THE ICARUS BOT

We make machines not art

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„Let me warn you, Icarus, to take the middle way, in case the moisture weighs down your wings, if you fly too low, or if you go too high, the sun scorches them.“

—Daedalus in Metamorphoses, Book VIII

Publius Ovidius Naso

Introducing Icarus

While learning about the fundamentals of electric circuits in Darsha Hewitt‘s class We make machines not art photoresistors and motors caught my special attention. I was fascinated by both quantity and complexity of functions these two simple elements offer in combination.

As a human being, moving through space for the biggest part means collecting and analyzing a constant stream of visual data while sending commands to the muscles according to the calculated results.
Armed with basic knowledge of how to create simple electronic devices supported by integrated circuits, I wanted to tackle my idea of creating a machine which follows that principle.

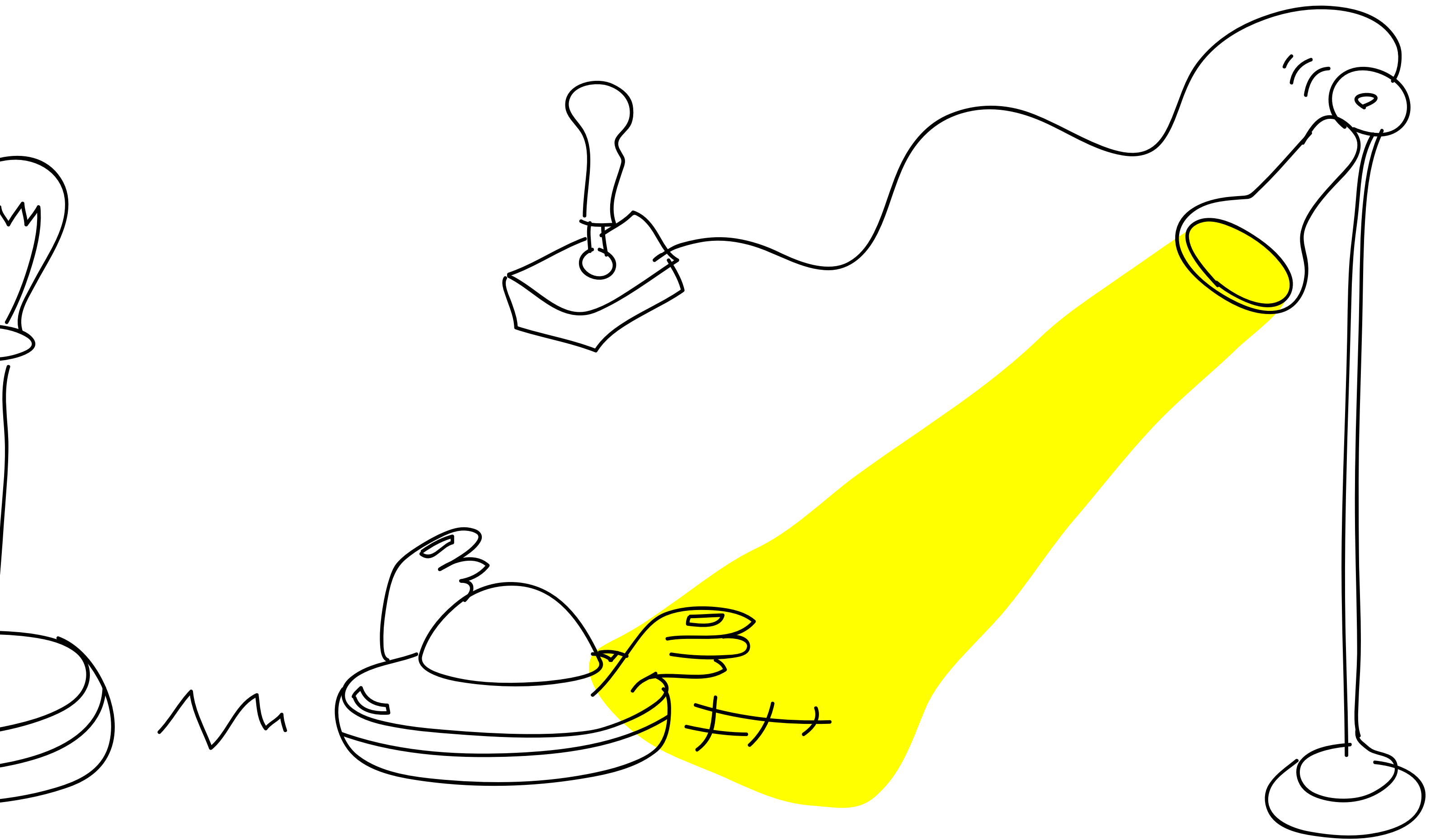
My plan was to reduce both input and output of the machine to a manageable level, which lead to the concept of a little robot moving on a plane, utilising two orthogonal wheeled motor axes.

Because photoresistors of course only deliver information for brightness levels, the obvious reduction for sensory input would be to light intensity and direction.
With these two functions in mind I created a concept for a game, in which a player chases away the robot utilizing an interface controlled directed light source.

