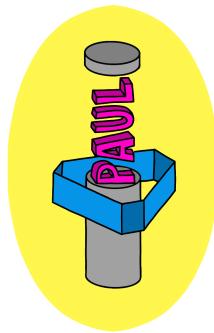


USER GUIDE



Group 6

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Introduction

This is the user guide for the PAUL (Pole Automaton Using Ultraviolet Light) robot created by Group 6 as part of their System Design Project course. PAUL is a pole climbing robot which is designed to disinfect poles in public transport via a band of low wavelength ultraviolet radiation (UVC).

1 Overview

Our system consists of two main components the **Web component** and the **Hardware component**. The Web component provides a user-friendly control mechanism to allow the user to select what actions the robot should perform. The Hardware component is used to carry out the actions defined by the user input received from the Web Component.

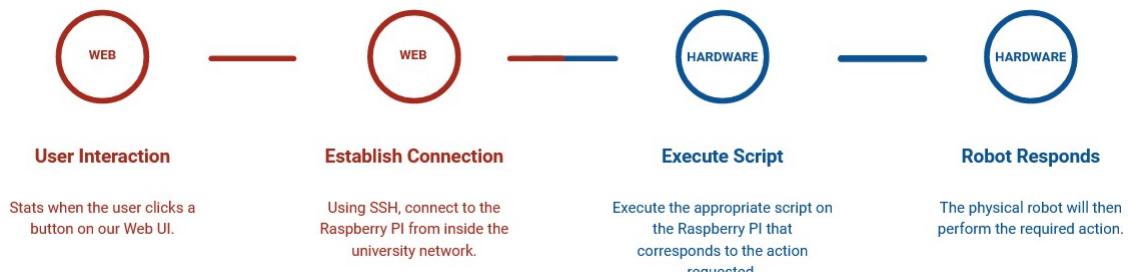


Figure 1: High-level System Diagram

1.1 Hardware Overview

In this section we will describe the hardware components that you should have received as part of your purchase of the PAUL system. Please check your robot against the list of components below to ensure that no parts have fallen off during delivery. The Hardware system consists of 3 main parts; the consumer's box (1), the wire arm (2) and the pole climber's casing (3).

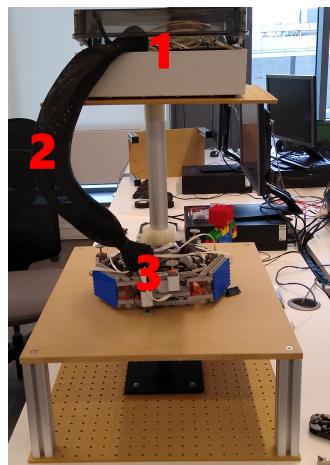


Figure 2: Hardware Diagram

The Pole climber (**figure 3b**) main parts are; three gear motors (1) that power the robot up and down the pole, three bump sensors (2) in charge of detecting interaction with external factors, three infrared sensors (3) to detect the ceiling and floor, and the UV module (4) which cleans the pole surface.

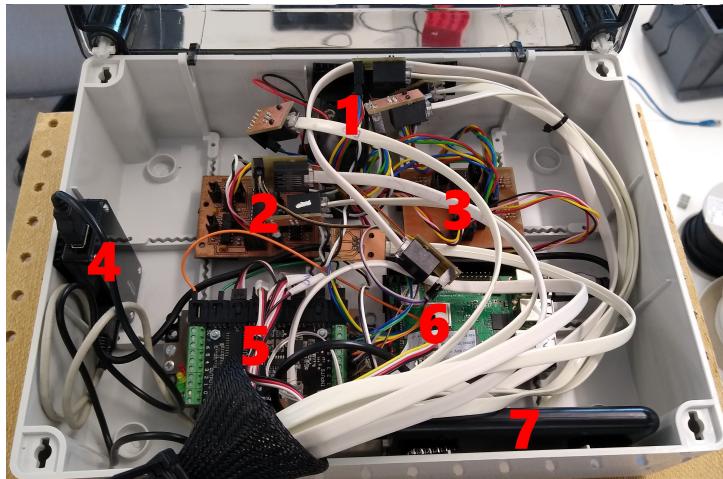
The wire arm wraps up all of the mentioned components into the Consumer Box (**figure 3a**), whose main parts are; a battery pack (1) that is the power source, motor/encoder boards (2/3) which handle the motors connections, a USB Hub (4) that links the power source to a USB Power bank (7), the Phidget Board (5) that receives the sensors readings and the Raspberry Pi (6) which acts as a motherboard.

