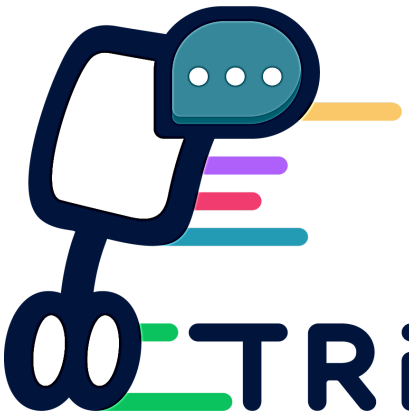

A BEGINNER'S GUIDE TO BUILD A TELEPRESENCE ROBOT

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A Guide to building a Telepresence Robot

A telepresence robot is a complex system with hardware and software components. It has mechanical and electronic components, as well as a robot firmware and a server application. This guide starts with a short introduction and definitions and then presents a complete guide to build such a robot from scratch. The software components are provided as open source projects.

Introduction

Telepresence robots are a combination of three areas i.e., **robotics**, **teleoperation** and **telepresence**. Robotics technology uses machines operated (or programmed) by humans to perform actions or tasks. **Teleoperation** involves control of a machine or framework from distances. **Telepresence** field consists of the feeling of being present for end users from both sides, who are separated by distance. Thus, telepresence robotics is the control of robots by the use of wireless networks or tethered connections virtually or at a distance [3, 4]. Telepresence robots are controlled via a tablet, laptop, PC or mobile phone. It consists of a screen, camera, microphones, speakers and receivers. Thus, telepresence robotics can empower people by giving them virtual eyes and ears while being distant [5, 6].

There are two types of telepresence robots, stationary and non-stationary. A **Stationary** telepresence robot can't be driven around by the user and is fixed in one place. The robot's head (or display) can be rotated to allow the user to face in any direction and better interact with by standers. **Non-Stationary** telepresence robots can be driven around by the user (shown below). This allows to move around on the premises, which allows for even better remote interaction with persons, position itself in a group or even follow someone.

Figure 1 shows an example of such a robot. The DIY telepresence robot described in the document is named and referred to as '**Telerobi**'.

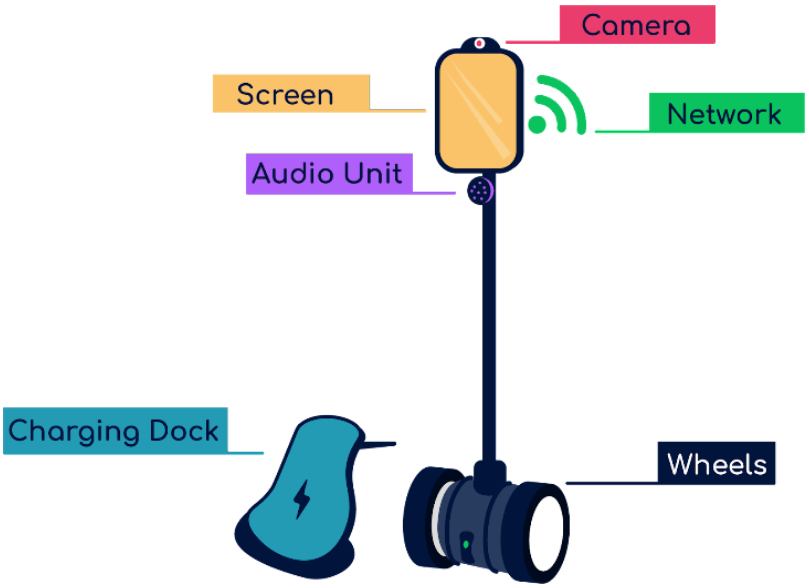


Figure. 1: Components of a Telepresence Robot [7]

Telerobi Hardware Components

Here's a list of the mechanical and electronic components needed for assembling the Telerobi project.

Mechanical Components

Component	Quantity	Dimension	Our Cost [€]
Plexiglass Plates	1	300x400x4mm	30,2
	1	300x300x4mm	
	1	300x200x4mm	
	1	Side Protectors (Reference: CAD-model)	
Wooden bars	2	Total minimum Length: 1240mm (usually sold as 1m bars, thus 2x 1m)	7,02
Plastic tubes	1	Lower tube: Ø50mm, length: 1000mm Upper tube: Ø40mm, length: 800mm	2,4
Plastic tube adapter	1	Inner diameter: Ø40mm Outer diameter: Ø50mm	1,15
Plastic tube socket	1	Outer diameter: Ø50mm	0,49
Curved plywood corner pieces	2	100x150mmx30mm	7,5
90-degree angle fitting	3	Used to connect Speaker Plate to tube	1,15
2-component glue	1	Pattex 2K-Kleber Stabilit Express (30g)	9,95
Double-sided tape	1	Transparent tesa Powerbond	7,75
Screws	2	M10x100mm	10
	6	M8x60mm + wing nuts	
	2	M6x70mm	
	multiple	smaller screws (M3/M5)	
Washers	multiple	div. sizes	
Nuts	multiple	div. sizes	
USB-to-Arduino pin power cable	1	-	
Cable ties	multiple	div. sizes	
Tablet mount	1	TRUST Universal tablet mount	11,76
Plastic washers	1	Recommended by us for mounting the ultrasonic sensors (purchase is optional)	13.99
Swivel castor	1	Height (wheel + socket): Approx. 70mm	3,76

Aluminium wheels	2	Outer diameter: Ø106mm	11,11

Electronic Components

Component	Quantity	Dimension	Our Cost [€]
Transistor	2	max.100mA	10
Electrical Resistors	3	1kΩ, 10k, 100Ω	
Arduino UNO WiFi Rev2	1	Check: https://de.rs-online.com/web/p/arduino/1763651/	30,84
Arduino motor driver shield	1	Check: https://www.conrad.de/de/p/arduino-motor-shield-entwicklungsboard-1969887.html	3,93
DC motors	2	Modelcraft RB350050-22H22R, 6V, 50:1	19,99
Power bank	2	Power Bank 20800mAh, with USB output, 5V / 2.5A	38,85
Tablet	1	Choose a model that fits into the tablet mount and is compatible with the telepresence software (e.g., Samsung Galaxy Tab A6)	200
Loudspeaker (optional)	1	Hama Sonic Mobil 185 (includes two speaker boxes 70x70x70mm each)	16,55
Microphones (optional)	1	DeLock Mikrofon 65873, schwarz, Desktop-Mikrofon, Kugelcharakteristik	22,93

Notes on the component list:

- the links are last accessed on 28.02.2023
- the prices were obtained at the end of 2021 and beginning of 2022 and can strongly differ in future

Tools

These are general suggestions. Below is the list of tools which may be useful while building a telepresence robot by yourself.

1. Soldering Iron with Holder, used for connecting electrical components.
2. Saw, used to cut precisely and remove extra material from the components of the project.
3. Wire Cutters/Strippers, to remove insulation without damaging the wire.
4. Multi-meter, to measure current, resistance, voltage, diode and continuity tests.
5. Pincers, used for pulling or gripping objects.
6. Socket wrench to tighten screws.

Figure 2: left to right, multimeter, wire cutter, soldering iron with holder, pincer[8-11]

Telerobi Assembly

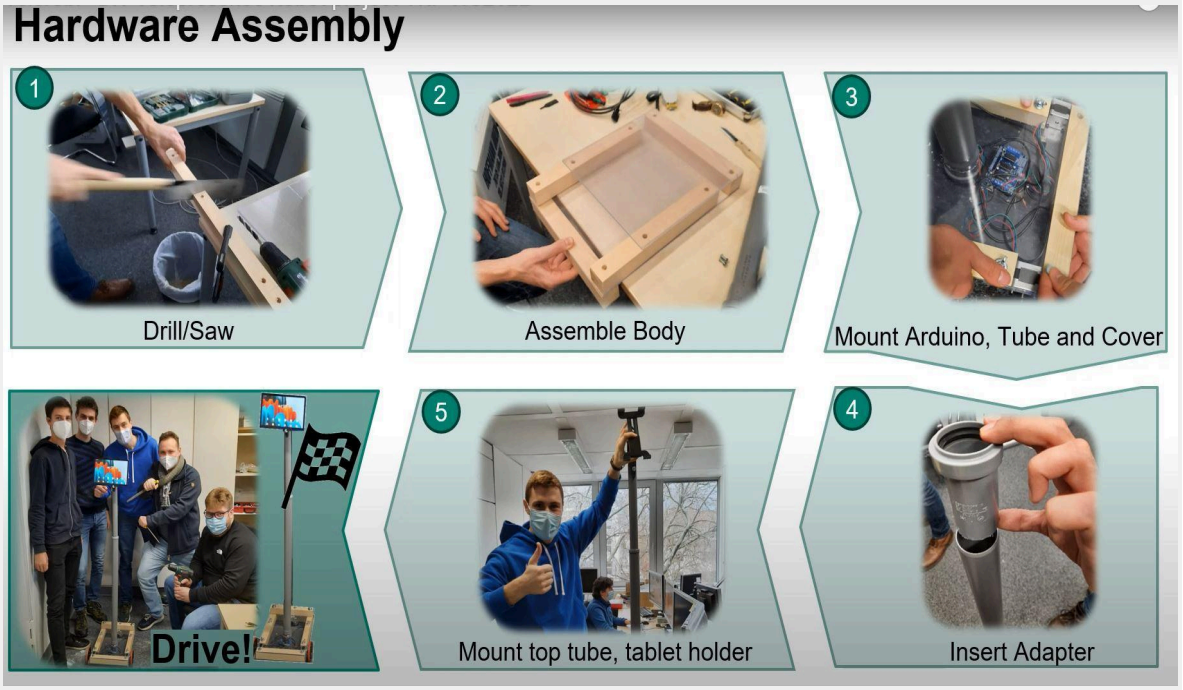


Figure 3: Assembly steps of Telerobi

Please refer the video in the link to get an idea of the assembly process instructions: https://www.youtube.com/watch?v=GZarpvYrOyE (9:36min to 12:17min)

Pre-manufacturing Process

Sawing

Step 1: Purchase wooden bars measuring 40x40x1000mm to make the wooden segments. The segments are supposed to be cut for assembling the rear wooden bulk for the base of the telepresence robot, as shown in fig.26.
Step 2: From the purchased wooden bar (with dimensions 40x40x1000mm), saw four segments of wood. Two of them with a length of 320 mm (see Fig. 8) and two with a length of 300 mm (Fig. 8 and 9).
Step 3: From 4 wooden segments, make 2 segments having length 320 mm each and the other 2 segments with length 300 mm each.
(Side Note: Remaining wood from the bars can be discarded as it will not be required for the robot anymore.)
Step 2: Saw off one end of the central tube adapter piece (fig. 16) such that it fits into the lower tube.
Please Note: The holes shown in fig. 6 can be drilled before or after sawing.

Figure 4: Process of sawing wooden bars into desired segments

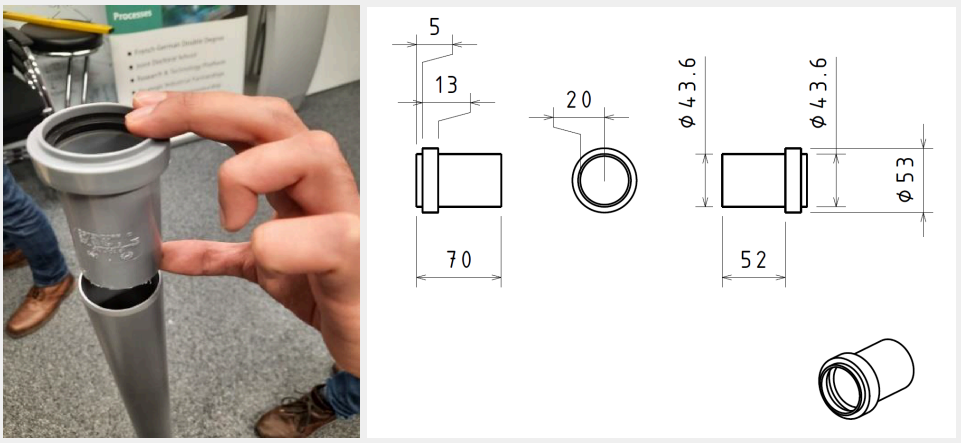


Figure 5: Process to sawing the adapter piece at one end of ring segment

Drilling

In order to put all the pieces together, holes of specific sizes need to be drilled at respective distances. This has to be done for the **wooden pieces**, **plexiglass plates** and **plastic tube** elements. Below are the specific instructions and technical drawings for these parts.

a. Wooden Pieces

Step 1: 2x Side Segments

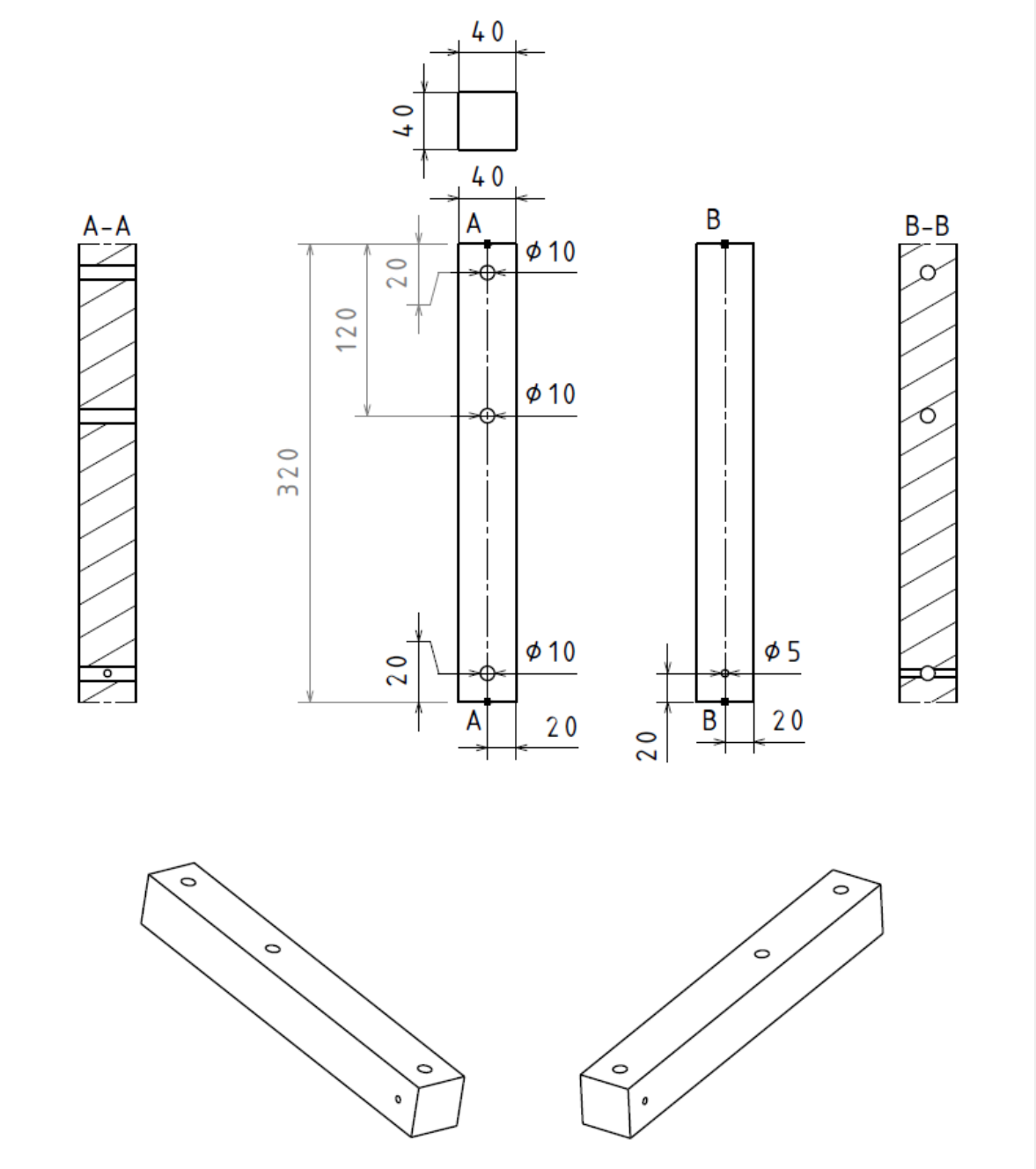


Figure 6: Drilled holes Ø10mm each at the edges in each of the two 320mm wooden side segments.