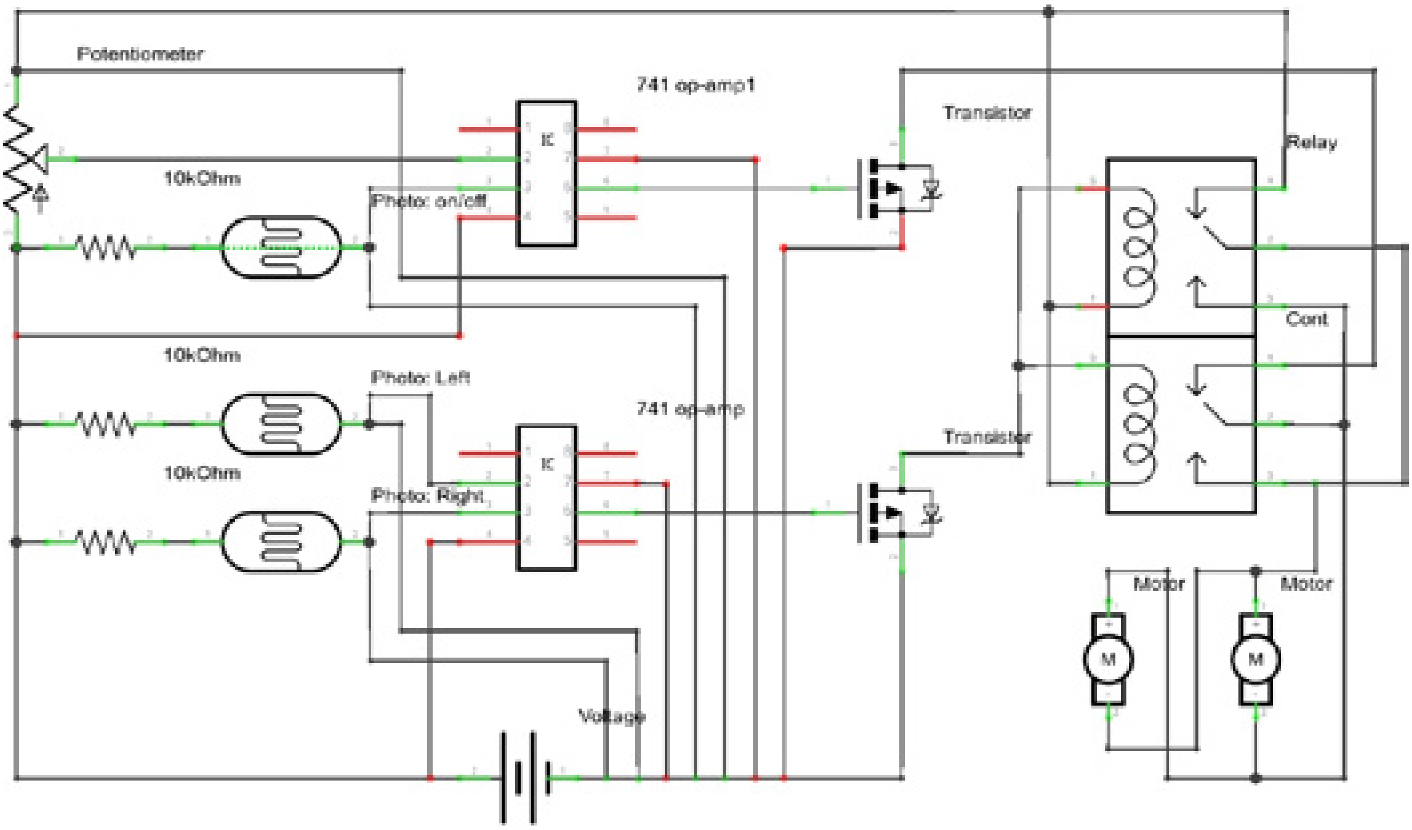
While the game as a whole could still be a final stage of the project, I decided to stay focused on the robot itself. I like the thought of a machine, created to hide.

Moving electronics draw a lot of attention, credited to their unnatural movement patterns, anorganic appearances or simply because our senses are very circumspective of creatures that could mean harm.

My robot‘s meaning of existence should be to stay low profile, stay in the shadows and keep itself out of attention – fearing the sun, as well as moisture (of course)!



Planning the circuit



In my attempt to layout a first circuit, I divided the machine into two separately working modules. One part should control the X- and the other part the Y-axis of actions and reactions.

I started to put elements I need into a chain: On the lowest level a relay, which controls the spinning direction of the motors by alternating their respective negative and positive poles, based on the high or low of an input current.

The input is fed by a transistor that amplifies the result of a comparator circuit. The comparator simply compares the resistances of two in opposite directions pointed photoresistors. This way, I can set the direction of movement on one axis just by checking where the light is stronger.

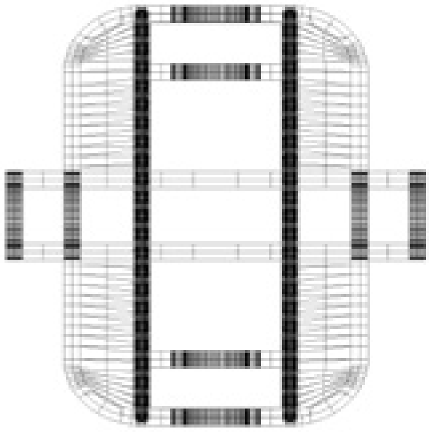
The motors' power is also patched through the relay. A second comparator circuit tests the resistance of a third photo cell against a poti (variable resistance). If the cell's resistance exceeds the poti, a current is sent to another transistor which feeds the motors with electricity.

The poti helps to adjust the robot to the current light situation. It's an easy solution to make the machine work in darkness, as well as dimmed rooms after just a quick calibration.

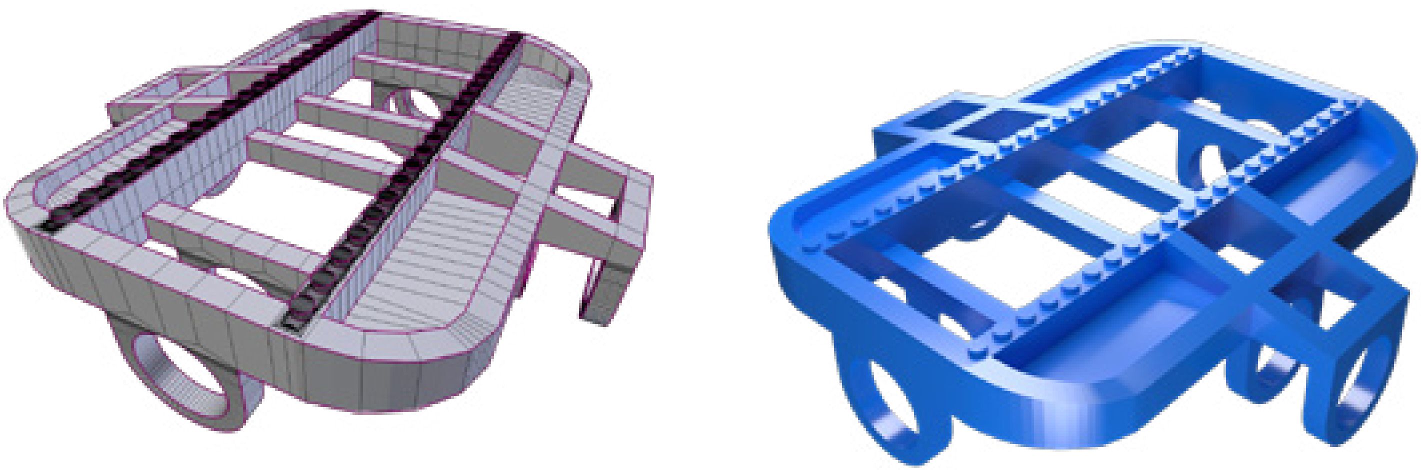
Thus in total there are three photoresistors – one that powers the motors and two that determine direction. For the final robot I would of course build two of those circuits, but for construction and testing this had to be sufficient.