Consumer Box Components

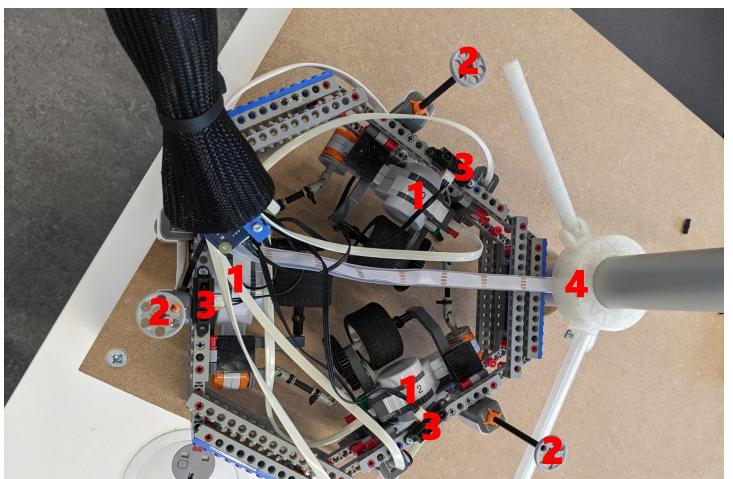
1. Battery Pack - 8xAA Batteries
2. Motor Board
3. Encoder Board
4. USB Hub
5. Phidget 888 Sensor Board
6. Raspberry Pi
7. USB Power Bank

Pole Climber Components

1. 3x Lego NXT Motors
2. 3x Lego EV3 Touch sensors
3. 3x SHARP Infrared sensors
4. UV casing



(a) Consumer Box



(b) Pole Climber

Figure 3: Hardware Component Diagram

Also included

1. 16x AA Rechargeable batteries (In two packs of 8).
2. 1x AA Battery Charger compatible with UK plugs.



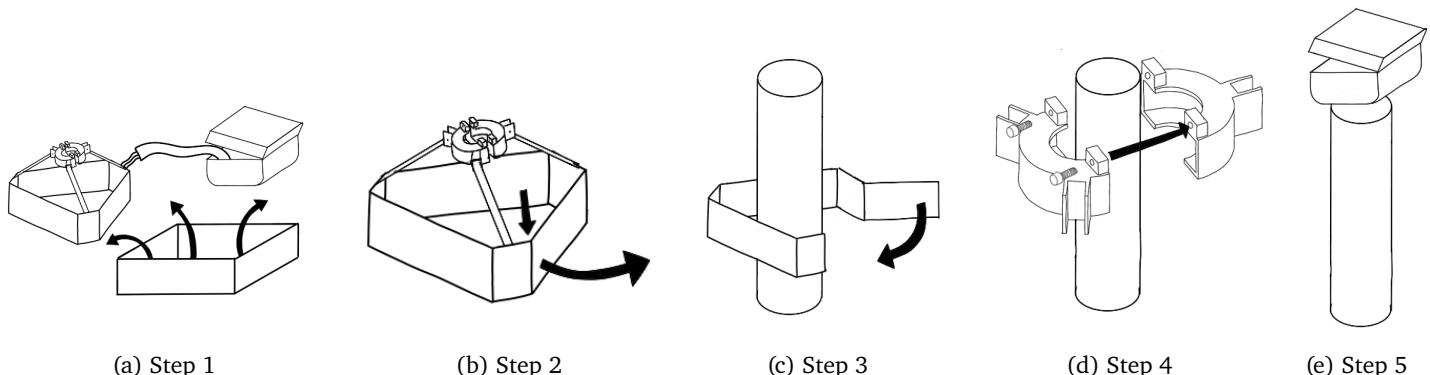
3. 2x M5 Bolts used to secure the two sides of the UV casing together.

2 Installation

2.1 Hardware Installation

To install your PAUL onto a pole please follow these steps:

1. Remove the system from all its packaging.
2. Unclip the pole climber's mobile side sheet.
3. Slot the robot onto the pole environment from the side and close the mobile slide sheet so the three wheel are surrounding the pole.
4. Bolt the two sides of the UV module around the pole.
5. Place the consumer box securely on top of the desired pole. (can design a 3d fixings for attaching the box on the ceiling)



To check that PAUL is ready to clean

- Ensure that the PAUL is turned on. (see [Turning the system on/off](#))
- Check the batteries have been inserted (see [Replacing the Batteries](#)) and the batteries have been fully charged (see [Charging the Batteries](#))
- Ensure there are no obstructions on the pole.
- Ensure that there is no damage to the UV cleaning module.
- Connect to PAUL using the Web Interface (see [Web UI Installation](#))

2.2 Web UI Installation

In this section we will describe how to connect a PAUL-bot with your account and use the web interface.

