Automatic Drone Charging Station

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RU Science and Engineering

August 23, 2021

1 Introduction

Getting drones to charge autonomously would enable them to work on tasks without the need of much management. This paper is about the charging station design and assumes the drone can land on its own near the charging station with a bit of inaccuracy. Thus the main challenges that will be solved here are the connector design, the movement of the connector to the drone and the logic of the charging port.

2 Ideas

There are many ways to make a charging station, at the beginning all the ideas where put into a chart with pros and cons. Later all the pros and cons are put into a score Table that gives each idea a score depending on it qualities. The scores can be seen in Table 1.

Crossbow

A crossbow that shoots the connector towards the battery on the drone could be a fun solution if it would not be very inaccurate and a lot of factors can be in the way of that working. Wind could be a big factor in screwing up the calculations. A good quality of this is that it does not take a lot of space and thus would not be in the way of the drone in any way. The crossbow idea came from Joseph Foley, it revolves around locating the connector that is located on the drone and shooting at it.

Robotic Arm

The Robotic Arm idea revolves around using 4-5 servo motors to control a robotic arm and having it connect the charger to the drone after locating it. The problem with this is that this design would need a sufficient algorithm to be able to move the motors to the right position. At Reykjavik University there where a few arms that where tested to see if they could be used for this project. One of the Arm that was tested was from a spider robot that was developed by Kjartan in the Mechatronics course 2 years ago. Each leg of the robot uses 3 LX-16A servomotora that are connected together in serial and controlled with an ESP32 computer, the leg was used as an arm but after some testing it was not ideal for this project.

Figure 1: Robotic Arm

Car

A car that drives around and lifts up a charging connector would be very handy to use as it can get around very easily but the problem would be to locate the connector and driving under the middle of the drone to connect it. It would also need some grid system so it does not go searching for the connector in the wrong place

3D Printer base

The 3d printer base has the same mechanism as a 3d printer, so it can move smoothly in every direction. It would be a very accurate solution but the problem would be that it takes a lot of space around the landing pad and could be in the way of the drone landing.

2/3 3d printer base

2/3 3d printer base is called that because it only has 2 axis it does not move up and down, the height can be adjusted manually but not automatically. This design has a slider that moves right and left and a sleight that moves forward and backwards. For this to work there is a camera on top of the slider that locates the connector, when the connector is located the slider stops and the sleight is pulled forward towards the connector. The problem with this design is that you have to manually change the height of the connector depending on the height of the drone.

Move Drone

Move Drone means to move the drone to the middle of the landing pad. This would be very handy because if the drone is in the middle of the landing pad and the connector is always located in the middle under the drone this design should work for all types of drones. A problem is though that drones have different types of legs, for example the Hamilton drone is huge and only as 3 legs, moving it to the middle of the landing pad might cause it to fall.