Building the body

In order to have a reliable base to work on, I chose to model the body in a 3D environment and materialize it with the help of a 3D printer. It was my first fairly complex model to be printed and other than getting used to the printing process I designed it to be as versatile as possible, keeping possible future robot projects in mind.



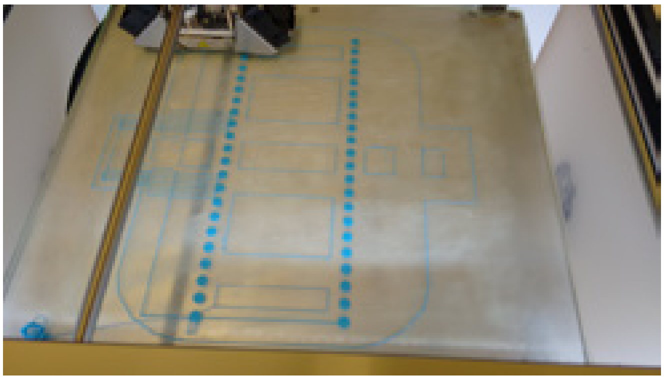
Modelling the base mesh of the body – orthographic side, front and top views

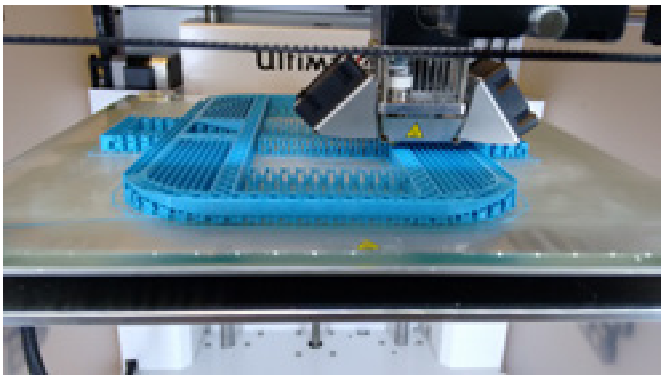


Perspective view of the finished model: solid grid and shadered

The model should provide a base for any bi-axial machine I want to build in the future, with enough space to hold a standard breadboard as well es some batteries. It's holding the motors I obtained in place and allows them direct access to the ground. The body is easy on printing material while still being robust enough for possible experiments. I chose to also add Lego compability to the model, in case I need to upgrade it with another board or other structures.

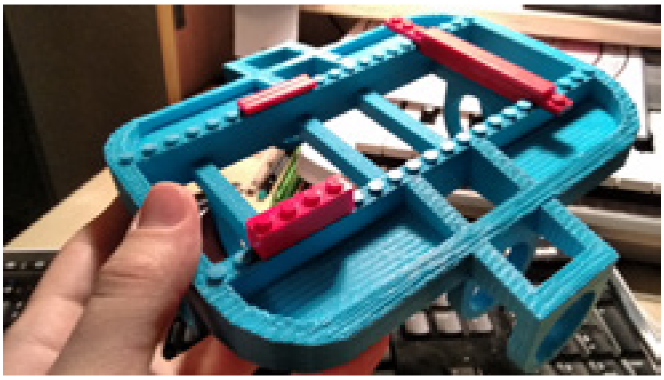
Printing the body





Printing in process, starting upside down and building on support structure

Finished print, after 16 hours of non-stop overnight printing

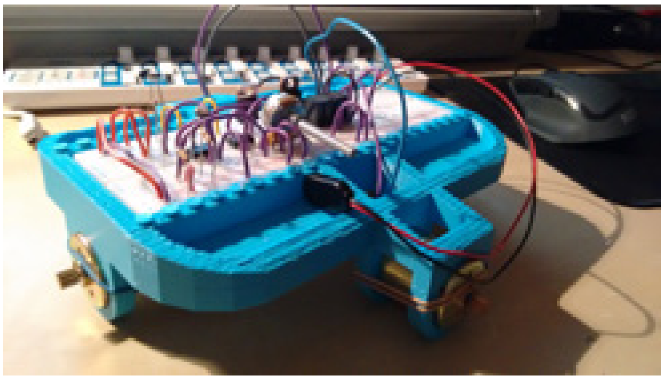


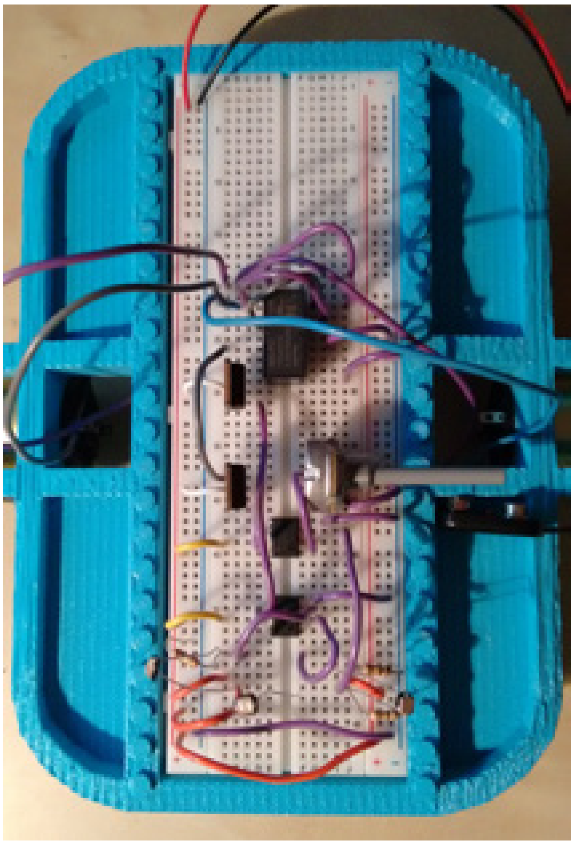
The support structures had to be carefully removed

Proof that the Lego support buttons work with actual bricks

Stacking parts

Planting my circuit into the model was an easy task. The motors fit into their mounts and rubber bands are holding them in place and keep them from turning.
Two holes provide access to the bread-board, which sits safely on top.