Step 2: Front Segment

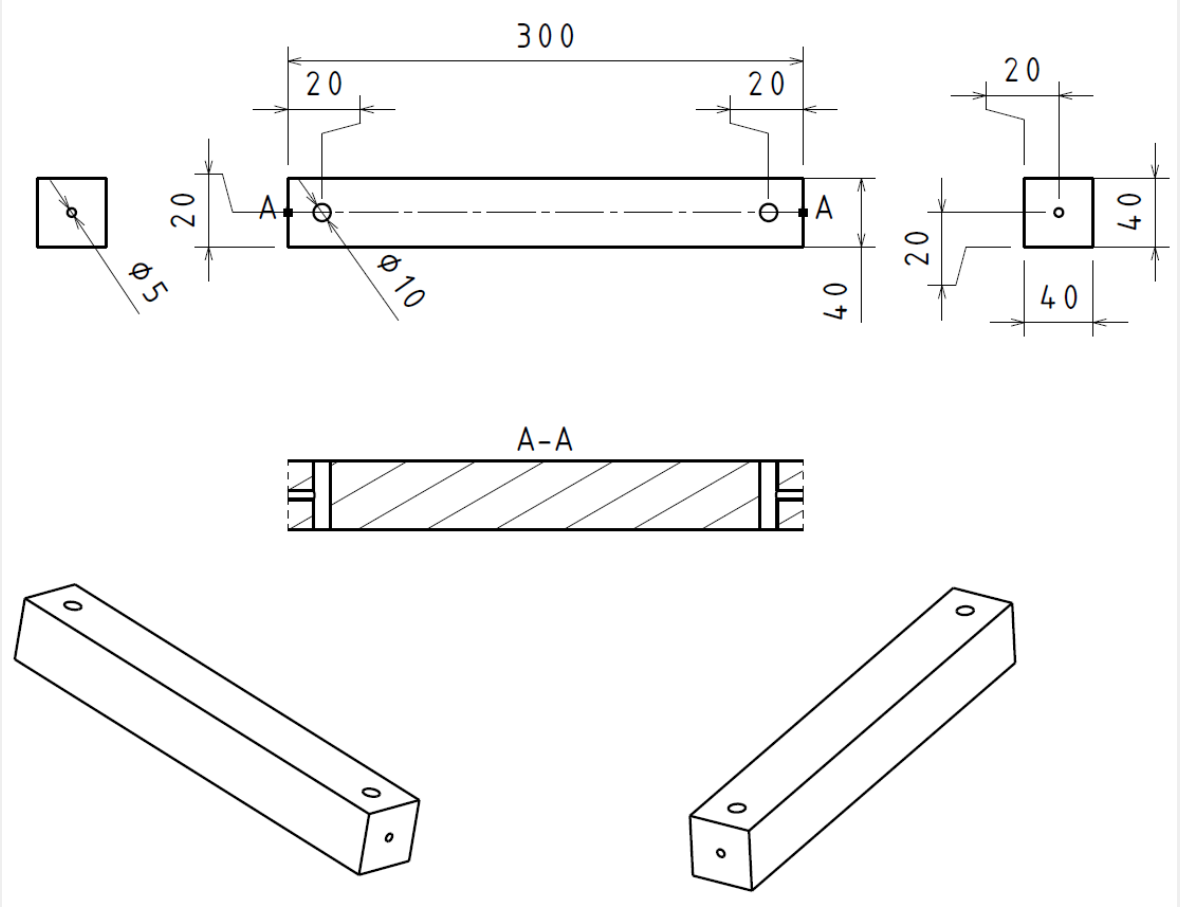


Figure 7: 2 Ø10mm holes drilled in the 40x40x300mm front wooden bulk

Step 3: Rear Segment

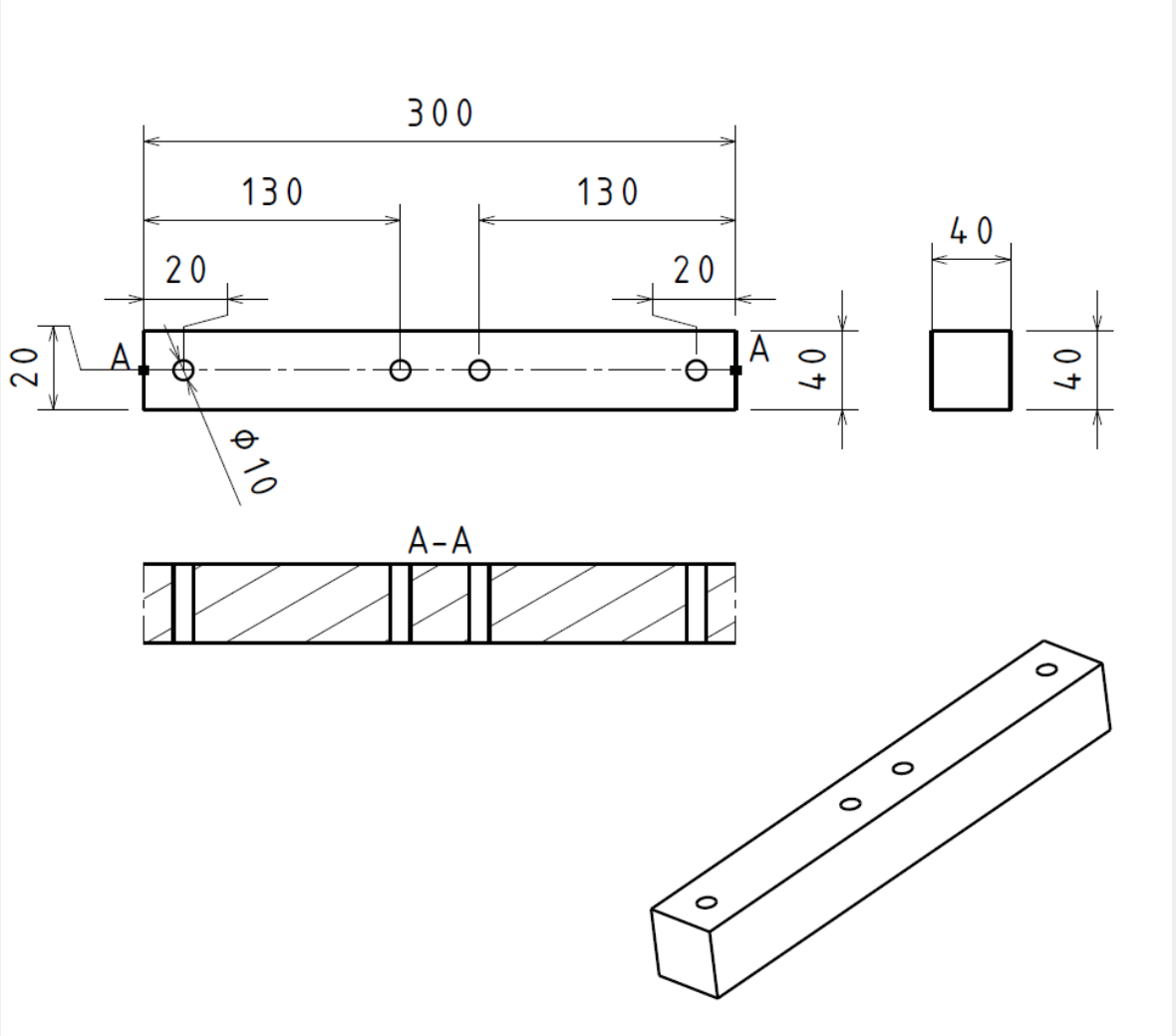


Figure 8: 4 Ø10mm holes drilled in the 40x40x300mm rear wooden bulk

b. Plexiglas Plates

Step 1: Base Plate

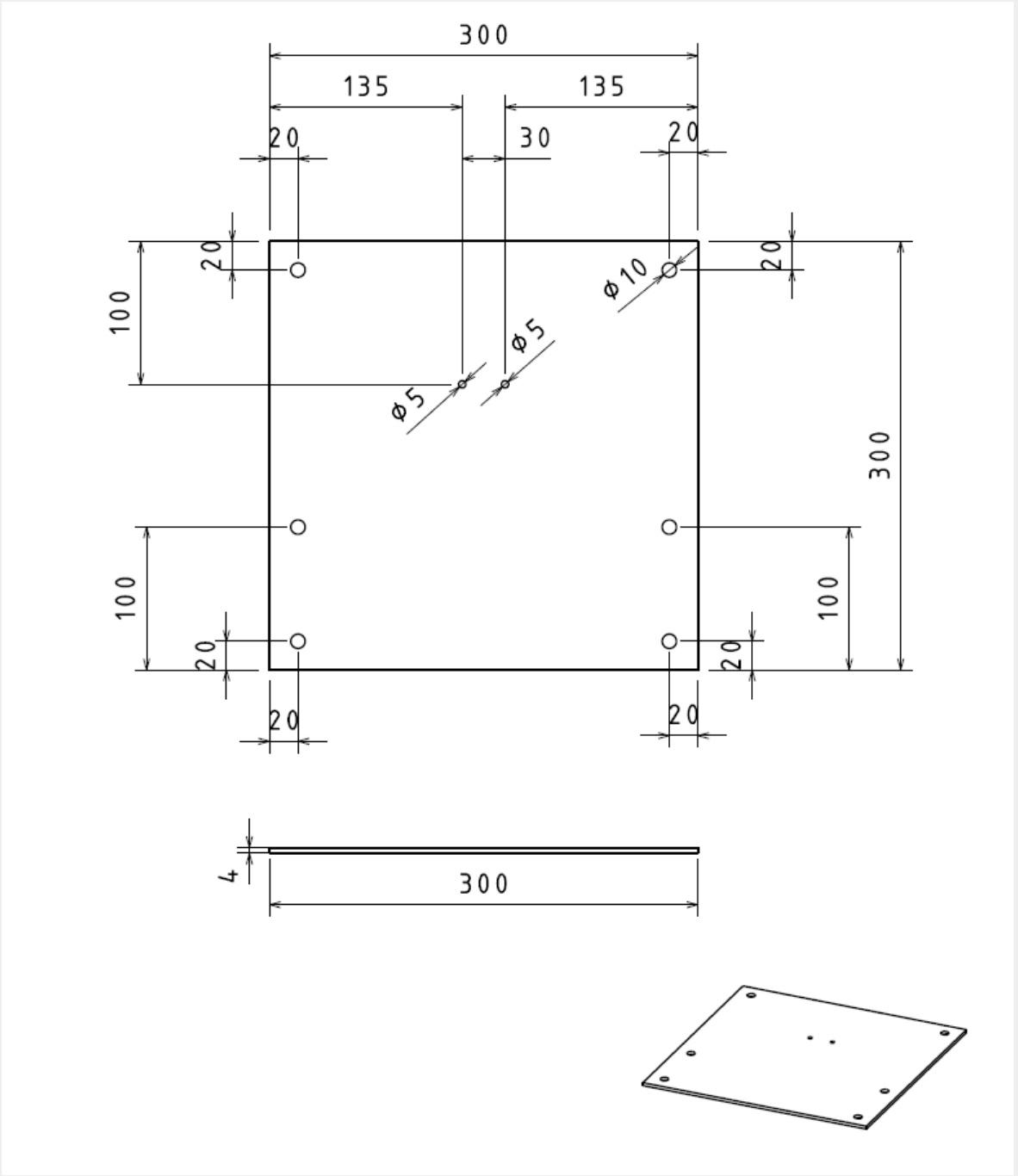


Figure 9: Drilled holes on a 300x300x4mm plexiglas base plate

Step 2: Top Plate

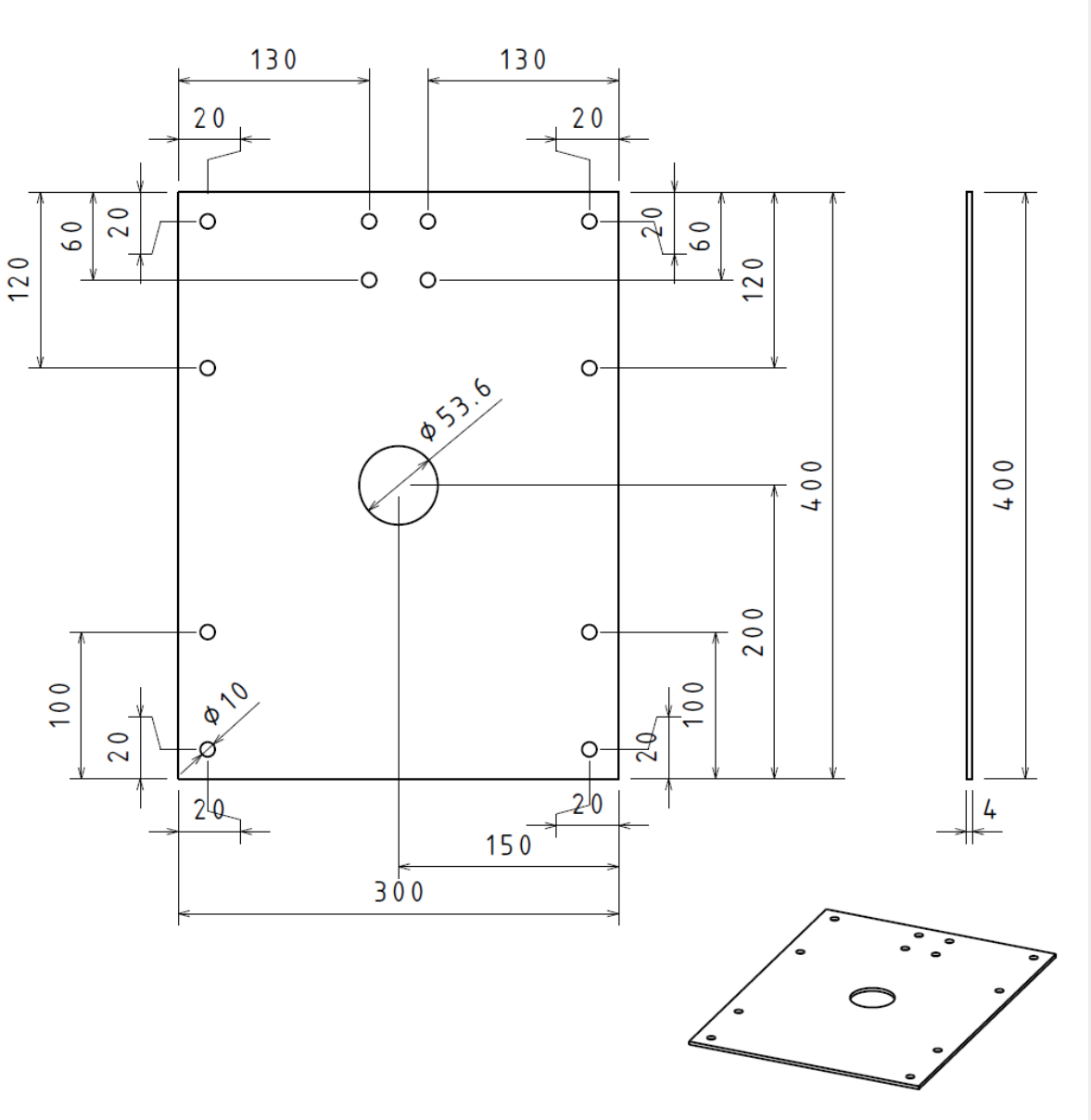


Figure 10: Drilled holes on the top plate.

Please Note: The large central hole is not drilled manually.

