ZANUS
PRODUCTION ROBOTICS

Pauli head User manual

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1. Safety and warnings

Follow all instructions and warnings marked on the product and given in this manual. These safety instructions must be followed to reduce the risk of personal injury and/or damage to the product and other equipment.

WARNING: Do not install this product onto a support, bracket or other equipment that is not designed to support the weight of the product and its payload. Make sure that the product and its payload are always well-secured.

WARNING: The payload needs to be installed on the product such that it is well-balanced.

WARNING: Regularly inspect the product for damages and do not operate it when damaged. In case of a malfunction please contact your dealer and do not try to disassemble the head on your own.

WARNING: This product needs to be connected to a power supply with the same voltage (V) and frequency (Hz) as indicated on the product and described in the specification section of this manual. To reduce the risk of electric shock, do not remove the cover and do not try to disassemble the product. Refer to qualified service personnel for all servicing.

CAUTION: Do not operate at very high speeds/accelerations when the rig is not sufficiently balanced.

CAUTION: This product is designed for remote operation. Do not attempt to manually operate the product unless it is powered off or in a disabled state.

CAUTION: Make sure that there are no obstacles in the working zone of the product. Restrict access to the working area of the product to reduce the risk of a person being hit by moving parts of the device. Power off the device before rigging, cleaning or adjusting the payload or equipment mounted on the product.

CAUTION: Do not use solvent or oil-based cleaners, abrasives or wire brushes to clean this product as they may damage protective surfaces. To clean mechanical surfaces, use only detergent-based cleaners.

2. General description and Technical specifications

Pauli robotic head is built for smooth, stable and effortless camera motion. It can be controlled by an online application or by a joystick (any joystick with VISCA over IP protocol, SKAARHOJ configurable joystick or similar).

Parameter	**Value**
Payload	20kg
Weight	8.4kg
Dimensions	434×276×144mm
Pan axis range	±175°
Tilt axis range	±180°
Pan/tilt axis velocity range	0.001-180°/s
Maximum acceleration	90°/s²
Shot Recall Repeatability	±0.025°
Power requirements	100-240 VAC
Operating temperature range	-10 to +45°C
Storage temperature range	-20 to +60°C
Ambient humidity	10% to 90% non-condensing
Presets	Preset play/run, preset array, maximum 100 points, preset in some axis and manual control in others possible
Connection	IP Ethernet
Noise level	40dB
Communication connectors	Ethernet with Ethernet switch in the head - 2 connectors in the base and 1 for the camera, all with a locking mechanism
Power output connectors	12VDC, 60W D-Tap and XLR
Zoom, Focus, Iris control	Interface for Canon and Fujinon lenses, interface for PDMOVIE external lens motors; LANC & Panasonic analog
Mounting	Standard tripod mount, reverse mount possible, 90° wall-mount with adapter possible
Protection class	IP52
Connectors (audio, video)	2× 6G SDI/Genlock coax pass-through

3. What is in the box

Pauli head is distributed in the form of the basic package and various additional accessories. The exact accessories that are included depend on the particular needs of the customers. The basic package, as well as the accessories, are listed below.

3.1. Basic package

The following parts are included with the **Basic package** of the Pauli head. This package includes the main parts for powering on the robotic head and attaching the camera to it.

ID	Part	Quantity
1	PTU "Pauli"	1
2	C14 Power Cord	1
3	Camera mounting plate	1
4	LANC/Panasonic cable 2.5mm	1
5	Panasonic cable 3.5mm	1
6	3/8'' camera mount screw	1
7	1/4'' camera mount screw	1
8	3/8'' to 1/4'' screw adapter	1

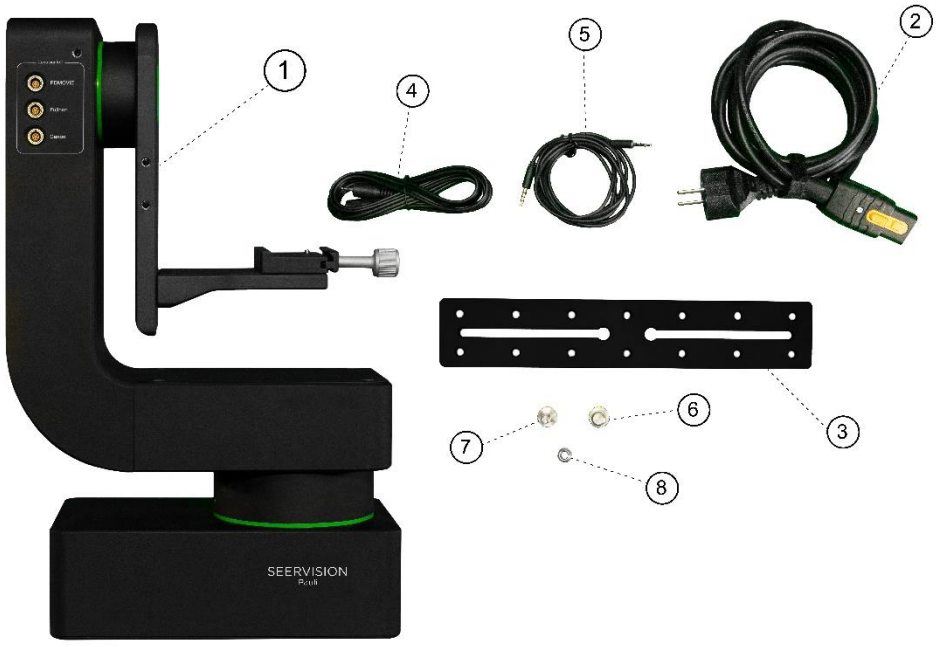


Figure 1: Basic package

3.2. Lens holder package

The following additional parts are included in the **Lens holder package** of the Pauli head. It is mainly made for supporting large cameras and their external lens motors so that everything stays completely stable during fast movements. The spacers are made for covering empty space that occurs between some cameras and certain Pauli head accessories when being attached.

ID	Part	Quantity
1	Carbon tubes short	2
2	Carbon tubes medium	2
3	Carbon tubes long	2
4	Carbon tube holder	1
5	Tube holder spacer for carbon tube holder	1
6	Camera spacer for carbon tube holder	1
7	Lens holder	1
8	Hex key 3	1
9	Hex key 5	1
10	1/4 camera mount screw - long	1
11	3/8 camera mount screw - long	1
12	M4 x 12 bolts	4
13	M6 x 45 bolts	2
14	M6 x 20 bolts	8

Figure 2: Lens holder package

3.3. PDMOVIE lens motor package

The following additional parts are included in the **PDMOVIE lens motor package** of the Pauli head. If your camera needs external lens control, the lens motors from this package are the accessory that could be very useful. Additional gears that are included have different lens step sizes to cover all possibilities.

ID	Part	Quantity
1	PDMOVIE lens motor	1
2	Lens LEMO Cable	1
3	Lens strip (compatible with 40-70mm lens)	1
4	Zip tie (90x2.5mm)	2
5	Zip tie (120x5.0mm)	2
6	Additional gear wheels	3

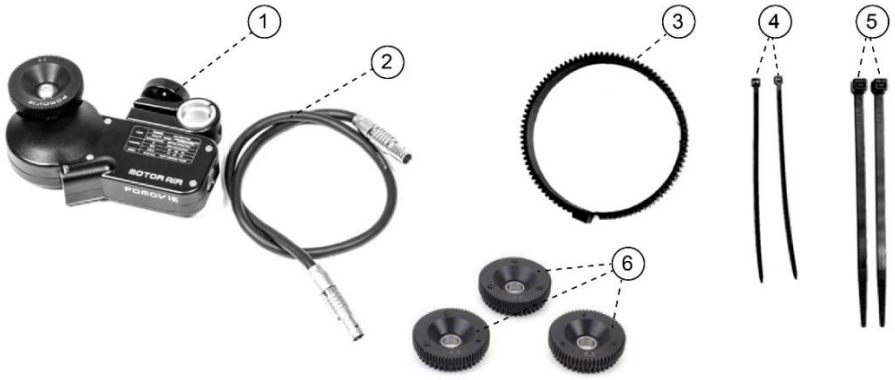


Figure 3: PDMOVIE lens motor package

3.4. Additional lens control cables

If the camera you are going to use has servo lenses with serial connection support, Canon and Fujinon lens cables are the only thing that needed to connect the camera to the Pauli head. There is an option for 10-pin or 20-pin Fujinon servo cable or 20-pin Canon servo cable.

Figure 4: Lens control cable

3.5. XLR cable for camera supply

This accessory cable represents a 4-pin XLR cable for the camera power supply.

Figure 5: XLR cable

3.6. Manual operation handle package

Manual operation handle package is made for those who want to be able to manually move the Pauli head. It can be easily screwed to the tilt axis of the robotic head with the screws included in the package.

ID	Part	Quantity
1	Manual handle	1
2	Hex key 4	1
3	M5 x 20 bolts	2

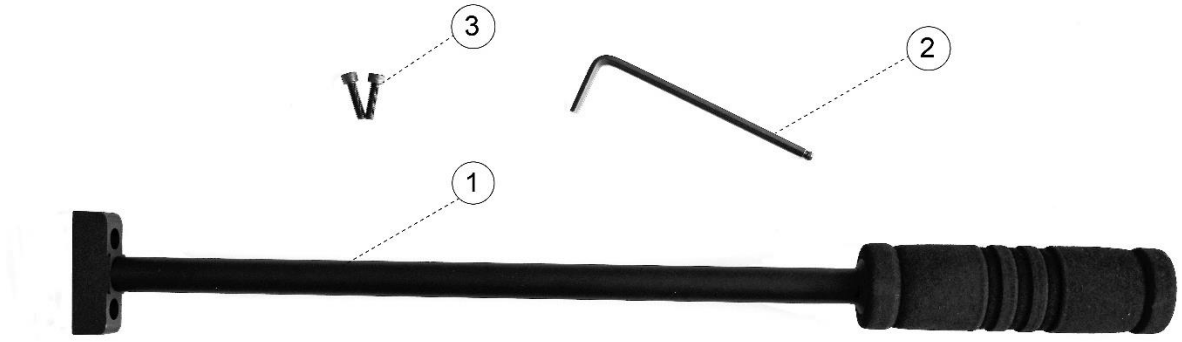


Figure 6: Manual handle package

3.7. Skaarhoj PTZ Extreme configurable controller

Skaarhoj PTZ Extreme configurable controller package includes all cables needed for full control of one or multiple Pauli heads. The controller has many possibilities and advantages that are explained in the section Control with Skaarhoj PTZ Extreme.

ID	Part	Quantity
1	Skaarhoj PTZ Extreme controller	1
2	12V power supply	1
3	USB programming cable	1
4	Networking cable	1

Figure 7: Skaarhoj PTX Extreme configurable controller package

4. Interface outline

Pauli head comes with many different possibilities when it comes to the interface. *Figure 8* and *Figure 9* show all interface connectors, buttons and indicators of the Pauli head.

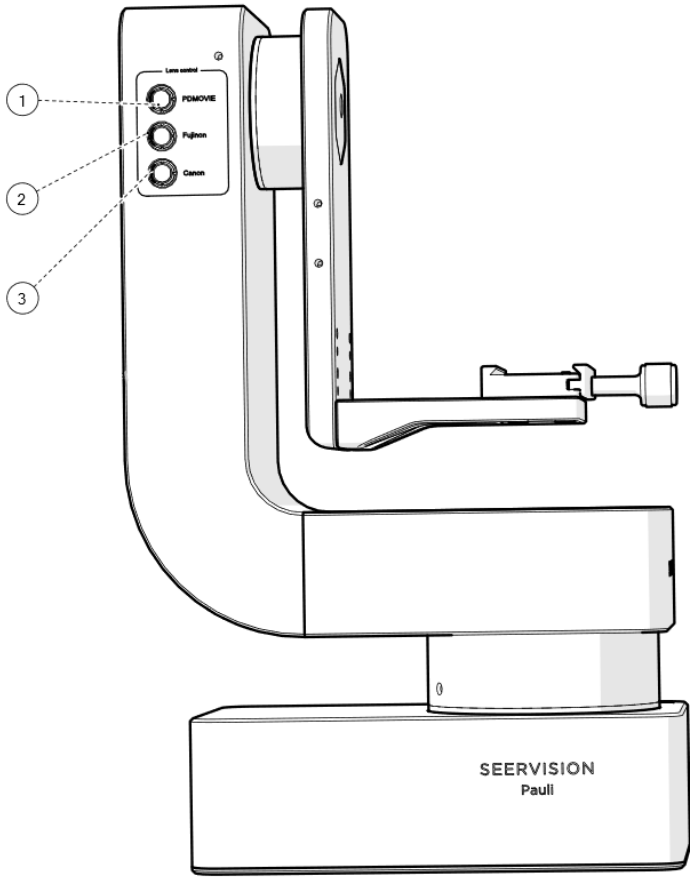


Figure 8: Pauli head front

ID	Part
1	PDMOVIE external lens motor LEMO socket
2	Fujinon external lens motor LEMO socket
3	Canon external lens motor LEMO socket

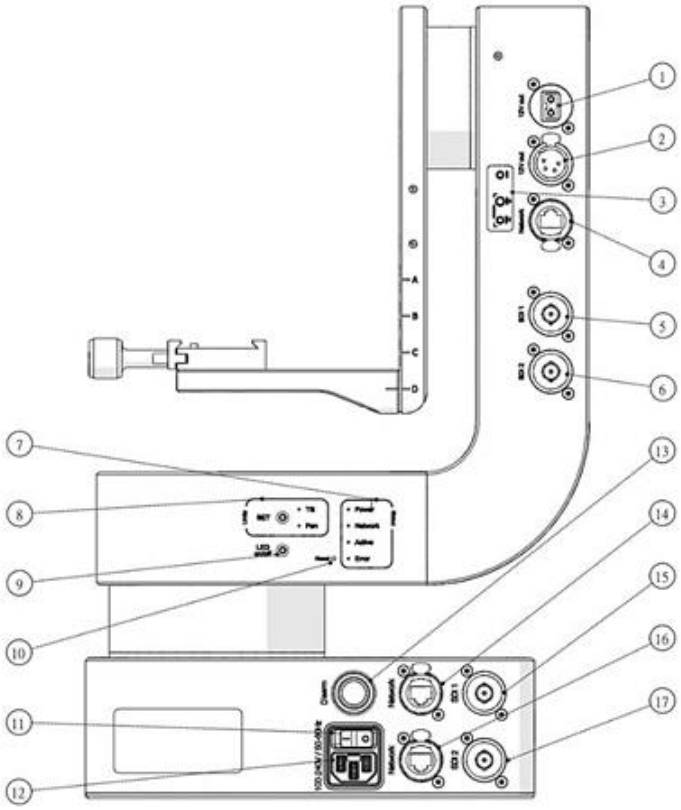


Figure 9: Pauli head back

ID	Part
1	D-Tap 12V Out Socket
2	XLR 12V Out Socket
3	LANC and Panasonic Zoom/Focus/Iris sockets
4	RJ45 Ethernet Socket
5	SDI 1/Genlock
6	SDI 2/Genlock
7	Status LED indicators
8	Limit set button
9	LED ON/OFF button
10	Reset button
11	ON/OFF Switch
12	C14 Power In (100-240V / 50-60 Hz)
13	Disarm Motors Button
14	RJ45 Ethernet Socket pass-through
15	6G SDI 1/Genlock 1 pass-through
16	RJ45 Ethernet Socket pass-through
17	6G SDI 2/Genlock 2 pass-through

5. System setup

The recommended procedure for the setup of the Pauli head would be as follows:

- Mount the Pauli head on a tripod, some other flat surface or the ceiling in an upside-down configuration
- Mount the camera and attach the lens holding accessories (if applicable)
- Add external motors and lens holder (if applicable)
- Connect and power on the Pauli head
- Set axis limits (if needed)
- Configure camera mounting style
- Lens control configuration

Follow the detailed instructions for each step, presented in the following sections.