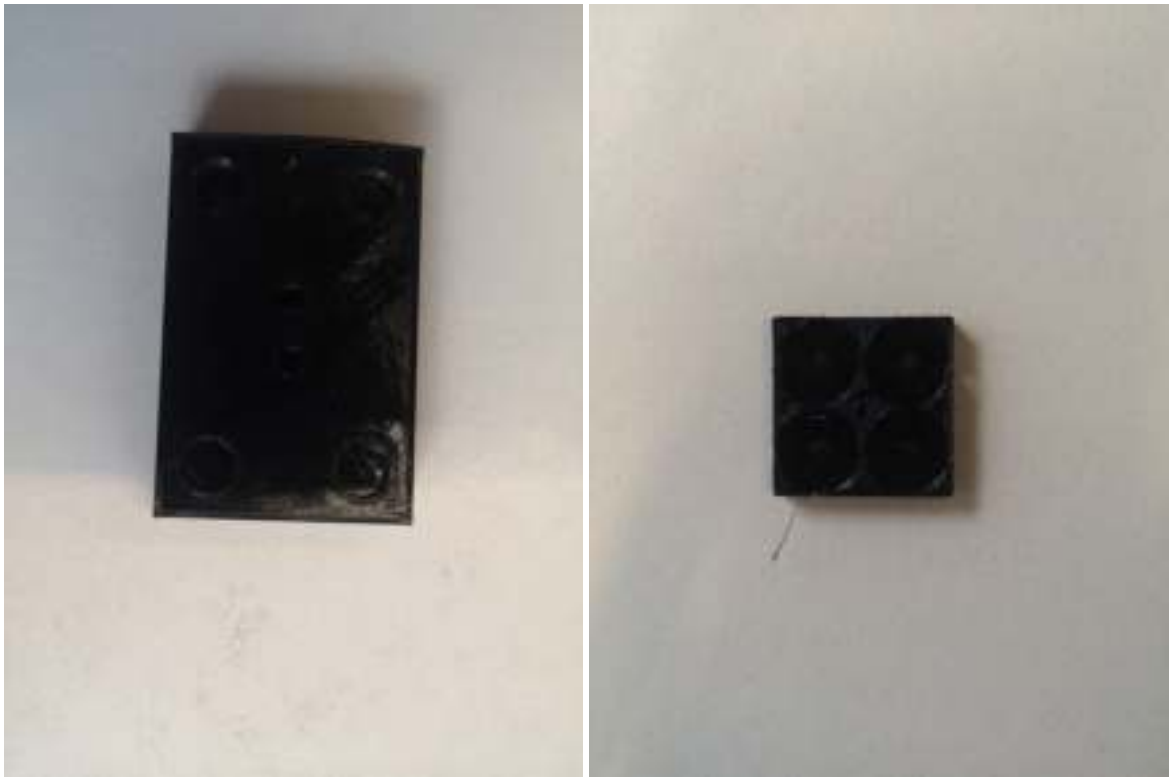
	Crossbow	Robotic Arm	Car	3d printer base	2/3 3d printer base	Move Drone
Easy to design			x	x	x	
Easy to program	x			x	x	x
Covers a lot of space	x	x	x	x		x
Takes little space	x	x	x		x	
Covers all axises	x	x	x	x		x
Easy to control				x	x	
Easy to setup	x	x	x	x	x	
Accurate		x	x	x	x	x
Works for all sizes	x	x	x	x	x	x
Sum	6	6	7	8	7	5

Table 1: Idea chart

There are two things that most of the ideas have in common, they all need a special connector and to find the connector on the drone. So the first thing to do was design a connector that could be plugged in with out any force.

3 Designing the connector

When designing the connector some factors needed to be taken into consideration, to charge a drone battery you need a charger, most charger need to be manually set for each type of battery and then an on button is pushed and the battery starts charging. For charging the battery the charger uses xt-90 connectors and balance connectors with different amounts of pins. It should be possible to charge the drone a few times without using the balance connector so the design is designed with that in mind. So the connector needs to have at least 2 holes for pins. Using magnets to get the pins connected was the ideal idea.



(a) (b)