Step 3: 2x Side Protector Plates

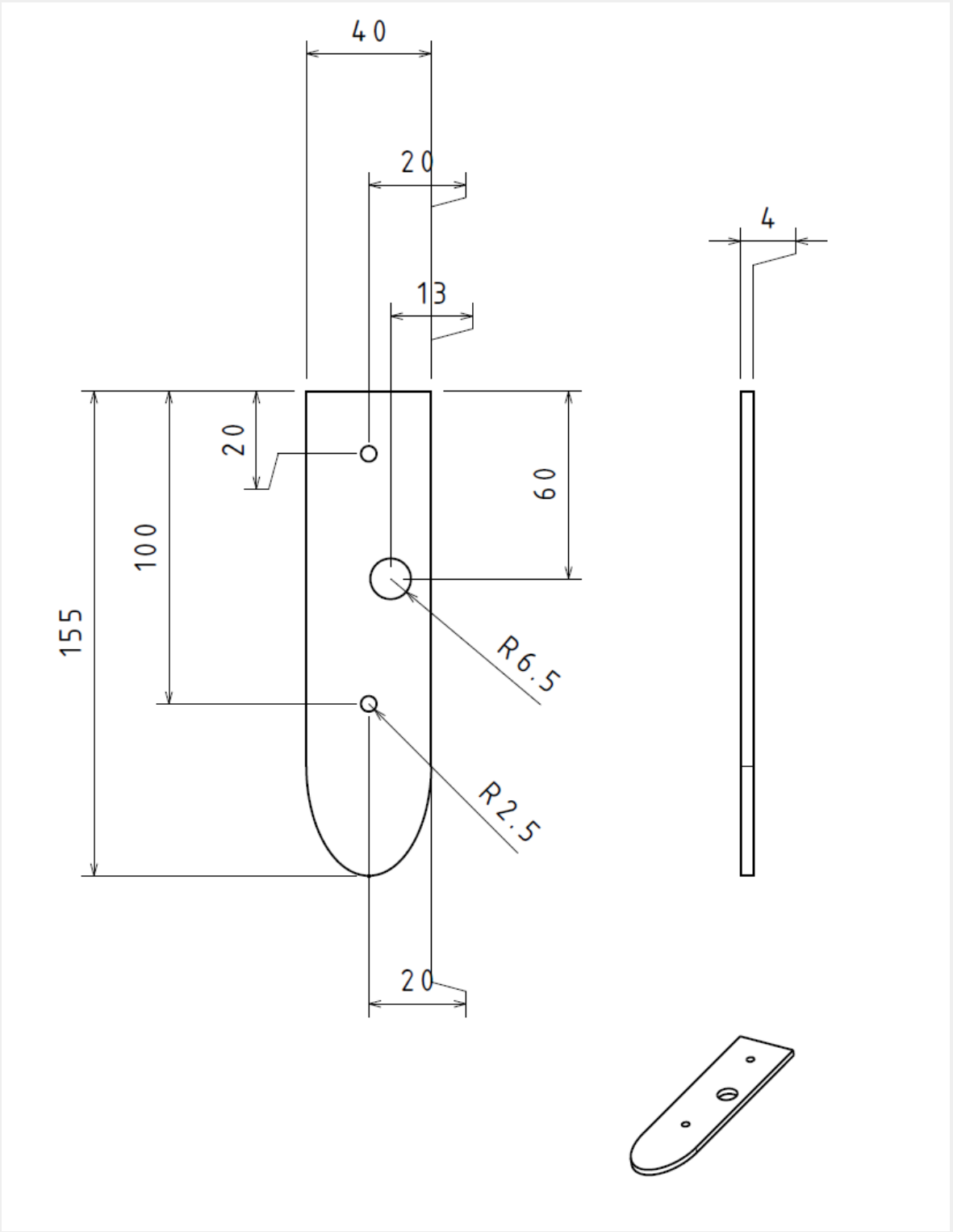


Figure 11: Dimensions of drilled holes in each of the two side protectors

Please Note: The 2.5mm holes drilled in the side protectors are to attach the SPAX screws that attach the motor shaft, side protectors with the respective wooden pieces.

c. Tube elements

Step 1: Adapter Socket

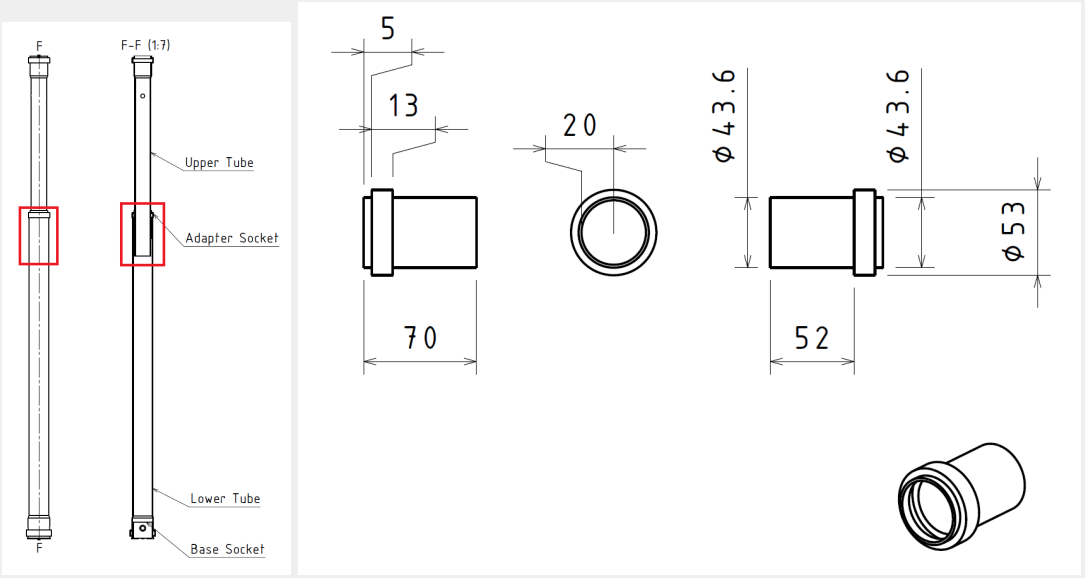


Figure 12: Adapter Socket placed and glued in Lower Tube

Please Note: The adapter socket should be placed into the lower tube and glued in place.

Step 2: Lower Tube

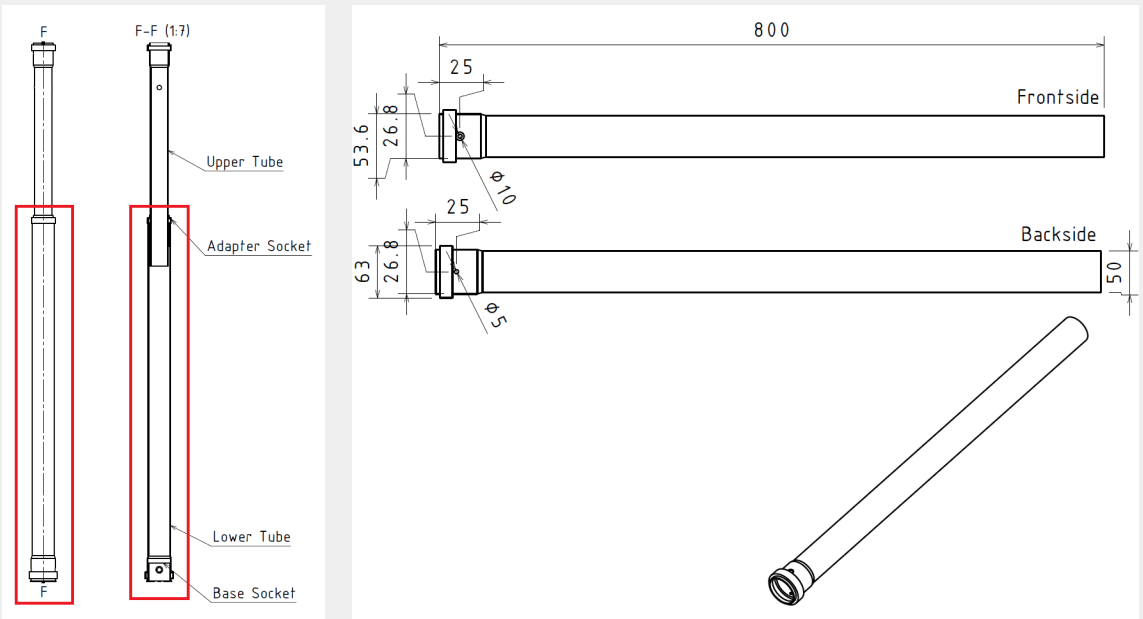


Figure 13: Dimensions of holes for lower tube

Please Note: The lower tube requires one bigger hole that serves as an access point/cable hole (modelled here with Ø10mm) and a Ø5mm screw hole right across from it.

Step 3: Base Socket

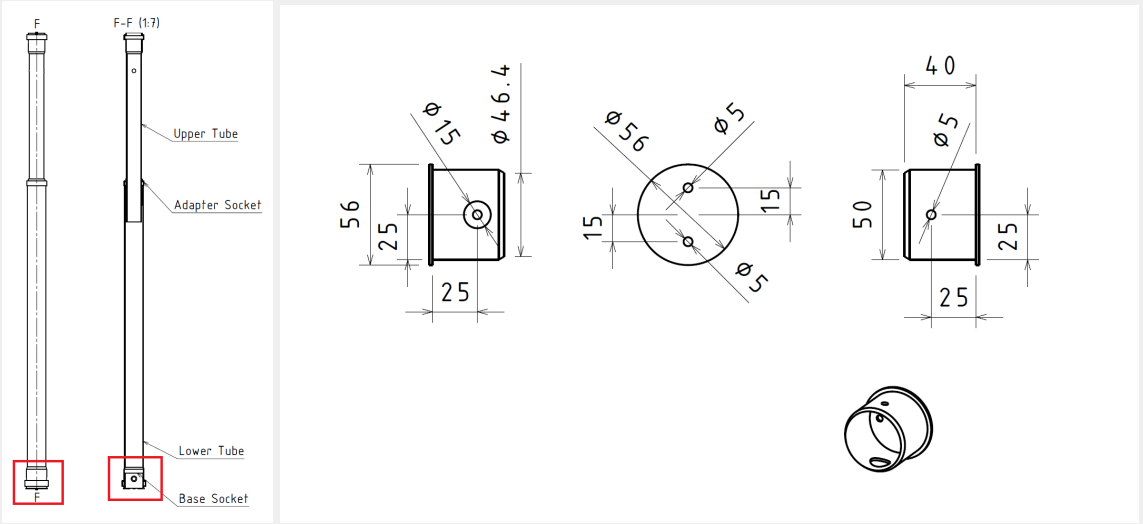


Figure 14: Drilled holes for tube socket

Please Note: The tube socket also needs some drilling to be done, including a large access opening matching that of the lower tube (at least Ø15mm).

Step 4: Upper Tube

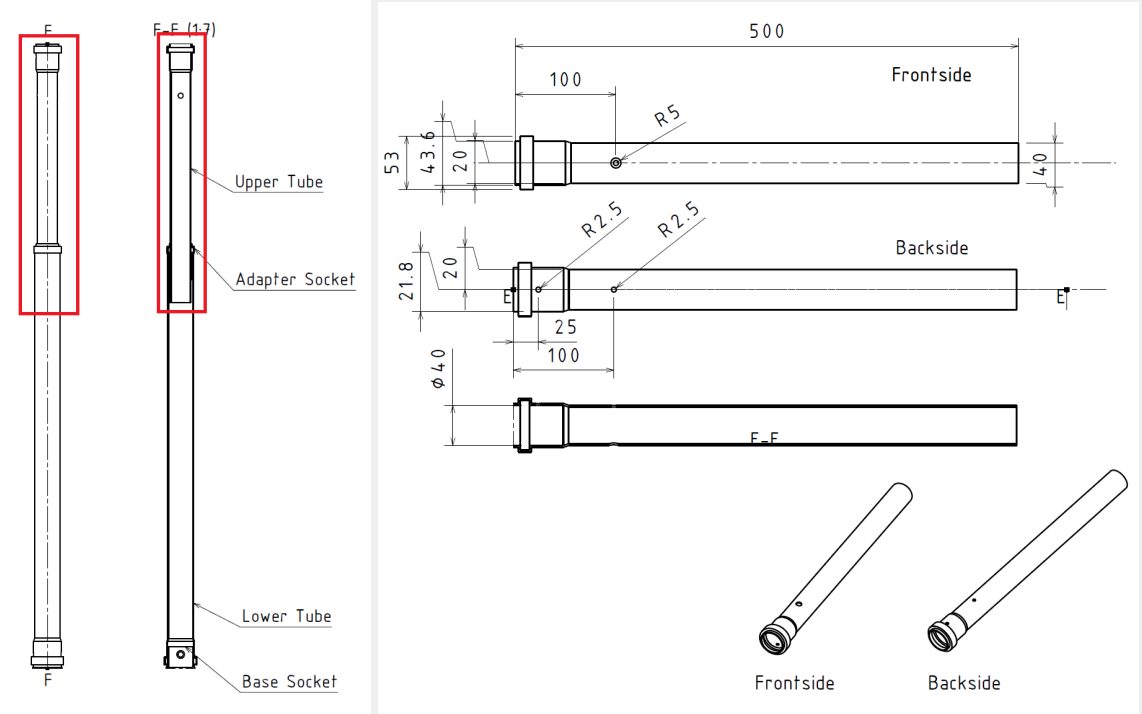


Figure 15: Dimensions of the 3 holes to be drilled in the upper tube

Adjusting tablet mount

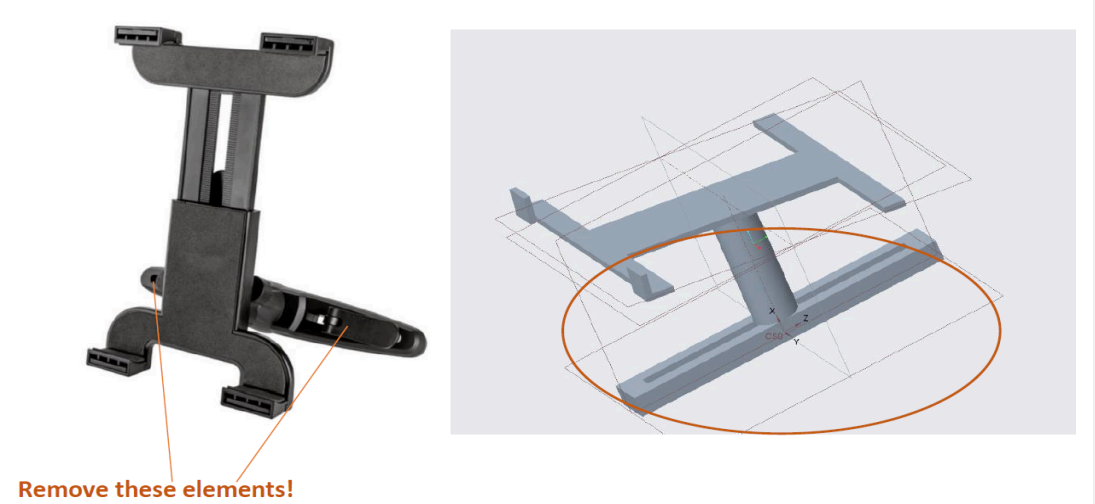


Figure 16: Tablet fixation clamp. original clamp (left). CAD-model of the final component (right)

Please Note: Remove the plastic fixation clamps on the tablet mount as shown in fig. 18 (left image), e.g., by breaking them apart with pincers or drilling into them until they break. They have to be removed completely, so that only the grooves remain. The final component has to look like the model on the right in fig. 20 in order to be properly mounted.

Wiring and Soldering

In the next picture (Fig. 19), you can see the overview of the system with the electrical components, which are listed below. The wires between the Arduino and the ESP need to be soldered. The motors are soldered to their connecting wires as well.