NOTE: Even though these steps are consecutive, some of them might need to be revisited in order to successfully mount and balance the camera on the Pauli head.

Figure 10: Pauli head with a camera

5.1. Mounting Pauli head

A Pauli head can be mounted on a mounting plate or a ball head. For mounting on a ball head, standard 3/8'' screws can be used. Additionally, 1/4" screws could be used together with an adapter, provided with the Basic package.

If mounting on a mounting plate is required, Pauli can be attached with 8 M5 screws. The length of the screws depends on the mounting surface width.

The bottom view of the Pauli head with denoted screw threads is shown in *Figure 11*. *Figure 12* gives a drawing of the holes for the M5 screws in case a custom-made mounting plate is required.

Depending on each specific setup, the Pauli head can be mounted on any tripod/pedestal, on a wall-mount unit (90° mounting), or upside down (e.g. from the ceiling).

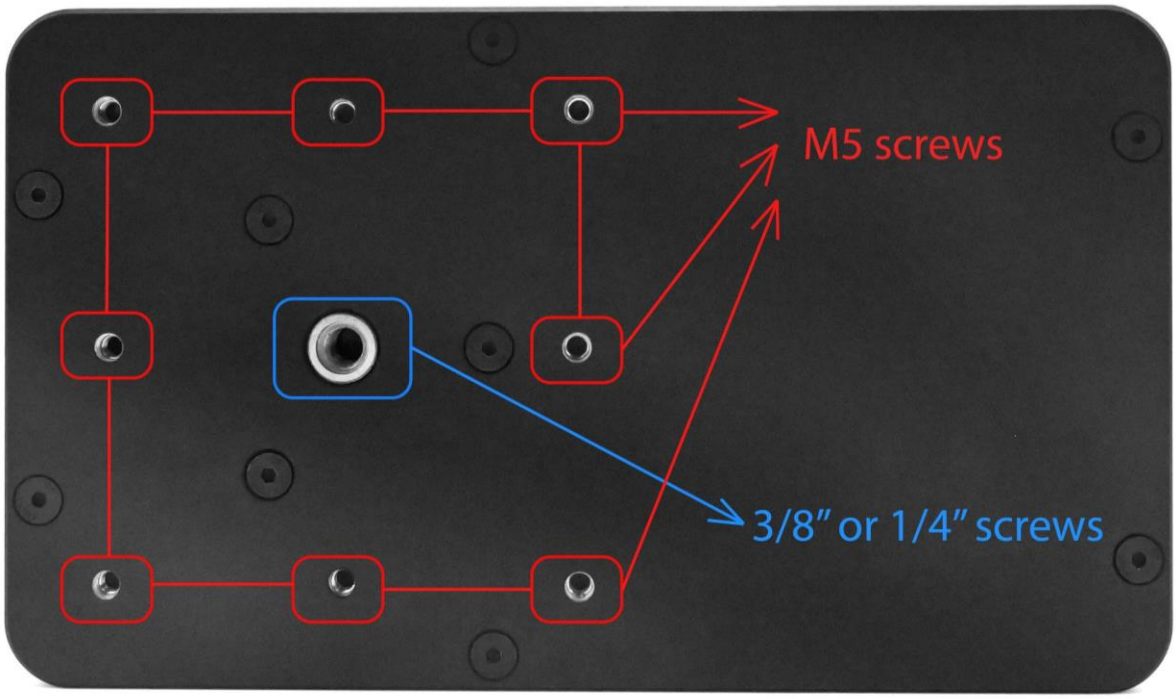


Figure 11: Pauli head bottom side

According to specifications, the weight of the Pauli head is 8.4 kg. Please ensure that all the mounting elements can withstand the weight of the Pauli head and its payload of up to 20kg.

For ceiling mounting (*Figure 13*), it is recommended to use a mounting plate securely screwed to the ceiling with no less than 4 screws. The mounting plate and screws are not provided with the system.

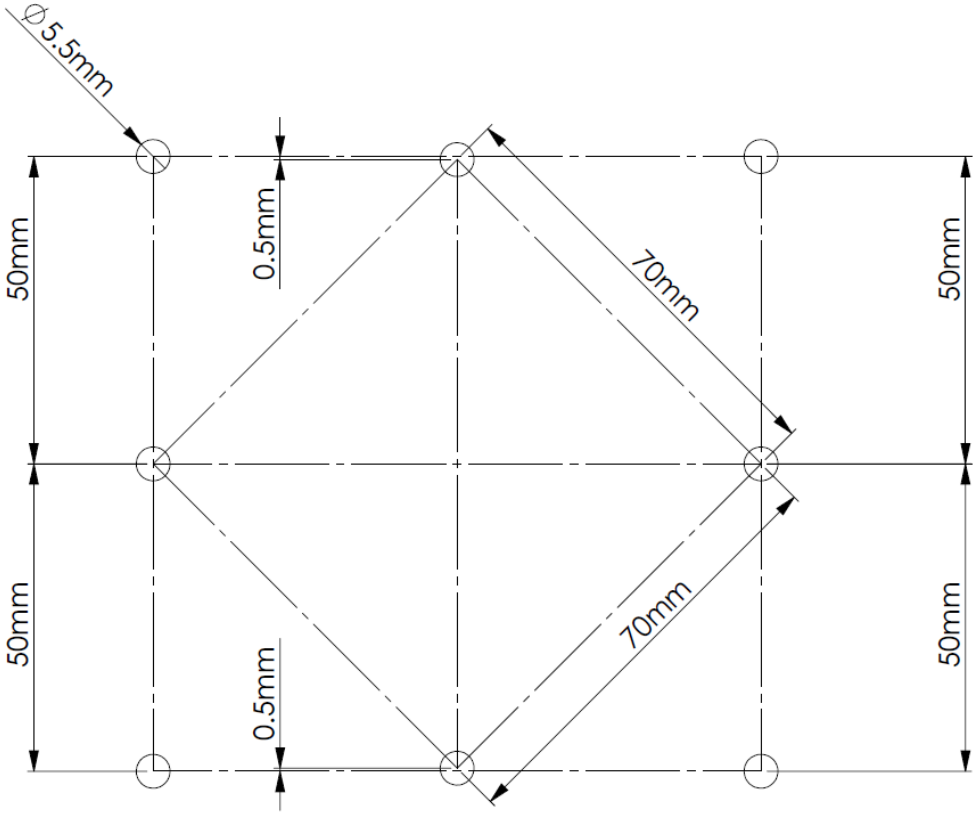


Figure 12: Schematic representation of threads

Figure 13: Ceiling mount

During the assembly and disassembly of the Pauli head, the power supply must be switched off and the power cable disconnected.

The Pauli head has an integrated level bubble (*Figure 14*) that can be used to ensure that it is perfectly leveled.

Figure 14: Bubble level

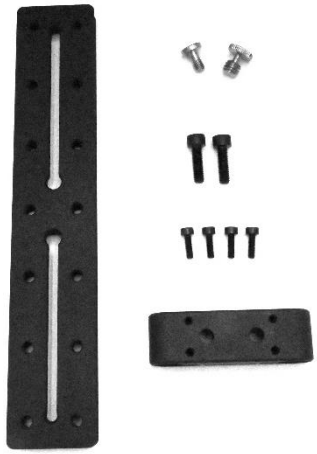
5.2. Mounting the camera and attaching lens holding accessories

The camera should be mounted on the camera mounting plate provided with the Basic package. Camera mounting plate has wider holes in the middle so that the camera mount screws can be fully inserted. For this purpose, 1/4” and 3/8” camera mount screws can be used. These screws are also provided with the Basic package. Relevant elements of the basic package, as well as the mounting plate attached to the camera, are shown in *Figure 15*.

Figure 15: Attaching the camera mounting plate

If external lens motors are to be used, the Lens holder package is required. This package contains carbon tubes, a carbon tube holder as well as two spacers that allow a multitude of possible assembly combinations for mounting the motor holding tools together with the camera. This allows for many mounting positions of the carbon tubes holder, which in turn means additional flexibility for mounting, depending on each camera and lens configuration. This also ensures that the system is correctly balanced and the external lens motors (if applied) can be properly mounted on the carbon tubes. Possible combinations are shown in *Table 1*.

Table 1: Lens holder accessories mounting

No.	Parts included	Initial construction	Construction on the camera
1			
2			
3			

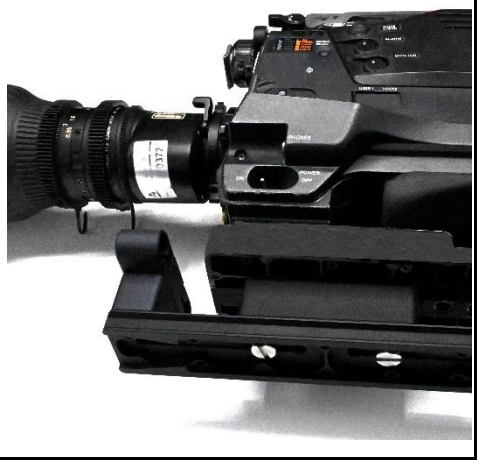
4			
5			

Table 1 covers all the elements and cases for mounting the lens holding accessories.

The 1st row in *Table 1* shows the most basic construction consisting of a camera mounting plate and mount screws from the Basic package, carbon tube holder with its 4 M4x12 screws (this already comes screwed and you can adjust it later) and 2 M6x20 screws from the Lens holder package.

The 2nd row in Table 1 shows the case in which the tube holder spacer for carbon tube holder is placed between the camera mounting plate and carbon tube holder using two M6×45 screws. It can be placed on both sides of the camera mounting plate and it is used in some cases for filling the distance between the carbon tubes and the camera lenses. In mounting this option, M6x45 screws should be used to connect the spacer, tube holder and mounting plate.

The 3rd row in *Table 1* shows the use of a camera spacer. Unlike the cases so far, for its mounting, long camera mount screws should be used instead of the short ones. In addition, six M6x20 screws for fixing the spacer to the camera mounting plate are required. All these elements are provided in the Lens holder package. This spacer is used to add additional space between the

carbon tube holder (along with the carbon tubes and lens motors that would be placed later) and the camera.

The 4th and 5th row in *Table 1* show the option in which both spacers are used. Depending on the dimensions of the lens and the spatial needs, the carbon tube holder with the spacer can be mounted on either side of the camera mounting plate.

NOTE When external lens motors are used, the camera needs to be mounted such that the focus, zoom and iris rings of the lens can be roughly inside the area defined by the carbon tubes.

While mounting the camera make sure to put it in the right position, the front side of the camera lens should match with the front side of the head. The correct position is shown in *Figure 16*.

Figure 16: Correct camera mounting position

When mounting the camera, make sure to balance it well. After clamping the camera with the mounting plate on the base of the mounting plate, move the camera along the tilt axis in both directions. If the tilt axis stays motionless in a couple of positions, then the structure is balanced. If it moves, the structure is not stable, and you need to clamp the structure again in a better position and repeat the tilt moving.

One more important thing when it comes to mounting the camera and balancing it, is the position of the horizontal part of the camera holder. It can be placed and screwed in one of the four dedicated places on the vertical part of the camera holder (Figure 17). In case the user has a longer camera, it is recommended to screw it in one of the upper positions because this leaves

more space for the tilt axis rotation. Moreover, for balancing a camera it is recommended to also put the tilt axis with a camera on in the ±90° position, then let go of it and see if the structure stays motionless.

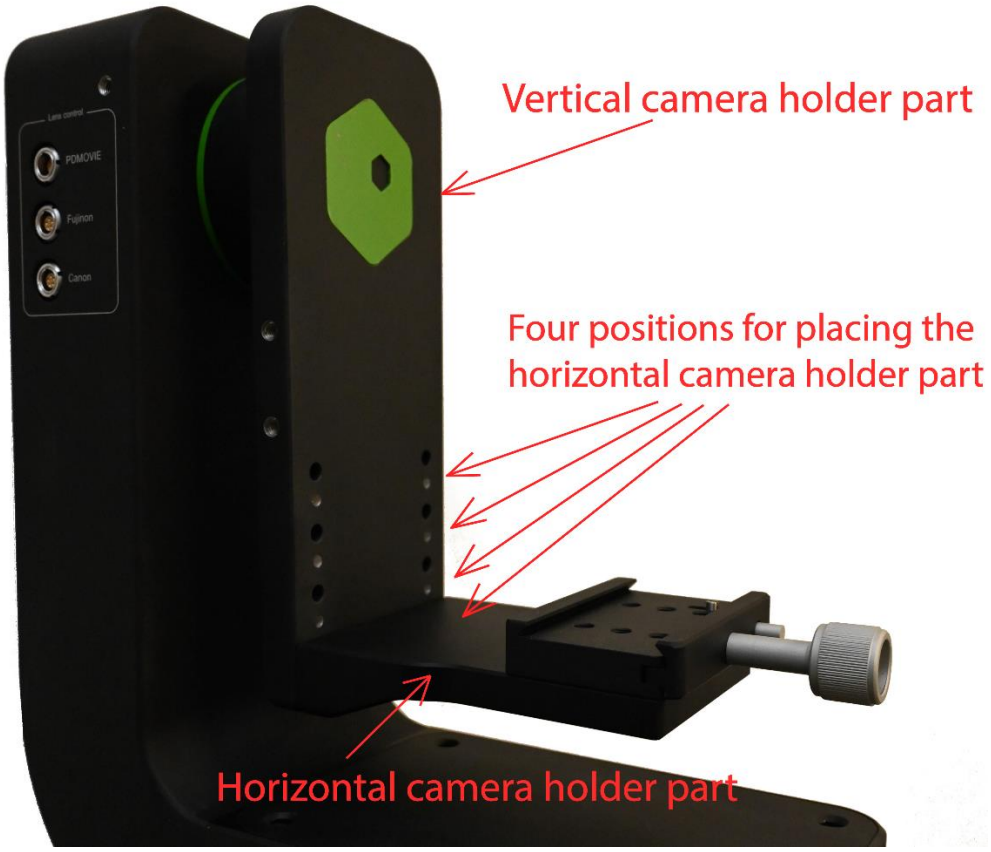


Figure 17: Horizontal camera holder part position switch

5.3. Mounting external lens motors

There are two options when it comes to controlling lenses.

If the camera being used has integrated lenses, there is a possibility of simple control by connecting Pauli head to the camera with one of the Canon, Fujinon or LANC/Panasonic cables.

Otherwise, external lens motors should be mounted. In this case, the carbon tube holder should be mounted as explained in the section Mounting the camera and attaching lens holding accessories. These external lens motors can be used with the Pauli head to control zoom, focus and iris. The PDMOVIE package contains external motors and accessories needed for their proper mounting and use.

Carbon tubes are used for mounting external lens motors. They are provided with the Lens holder package and come in three sizes for more flexibility in operating with lenses of various lengths.