Designing wheels

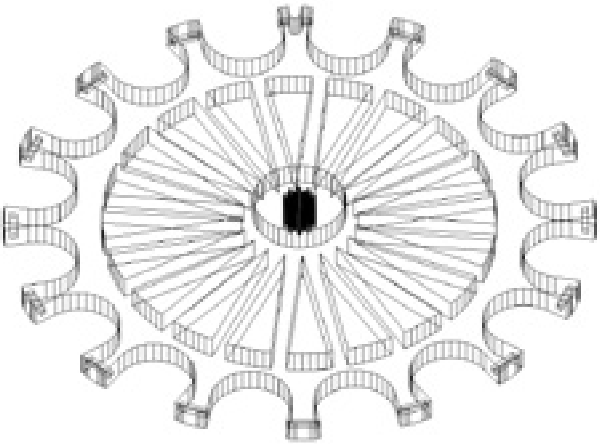
Omni wheels used in robotics

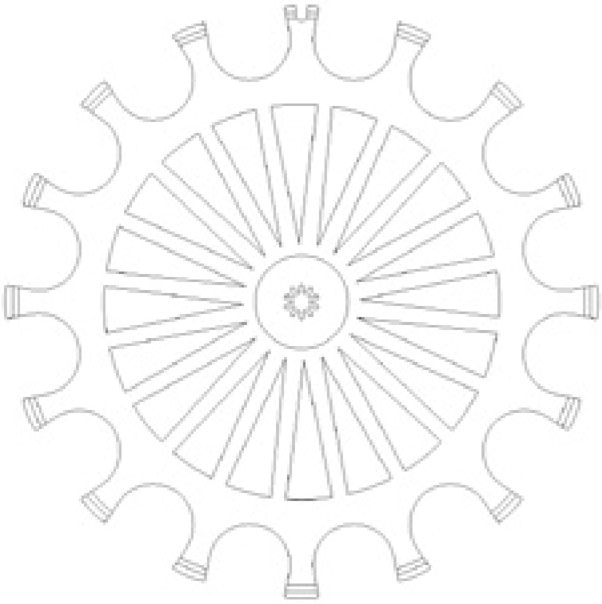
One of the biggest obstacles is the design of wheels, that allows bi-directional move-ment over orthogonal axes. A movement apparatus containing steering would have been to complicated to control electron-ically, which is why I had to seek some inspiration looking at *classic* robotic exam-ples.

What I found was the principle of the omni wheel. Omni wheels have small discs around their circumference, perpendicu-lar to their turning direction. They can be driven in their natural direction of turning, while still being able to slide laterally.

Omni wheels seemed perfect for my need to create a *holonomic* machine within a two-dimensional space. As it turned out, effective omni wheels are not easy to craft and seem to require cleverly adjusted struc-tures and material properties.

Constructing wheels



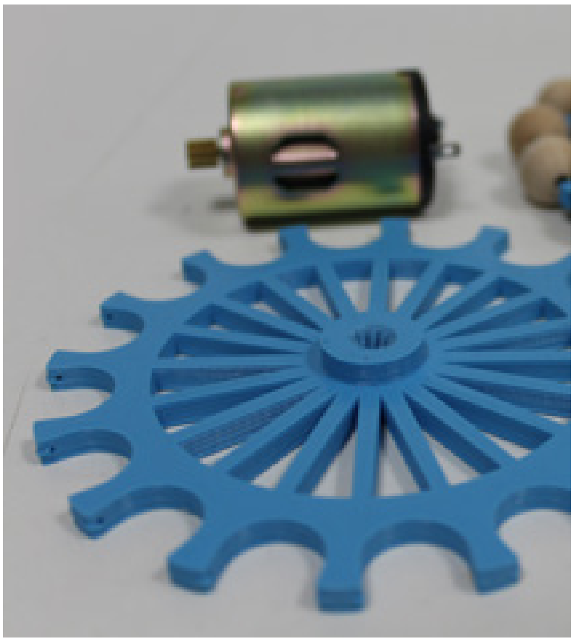


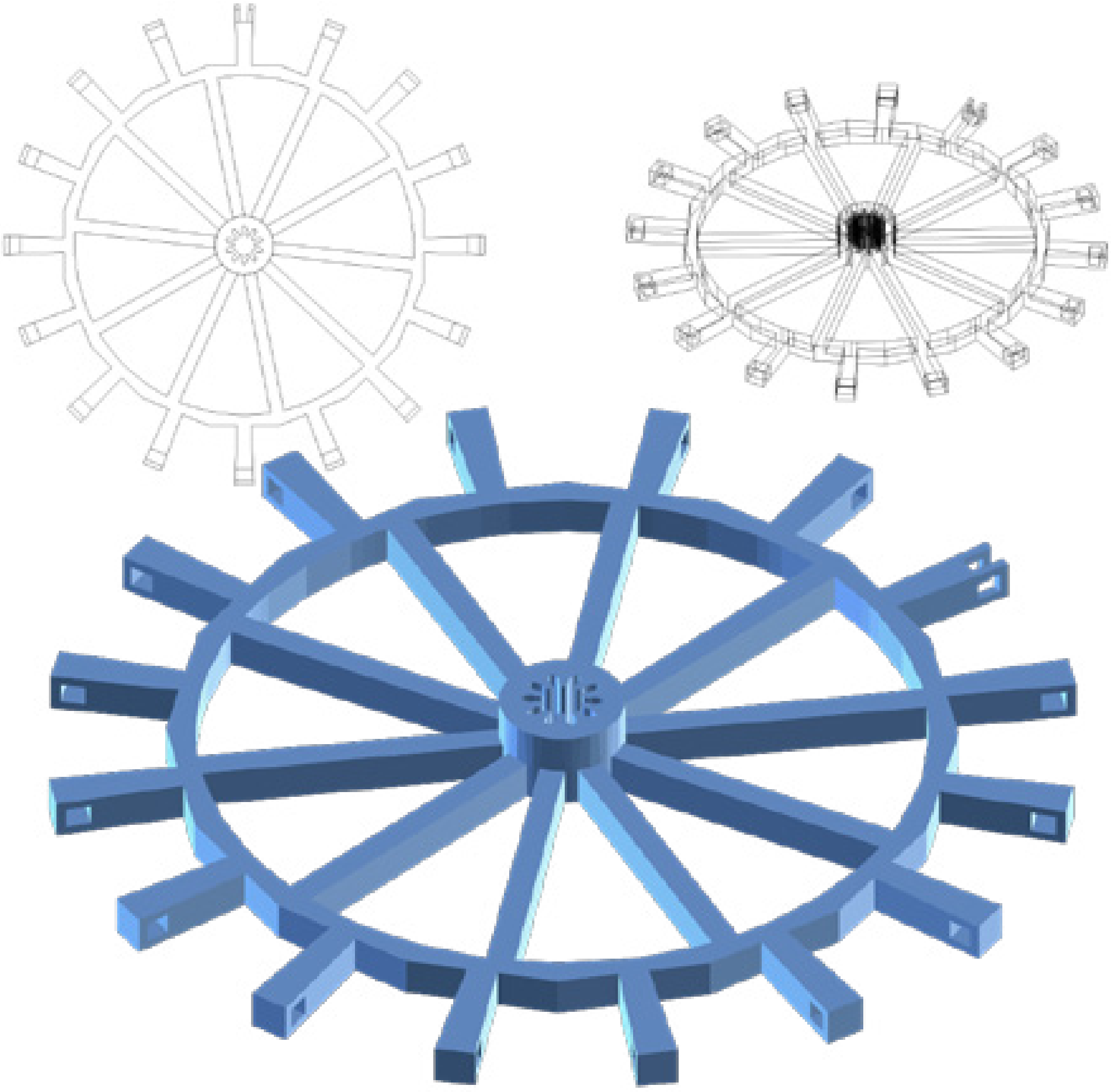
My first design was based on a simple wheel with spokes, holding 16 wooden balls in place with a wire.