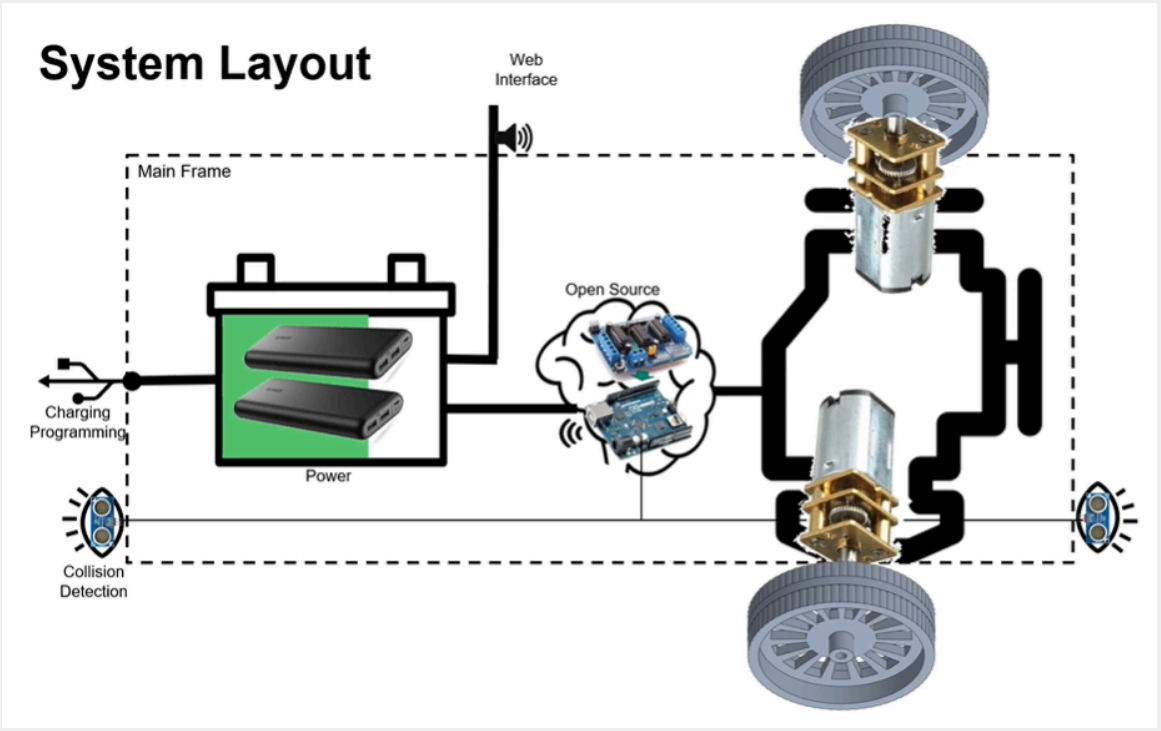


Figure 17: Internal Assembly of the electronic components

- The Esp32Cam with WIFI is connecting to the internet and the connection point to the remote user.
- The Arduino is getting the motor driving commands from the ESP32Cam through serial connection on port 2.
- A powerful motor shield is stacked on the Arduino Board.
- The motor shield drives the two DC motors with integrated gear boxes that provide enough torque to propel the robot.
- The Arduino and the driver shield are powered by two power banks, as shown in fig. 20.
- *Optional:* Additionally, two ultrasonic sensors, one at the back and one at the front, can be mounted to warn Telerobi about possible collisions.

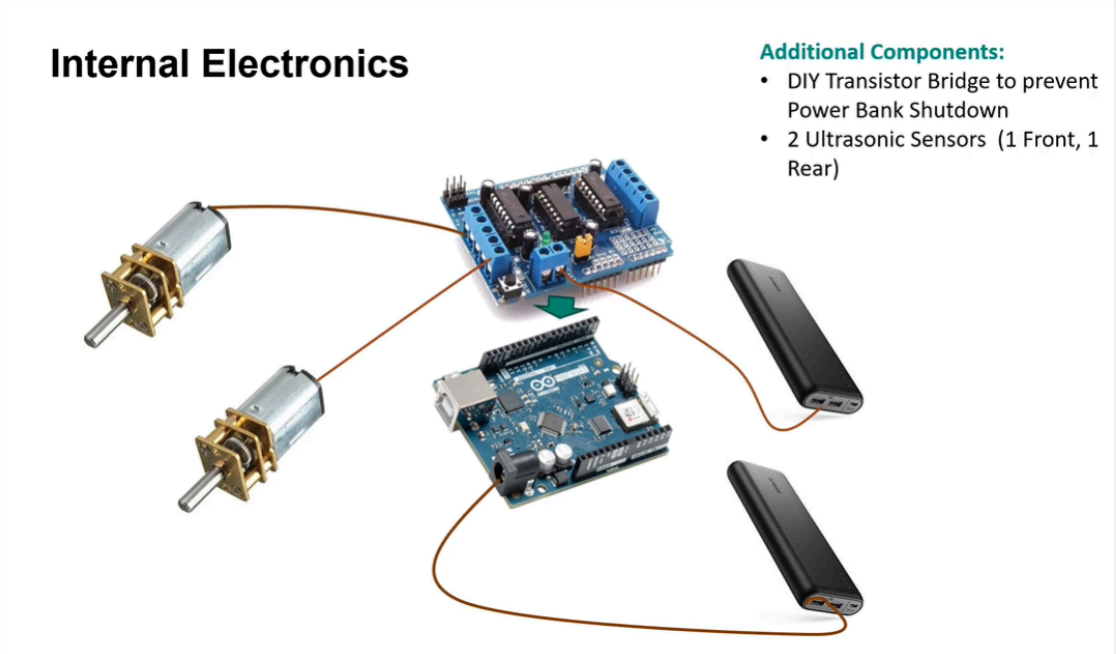


Figure 18: Internal electronics of the Telerobi

To connect the electronic components follow these steps:
Step 1: Firstly, the driver shield needs to be stacked physically onto the Arduino.
Step 2: A cable needs to be soldered to the two contact patches of each DC motor.
Step 3: The other ends of these connecting cables can be plugged into the connectors on the motor shield directly and fastened with the existing screws. Polarity and turn direction of the wheels need to be checked when first drive tests are done and might need to be reversed if wheels turn the wrong direction.
Step 4: For the ESP32 three wires need to be soldered between the ESP and the motor shield (which is stacked on top of the Arduino). One wire for 5V, one for ground, and the last for serial data transmission from the ESP to the motor shield. On the ESP the GPIO1 is used for serial output, and on the motor shield/Arduino Port 3 is used for serial input.

Please also refer to the schematic circuit diagram in fig. 21.

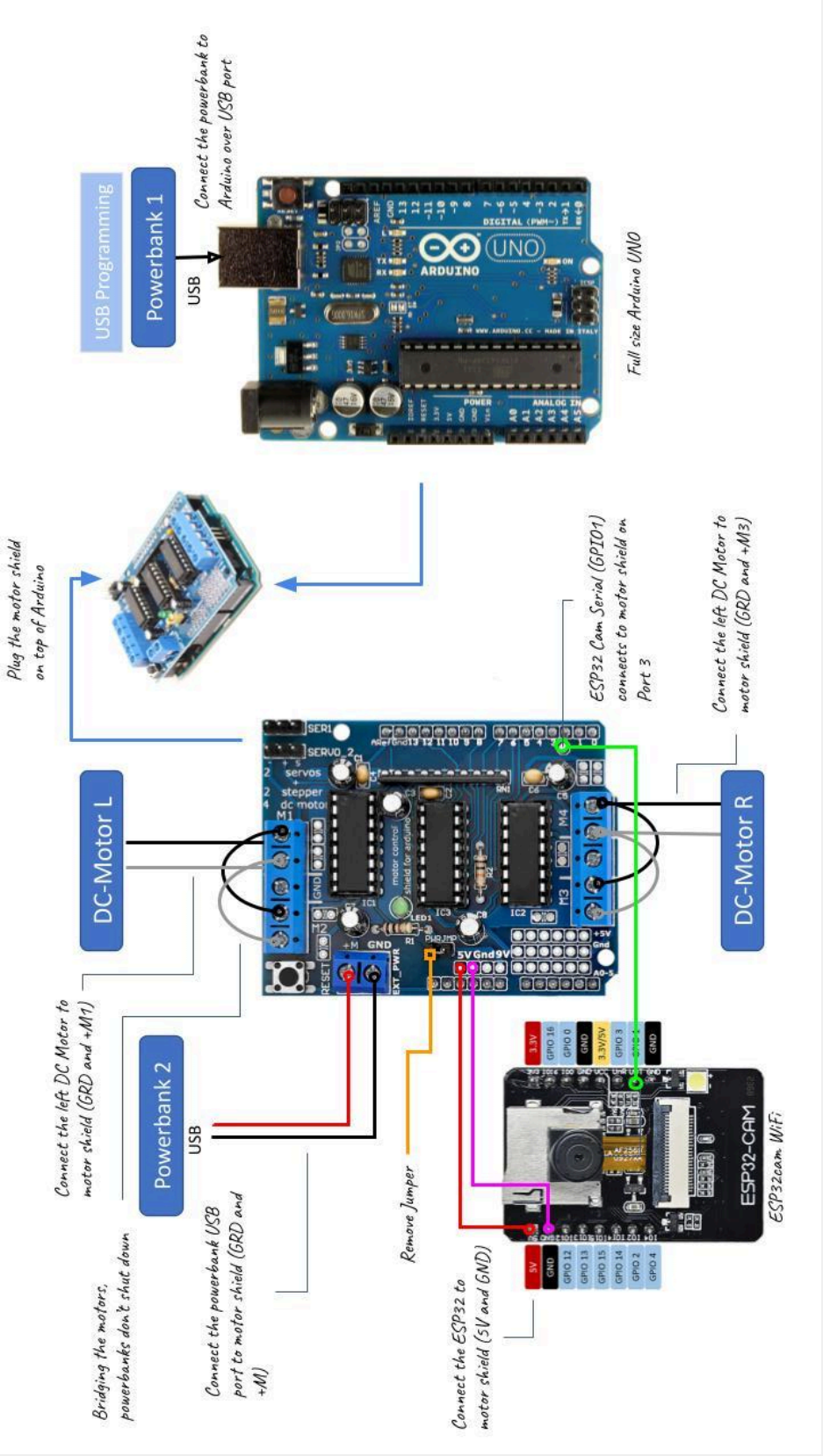


Figure 19: Connections to form a transistor bridge, Original file, see link in reference [12]

Assembly Stepwise Instructions

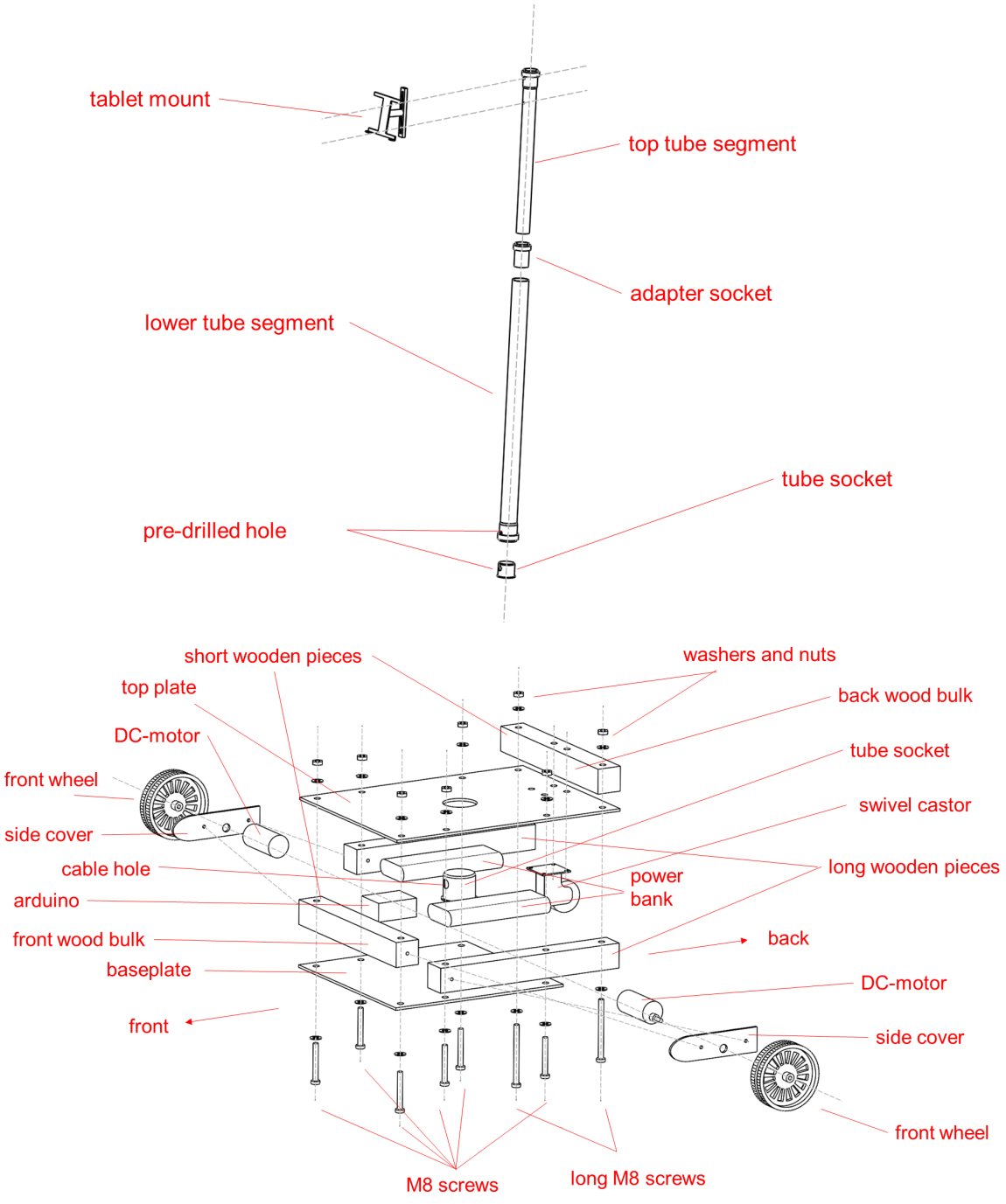


Fig. 20: Explosion view of the Telerobi

After finishing all the previous preparations, assembly of the telepresence robot can begin.

1. Tube Socket

Step1: Attach the plastic **tube socket** to the plexiglass **baseplate** (300x300mm) using two M3 screws, washers and nuts.
Step 2: Make sure that the pre-drilled **cable hole** (Ø20mm) faces toward the front.

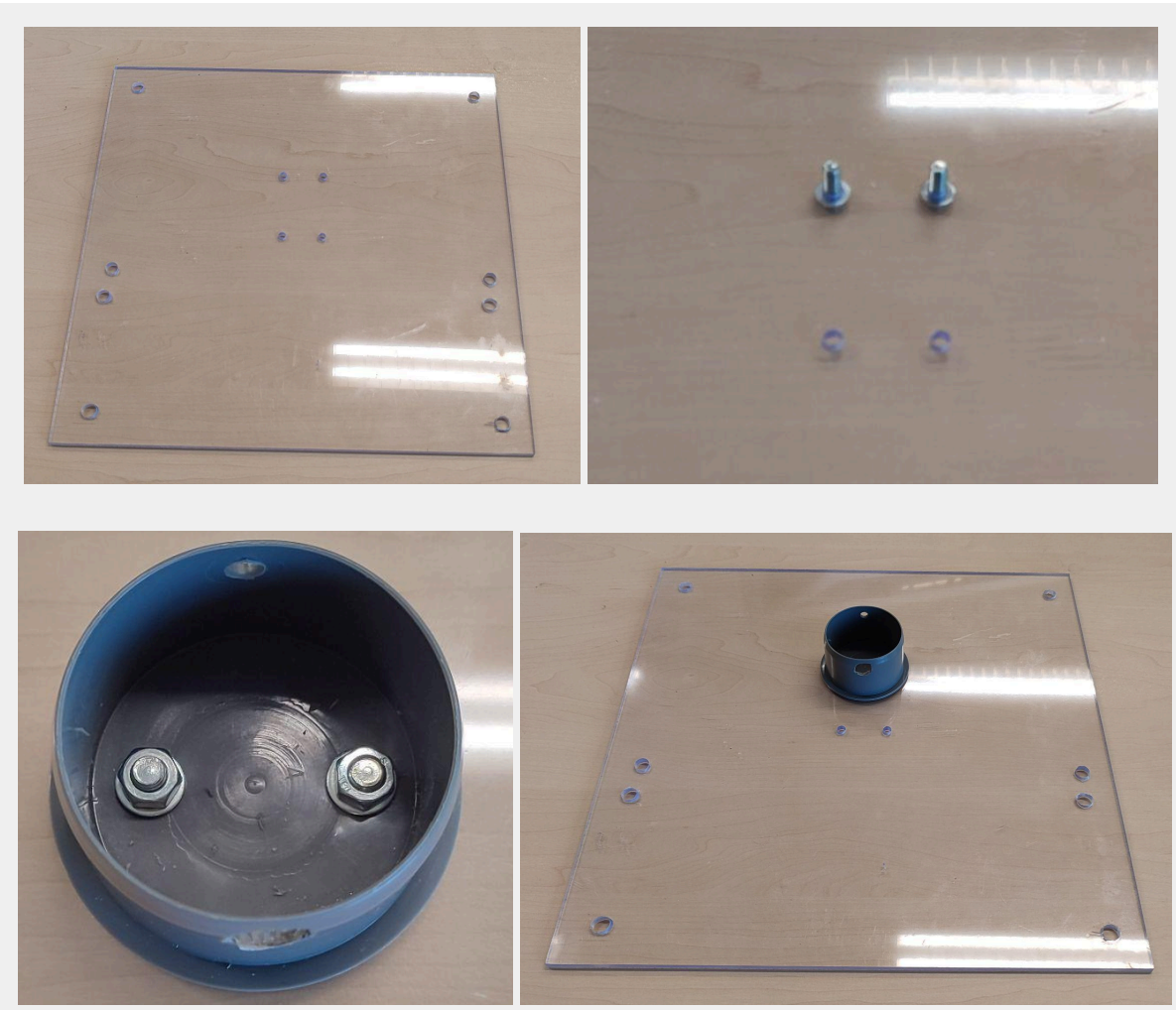


Fig. 21: Mounting the pipe base

2. Add Wooden Support Structure

Step 1: Place the two 320mm **long wooden pieces** on the left and right sides of the **baseplate**.
Step 2: In both cases, make sure that the pre-drilled holes on the wooden piece and the plate align.
Step 3: Push 4 of the short **M8 screws** (+added washers) through both pieces, two on each side. (Start from the bottom of the plate, so that the screws point upwards through the holes.)
Step 4: Likewise, push the two longer M8 screws through the rear holes of the wooden pieces, also starting from the bottom side.
Please Note: *Do not add the wing nuts onto the screws yet!*