The following steps should be followed in mounting external motors:

1. The first step is to check whether the additional lens strips should be mounted onto the lenses. A set of 3 different gear wheels is provided for each of the lens motors. These gear wheels have 0.4, 0.6 and 0.8mm tooth sizes. The gears can easily be switched on a lens motor by unscrewing the Allen bolt holding the gear (*Figure 18*). If the lens is such that it already has teeth with one of these three sizes, then these gear wheels could be used to directly actuate the lens. One can easily check if they make a good match by putting the wheel over the teeth on the lens. In case that the lens does not have teeth that form a good match with the wheels, lens strips provided with the PDMOVIE lens motor package that are compatible with 40-70 mm diameter lenses and 0.8mm teeth can be mounted on the lens.

Figure 18: Lens motor gear wheels switching

A lens strip should be placed to cover the center of the moving ring. The diameter of the lens strip should be a bit smaller than the diameter of the moving ring. If this is not the case, a part of the lens strip should be cut away. When cutting, one should make sure to leave at least one hole on both ends of the lens strip, because the lens strip should then be tightened with a zip tie (provided with the PDMOVIE lens motor package) using these holes. The tightening part of the lens strip should be placed such that it is guaranteed never to meet the lens motor gear. The zip tie should go through the two holes on each end of the lens strip and then be tightened. *Figure 19* shows how this setup looks like. In the end, the redundant part of the zip tie can also be cut away as illustrated in *Figure 19* on the lens strip on the right side.

Figure 19: Lens motors and lens strips with zip ties

2. Insert the carbon tubes into the carbon tube holder (*Figure 20*). To tighten the carbon tubes in the carbon tube holder, use four M4×12 screws (provided with the Lens holder package). In the beginning, slightly tighten these screws, as the tubes may need to be shifted later depending on the spacing. Select the carbon tube length that matches the length of the lens at your disposal. External motors can be mounted all on the same side. In this case, it could be enough to mount just one tube. However, if more than one external motor is mounted, it is recommended to use both tubes and mount external motors on both. If possible, one should position the carbon tubes in way that they don't affect the tilt movement.

Figure 20: Carbon tubes in the carbon tube holder

3. Mount the PDMOVIE lens motors onto the carbon tubes and align them to their respective lens gear rings. It is recommended to mount the motors on alternating sides of the lens if the space allows. This ensures an equal distribution of the forces for optimal use (*Figure 21*).

Figure 21: Lens motors

4. Verify the alignment of the lens motors with the lens gear rings. This step may require multiple iterations. Alignment adjustments can be made by either shifting the motors, or the carbon tubes in their holder, depending on space allowances. If necessary, a spacer can be used. *Figure 22* shows the correct alignment and incorrect alignment where the gear is far away from the lens gear ring.

Figure 22: Incorrect and correct lens motor alignment

5. Verify that the gear disk of the lens motor is at the same height as the middle of the lens (see *Figure 23*). Additionally, a snug fit between the lens gear and motor gear should be ensured so that there is no risk of the gear wheel becoming disconnected during operation.

Figure 23: Lens gears mounting

6. Finally, mount the lens holder (*Figure 24*) on the carbon tubes and align it with the end of the lens. Secure the lens in place by tightening the Velcro strip. This part is optional.

Figure 24: Lens holder Velcro strip

If there is a need to fasten the camera so that it doesn't oscillate due to the very fast movements of the head and very long lenses, the Lens holder package can come in very handy. To put it in place, the lens holder is used along with its Velcro strip.

Lens holder mounting can happen directly after mounting the camera or after mounting the external lens motors in case they are used. The steps to do this are as following:

i. First, place the holes of the lens holder onto the carbon tubes. The final lens holder position should be right below the camera lens part that the Velcro strip will cover. Make sure that the lens holder is not blocking any of the moving parts of the lens gears.
ii. Then, screw the screw mounts placed at the bottom of the lens holder to make the structure tightened. In the middle part of the lens holder, there is another screw where you can adjust the vertical position so that the lens holder comes closer to the camera lens. Do not screw this one too tight yet.
iii. Put the Velcro strip around the desired place on the lens and close it up.
iv. When the strip is placed you can screw the top screw and finish screwing on the middle part of the lens holder to fine-tune the whole structure.

The lens holder setup is shown in *Figure 25*.

Figure 25: Lens holder assembly

Each PDMOVIE lens motor comes with a LEMO connector cable. To power on and send/receive data from the lens motors, the cables need to be connected in series and one of the lens motors needs to be connected to the connector labeled “PDMOVIE” (connector 1) of the Pauli head (see *Figure 21*).

5.4. Connecting and Powering on the Pauli head

First, plug in the AC cable and the RJ45 cable into one of three available ports on the Pauli head that is used for network connection (two on the bottom and one on the upper side). For details, see the Interface section.

Note that for safety reasons, it is recommended to use the AC cable with locking (it is provided with the Basic package). Also, it is recommended to use the Ethernet cable with locking. However, if cables with locking a mechanism are not available, regular cables may be used.

Press the 0/1 switch to turn on the Pauli. Diodes on its front side are the indicators of certain head states (*Power, Network, Active*). After turning it on, *the "Power"* diode will also turn on, and 10 seconds after, the "Active" and "Network" diodes should turn on. This signals that the robotic head has properly started as in *Figure 26*.

Figure 26: Connecting the Pauli head

5.5. Limit setup

After mounting the camera and the head, pan and tilt limits on the head should be set. These limits are hard limits that prevent any movement of the head beyond the set limit. Their purpose is to prevent any physical damage to the head, camera and other equipment mounted on the head due to physical space constraints.

Each head is shipped with the default pan limits set to -120° and 120° and tilt limits set to -30° and 30°. If these constraints do not match the requirements of your production or physical constraints with the mounted equipment, be sure to adapt them to your needs.

Limits can be set in two ways. One way is to set them with the head control app. The way to start the app is explained in the section Control application, and the way to set the limits is explained in its subsection Pan/tilt control in Velocity and Position mode.

Alternatively, the limits can be set manually by using the Set button on the back of the Pauli head (Limits section – see *Figure 27*). The process of manual limit setting can be started by pressing the Set button twice. After this the following set of events and actions should follow:

1. The LED on the tilt axis will turn orange (*Figure 27*) which means that this axis is ready for setting up.
2. Manually move the tilt axis to one side in the desired limit position and leave it there.
3. Press the limit set button for at least two seconds to save the limit position.
4. Move the tilt axis to the desired position on the other side and leave it there
5. Press the limit set button for at least two seconds to save the limit position.

To switch to the pan axis, press the Set button twice (as for the tilt axis). The limits for the pan can be set by following the same set of steps as for the tilt axis. For this part see *Figure 28*.

Figure 27: Tilt LED light up

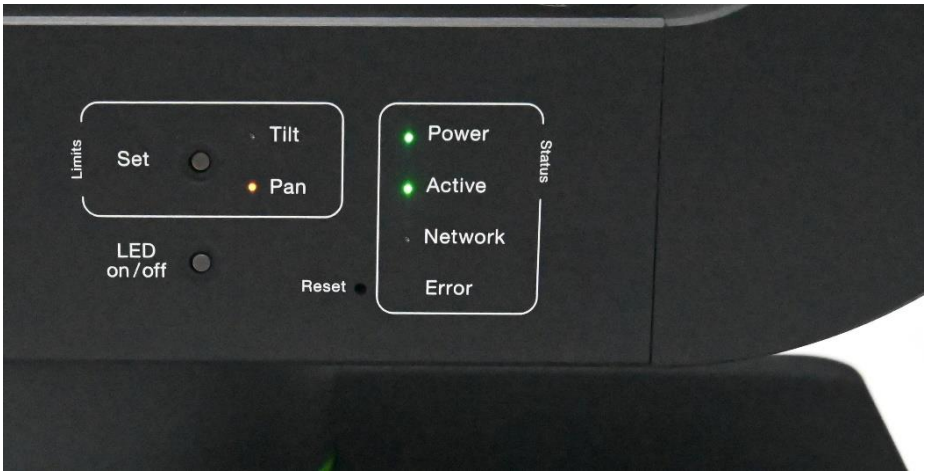


Figure 28: Pan LED light up

If at any step, the diode does not light up after pressing the button as explained in this manual, just repeat the action until the LED state becomes as expected.

5.6. Setup of the head orientation

As stated in the section Mounting Pauli head, Pauli head can be mounted to stand upright or upside down (inverse mount). Each head is by default set up for regular mount. In case the head is mounted in an upside-down position, it should be properly configured so that the commands issued to the head have the proper effect. This configuration can be done over the control app or manually by using a button on the head. Once configured head retains its mount type until next explicit configuration.

The way to start the control app is described in the Control application and the setting up of the mounting orientation is explained in Motion control settings.

For the manual setting of the head orientation, press the LED ON/OFF button for at least five seconds. The indicator light for Active mode will turn from green to blue (*Figure 29* and *Figure 30*). The angles of movement will remain the same as in the normal mount. To turn back to a normal (straight) mount, repeat the same procedure.

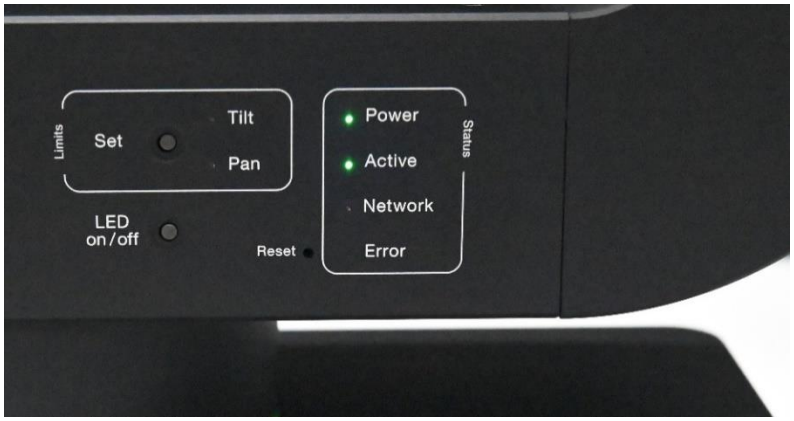


Figure 29: Active diode in straight mount

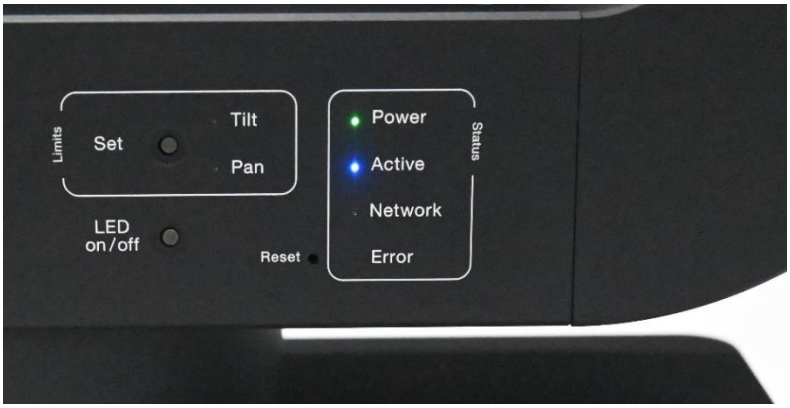


Figure 30: Active diode in inverse mount

NOTE: By the color of the active diode, you will always be able to tell in which mode the head is. If the Active diode is green, the head is in the regular (straight) mount. If the Active diode is blue, the head is in the inverse (upside down) mode.

5.7. Lens control configuration

5.7.1. Lens control setup

When configuring the lens control, there are several options available with Pauli. These are:

1. Control with Canon lens motor
2. Control with Fujinon lens motor
3. Control with external lens motors (PDMOVIE)
4. Control with LANC or analogue interface for camcorders

The preferable lens control option should be selected in the Settings tab of the Pauli control application. This procedure is explained in detail in the Lens control settings.

In addition to selecting the proper lens control interface, for each of these lens control types additional configuration of the particular control unit may be required.

5.7.2. Canon lens motor configuration

If Canon lens control is used, the head should be properly connected to the servo drive unit attached to the lens with a cable. Note that only full servo lens controllers are compatible. For successful control, the cable connecting the lens unit and the Pauli should be plugged in the remote port of the servo drive unit, as shown in *Figure 31*.

Figure 31: Lens controller remote port

5.7.3. Fujinon lens motor configuration

If Fujinon lens control is used, the head should be properly connected to the lens motor with a cable. Note that only lenses with serial connectors are compatible. For successful control, the lens should be plugged in the remote port.

5.7.4. External PDMOVIE lens motor configuration

If external lens motors (PDMOVIE) are used, they should be properly configured. To ensure the smooth function of the system, the lens motors need to be configured for the first time. This ensures that zoom, focus and iris channels correspond to the correct channel on each lens motor. Moreover, you should choose in the Settings tab of the application, the appropriate lens option that you are going to use for each axis. The options available for choosing are Canon, Fujinon, PDMOVIE and None. This is not necessary each time you want to use the head, but only when you want to initialize a new camera.

Figure 32: Lens motor configuration button

The lens motors have a button on the bottom part (see *Figure 32*). This button serves a different function based on the times and the duration it is pressed. The following table shows the different functions of this button:

LENS	▬▬▬	CALIBRATION
	●●●●	RESET/RECOVERY CALIBRATION (POWER OUTAGE)
	●●●●●●●	MOTOR DIRECTION
CHANNEL	●	STOP CALIBRATION
	●●	R1 G2 B3
	●●●	Y4 C5 P6
SPEED	●●●●●	FAST/MEDIUM/SLOW

NOTE: The dot indicates a short press of the button, and the bar a long press (2 seconds).

The desired configuration for the lens motors is:

- Fast speed (LED is always ON and it is not blinking slow or fast)
- GREEN CHANNEL for FOCUS
- RED CHANNEL for ZOOM
- BLUE CHANNEL for IRIS

NOTE: The Direction needs to change according to the side of the lens on which the lens motor is mounted. When the motors are initially calibrated (either manually or automatically), before the firmware has booted up, they go to the middle position and remain there. As soon as the system is on, an initial command is given to the motors to go to their zero position.

For the initial configuration of the system, the zero position of the motors should correspond to:

- iris fully open
- focus to closest focus possible and
- zoom to Wide (completely zoomed out) view

If any of the motors is in the opposite configuration (iris closed, focus to infinity and zoom to Tele -fully zoomed in), then the direction on those specific motors should be changed by hitting the button of the lens motor seven times.

Automatic Calibration: If the lens gears have hard stops, the motors can automatically calibrate themselves by detecting the hard stops. To initiate automatic calibration on the lens gears with a hard stop, press and hold the button at the bottom of the lens motors for two seconds.

If the lens used does not have hard stops, then the user needs to calibrate the lens motor manually. The procedure is the following:

- Move the motor towards one end of the lens ring until it reaches near the closest focus or infinity for focus
- Move the motor in the opposite direction until it reaches the infinity or closest focus distance for focus
- Move the motor in the opposite direction slightly, and it should automatically move to the center of the range in which it can move

The procedure is similar for zoom or iris lens rings without hard stops.

6. Control application

To access the control application on Pauli, the following elements are required:

1. PC, tablet or mobile device
2. An Ethernet connection between the control device and Pauli
3. A browser (Google Chrome, Mozilla Firefox, Opera or similar)

The Pauli control application can be used to configure axis limits, lens control or head orientation. Moreover, it can be used for updating the head firmware or changing the IP address. Lastly, the control application can also be used for manually operating the head.