Sadly – although my measurements seemed exact – the printer got most of the holes and connections slightly wrong. There was no way to get the wire through all of the loops and the connection to the motor was too small. One way to avoid this would have been to tweak the overall quality of the prints, which results in extremely high printing times.

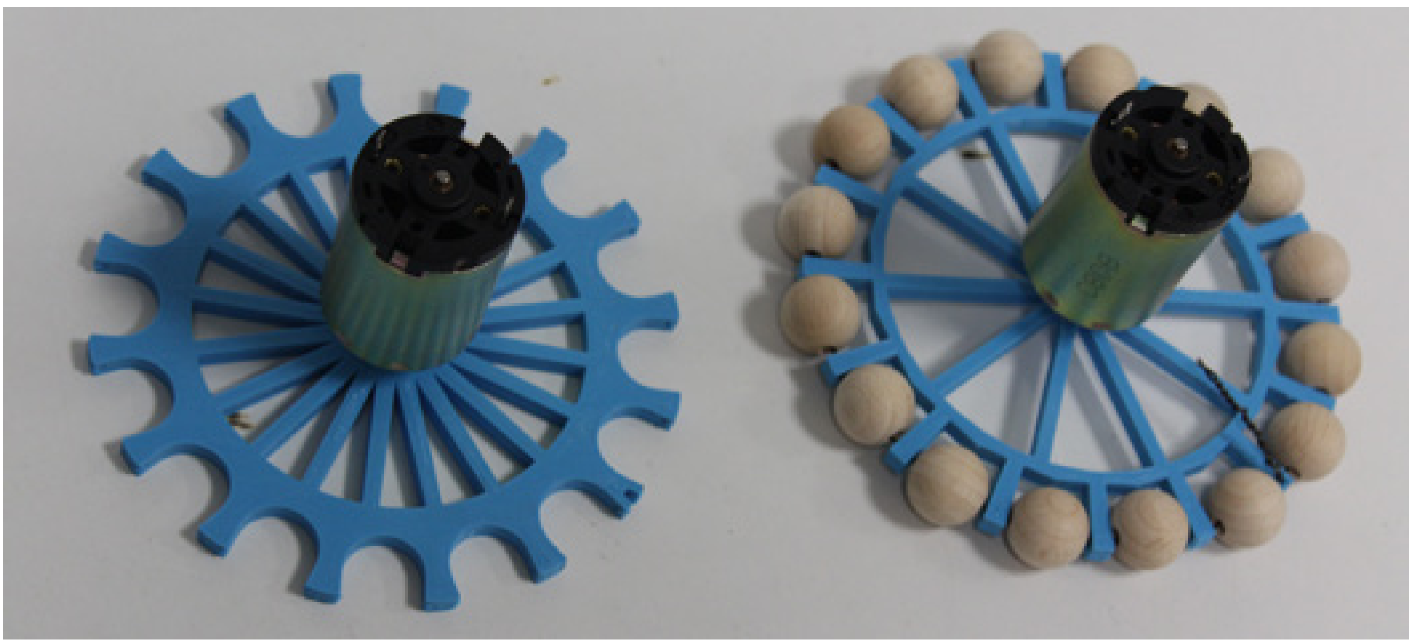
I decided to rather improve the design and use the first prototype to see where I can save material.

The new design should still be stable enough to support the whole robot in movement, but use less resources and provide a solid way to attach to the motors.





Second omni wheel design in its simple polygon mesh form



Both old and new design side by side

Assembling elements

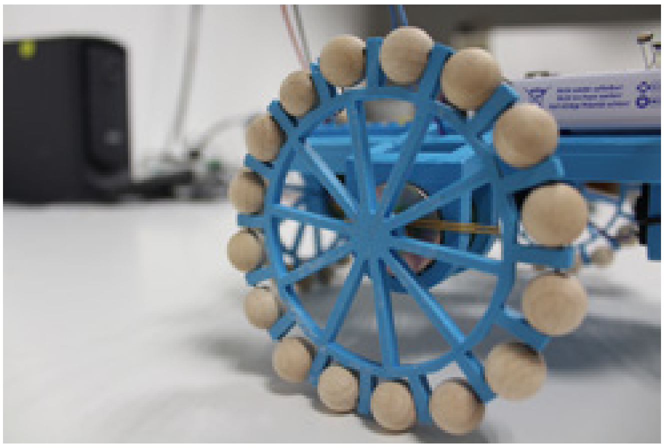
After wiring 64 little balls to the wheels I could finally attach them to the body. A few try-outs however made obvious that the robot was unable to move on its own. The motors simply cannot gain enough momentum to make it move – even when attached to a 12V plugged power supply. The wooden balls are too much of an obstacle to let the wheels start turning, although they reach a formidable maximum speed if they overcome their first difficulty.