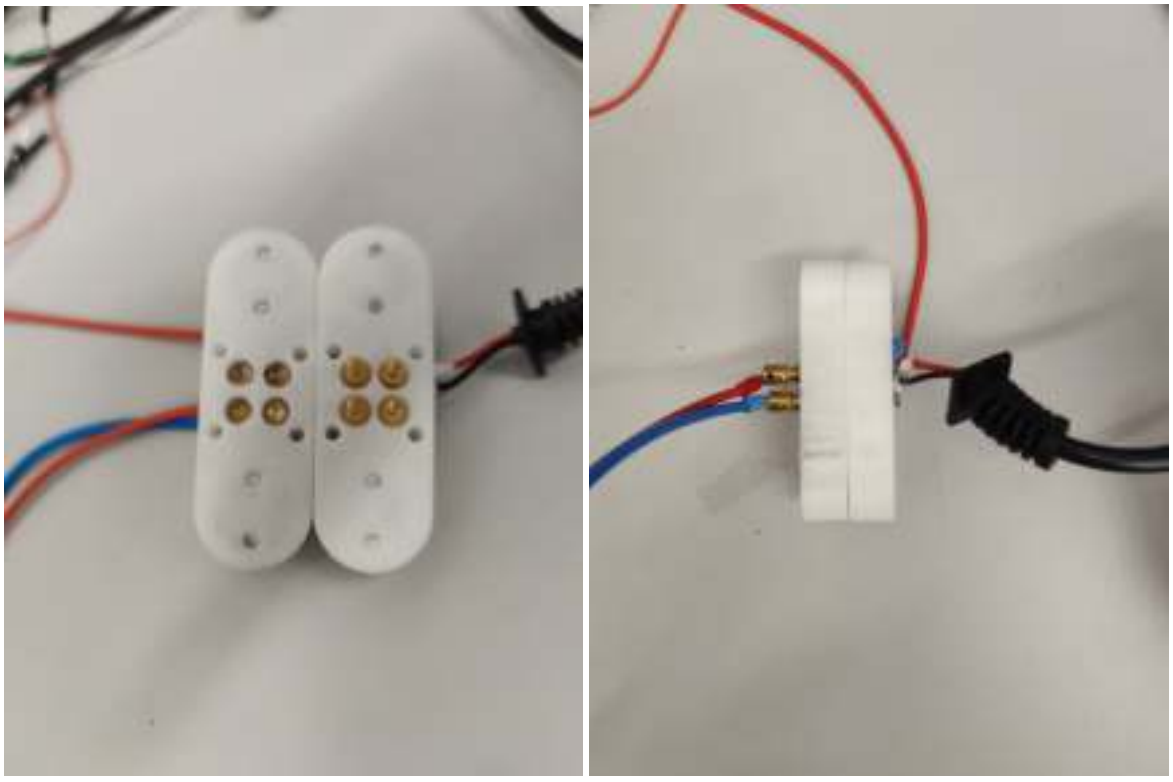
Figure 2: Here are the first 2 prototypes

At first the idea was to have 4 magnets on each side so 8 magnets in total, seen in Figure 2, but the magnet where extremely strong, so strong that they broke each other when they crashed into each other. After breaking a few magnets the connector ended with 2 magnets on each side of the connector, 4 magnets in total, as seen on Figure 3. The male pins used are called pogo pins or connector pins and are bought in Íhlutir and the female pins are pins found in the LUV(lab for unmanned vehicles) and then grinded down to the correct size. Later 2 pins where addes to the design so that a relay could be connected for switching the power from the drone to the charger. It should be able to combine these pins into 2 pins and even combine the pins from the balancing connector also all into 2 pins according to Joseph Foley and with more time that would have been done.

(a) (b)

Figure 3: Here are the second 2 prototypes

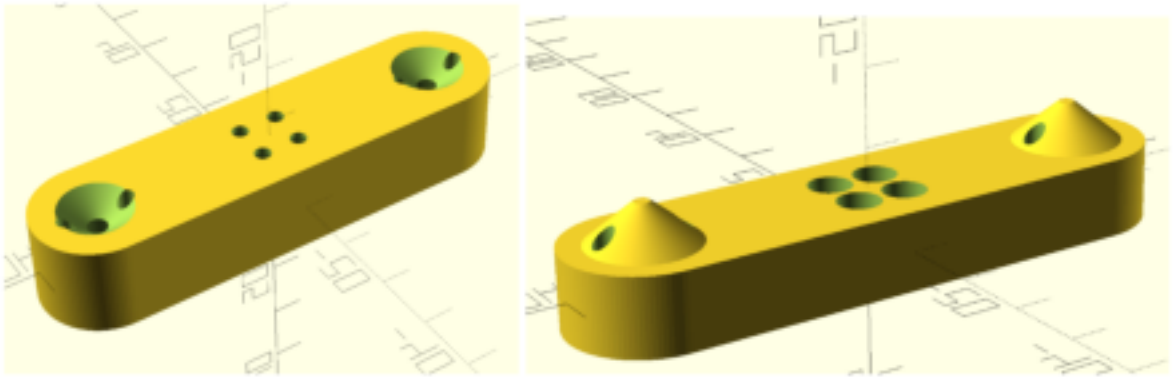
On the drone the battery needs to disconnect from the drone and connect to the charging station, this was done using a relay connected to a battery that powers the relay when the connector is connected. When the relay gets power the battery switches from being connected to the drone to being connected to the charger.