Head can be connected to the PC, tablet or mobile device directly (point-to-point) over an RJ45 cable. Alternatively, both devices should be connected to the same local network. In case the devices use a local network to communicate, a configuration of the subnetwork might be required.

Pauli uses the 10.10.12 subnet so the IP address for the PC or tablet needs to be configured manually. Below is the description of how to do this on Linux and Windows operating systems.

NOTE: If subnetwork settings are already configured, skip to the next section.

a) Linux OS

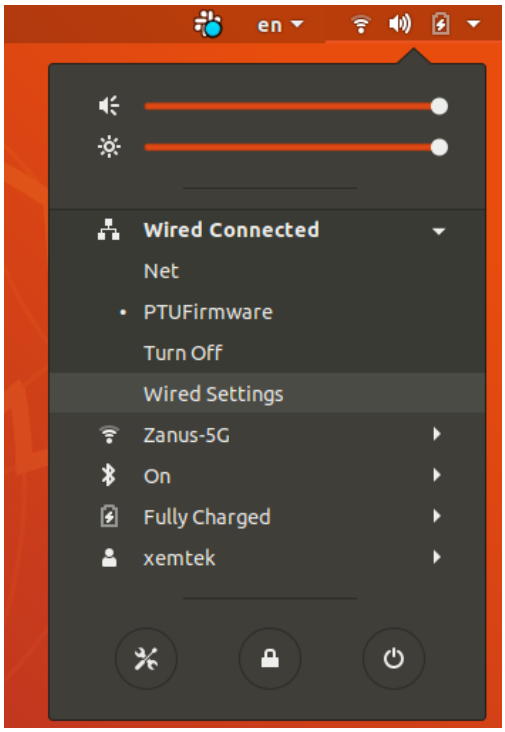


Figure 33: Linux network settings

In the dropdown menu of the Network settings, select Wired settings (*Figure 33*). Add a new profile by clicking on the plus symbol. Populate the address and netmask areas and assign a new name. Check if the IP address is not already taken (ping Pauli just to be sure). After these actions, a new profile should be visible in the Profiles section. *Figure 34* gives an example of how a profile with the name Pauli, address 10.10.12.161 and netmask 255.255.255.0 is added.

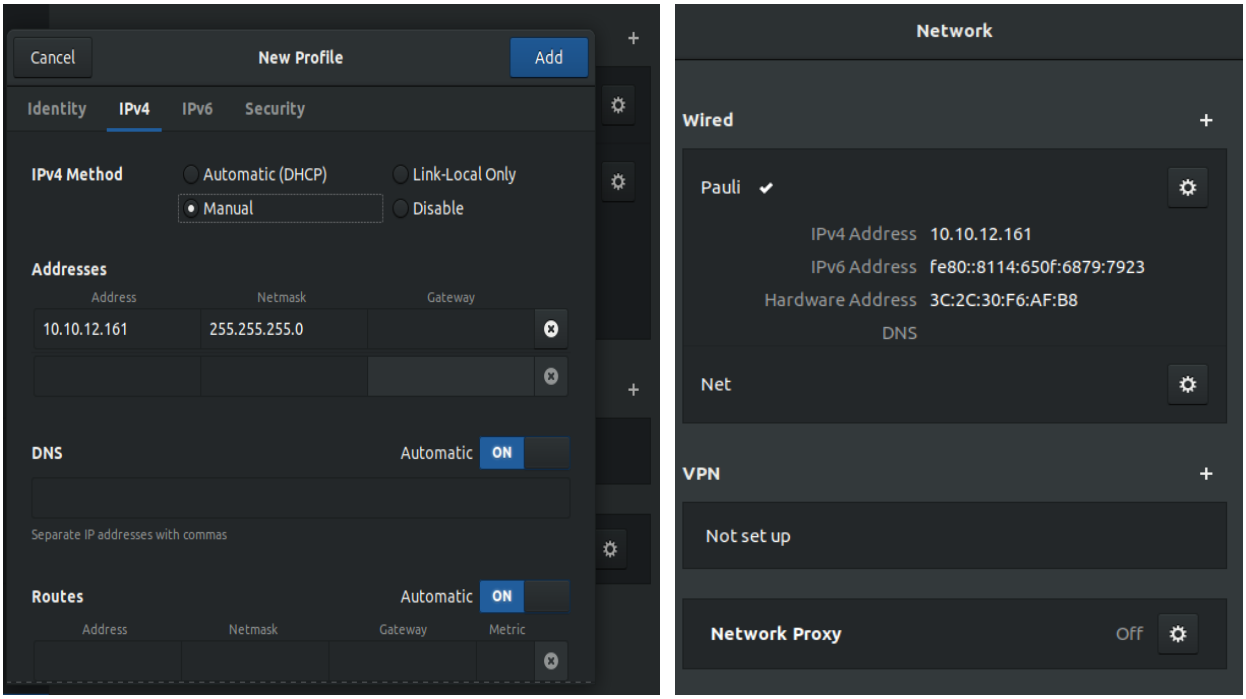


Figure 34: Profile adding

b) Windows OS

In the Network & Internet settings, open the Change adapter options and then choose Ethernet (*Figure 35*). In the Ethernet window, open Properties and then double click Internet Protocol Version (TCP/IPv4). Change the settings as illustrated in *Figure 36*. The last number inside the IP address section can be any number in the range from 0 to 255, but not the same as the number of the head.

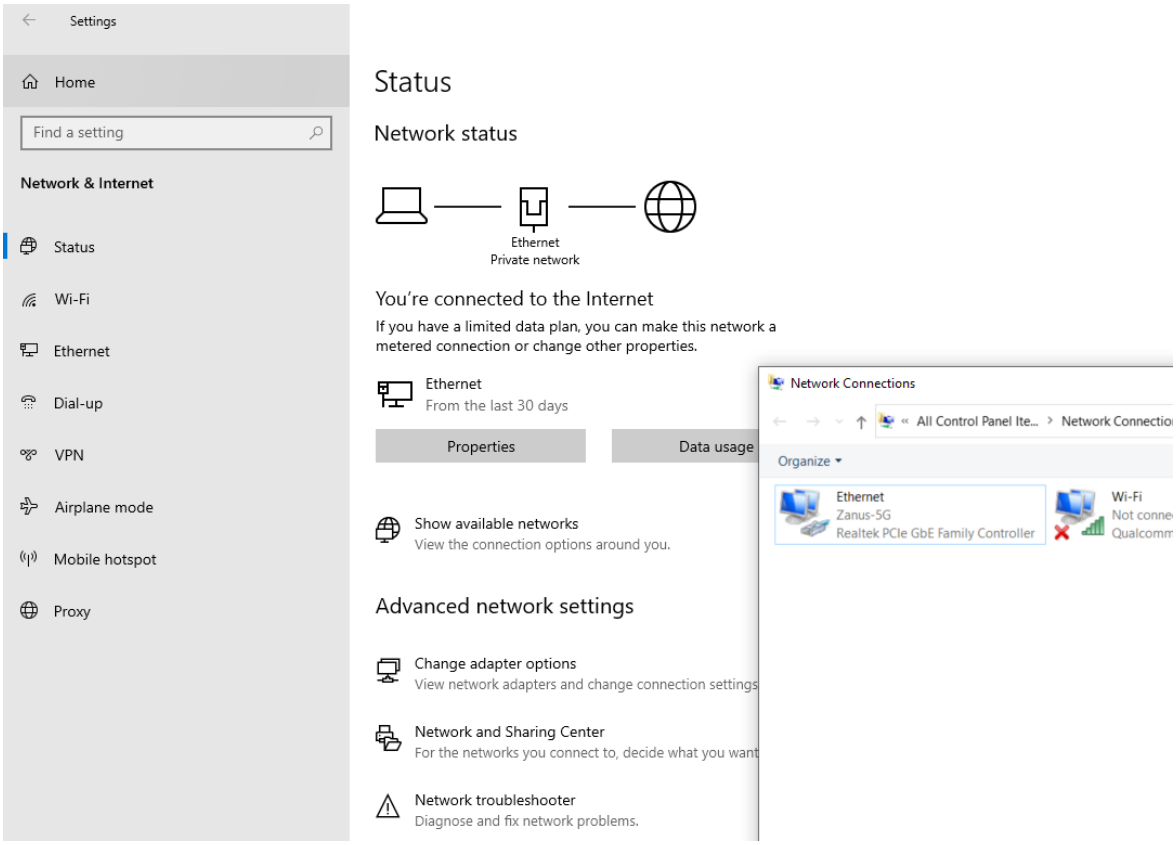


Figure 35: Windows Network settings

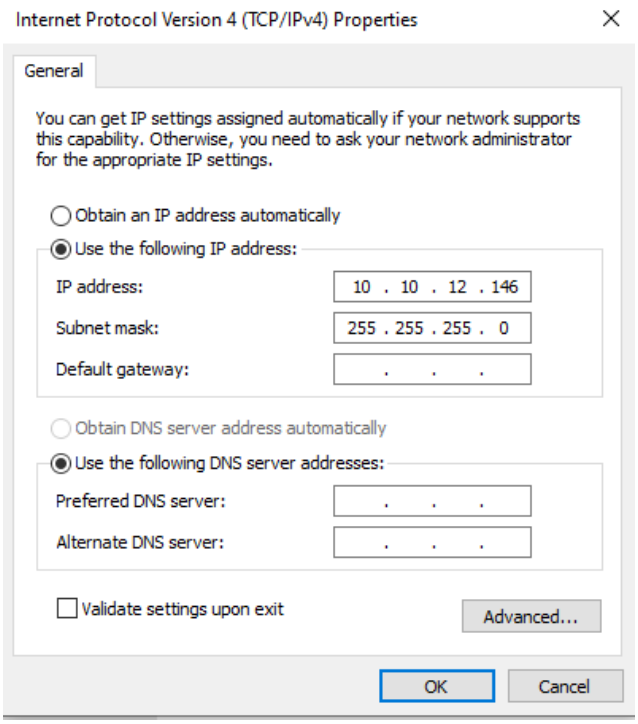


Figure 36: Internet Protocol properties

6.1. Opening the Application from the Browser

Open the browser and call Pauli homepage by typing 10.10.12.X:3000 into the browser search bar. X indicates the port or the IP address for that head. Each Pauli is shipped with the **default IP address 10.10.12.10**. This IP address can be changed through the application (for details see section IP address setting). When opening the application for the first time, **you should type 10.10.12.10:3000 to open the web application**.

Figure 37 gives an example of opening the application homepage with the default Pauli IP address.

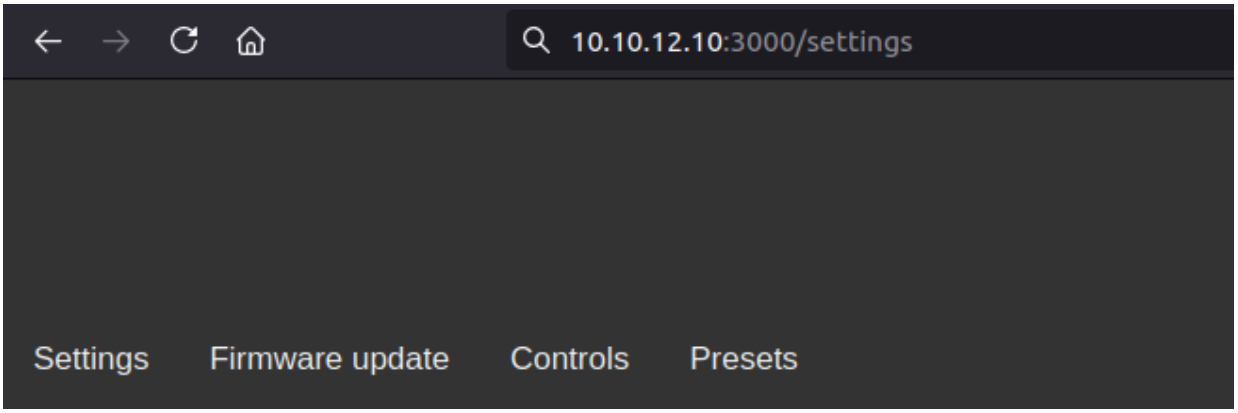


Figure 37: Pauli default IP address homepage opening

In case that at any point, you change the IP address of your Pauli head and forget it, you can restore the default IP address by pressing the reset button (as illustrated in *Figure 38*).

Figure 38: Reset button

If the call was successful, the application homepage will open as shown in *Figure 39*.

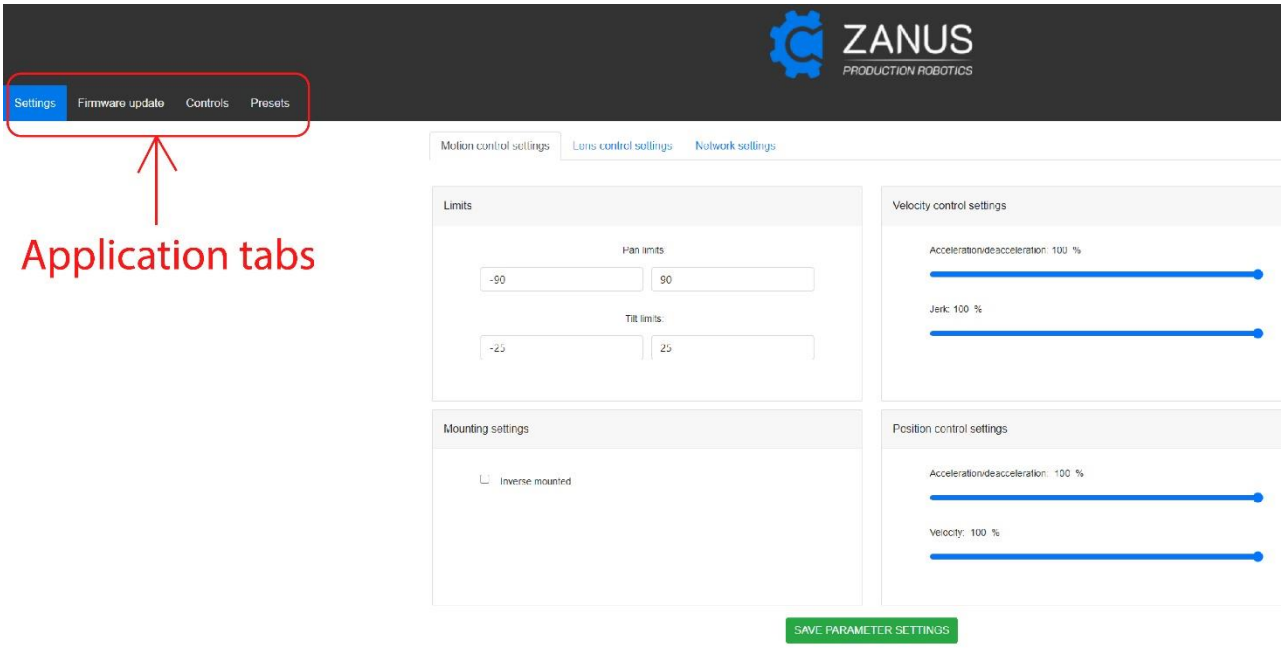


Figure 39: Application homepage

The Application has four tabs in the Menu:

- Settings tab
- Firmware update tab
- Controls tab
- Presets tab

6.2. Settings tab

The Settings tab is the first one that opens when the application is opened. It consists of a couple of separate tabs:

1. Motion control settings
2. Lens control settings
3. Network settings

Figure 40 shows the general overview of this Tab.