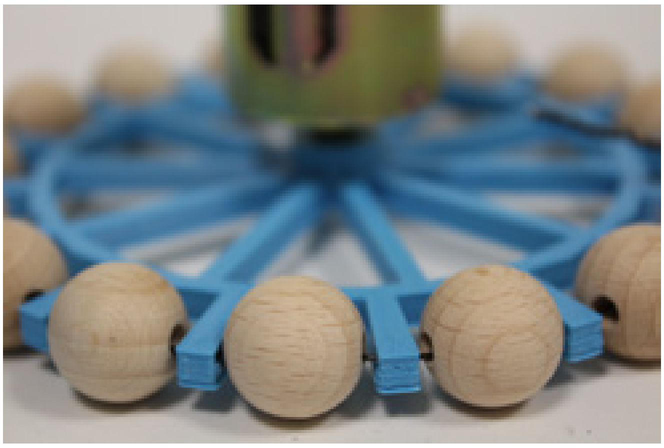
Deceived by this conclusion I still tried different setups for the machine and it seems that with a little help and a few pushes the tiny guy at least makes a few jumps. Moving the robot around by hand also shows that the omni wheels principle could work.

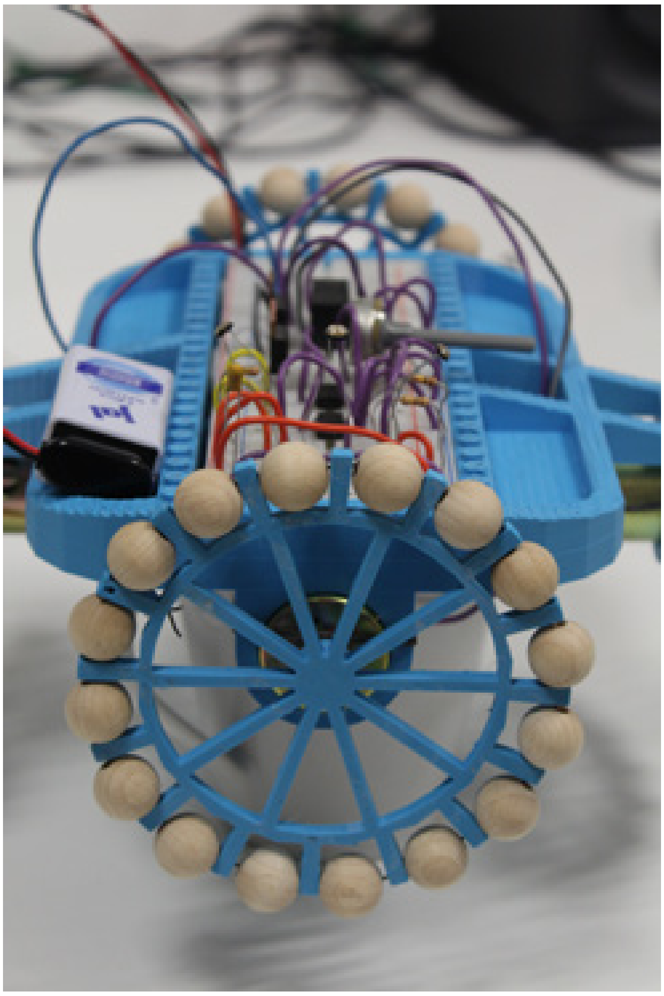
The next improvement will be to either further improve the wheels using more suitable materials to decrease the power needed for the initial thrust, experiment with different motors and find an electric solution to make the starting movement more effective.

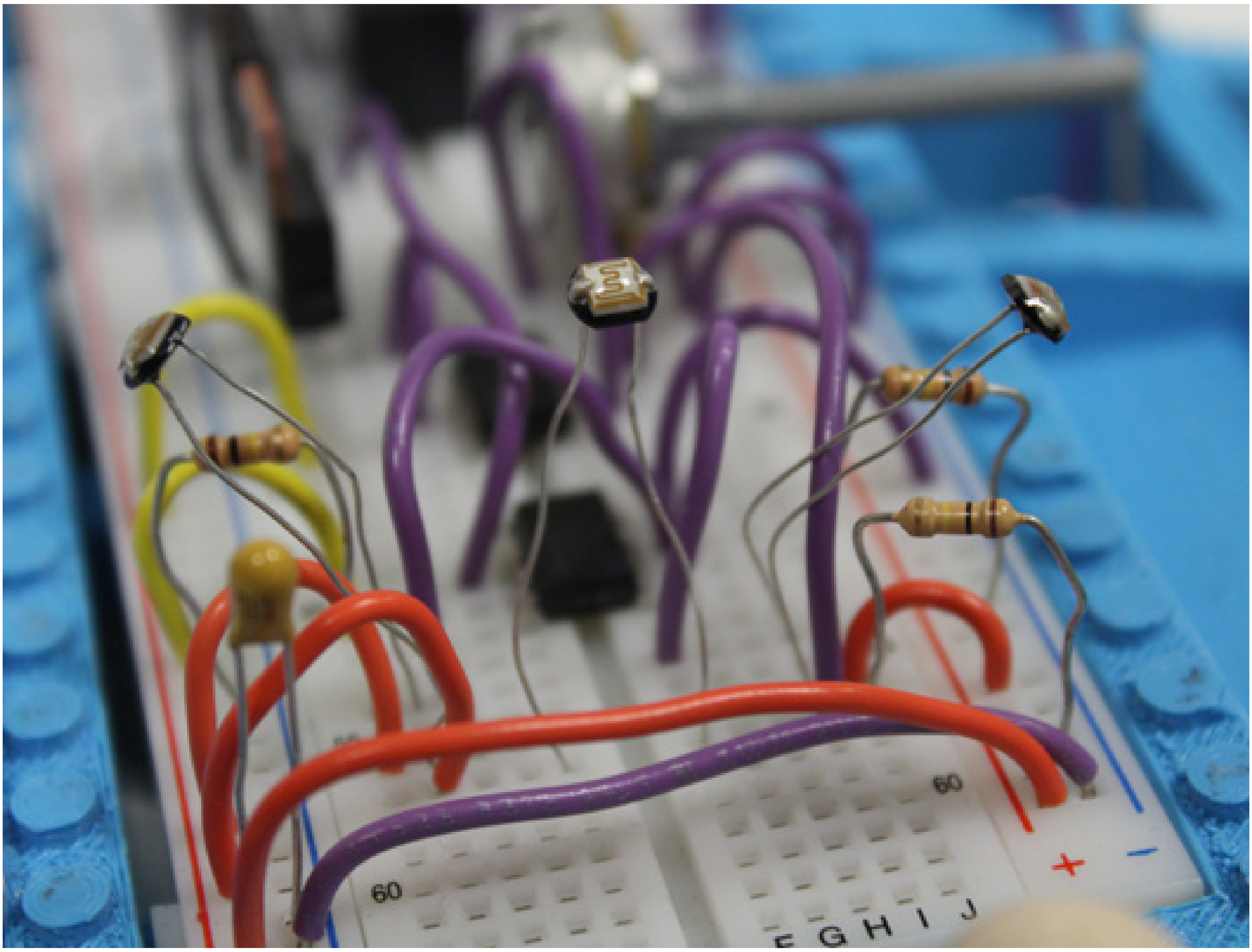
To prevent checkerboard-like diagonally limited movemet I also want to controll the motors' speed via pulse-width modulation.

