending on how less light the LDR (and thus the leaf) receives. The end result of *Artificialis Photosynthesis* is shown in Figures 13 and 14.

Figure 5. The base

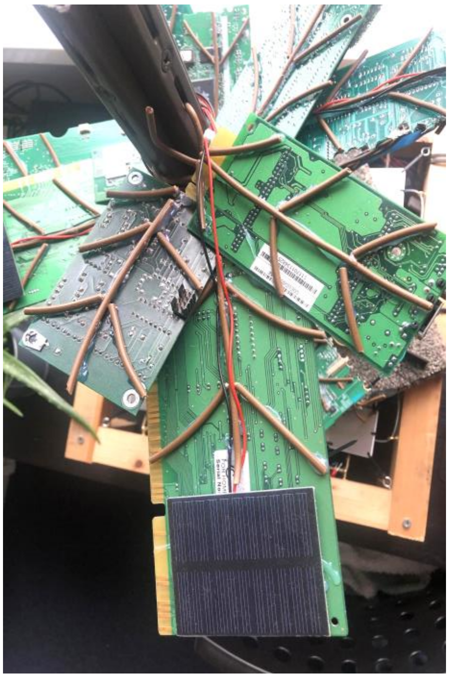

Figure 6. Leaves, their nerves and the solar panel

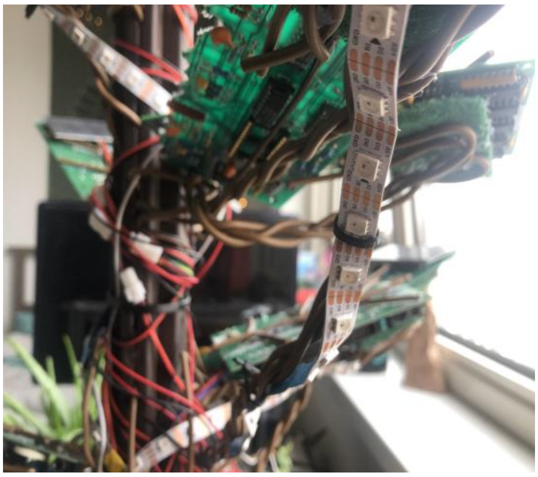

Figure 7. LED strip attached to branch

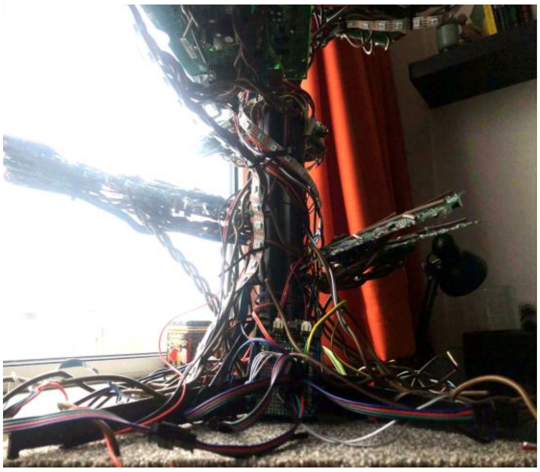

Figure 8. Look-a-like roots of copper and electrical wires