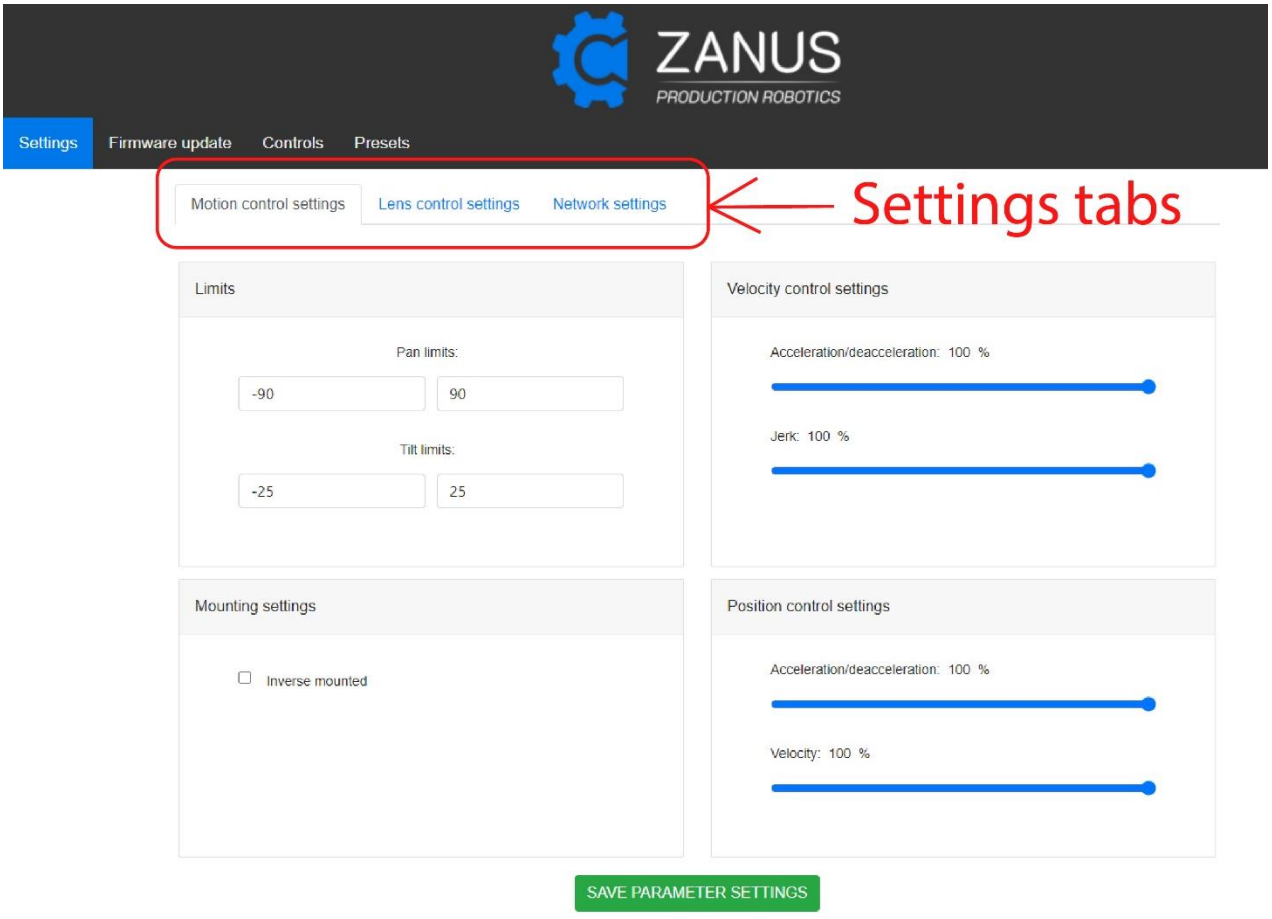


Figure 40: Settings Tab overview

6.2.1. Motion control settings

Motion control settings tab is used for changing the following settings (as illustrated in *Figure 41*):

1. Velocity and position control settings
2. Settings of the pan and tilt axis limits
3. Settings related to the way Pauli is mounted

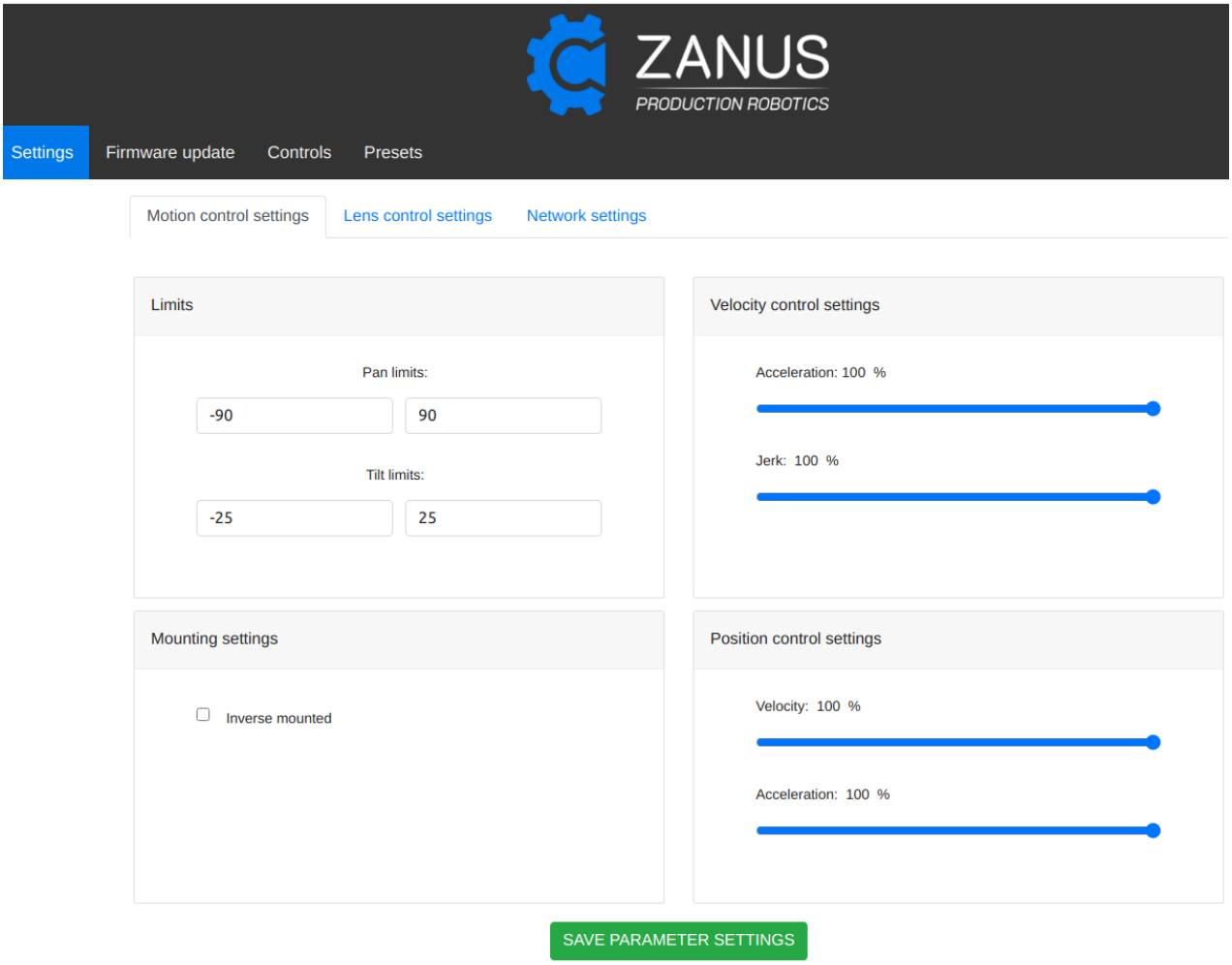


Figure 41: Motion control settings

In the velocity and position control settings, one can set the maximal allowed acceleration and jerk (a derivative of acceleration) for the velocity control and maximal allowed velocity and acceleration for the position control. These limits determine how aggressive the Pauli head would be in regulating velocity and position. For smooth regulation, the limits should be set to low values and for aggressive operation, these values should be set to high. Please note that these limits can also be set in the Controls tab of the application (for details please see Pan and tilt velocity and position control).

In the Limits settings, one can set the lower and upper limits for the pan and tilt axes. These limit values are represented in degrees. Note that the limits can also be set manually (see Limit setup) and in the Controls tab (see Pan and tilt velocity and position control).

In the settings related to the way Pauli is mounted, one can specify if the head is mounted upside-down (inverse mount). In the mounting settings, if the checkbox is ticked, the head is set to the inverse mount and if it is not ticked it is set to the normal mount. Note that the head orientation can also be set manually (as described in the section Setup of the head orientation).

After setting certain parameters of interest, the user should click on SAVE PARAMETER SETTINGS button in order to save these settings and proceed with using the Pauli in accordance with them. A notification would appear showing the settings are successfully saved.

Figure 42: Motion control settings successful saving

6.2.2. Lens control settings

Lens control settings include settings for Zoom, Focus and Iris (*Figure 43*). One can choose the control method for each of these axes separately. Selection of the preferable control method can be done by clicking on the field below the name of the axis, which opens a dropdown menu. The available options are:

1. none
2. Canon
3. Fujinon
4. PDMOVIE
5. Camcorder

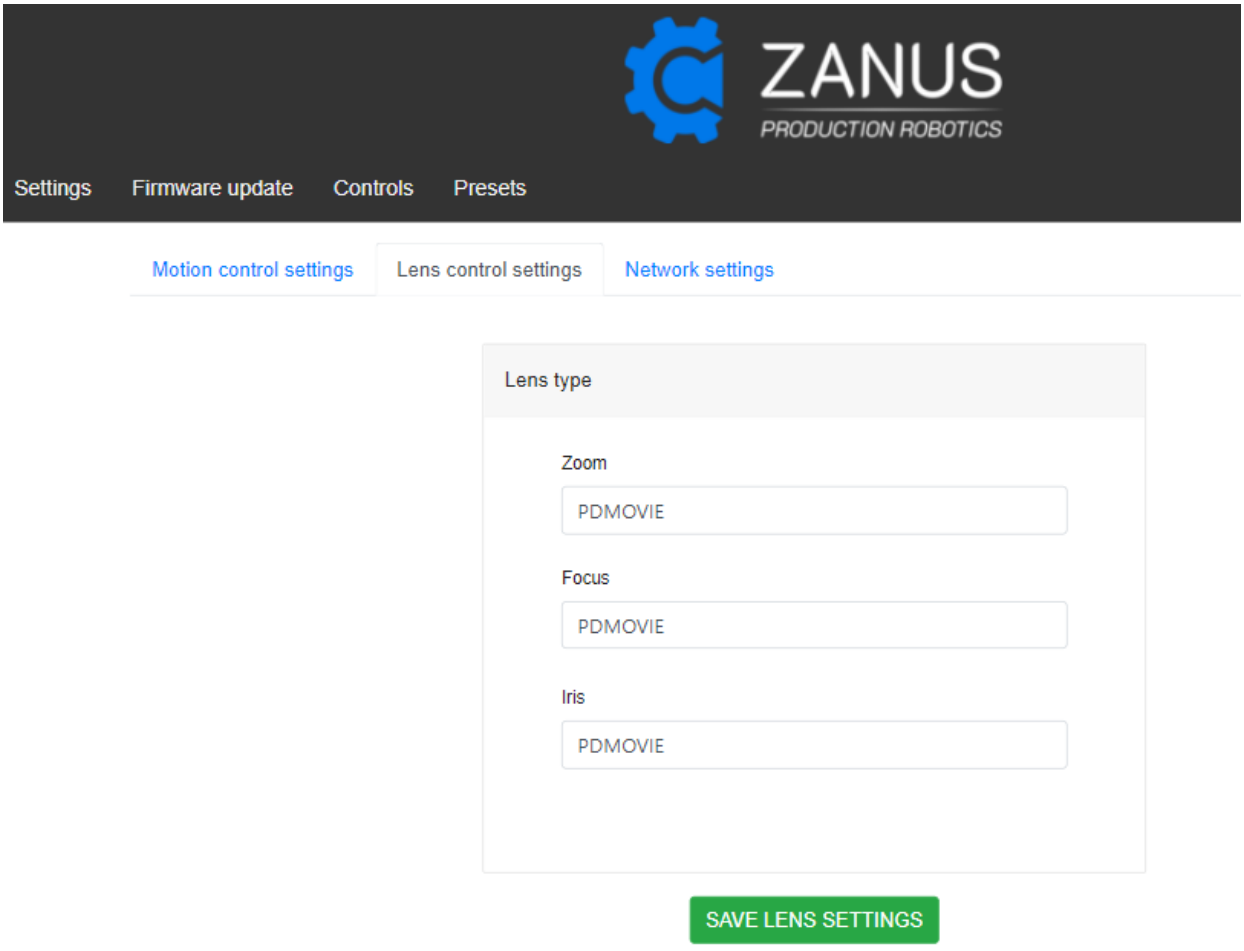


Figure 43: Lens control settings tab

The one thing to have in mind is that not all control combinations for zoom, focus and iris are possible. For example, choosing Canon for Zoom and Fujinon for Focus is not a valid option because it is physically not possible to use this combination. On the other hand, for example, selecting the Camcorder option for Zoom, and PDMOVIE for Focus and Iris would be a valid option.

When choosing the Camcorder option, an additional field would open asking to choose a Camcorder model from a dropdown menu (*Figure 44*).

Figure 44: Camcorder options

After setting options for each of the lens axes, click the Save lens settings button to finish the process. The message as shown in *Figure 45* will appear.

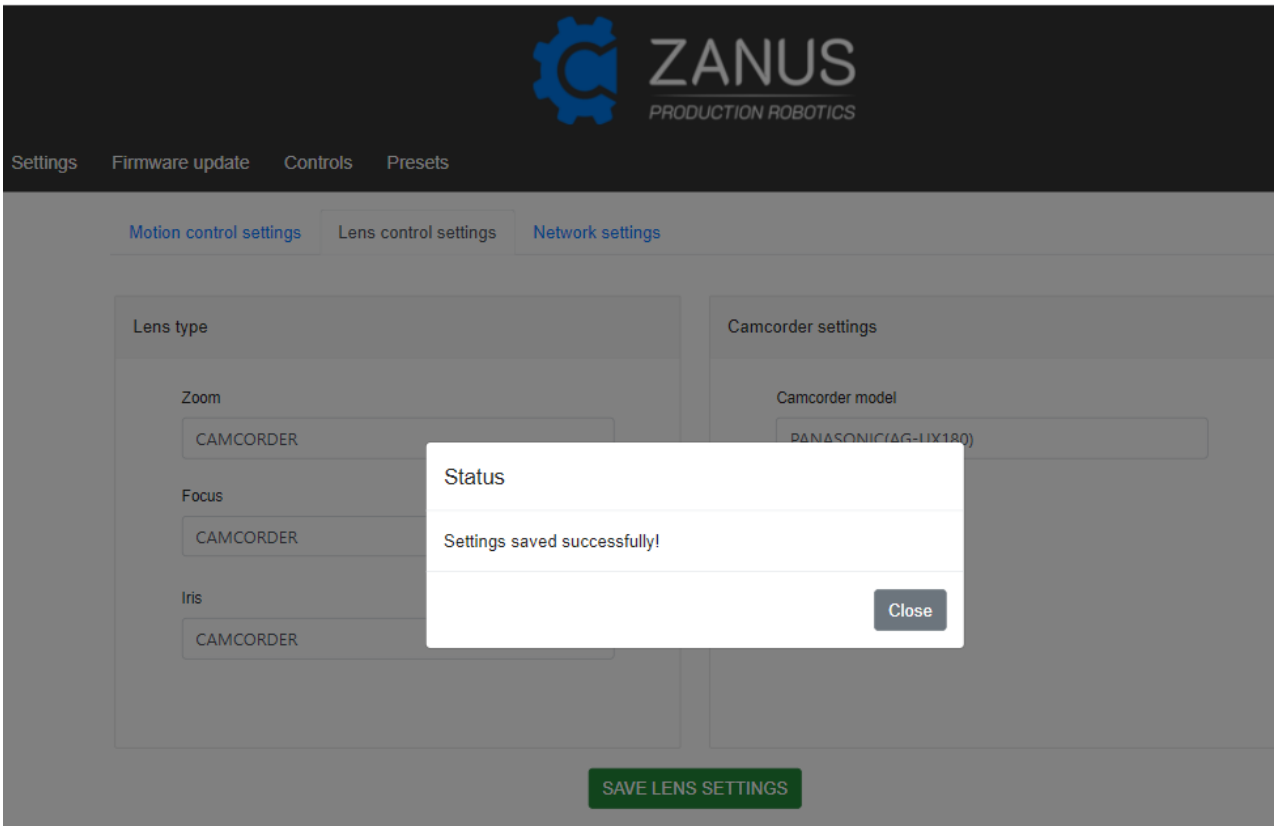


Figure 45: Lens control settings successful saving

6.2.3. Network settings

This tab includes the settings for the Pauli IP address.