The ability to move has of course top priority, which is why I have not yet bothered to implement new modules, improve the circuits or work with the second axis.

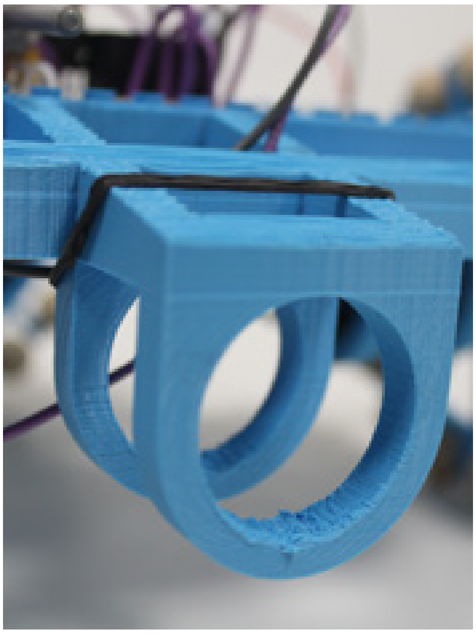




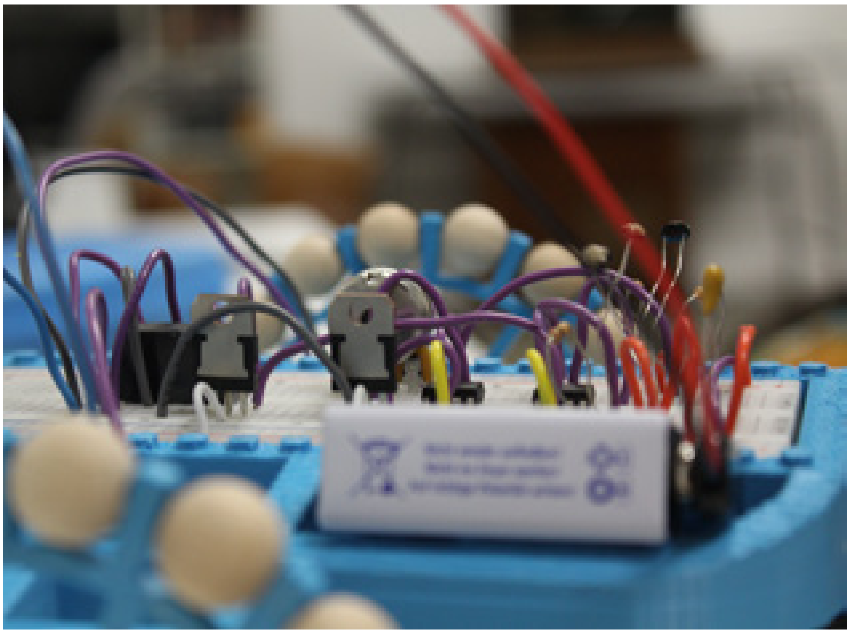




Close-up of the photoresistors for triggering the motors (middle) and controlling directions