(a) (b)

Figure 4: The final prototype

This design needs to be perfected as there is a design flaw that makes it possible to accidentally put the pins into the wrong hole. This can be fixed using a design as seen in Figure 5



(a) (b)

Figure 5: Idea for a better design

The magnets go into the connector on the backside and do therefor not need to be fastened, the placeholder holds it in place, there are 2 holes underneath the magnets to be able to get them out. The holes around the wires where designed to be able to fasten the wires from the other side so they will not get loose and fall off As the 3D printer spent the whole summer either being in constant use or being broken some parts have been designed but not printed as the old parts have just been modified with glue or other implementations to make it work.

Circuit logic for the connector

The battery of the drone needs to be disconnected from the drone and plugged into a power source to charge it. This issue was solved with a relay that disconnects the battery from the drone when it is connected to a charger. The relay is activated with two of the pins from the four pin connector that switched the battery to charge on the other two pins. The voltage of the two pins is controlled by a 5v battery which is enough to activate the relay.

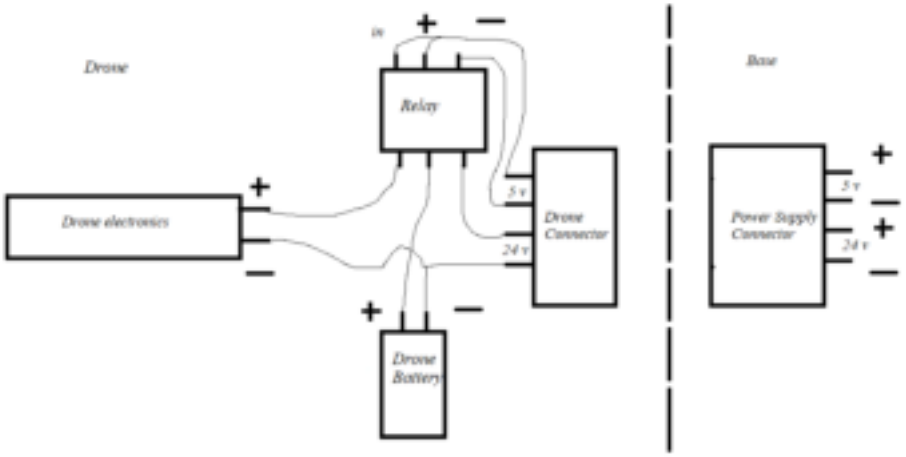


Figure 6: Charger logic

4 Finding the connector

To be able to plug in the charger the connector needs to be located. There are a few ways to locate the connector, the ideas for locating the where:

Beam breaker

Using a beam breaker in the opposite way, so it sends a signal when the beam is located and not when it breaks

AprilTag

AprilTag are a type of fiducial marker, similar to QR codes, a camera is used to locate the AprilTag and ROS(Robotic Operating System) is used to read the date from the AprilTag, like how far the camera is from the AprilTag and ID of the tag to tell which tag it is if using many different tags.
Even though the AprilTag is maybe not the easiest way to do this, all the equipment for it was already set up and should be easy to connect to the program. When the AprilTag is located it should be able to tell how far away it is and how to get close to it in the most efficient way. A Raspberry Pi 4 and a Raspberry Pi camera module was used for detecting the AprilTag. The AprilTag can be seen on Figure 7