Pauli head IP address can be modified by opening the application in the browser. First, the user should open the Settings tab and then the Network settings tab as shown in *Figure 46*. In the IP field, type the IP address that you want to have.

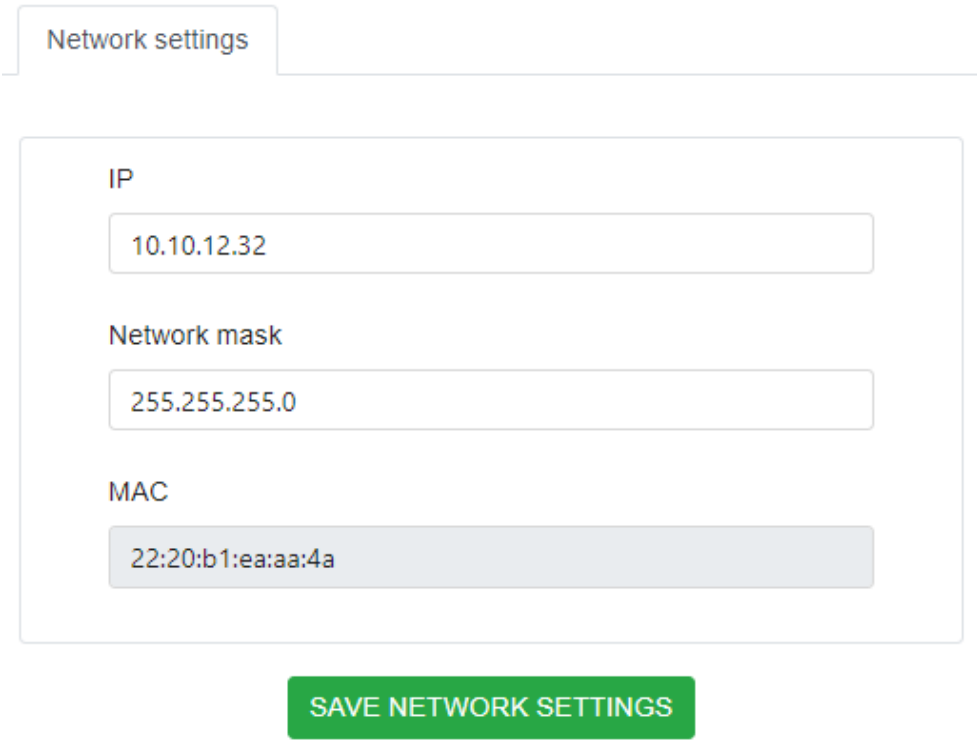


Figure 46: IP address setting

Save the changes by clicking Save Network Settings. The notification will appear upon successful saving. After clicking the OK button on this notification, the application will automatically refresh, and it will be redirected to a homepage with the newly set IP address.

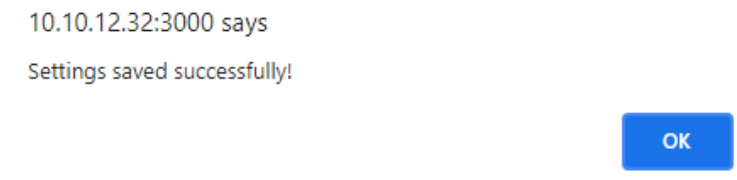


Figure 47: Network settings successful saving

Note that the newly set IP address should be used for opening the control application for communicating with Pauli in the future.

6.3. Firmware update tab

The Firmware update tab can be used to check if Pauli is running with the latest firmware version.

Figure 48 gives an illustration on how to identify the number of the firmware running on the Pauli head.

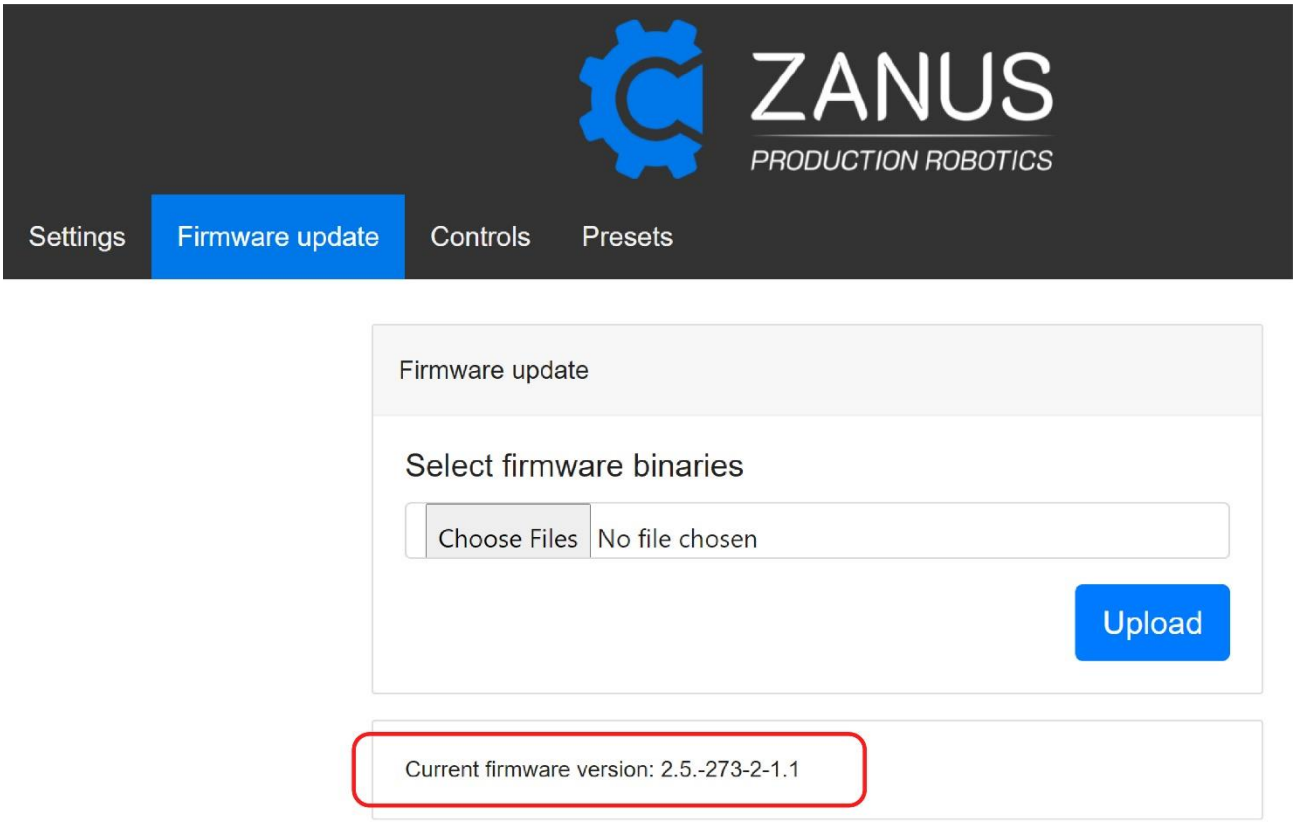


Figure 48: Current Firmware version

Check if there is a newer version of the firmware available. This can be done by navigating to the file that contains the latest release of the Pauli firmware. It is located on our webpage https://zanusrobotics.com/downloads/. The name of the file indicates the numbers corresponding to the latest firmware version. If the name of the file and the name that is displayed under the Firmware update tab match (field marked in red in *Figure 48*), the Pauli is running with the latest firmware version. If this is not the case, the firmware on the Pauli head should be updated. This can be done by first downloading the file to the local folder and uploading it through the Firmware update tab of the application (an example is shown in *Figure 49*). Before pressing the Upload button, make sure that the head is in the disabled mode (for details on how to put the head in the disabled mode see section Head state control and indication).

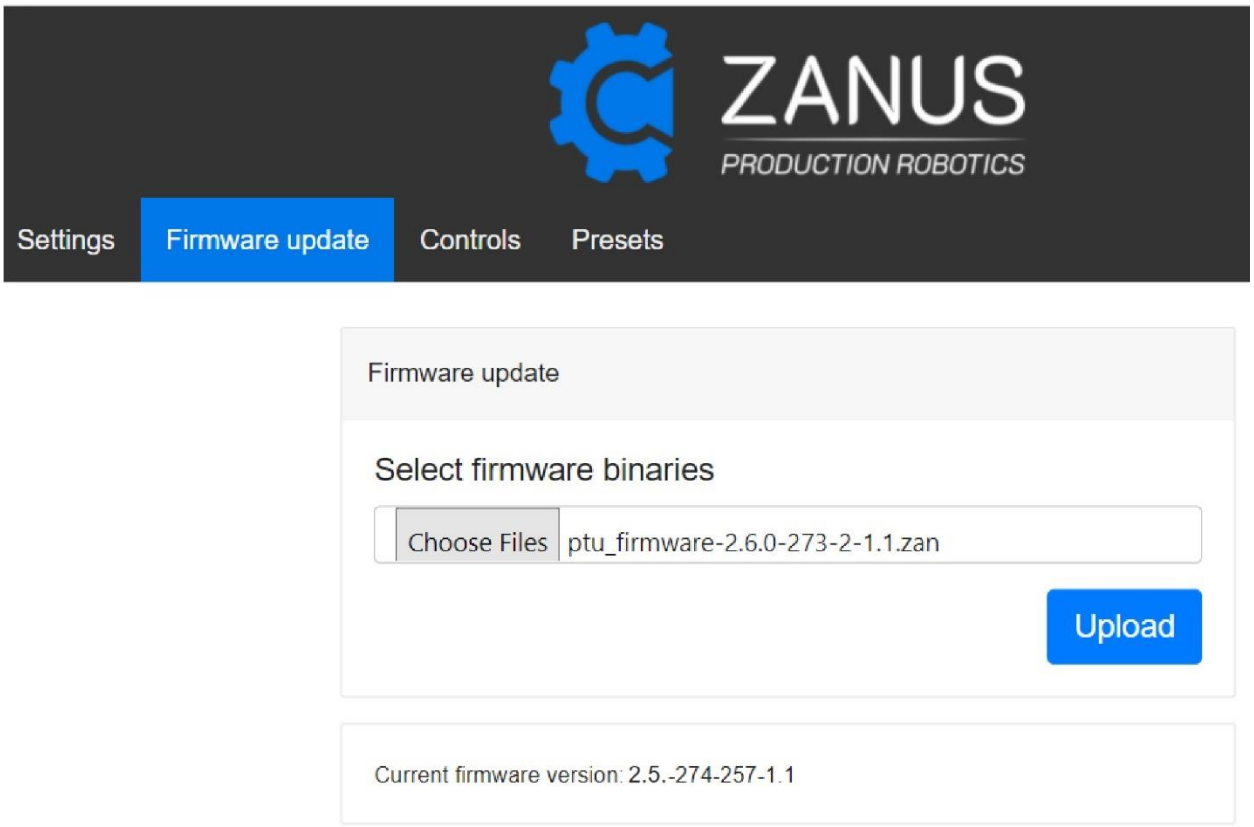


Figure 49: Firmware update archive upload

NOTE: Make sure to only download software from the official webpage of Zanus for production robotics (https://zanusrobotics.com/downloads/). In case any other file is selected during the upload procedure it will be rejected by the upload software.

Click the Upload button and the upload should start right away. The upload status indicators can be seen during the process, as shown in *Figure 50*, *Figure 51*, *Figure 52*, *Figure 53*, *Figure 54*, *Figure 55* and *Figure 56*. Note that, before the status indicator window appears, some browsers may display the message that the page is not responsive. If this happens, just select the “Wait” option and wait for the processing to start.