- Along with your robot, you will have received a small leaflet with a QR code & a link. Either scan the URL with a smartphone or type the URL in your computer's browser. This will redirect you to the login page.
- Login with the credentials provided to you by your company. Enter the username and password as usual.
- That's it! Now our interface will connect your new PAUL-bot with your account you'll immediately see a green pop-up at the top showing its successfully connected, you'll also notice a new bar and a robot in your train. You can control it as you control other devices.

2.3 Constraints and Safety

- PAUL is not designed to be operated when there are customers currently nearby and is intended to be used when the vehicle has come to a stop at the end of its journey.
- PAUL uses UVC light within an enclosed container which should help prevent the UVC light from coming into contact with any persons should they come near the robot during the cleaning process. However, if the casing was to become damaged then UVC light could be emitted outside the container. If any damage or light is seen escaping from the robot then the robot should be turned off immediately and support should be contacted to replace the UV container.
- PAUL is designed for circular poles with a diameter of 40mm. Poles should not be excessively slippery or sticky as this could interfere with PAUL's operation. The pole should also not contain any obstructions as this could damage the wheels.
- PAUL contains electrical components so users take care when using and avoid using liquids near PAUL.

2.4 Customisation Guide

To allow users to customise the PAUL design we have made all our code and CAD designs available on our [GitHub Page](#). Here is a list of all the software packages we used to control our hardware components:

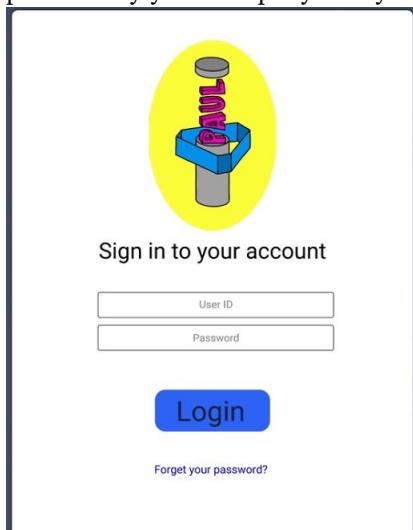
- Libraries for Grove WS2813 RGB LED Strip
 - Grove Control library - https://github.com/Seeed-Studio/grove.py/blob/master/grove/grove_ws2813_rgb_led_strip.py
 - Required Dependency Python Library - <https://pypi.org/project/rpi-ws281x/>.
- Phidget board Python library - https://www.phidgets.com/docs/Language_-_Python.
- Motors Python library - <https://pypi.org/project/smbus2/>.

3 Operation

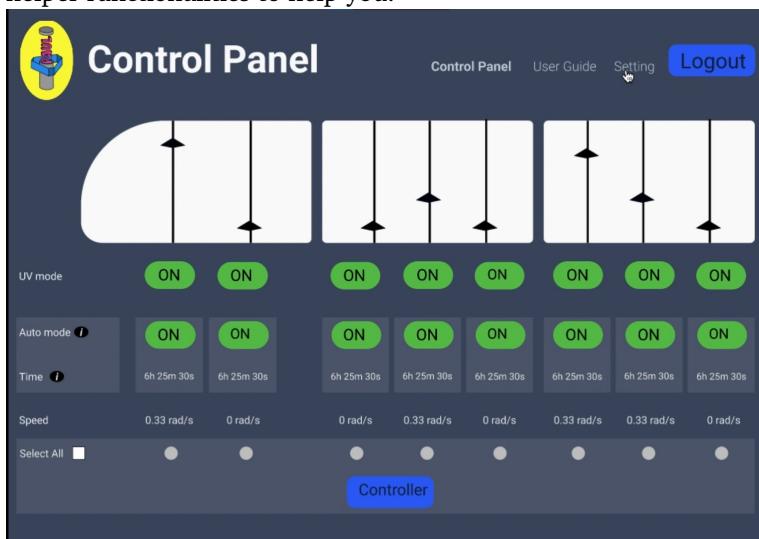
3.1 UV Cleaning Operation

Our web Interface allows customers to control their PAUL(s) remotely in a user-friendly environment.

1. Before you start using the control panel, you need to log into the web interface. You can do this with the login credentials provided by your company. Use your username and password to login.



2. If you forgot your password, you can click on the forgot my password link which will send a password reset link to your username immediately
3. After logging in, you'll see the control panel. There are several buttons here, but don't be overwhelmed as we have many helper functionalities to help you.