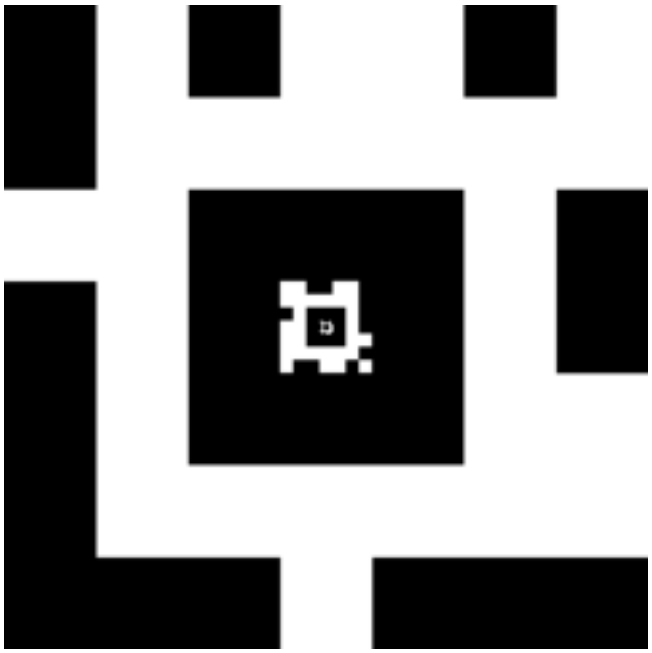


Figure 7: AprilTag

5 Circuit Design

The Nema 17 stepper motors are driven be EasyDrivers that are powered by a battery or a powersupply of 9V. The two buttons are the buttons that can be seen on each side of the Sled seen on Figure 9 the buttons switches the direction the stepper motor turns so that when the drone lands the program starts looking for the AprilTag.

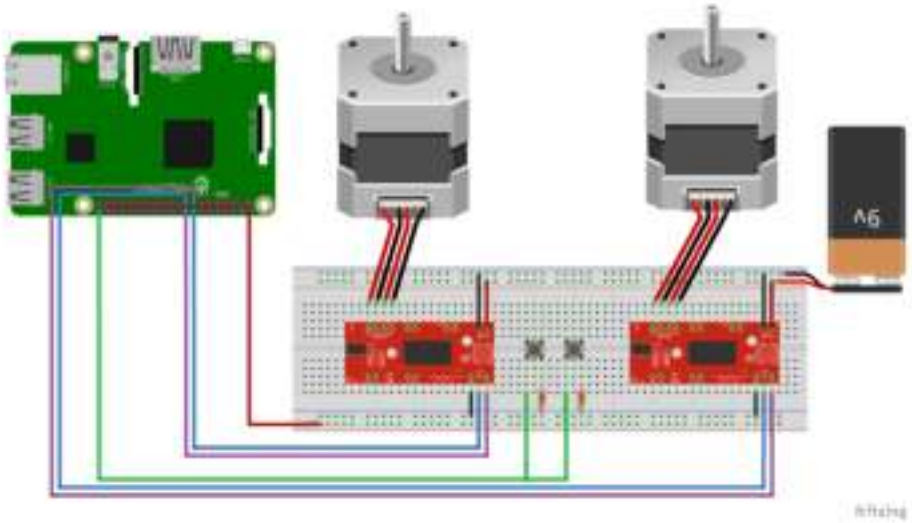


Figure 8: Caption

6 Sled Design

The sled was designed with two rods, one to keep the sled from rotating the other one was threaded to move the sled back and forth. The end blocks were designed to fit one stepper motor and two rods. The sled would then lay on top of the rods, move back and forth, where it is possible to mount a piston to move the connector to the drone.