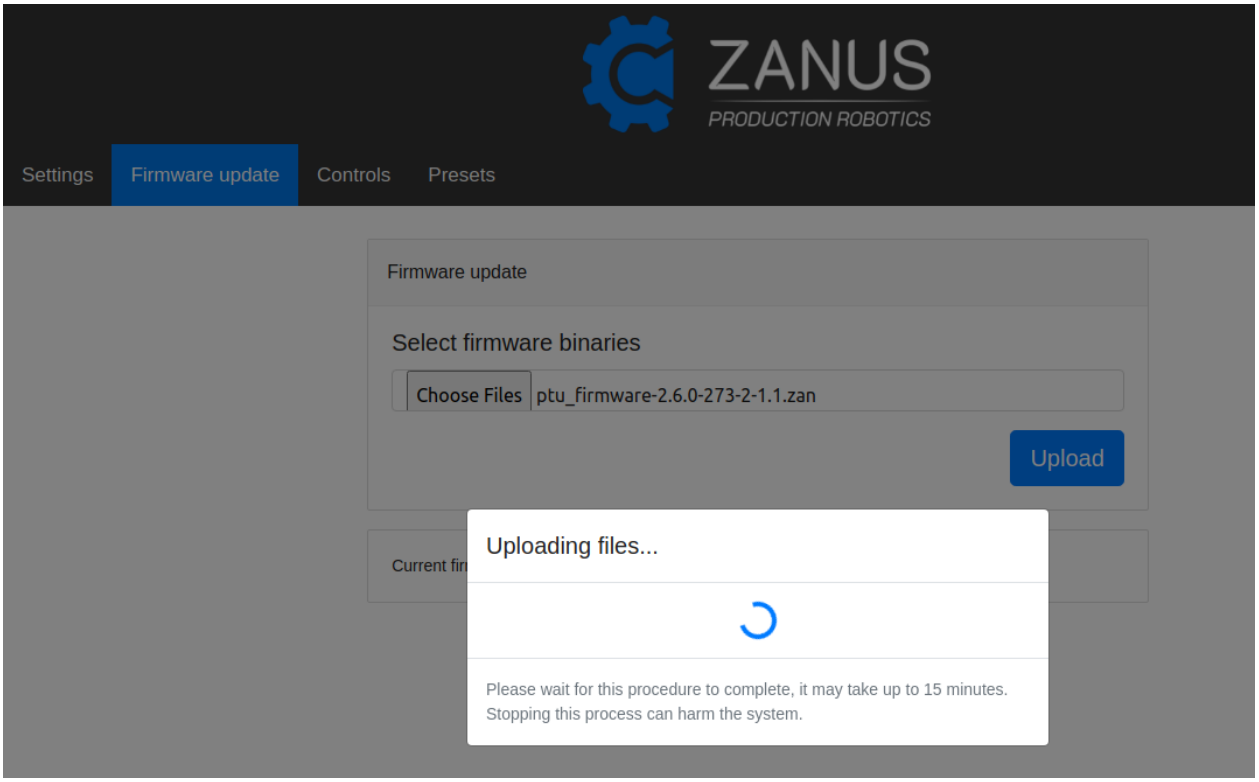


Figure 50: Uploading files indicator

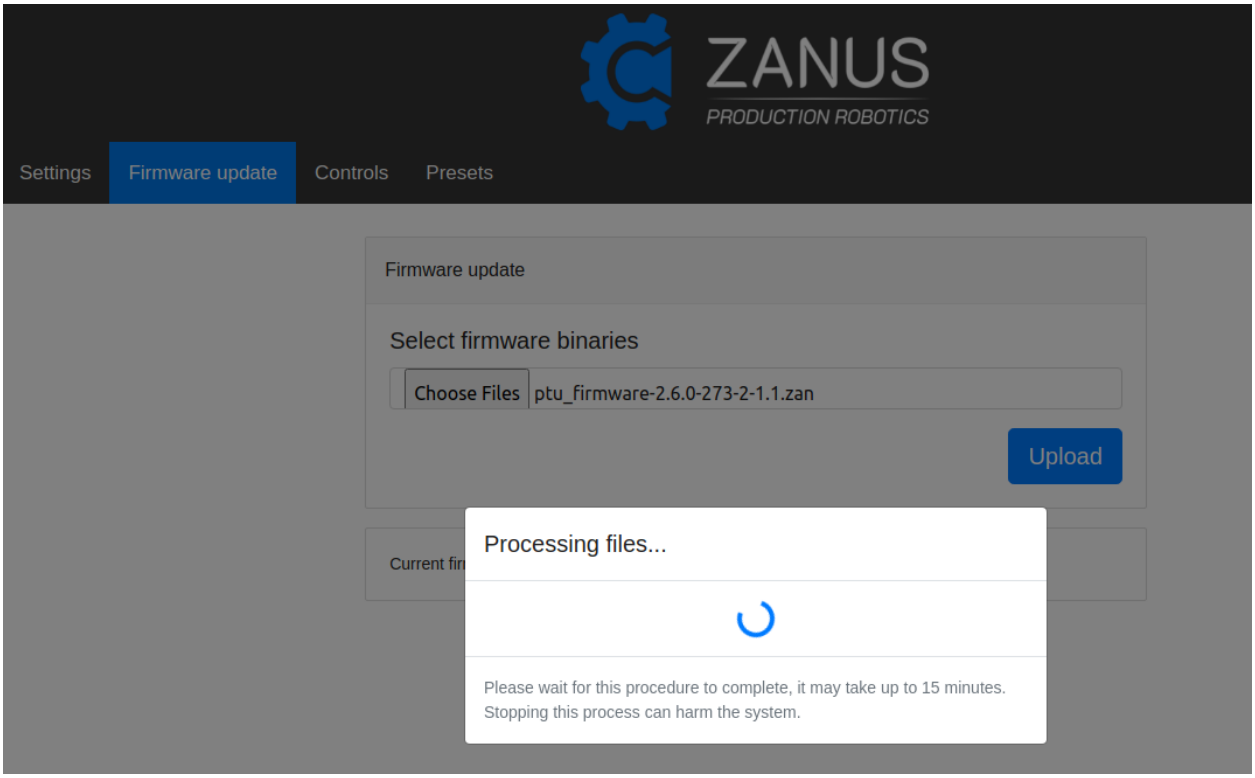


Figure 51: Processing files indicator

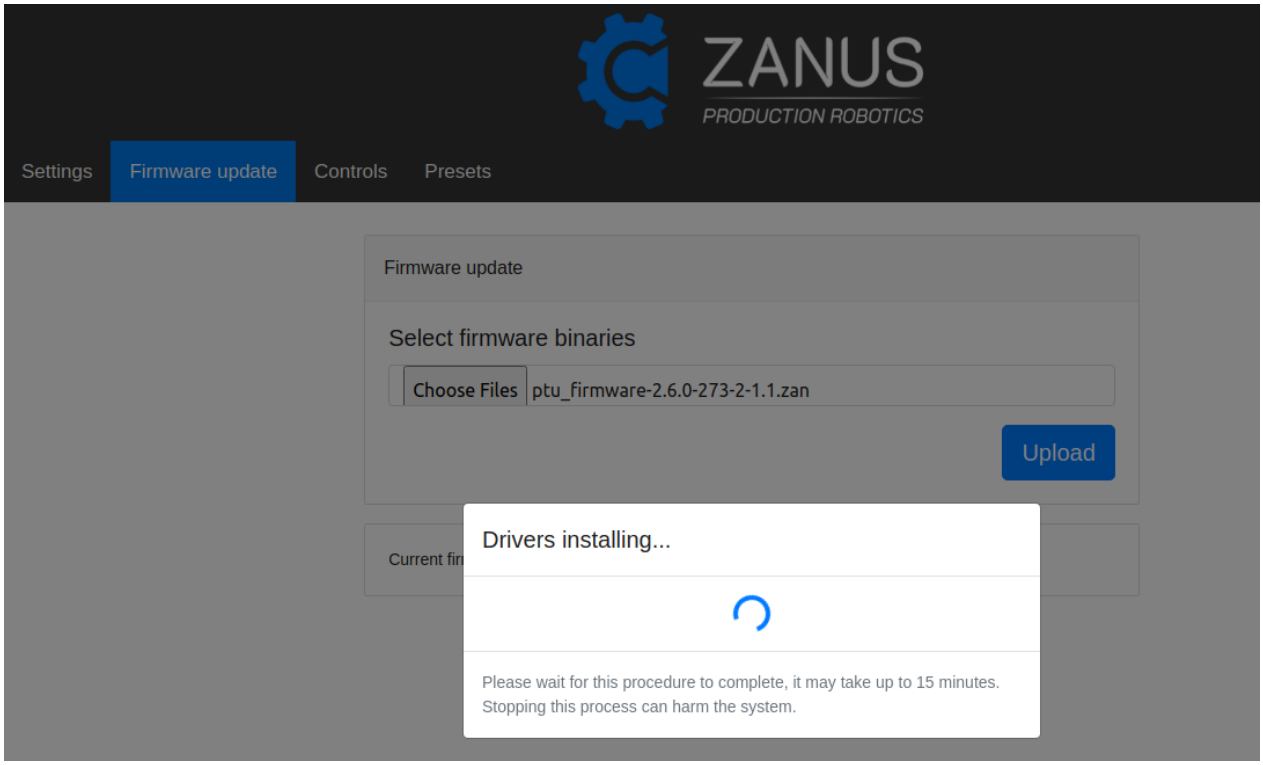


Figure 52: Drivers installing indicator

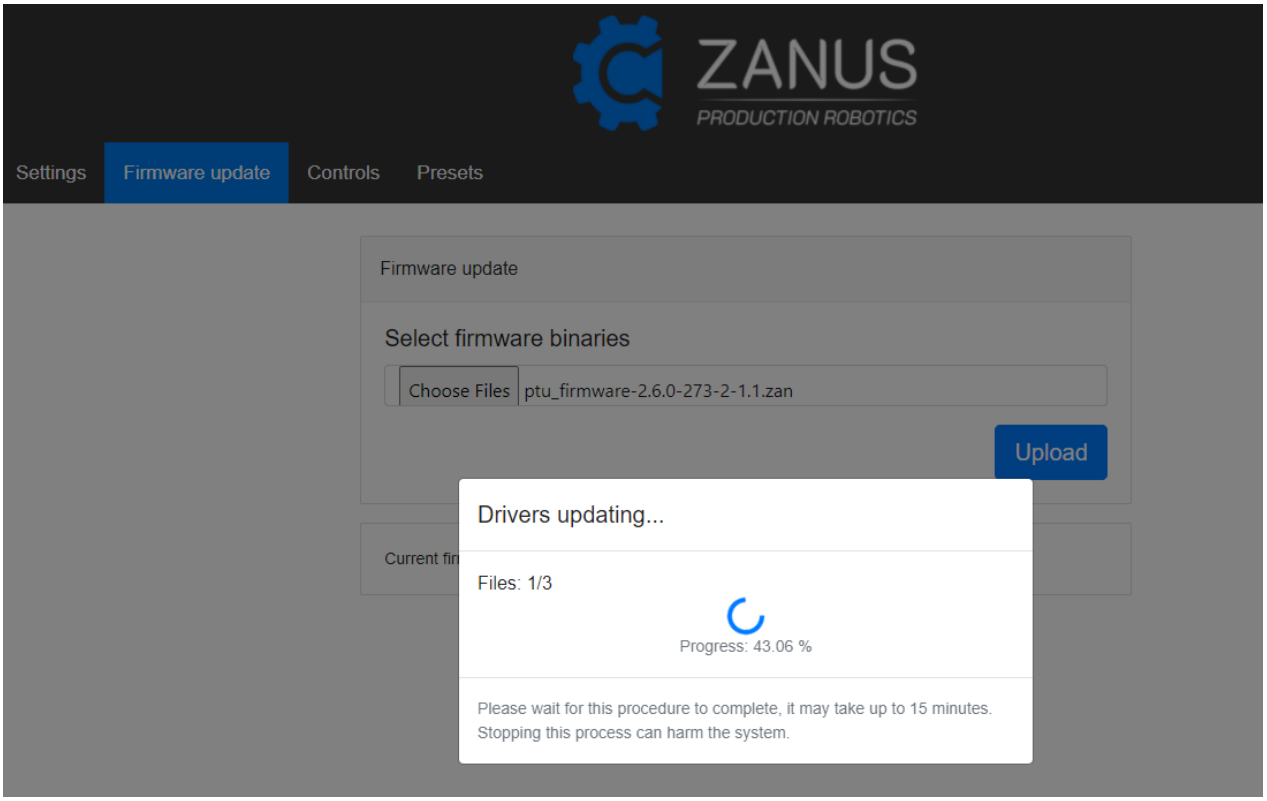


Figure 53: Drivers updating indicator

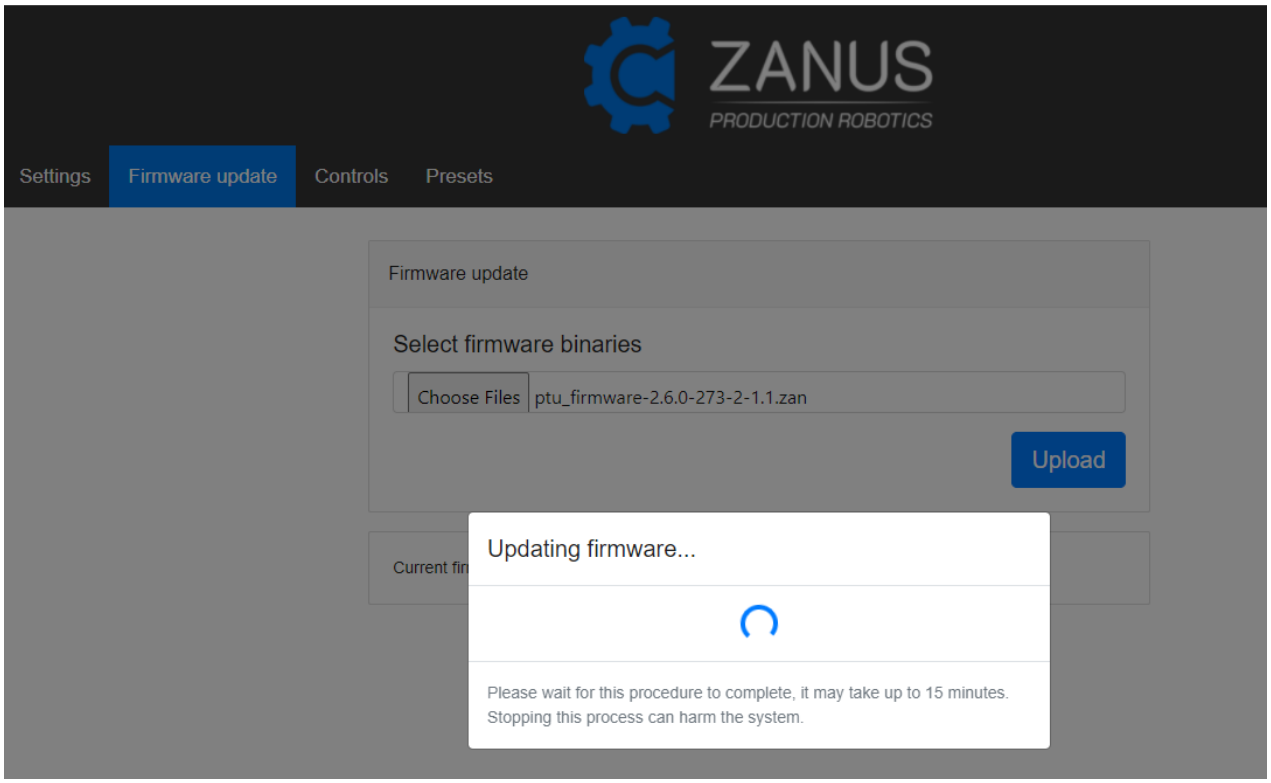


Figure 54: Updating firmware indicator

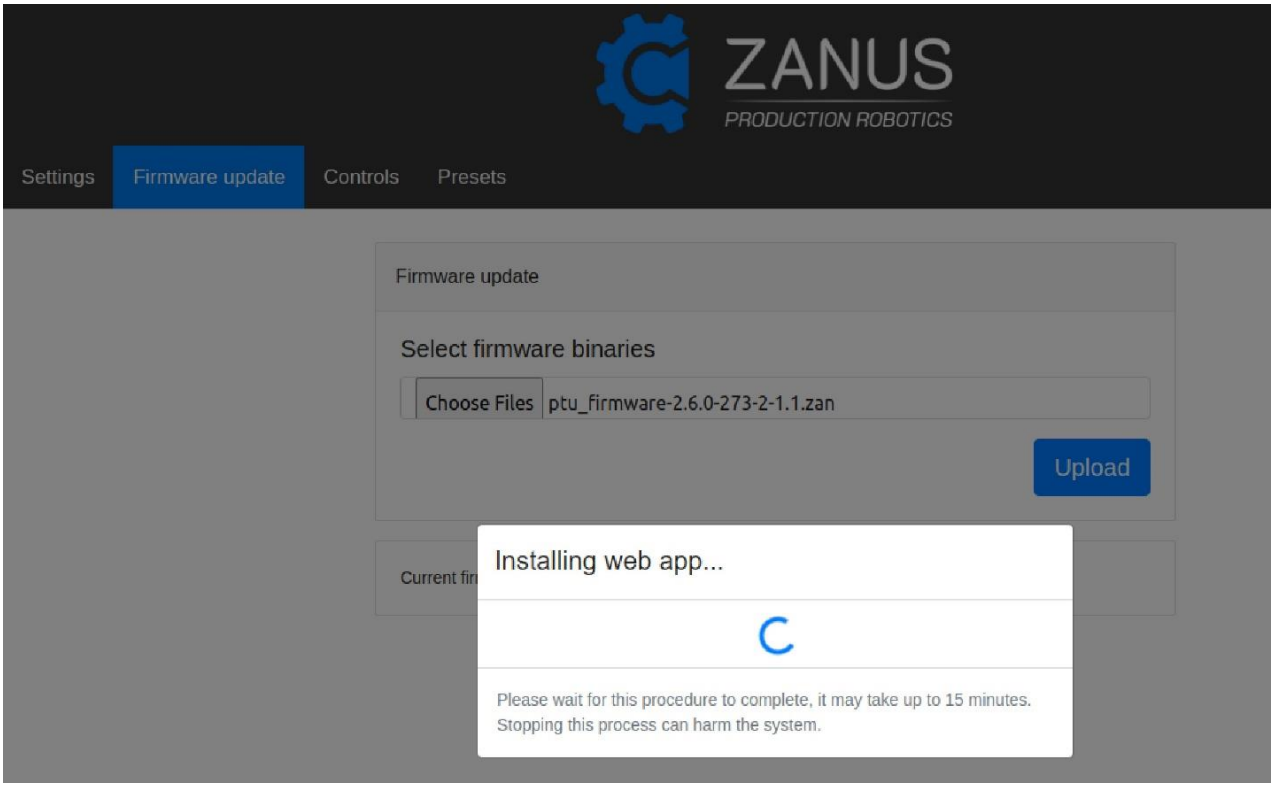


Figure 55: Installing web app indication

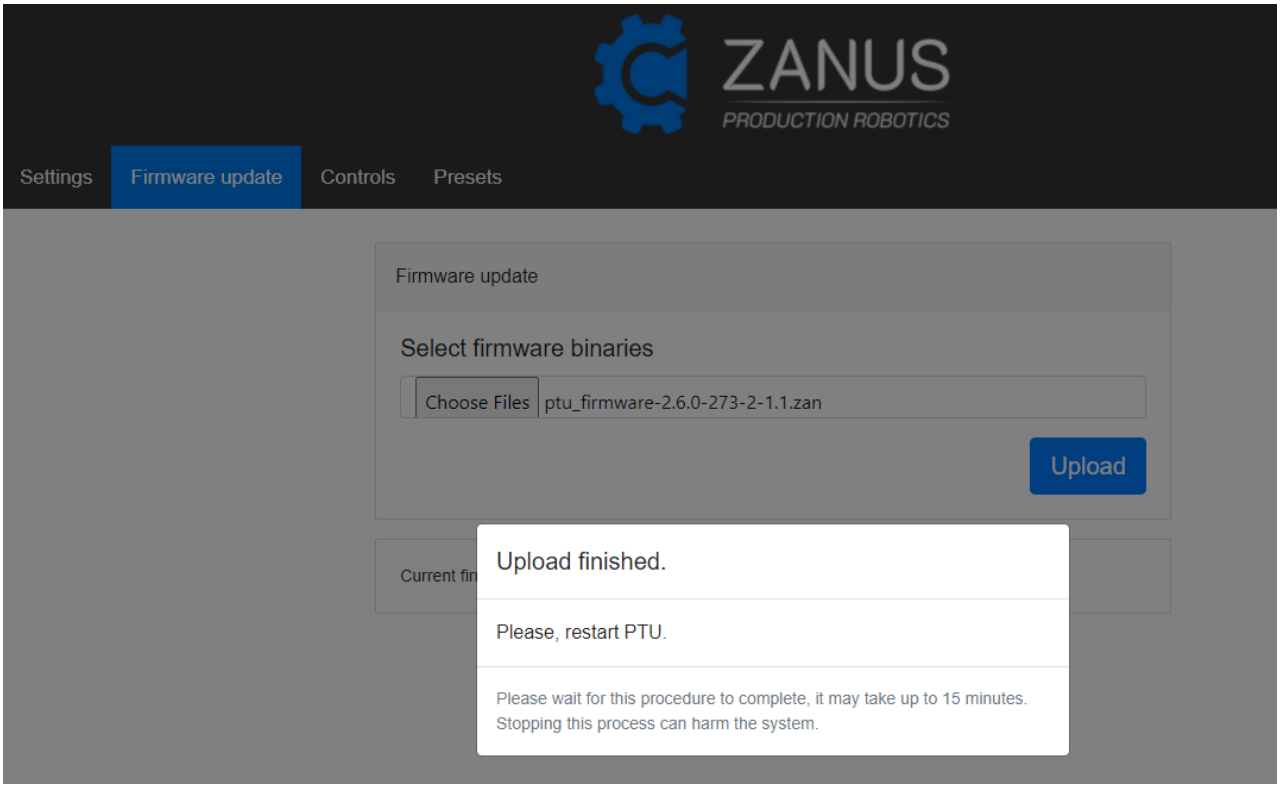


Figure 56: Firmware update finish indicator

When the firmware update process is finished, a notification will appear requesting the head to be restarted (*Figure 56*). Turn Pauli off and on again and refresh the application page. After the Pauli restarts, check the Firmware update tab again. The updated firmware version should be displayed.

6.4. Controls Tab

The Controls tab allows full control of the Pauli head. It consists of several control buttons, sliders and joysticks logically grouped to allow full control of the Pauli. The control functionalities that can be achieved with the Control tab are the following:

1. Head state control and indication
2. Zoom, focus and iris control
3. Pan/tilt control in Velocity and Position mode
4. Preset adding

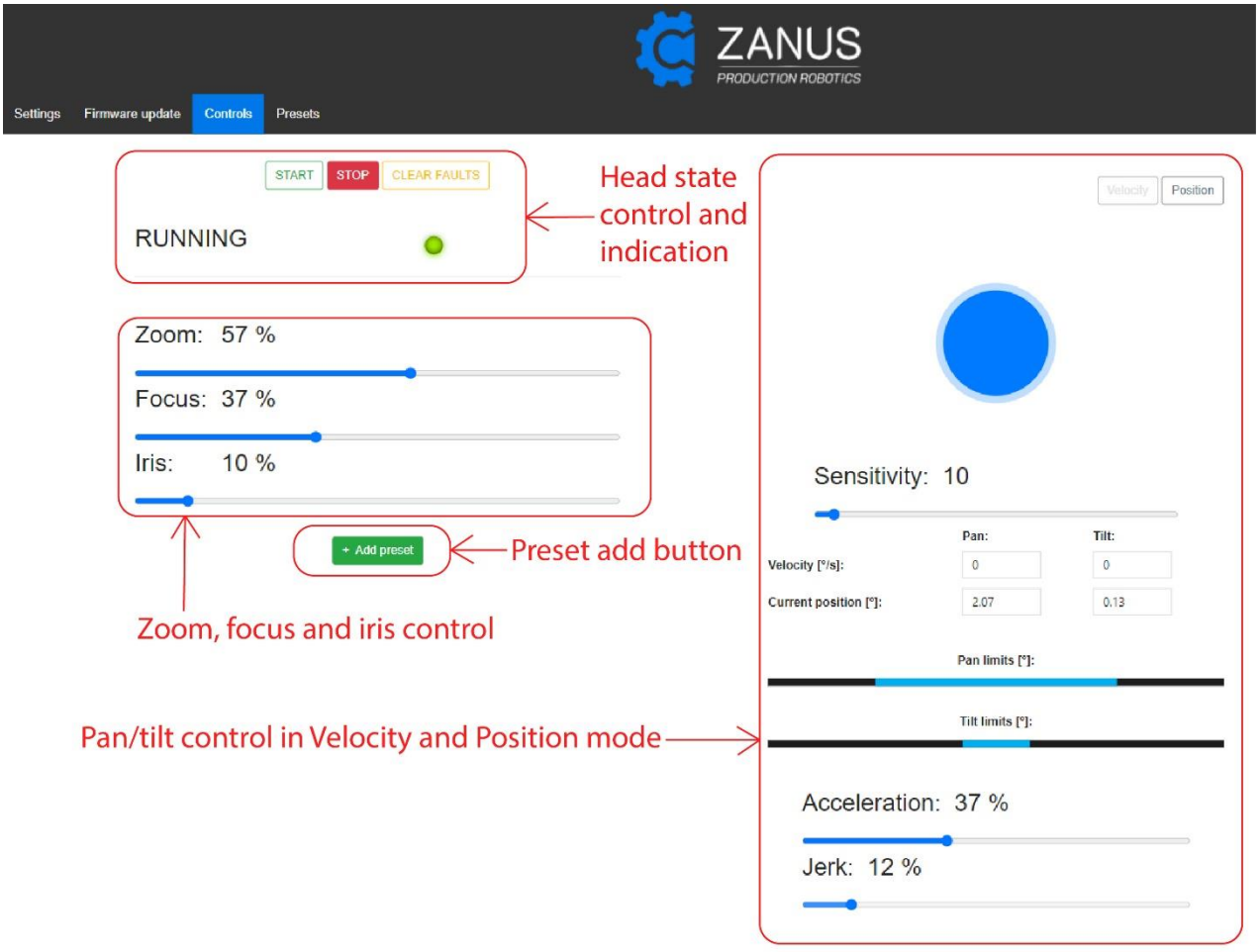


Figure 57: Controls tab overview

6.4.1. Head state control and indication

Pauli can be in one of the following states - disabled, ready and running. The transition between these states is shown in *Figure 58*.

Figure 58: Application state transitions illustration