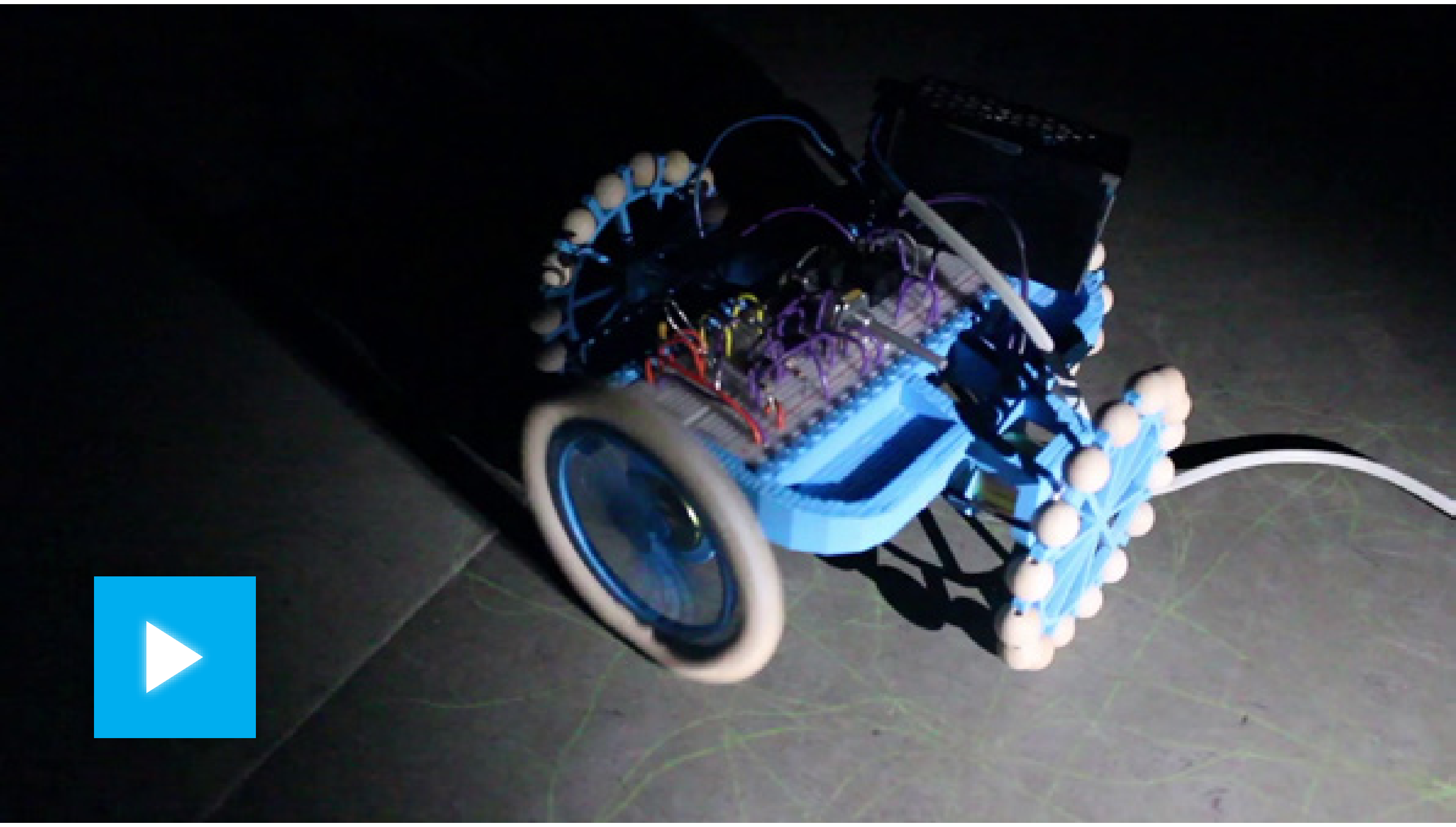
Structure holding the motors



The whole circuit in detail

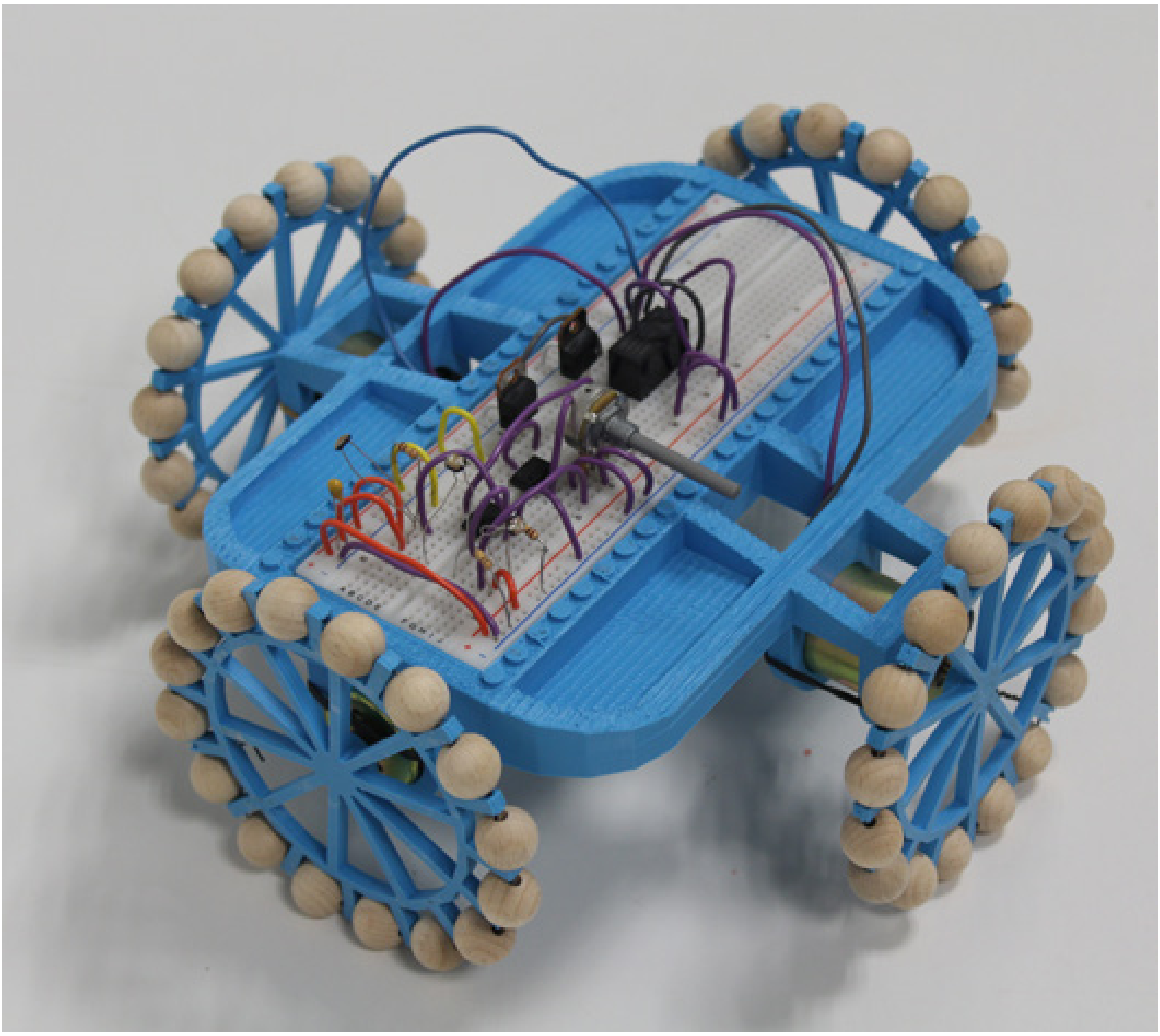
Recording action

Although the machine doesn't move yet, I recorded a quick demonstration to show what this simple circuit could be capable of and give you a feeling for the robot's appearance.



Click to see Icarus in the dark! (Youtube)

Discussing further development



Besides finding a solution for the movement problem, a plan for the future of the robot involves upgrading it with an Arduino board to controll it digitally. This way I could use any source of input to feed the robot's movements, opening a whole new world of possibilities and experiments.

Even in its current state, this project already taught me a lot in how to design a device, working with and handling a 3D printer, facing difficulties, and, of course: The underlying principles of electric circuits.

Thanks to Darsha Hewitt for her awesome class!