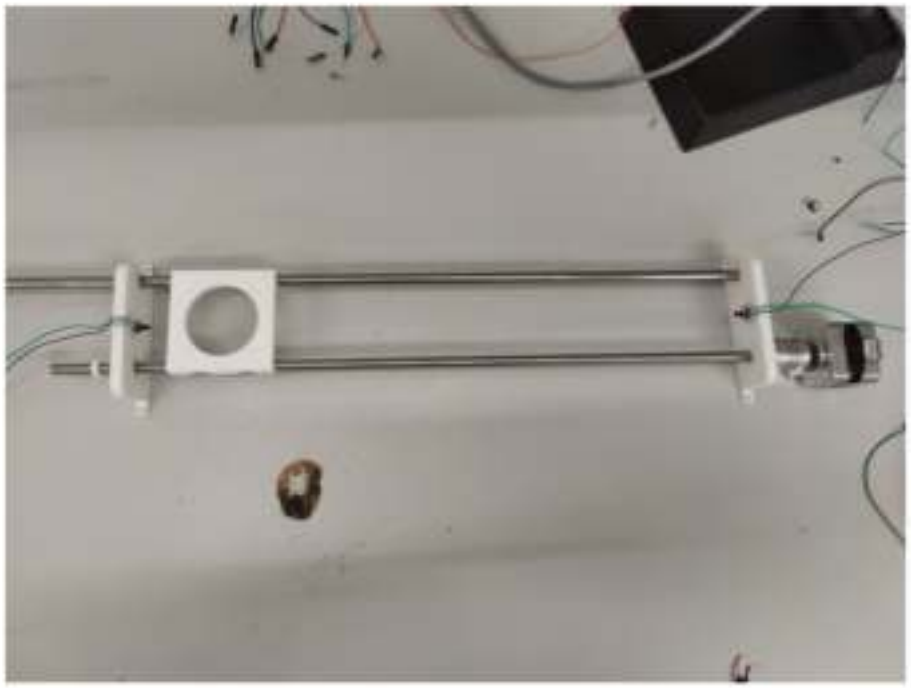
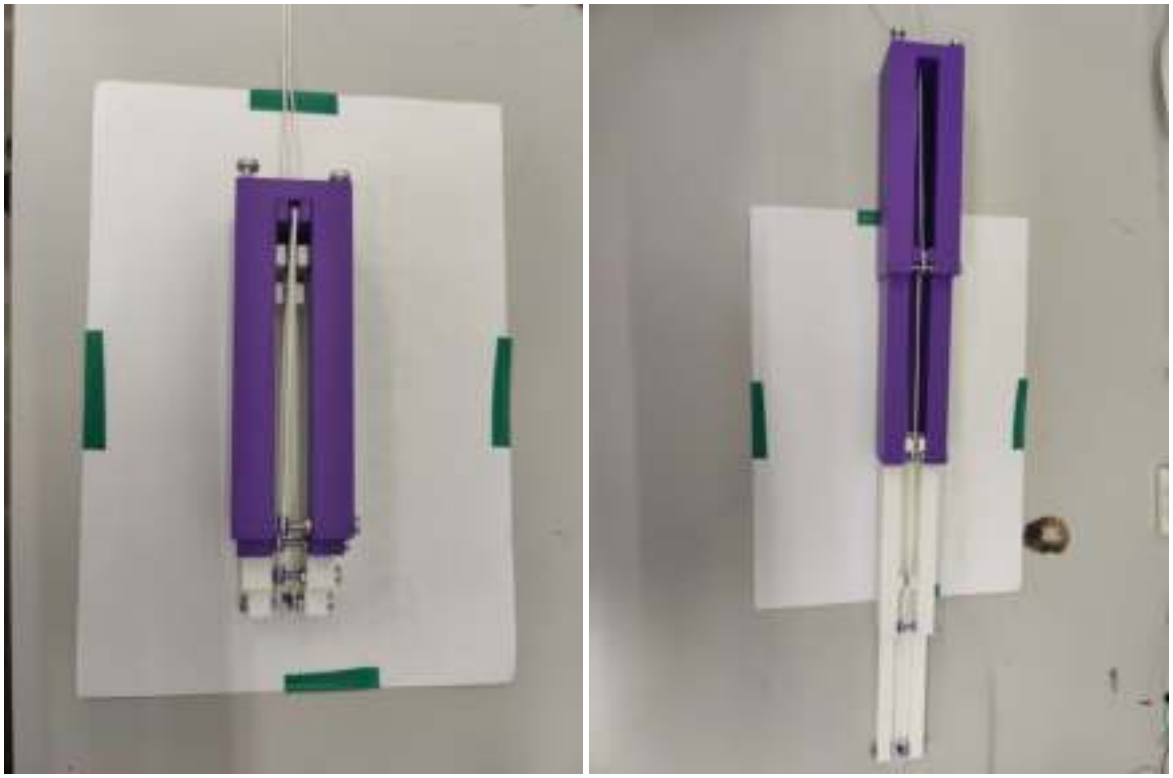