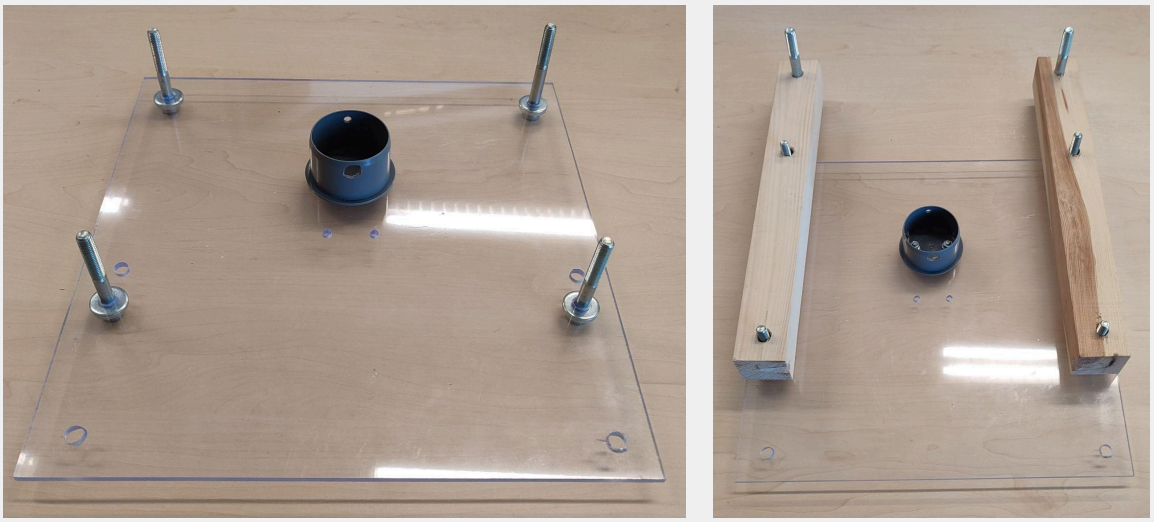


Fig. 22: Mounting the pipe base

3. Insert Lower Tube

Step 1: Place the **lower tube segment** (Ø50mm) into the **tube socket**. Make sure the pre-drilled holes on the tube and socket align.

Step 2: Insert a M3 screw through the hole in the front and place it so that the tip of the screw points out of the rear hole. This is best done via an Allen key with a sufficiently long handle.

Step 3: Put a nut onto the screw from the outside and tighten it to attach the tube to the socket.

Fig. 23: Mounting the pipe base

4. Power Banks

Step 1: Place the two **power banks** on the **baseplate**, one on each side of the **tube socket**.
Step 2: Make sure that the activation buttons of both power banks point upwards and the charger plug-ins point inwards (away from the wooden side pieces).

Figure 24: Addition of power banks

Please Note: The Arduino and DC motors are added in the next steps. The motors pictured here are placeholders, not the actual DC motors needed.

5. Add Arduino and Motors to the base

Step 1: Connect the **Arduino's** power inlet to one of the power banks.
Step 2: Use the double-sided tape to attach the **DC-Motors** to the **baseplate**. For optimal stability, add four strips of tape to each DC motor housing in a 90-degree angle relative to each other.
Step 3: As shown in fig.23 place the **DC-motors** directly in front of the wooden side pieces on the left and right side, so that the output shafts point outward on both sides and the gearbox cover plates on the motors (and their screw heads) do not reach past the rim of the **baseplate**. They should now be taped to both the baseplate and the front face of the wood side bulks, they were positioned in front of.
Step 4: Place the Arduino in between the two motors. Make sure all the wiring is stowed as efficiently as possible.

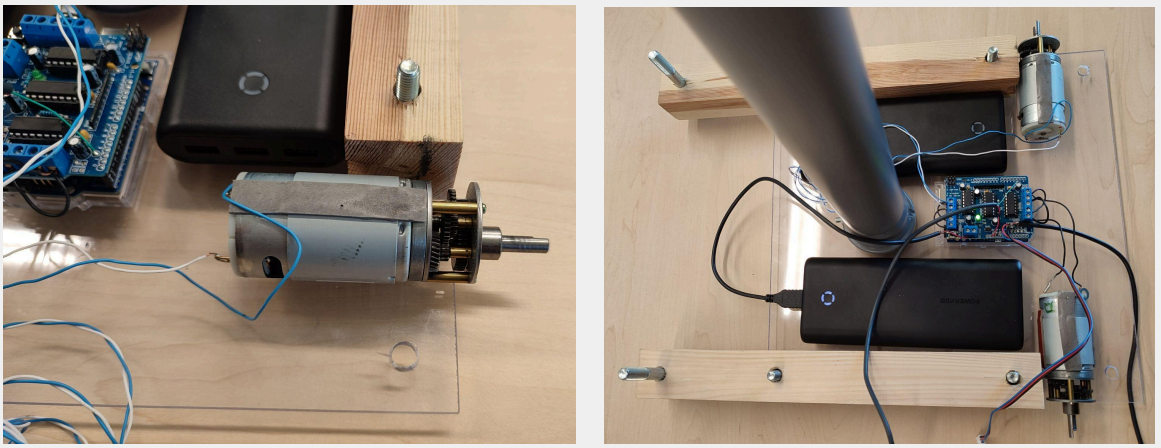


Figure 25: Tape strips arrangement around the DC motor housing as well as fixation of the motor

6. *Add Top Plate*

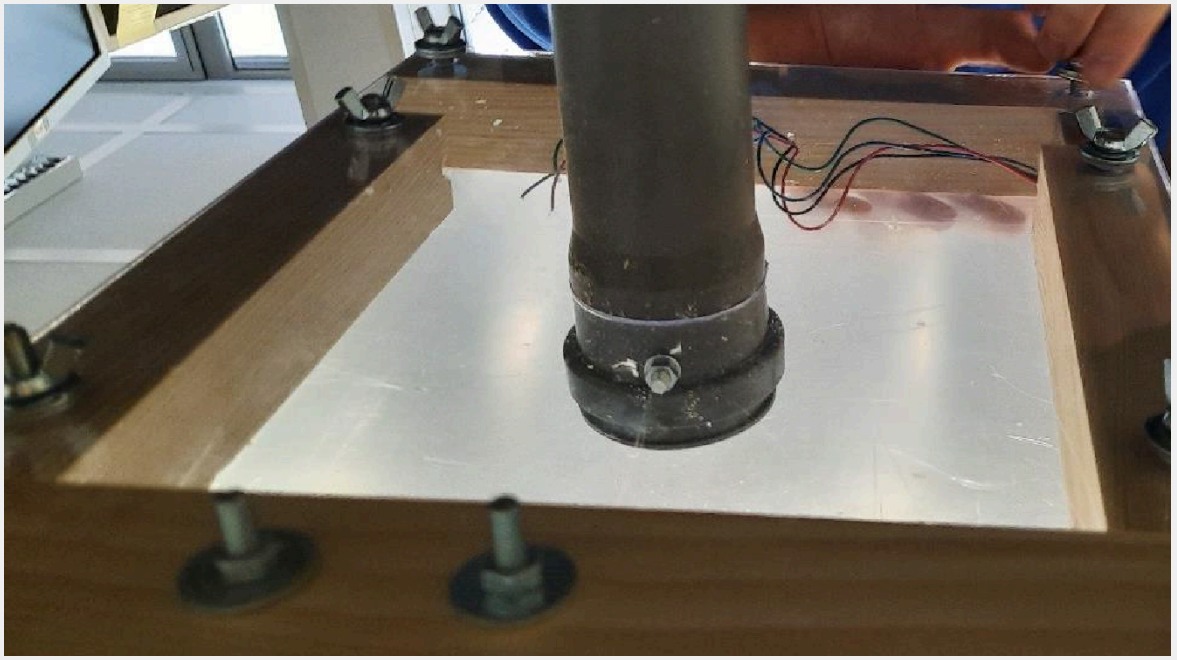


Figure 26: Attachment of plexiglas top plate and the tube with wooden support structure

Step 1: Attach the plexiglass **top plate** (300x400mm) onto the structure.
Step 2: Slide the tube through the big central hole and lower the plate all the way down onto the wooden support structure.
Step 3: Make sure it is positioned properly, so that the side with the square pattern of pre-drilled holes for the swivel castor is located in the back.
Step 4: Put the connecting cable for the frontal ultrasonic sensor through the pre-drilled hole in the plate.

The holes on the left and right sides of the top plate should fit with the tips of the M8 screws that were attached to the bottom plate and wooden pieces in Step 2).
Step 5: Now, place the thick washers and wing nuts on the four short M8 screws connecting the wooden side structures with both plexiglass plates and tighten the wing nuts.
Step 6: Make sure that the top plate properly presses onto the tape strips on top of the DC motors, so that another fixation for the motors is provided.

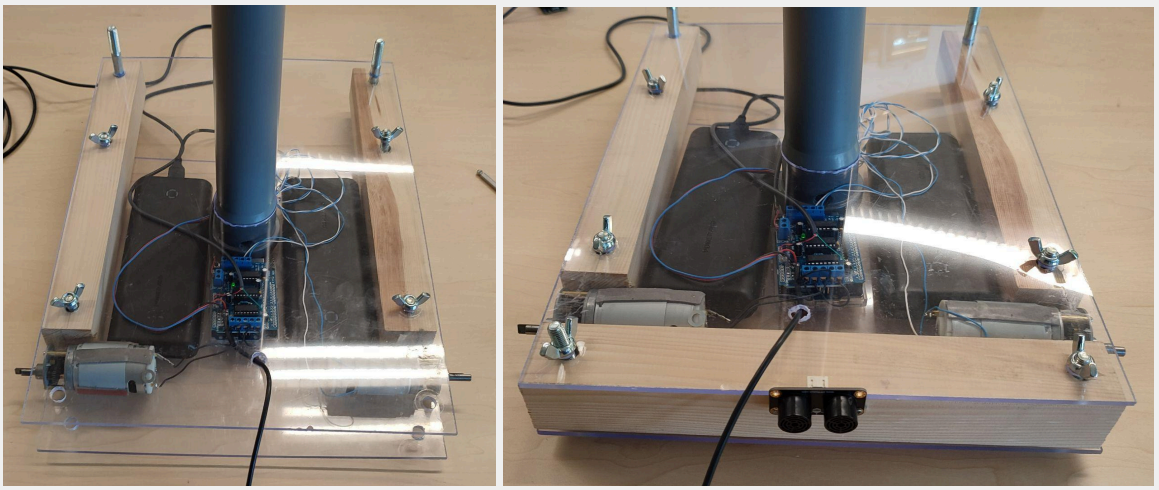


Figure 27: Motors mounted

7. Add Front Wood Bulk

Step 1: Insert the 40x40x300mm wood segment with two pre-drilled holes into the front portion of the structure.
Step 2: Make sure the pre-drilled holes align with those of the top and bottom plates and that the rear-facing face of the wood piece presses against the remaining tape strips.
Step 3: Use two M8 screws, washers and wing nuts and fixate them analogous to the previous ones.

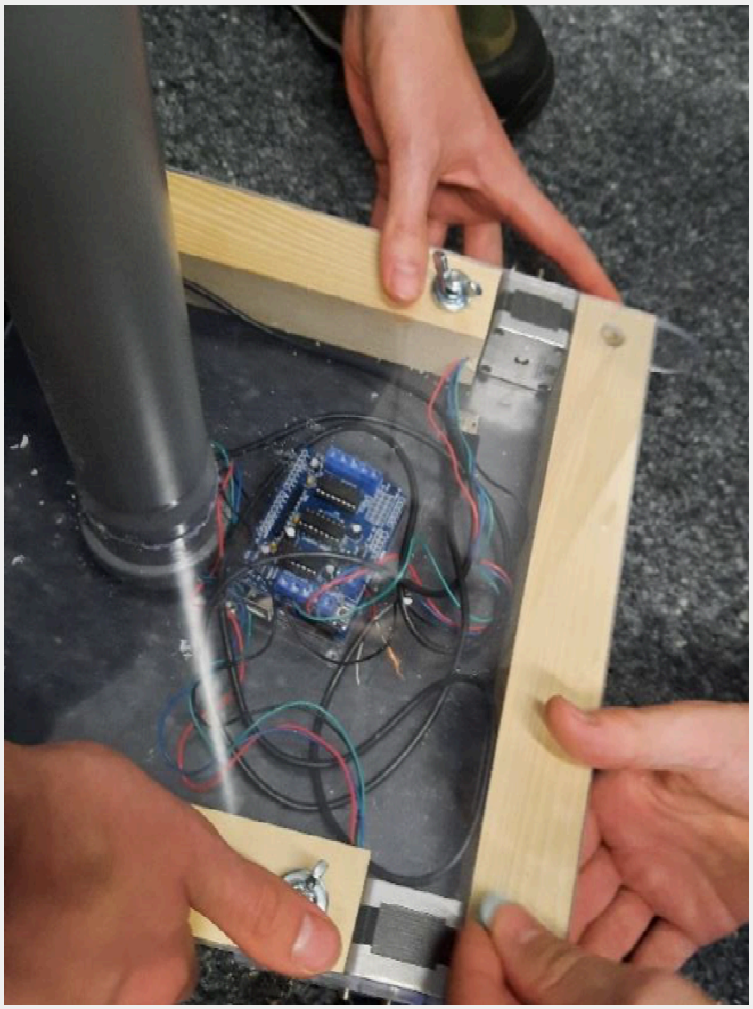


Figure 28: Top view of the structure

Please Note: *The motors pictured are not the actual DC motors used. Power banks are not visible here, but should be next to the tube socket.*

8. Add Rear Wooden Bulk

Step 1: Place the remaining wooden piece (40x40x320mm, 4 pre-drilled holes) on top of the **top plate**. The **long M8 screws** in the back should now point outward through the two holes closest to the sides.
Step 2: Use the M8 nuts and some washers to fixate the bulk piece.
Step 3: Make sure that the two central pre-drilled holes correspond to those in the plate.

Please Note: While the screws, tube socket and interior elements are missing in the picture, this image gives an overview over the sandwich structure in general.