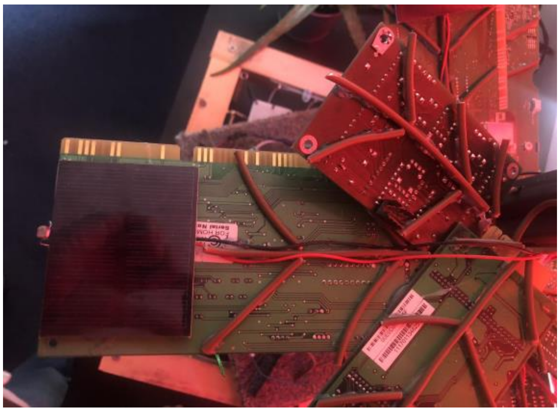

Figure 9. Solar Panel

Figure 10. LDR

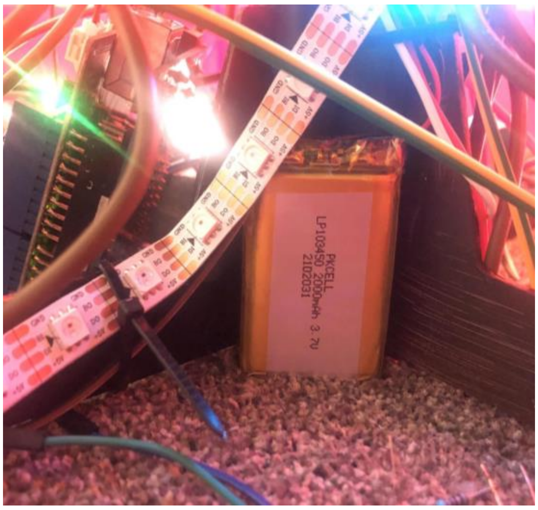

Figure 11. Li-Po Accu & LED Strip

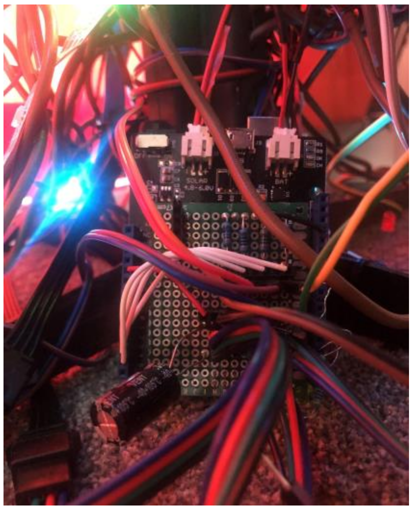

Figure 12. Solar & Led Shield

Figure 13. Overview in daylight

Figure 14. Overview in dark room

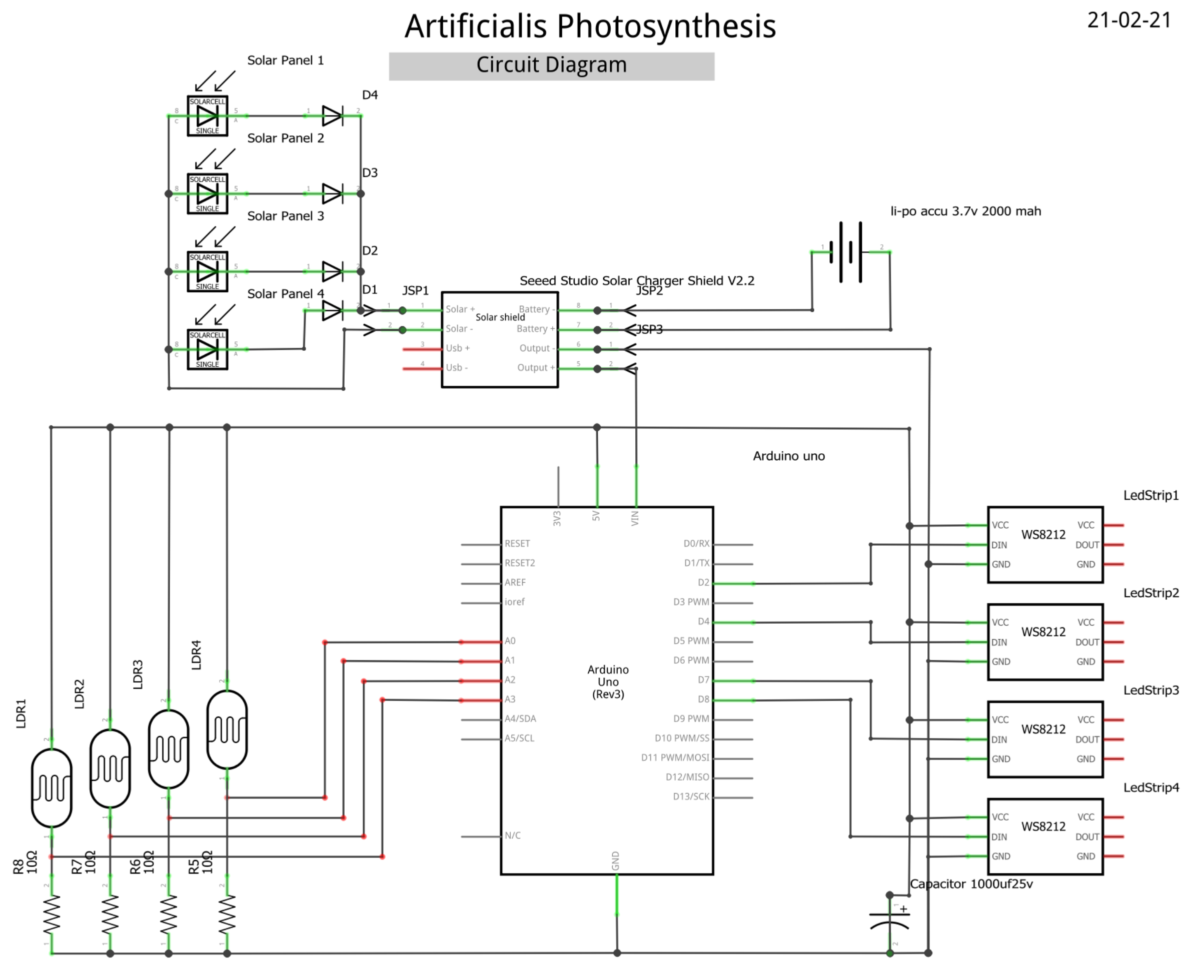

Figure 15. Final circuit diagram

6. Licensing