4. You can also click on the "select all" button to control all the PAUL-bots in the train at the same time or you can uncheck it and control the settings of each PAUL-bots individually.



Info: You can also click on the "select all" button to control all the PAUL-bots in the train at the same time or you can uncheck it and control the settings of each PAUL-bots individually.

5. To begin the cleaning process, select the pole on the train visual image. This will select the paul-bot you'll be controlling. You can skip this step if you want to control all the bots at once.
6. Then click on the ON button beside the auto mode. This will start a slow movement of the bot up and down the pole with a delay of 5 seconds.
7. Click on the UV mode's ON button start the cleaning process.

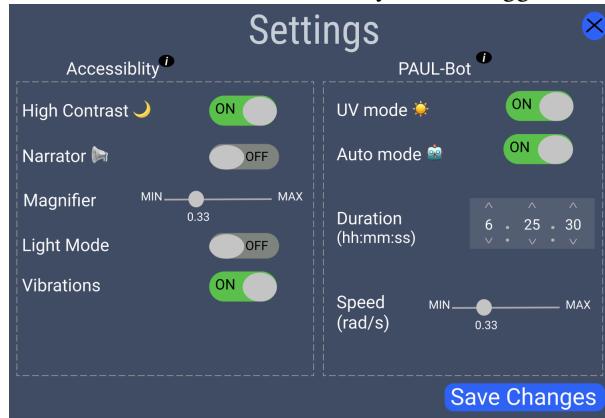


Info: If you click on the button labelled "controller" you can change the duration for the auto mode feature, and the speed of the device.

8. Finally, click the "ON" button beside auto mode again to stop this PAUL. Note: it can take up to 20 seconds for the bot to go back up to its original position.



Info: You can open the Accessibility menu from the control panel by clicking the 'Setting' button in the top right hand corner. From this menu you can toggle on/off High Contrast, Narrator, Magnifier, Light Mode and Vibrations.



3.2 Hardware Maintenance

Turning the system on/off

1. Open the consumer box located on top of the pole.
2. Locate the USB Power Hub (see **Consumer box diagram** for more help)
3. Press the power button on the USB power hub to turn the hub on/off. Note: a GREEN light on the USB hub indicated the power is turned on and a RED light indicates the power is off.

Replacing the batteries

1. Open the consumer box located on top of the pole.
2. Turn off the system fully as described above.
3. Locate the battery pack (see **Consumer box diagram** for more help)
4. Remove any batteries currently in the battery pack.
5. Insert a new set of 8 AA batteries (you should have received two sets of 8 AA batteries and a power charger along with PAUL). Ensure these batteries are fully charged by following the steps below.

Charging the batteries

1. Locate the battery charger you should have received along with PAUL.
2. Open the case on the battery charger and insert your batteries into the charger. Ensure that you match up the + & - symbols on each battery with the + & - symbols on the charger.
3. Plug the battery charger into the a wall power socket and turn the power socket on. Note: the battery charger included with only work with UK style plug sockets.

4. Ensure that your battery charger is set to 'charge' mode as shown in the picture below. You should see a **RED** light on the case above each battery this indicates the batteries are charging.



5. When all the lights have turned **GREEN** then turn the battery charger off at the plug socket and remove the plug.
 6. Open the case and remove your batteries.

4 Troubleshooting Guide

Issue	Steps to resolve
PAUL does not change direction when it reaches the top/bottom of the pole	1. Turn the system off. 2. This is likely an issue with the calibration of the sensors so please contact support .
The Motors are running but PAUL is not climbing the pole	1. Turn the system off. 2. Recharge the batteries. 3. Check for any visible damage to the motor shafts and clip back in any loose motor shafts 5. If issue persists contact support.
PAUL's case is tilting when it is climbing the pole	1. Turn the system off. 2. Replace the batteries. 3. If issue persists contact support.
There is a RED or no light on the USB Power Hub	1. Turn the system on. 2. Turn the system off. 3. Recharge the batteries. 4. If issue persists contact support.
LED on UV module does not turn on when I activate the LED	1. Turn the system off. 2. This is likely an issue with light connection or led itself please contact support .
UV light is coming through the UV casing	1. Turn the system off. 2. do not turn back on and contact support .
One of the components appears to be damaged	1. Turn the system off. 2. Running PAUL with broken components may lead to a malfunction which might damage other components please contact support .

4.1 Support Contact

Website: <https://sdp-team-6.github.io/>
 Email: sdp-team-6@inf.ed.ac.uk