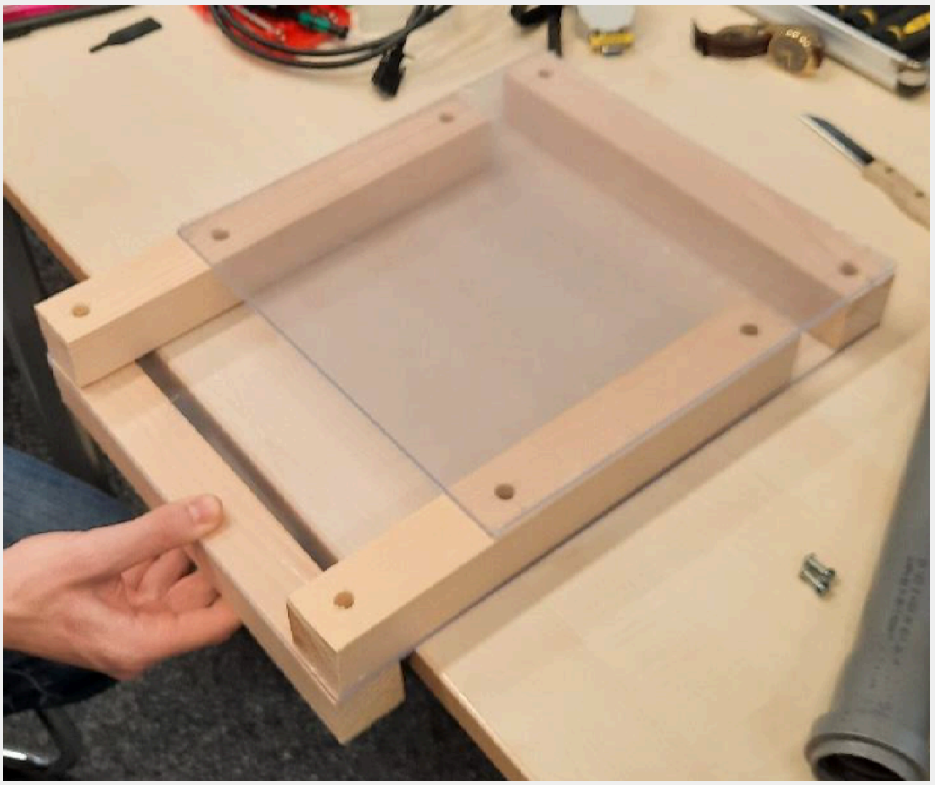


Figure 29: Structure of the rear wooden bulk

Please Note: The power banks and Arduino are not visible in this image in fig.26, although they should be if the assembly was done in the order proposed in this document.

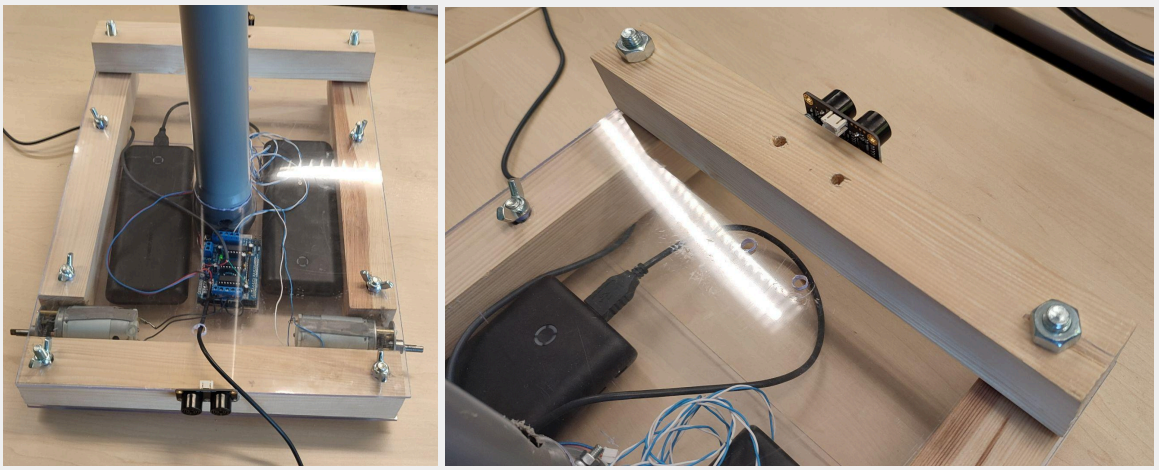


Figure 30: Structure of the rear wooden bulk

9. Add Side Covers

Step 1: Use the two pre-made plexiglass **side covers**.
Step 2: Place one of them on the left and right sides of the body structure so that the output shafts of the DC motors stick out through the central holes.
Step 3: Make sure that the curved endings point out of the robot's front. Now, use SPAX screws to screw the side plates onto the wooden bulks.

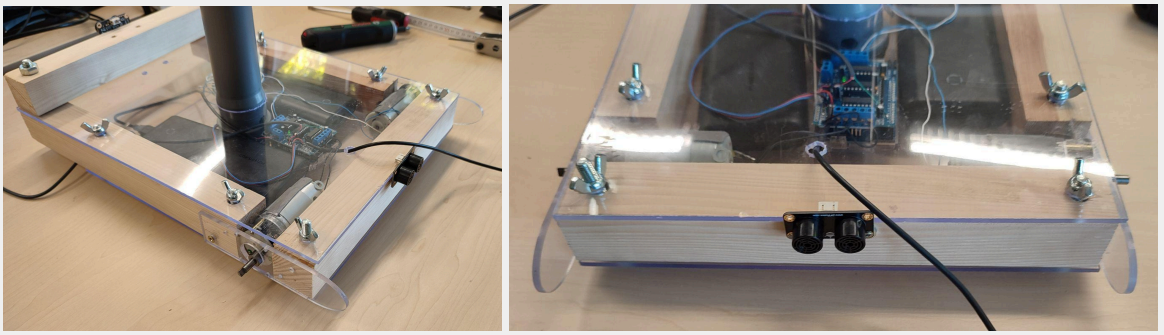


Figure 31: Side Covers

10. Add the Tube Adapter

Step 1: Take the sawed-off tube **adapter socket** and spread multi-component-glue on the entire cylindrical outer area.
Step 2: Stick the **adapter socket** all the way into the top opening of the lower tube (Ø50mm), until only the wider ring segment including the rubber seal ring remains visible.

Please Note: The glue may take some time (approx. 1hr) to harden. Spread glue on the entire side area, then insert the adapter piece into the lower tube.

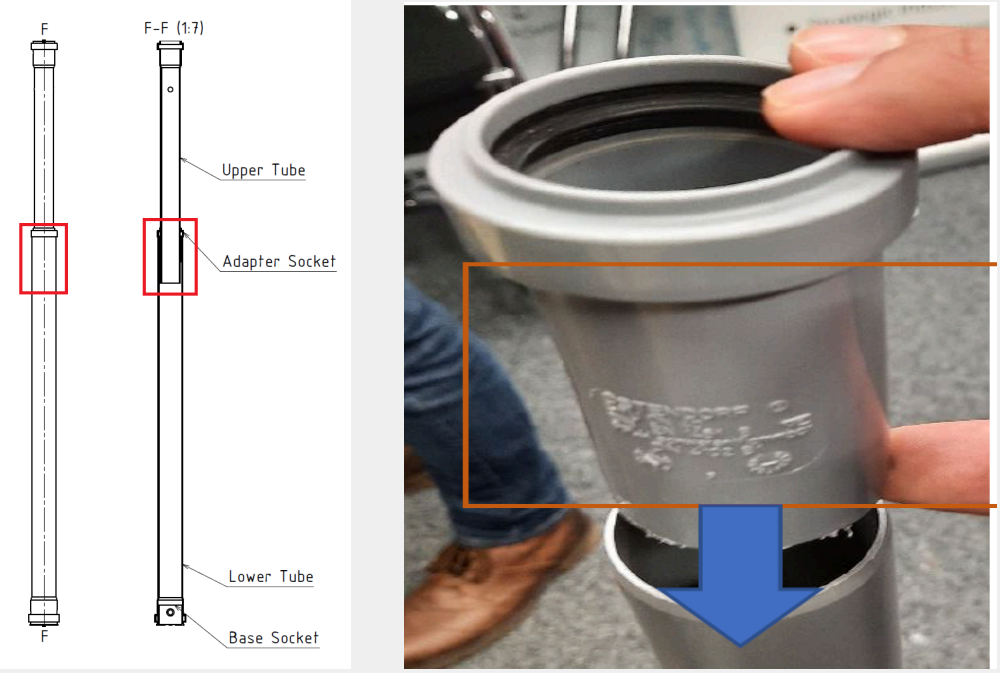


Figure 32: Inserting the adapter into the lower tube

11. Construct the Top Tube Assembly

Step 1: Attach the **tablet mount** to the top of the tube piece (Ø40mm). To accomplish this, insert 2 M5 screws through the pre-drilled holes.

Step 2: The upper screw can be added through the top opening of the tube, for the lower one we recommend using the extra hole that was drilled into the back of the tube element at this level.

Step 3: In the end, attach the **tablet mount** onto the screws in such a way that one of the screws each pierce through one of the grooves on the **tablet mount**.

The specific position of the mount can then be adjusted along these lines based on user preference.

Step 4: The ball joint of the **tablet mount** can also be used to adjust the position of the tablet later on. Use washers and M5 nuts to tighten the connections.

Figure 33: Tablet Mount

12. Attach the Top Tube

Once the glue has dried, the top tube can be inserted into the adapter piece. Thanks to the rubber seal, the top tube is height-adjustable.

Please Note: The total height of the DIY Robot can vary in-between approx. 1200 and 1500 mm, depending on the adjustment.

13. Attach the Swivel Castor

Step 1: Place the **swivel castor** underneath the square 4-hole-pattern in the top plate.

Step 2: Push two short M5 screws through the two holes in the front of the castor flange and the top plate, starting on the bottom side of the flange.

Step 3: For the two rear holes, use long M6 screws in the same fashion to connect the flange, top plate and the rear wooden bulk.

Step 4: Use nuts and washers to tighten the castor's connection.

Please Note: The power banks are not visible in this image, although they should be if the assembly was done in the order proposed in this document.

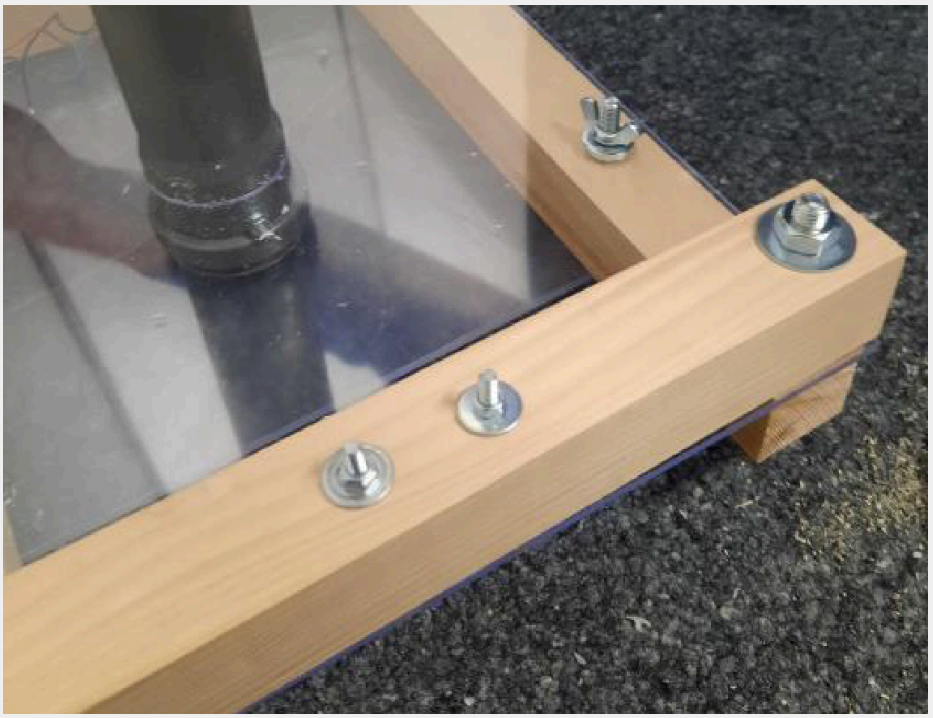


Figure 34: Top view of the rear bulk with Castor attached to the underside

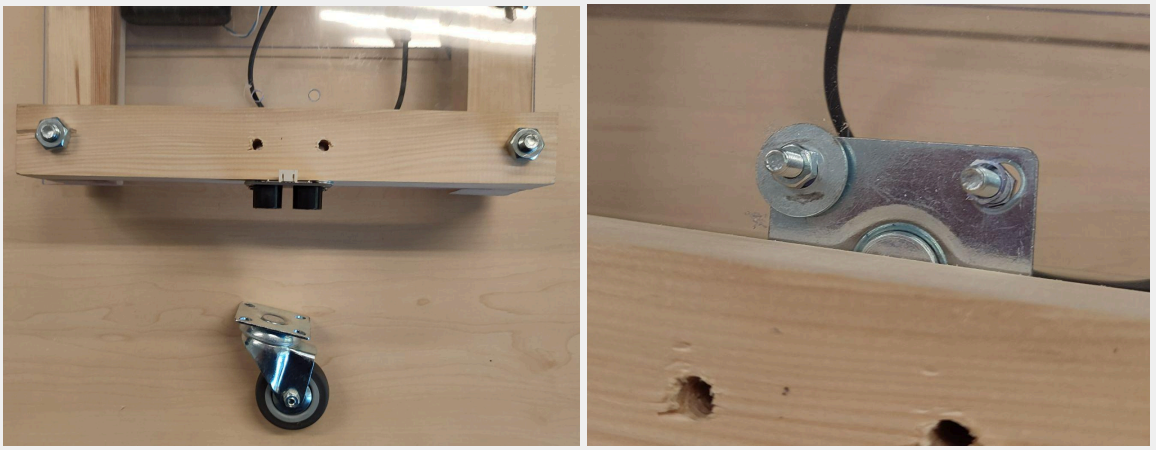


Figure 35: Swivel Castor

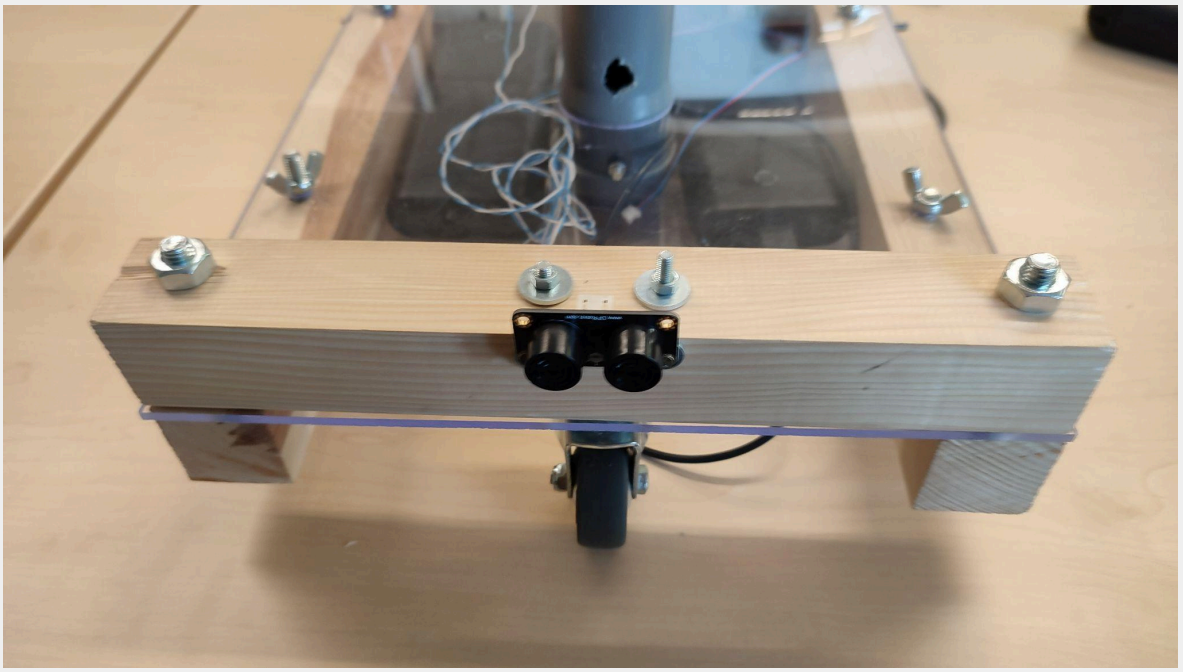


Figure 36: Swivel Castor

14. Attach Front Wheels

Step 1: Place the **front wheels** on the shafts of the motors.
Step 2: Push them onto the shafts all the way, then use the grub screws to axially secure them.
Step 3: The wheels have to be attached to the motor shafts.
Please Note: Since the wheels have a hub diameter of 5mm whereas the output shafts have one of 5.5mm, you may have to use a metal drill to widen the hubs on the aluminum wheels.