Figure 9: Sled

7 Piston Design

The piston was designed to move the connector back and forth, on top of the sled, to finally connect to the drone. The piston used a recursive sled design where each sled would extend the reach of the piston. The sled would then be moved back and forth with a rope that would be spun on a drum at the back of the piston with a stepper motor. The drum would be threaded so the rope would not get tangled. There was also a design for a adapter from the sled to the piston such that the piston could be held on top of the sled.



(a) (b)

Figure 10: The piston

8 Current status

In the end of summer all the parts worked independantly, the sled was able to move stop and start the other stepper motor, the camera was able to find the AprilTag, the piston was able to extend and the connector was able to charge the drone. The problem is getting them all to work together. This was not finished by the end of summer. There where a few problem here and there, one of the main ones was that the 3D printer was always broken or in use and since the almost every part was designed to be 3D printed this was a big problem. The Stepper motor drivers also stopped working for a few days, the AprilTag program stopped working as soon as the driver began working again and many more small problems came up.

There are a few items that are ready to be printed, for example the camera holder seen on Figure 11 and another rod holder for the Sled that so that the rods are more stable seen on Figure 12

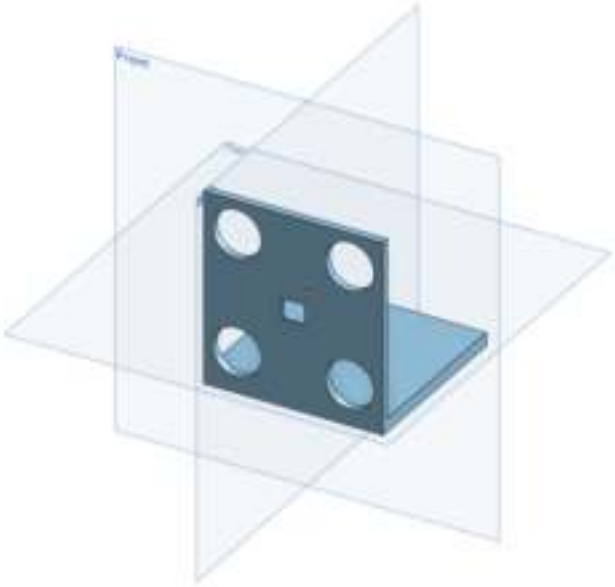


Figure 11: Camera Holder

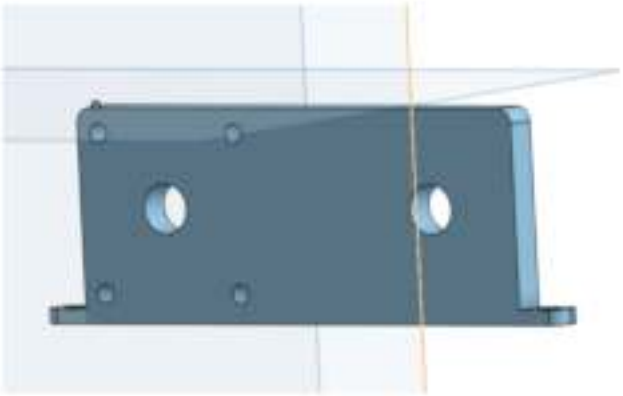


Figure 12: Rod Holder