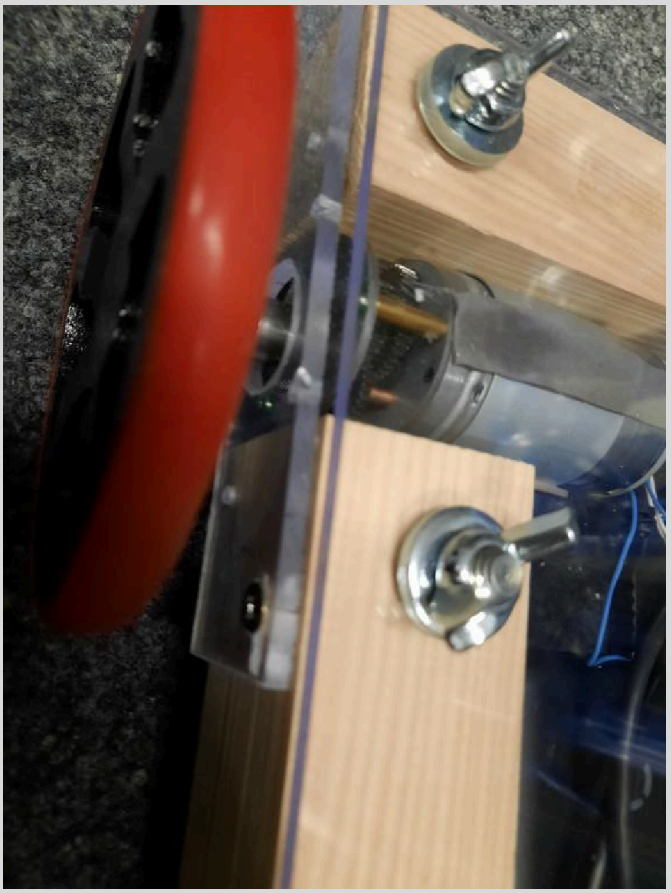


Figure 37: Font wheels attached to the chaises

15. Finished Product

Telerobi in comparison to a commercial TPR.

Aside from the missing power banks and stand-in wheels and motors, all the components pictured are part of the actual finalized system in fig.30

Figure 38: Final Product – Telerobi besides Ohmni

Option 1: Sound System

Due to time constraints, simply attached the loudspeakers to the lower tube with cable ties:

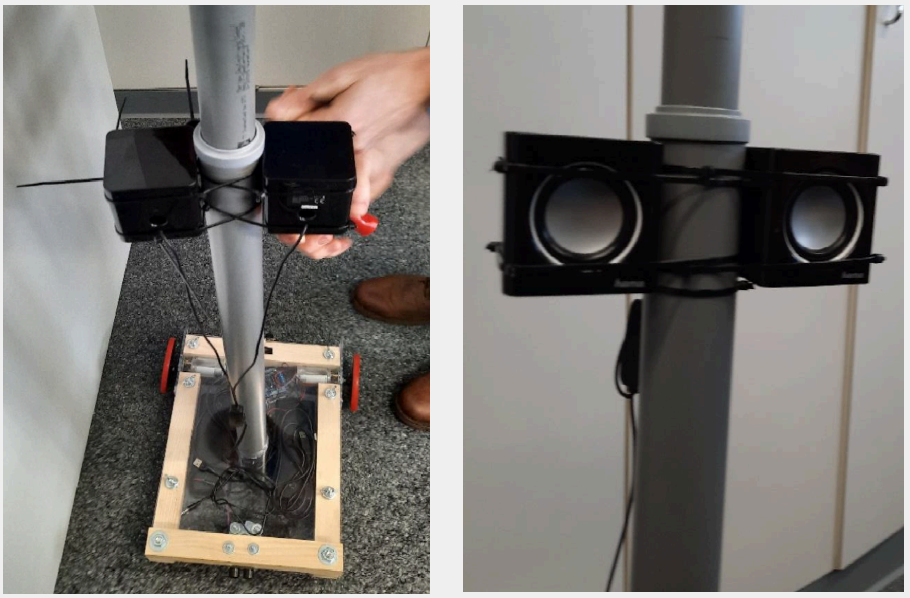


Figure 39: Loudspeakers attached to Telerobi via cables

If the speaker platform is properly finished (as seen in the CAD imagery), it can also be attached to the lower tube via the metal angle fittings.

In this case, the speakers can simply be attached to the upper side of the platform via double-sided tape.

Figure 40: Microphones attached to the tube of telerobi

Finally, the microphone can be attached to the tube as well with a piece of double-sided tape.
First, remove the smooth cover on the underside of the microphone.
Then, attach the microphone using a piece of double-sided tape.
Finally, drill an additional hole (Ø20mm) into the back of the lower tube for the microphone cable and speaker power cable.
Connect the USB plug-in of the speakers to one of the power banks.
Lead the microphone cable upwards through the entire tube until it comes out on the upper side of the top tube.
Use the dual adapter of the microphone to combine the speaker and microphone cables and insert it into the tablet.

Option 2: Ultrasonic Sensors

Step 1: Add the two ultrasonic sensors (one in the back, one in the front).
Step 2: Just connect the one in the front to the cable protruding from the hole in the top plate.
Step 3: For the one in the back, just pull the required connecting cable through the rear of the structure and connect that one as well.
Step 4: Finally, use two SPAX screws each to attach the sensors as pictured below in fig. 34:

Attention:

1. The washers in-between the sensors and the wood are needed in order to prevent the Surface-mounted devices (SMDs) on the backside of the sensors from being pressed onto the surface, which can damage them and render the sensors useless.
2. We highly recommend using special washers made from plastic (e.g., the model https://www.conrad.de/de/p/unterlegscheibe-polyamid-312-teile-838639-838639.html)

3. The components listed in section 2 can be referred) as they have small diameters and pose very little risk of damaging the SMDs themselves, which cannot always be guaranteed when using metal washers.
4. If necessary, the cables can be fixed to the plexiglass plates with black isolation tape.

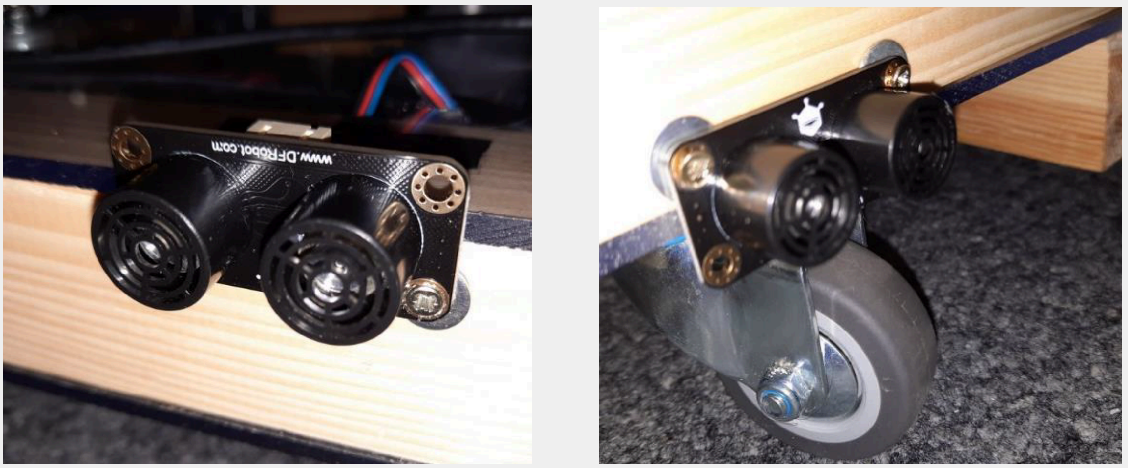


Figure 41: Attached Ultrasonic sensors. Front (left). Rear (right)

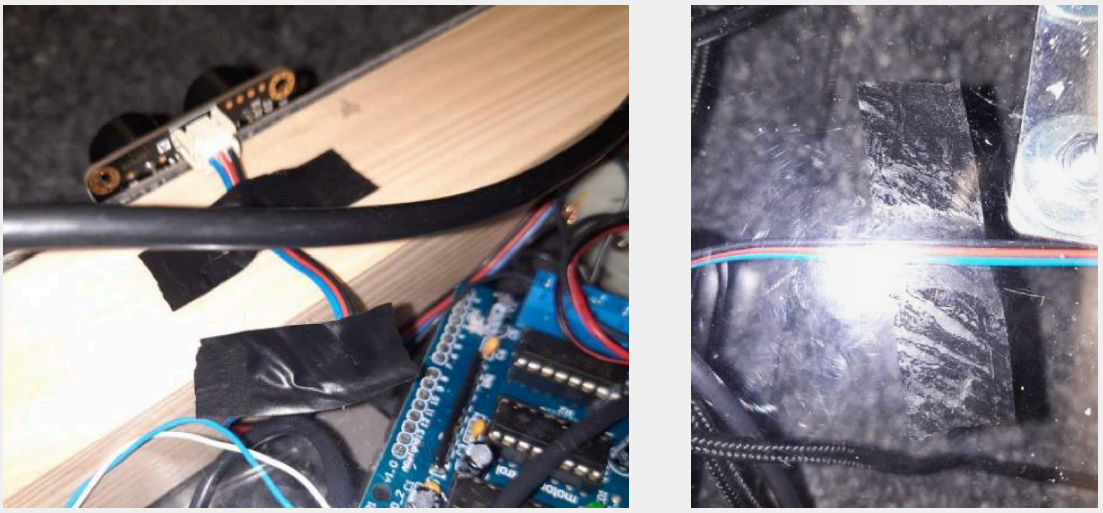


Figure 42: Cables connected to Plexiglas via insulating tapes

Option 3: 3D Printed Wheels

As an alternative, we used 3D-printed wheels. The disadvantage is that the plastic does not have good friction on the floor. For this purpose, a rubber coating can be applied around the wheels. You can find the files for 3D printing in the Telerobi Github repository.

Telerobi Software Components

System Architecture

Figure shows the system modelling of Telerobi, how Telerobi works.

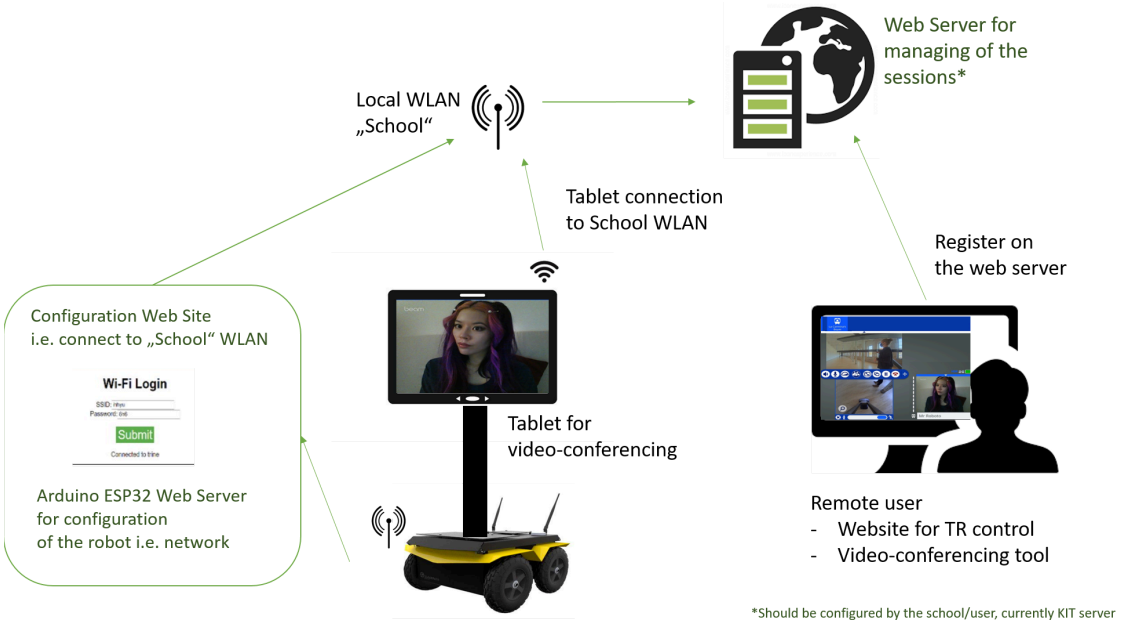


Figure 43: System architecture of Telerobi

Arduino Development Environment

The Arduino IDE (Integrated Development Environment) is an environment that connects to the Arduino and ESP32 boards and allows to upload programs. Arduino IDE is available for all operating systems, including Linux, Windows, Mac and Chrome OS. The programming language is C++. Download the Arduino IDE and install it.

Telerobi uses **two** boards:

- Arduino UNO WIFi Rev2, available by default
- AI Thinker ESP32, driver needs to be installed

Install ESP32 Board

Install the ESP board in the Arduino IDE. For that, go to *File -> Preferences* and add the link below to the Additional Boards Manager URLs and press OK. https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json

Then go to *Tools -> Boards -> Boards Manager*. Search for 'esp32' and install.

Uploade the Firmware

Clone the GitHub Repository called Telerobi (https://github.com/Victor-Haefner/telerobi) on your PC. The Arduino project files are **firmware/esp32/esp32.ino** and **firmware/arduino/arduino.ino**.

Open the **arduino.ino** project, connect the Arduino to your PC via USB. Make sure the board, port and baud rate are properly configured in **Tools > Board > Arduino AVR Boards > Arduino Uno Wifi**. Finally, upload the Arduino Code, this may take a few moments.

Open the **esp32.ino** project, connect the esp32 to your PC via USB. Again, make sure the board (**ESP32 Arduino > AI Thinker ESP32-CAM**) and port are properly configured. Upload the code to the ESP.

After uploading the codes, connect the ESP32 and Arduino to the power sources (the power banks). There will be one USB cable from the Arduino which gives power to the motors. The other USB cable connected to the main port powers the ESP and Arduino.

Configure the Robot

Connect a device, laptop or smartphone, to the WLAN with the SSID named '**trineBot**'. Connect to it using the password **bot12345**. If connecting from a smartphone, you may have to explicitly ask it to stay connected because the network does not provide internet access. Once connected, open '*192.168.4.1/settings*' on your browser, which is a configuration website:

- **Server Address**: IPv4 where you will run the server application
- **Robot Name**: A name, any ASCII string without whitespaces should work, It will be displayed on the web interface
- **RobotModel**: Choose between Telerobi and Elegoo, for this guide set it to Telerobi
- **SSID**: Set to the local SSID the robot should connect to for internet access
- **Password**: Give the password used to connect to the local SSID

Click submit to apply and store the robot configuration. Below the settings, the website also shows the status of the robot, the status does not update dynamically, reload the website to get the current status. To make the robot reconnect to the server, just reset the ESP board, either by pressing its reset button or plug out and in the power supply.

Server Application

To be able to control the robot, a server application needs to be hosted on a server, accessible to the robot. The easiest way is to set up an Ubuntu server and install Apache with PHP support:

```
sudo apt install apache2 php php-cli libapache2-mod-php
```

Clone the Telerobi repository and make sure it is in ~/Projects/web/trine. The path is currently not configurable, you can change it in the ESP firmware if necessary.

```
mkdir -p ~/Projects/web
```

```
git clone https://github.com/Victor-Haefner/telerobi.git ~/Projects/web/trine
```

Create a symbolic link to make the project visible through apache:

```
sudo ln -s ~/Projects/web /var/www/html/web
```

Try connecting to the website with http://localhost/web/trine . If you get an error 403 you can try:

- Fix permissions in your home directory, the line below will **recursively** set all permissions:

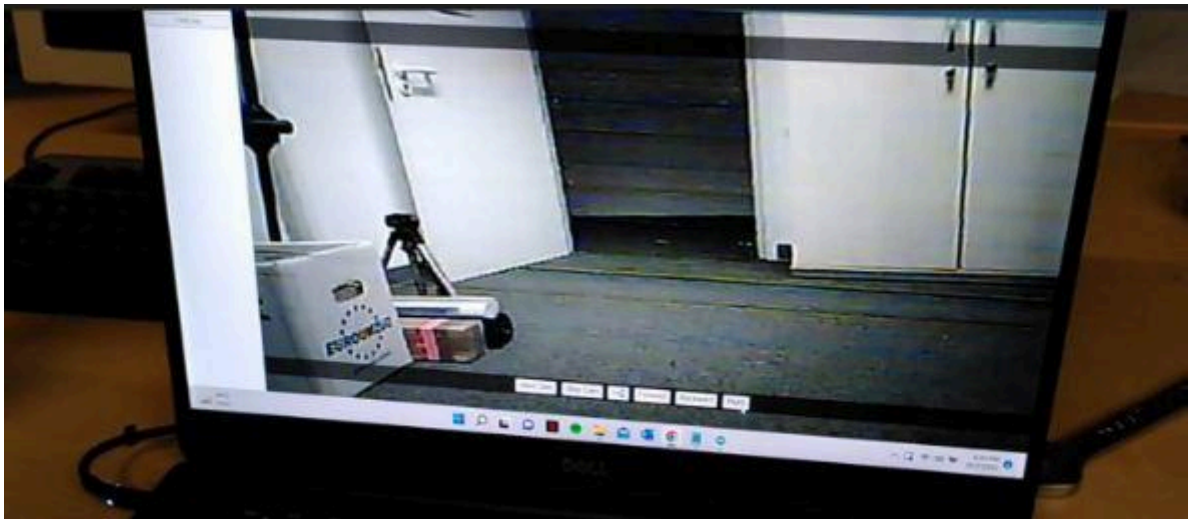
  sudo chmod 755 /home/$USER

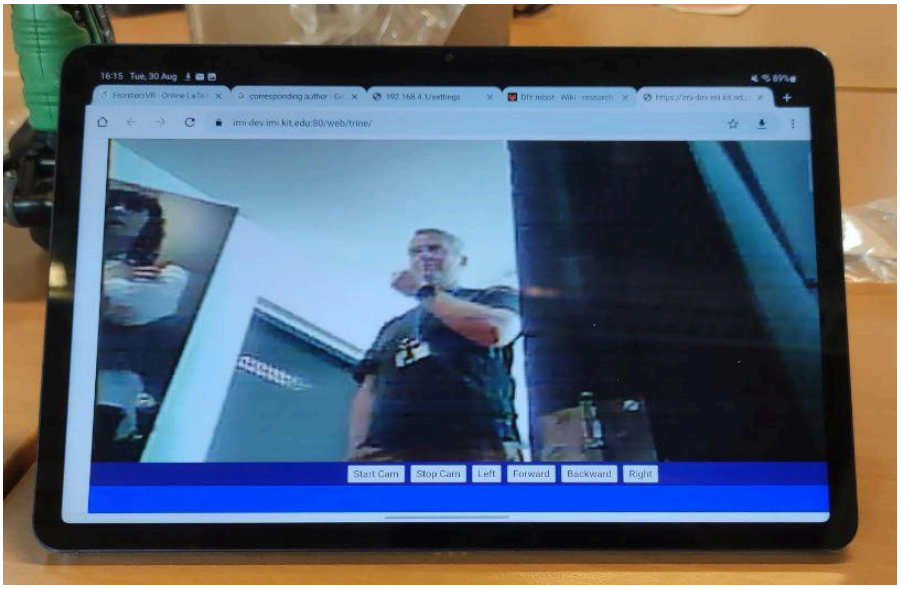
- add the user to www-data group (restart the server to take effect)

  sudo adduser $USER www-data

Drive the Robot

Open the website SERVERADDRESS/web/trine in your browser. This is the website to manage and control your robots, reset the robot if it does not appear in the list. The left side column lists the robots registered on the server. At the bottom of this page you can see basic commands which you can use to control the movement of your robot and also turn the camera on and off.





Conclusion and Future work

While the current version of the DIY telepresence robot kit provides a good starting point for building your own robot, there are still many possibilities for future development and improvements. For instance, one could explore ways to improve the robot's stability and maneuverability or add additional features, such as sensors for navigation or object recognition. The graphical user interface could also be optimized and made more suitable for the specific target group. Currently, the robot uses a tablet for sound input and output; a microphone array and speakers could be added. For a better connection to the local wifi, we recommend installing an additional antenna on the ESP board. Additionally, the kit could be adapted for different use cases, such as remote inspections in industrial settings.

Overall, the DIY kit for telepresence robots offers a cost-effective and educational way for individuals and organizations to create their own robots. With the detailed guidelines provided in the document, anyone can follow along and create their own telepresence robot from scratch.

References:

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[8] https://ae01.alicdn.com/kf/Sa19151ae44ed4ab7b0f9bb786c936e7dS.jpg
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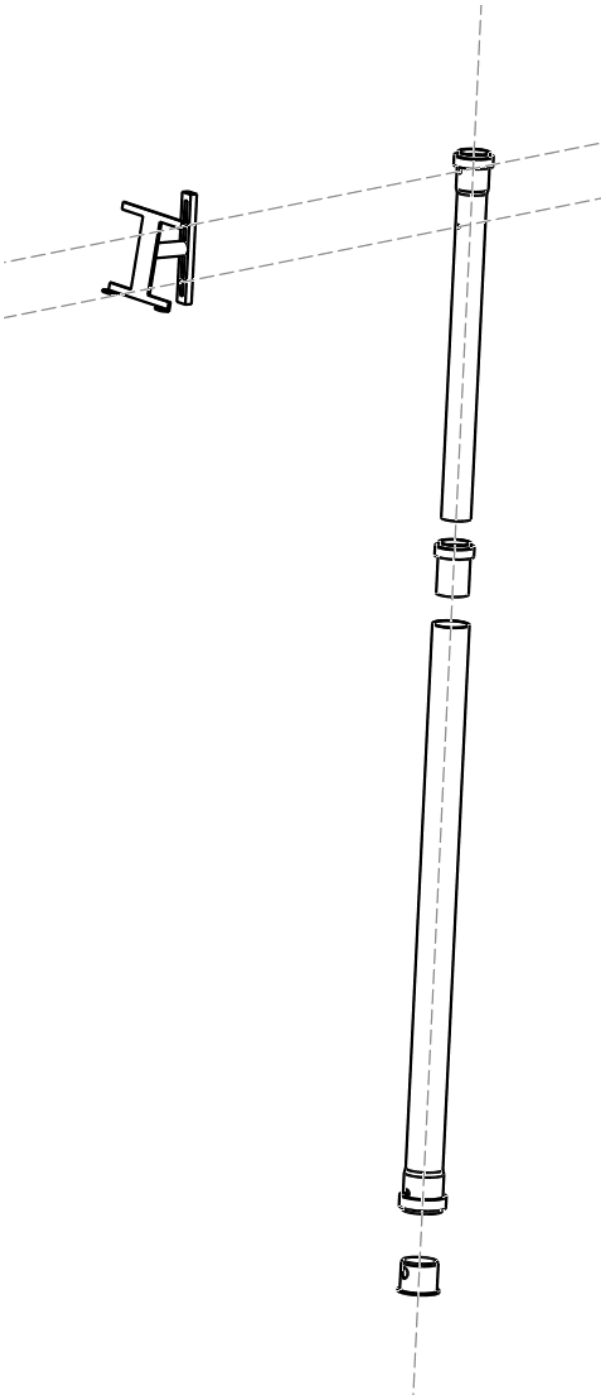
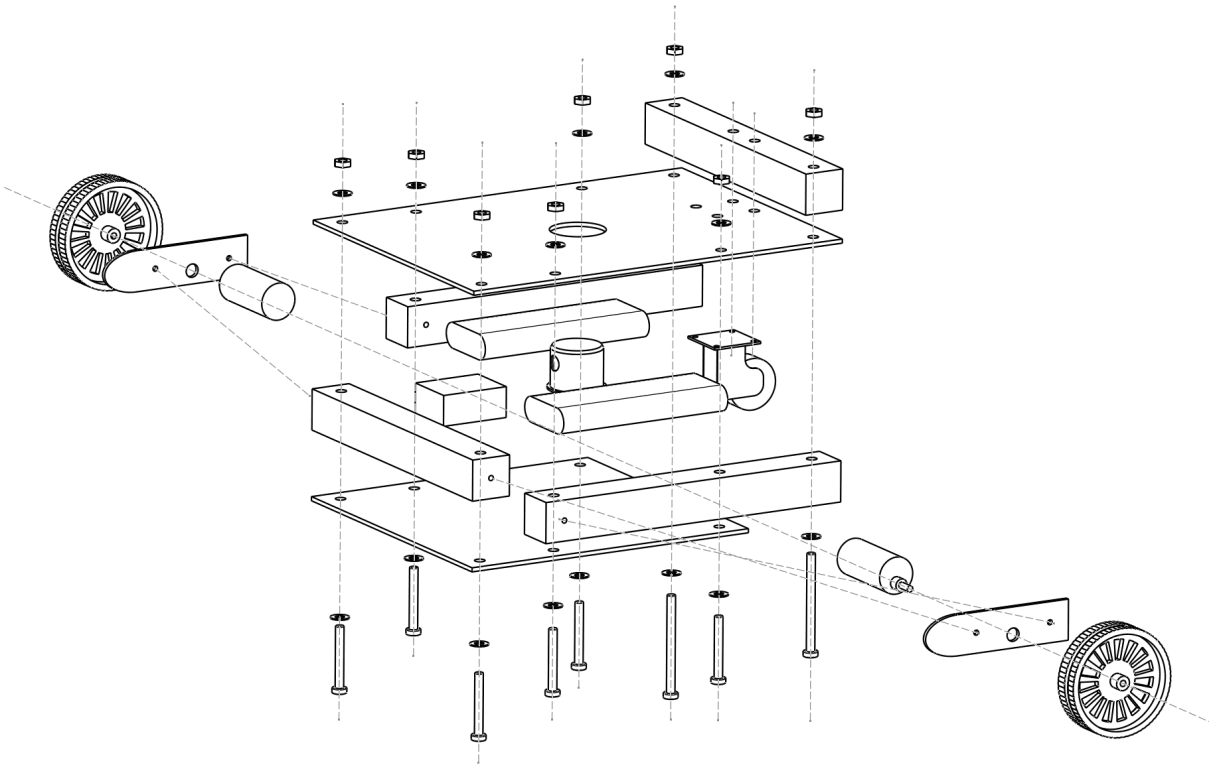
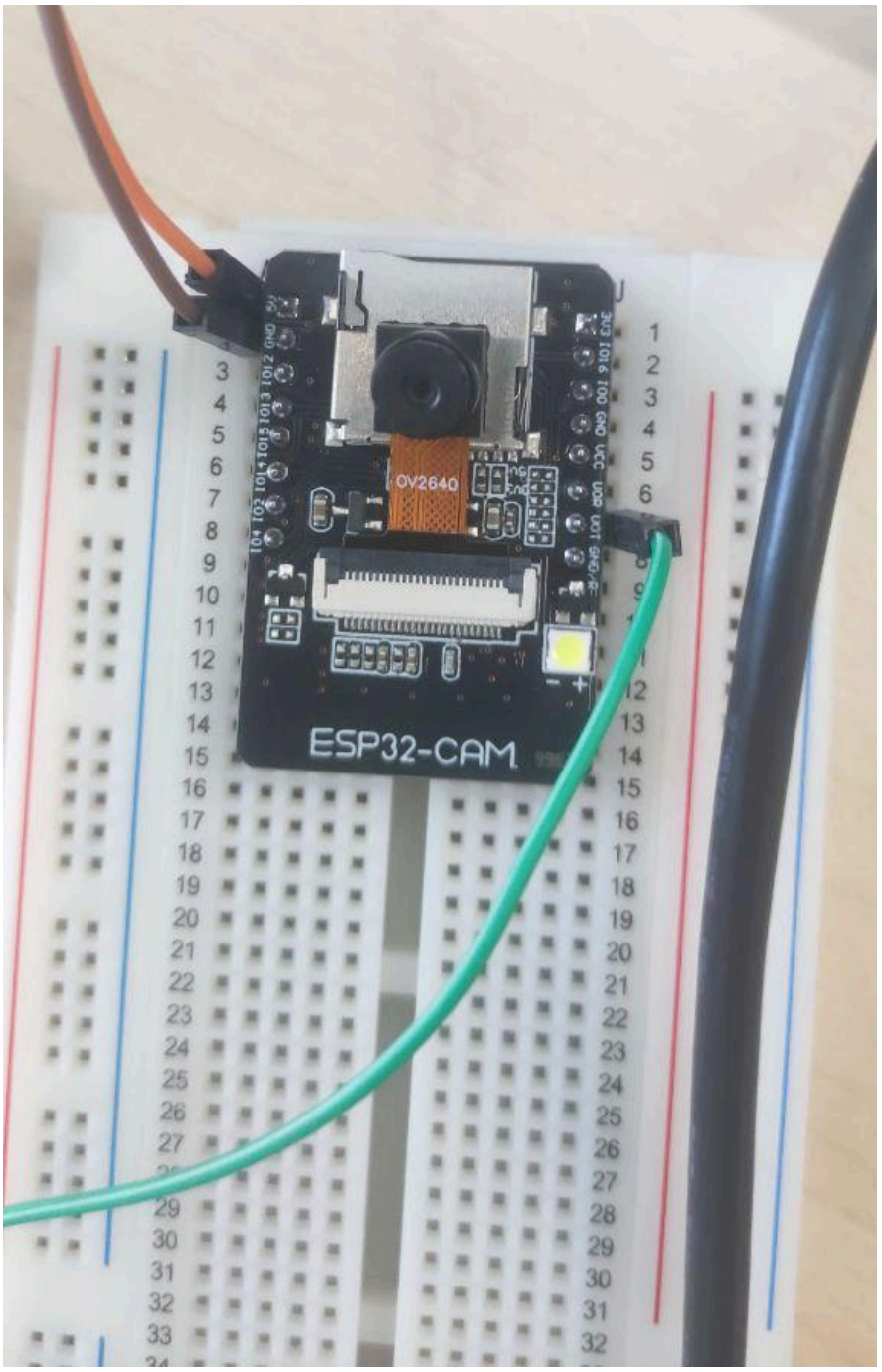
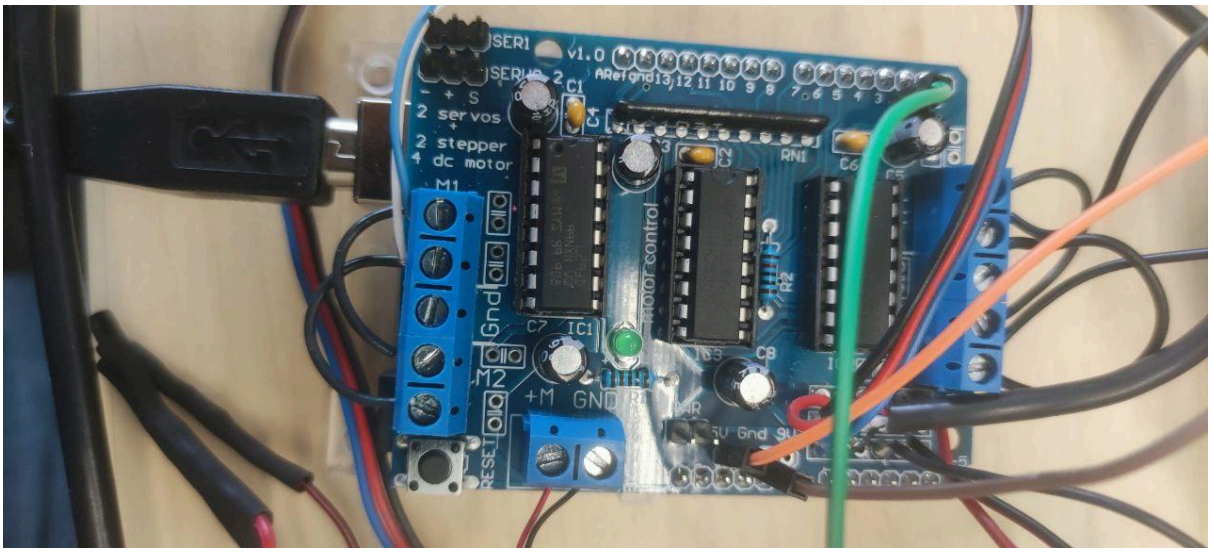
[10] https://m.media-amazon.com/images/I/51bXQM7pfrL._SX342_SY445_.jpg
[11] https://dictionary.cambridge.org/de/worterbuch/englisch/pincer
[12] Schaltplan.pptx

Additional Images:






OV2640
ESP32-CAM


SER1
v1.0
SERVO 2
C1
2 servos
2 stepper
4 dc motor
M1
Gnd
M2
+M
GND
motor control
IC1
C7
C8
RN1
RESET