On every press of the START button, the head state moves one place on the right on the diagram. On each press of the STOP button, the head state moves one step to the left on the diagram.

Below the START and STOP buttons, there is an indicator of the current Pauli head state. These indicators are as in *Figure 59*.

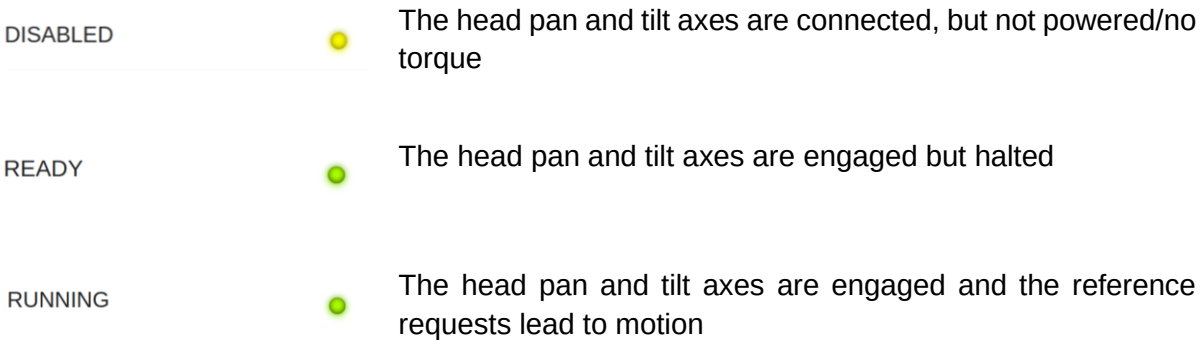


Figure 59: Transition between the states

To actively move and control the axes of the Pauli head, it should be either in the READY or the RUNNING state.

NOTE: Before doing the Firmware update, Pauli head should be brought to the DISABLED state, by using the STOP button. For details on the Firmware update, please see the section Firmware update tab.

The area below the START and STOP buttons is also used to notify the user of possible errors. An example of such an error notification is shown in *Figure 60*.

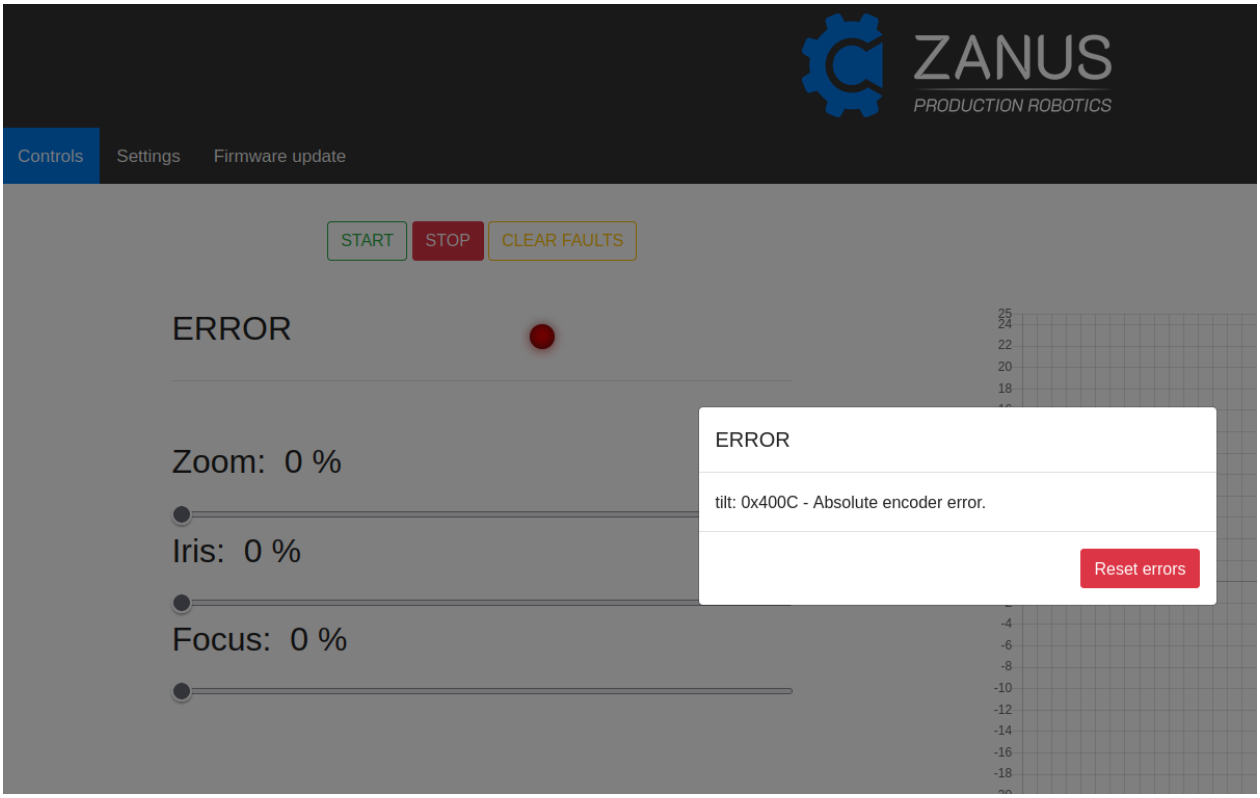


Figure 60: Error notification

Note that when an error occurs, Pauli automatically goes into the DISABLED state. In case of an error, press the CLEAR FAULTS button to clear the error, and if the error message disappears, it means that the error has been cleared. The application will automatically restart, and the head will move to the ready state. After this, the head should be brought to the running state by pressing the START button.

If pressing the CLEAR FAULTS button does not clear the error, please try restarting the head (powering it off and on again). If after the restart, the error is still there, please contact support.

6.4.2. Zoom, focus and iris control

Sliders for setting zoom, focus and iris values (shown in *Figure 61*) are positioned on the left side of the tab. Values in these sliders are expressed in percentages from 0% to 100%.

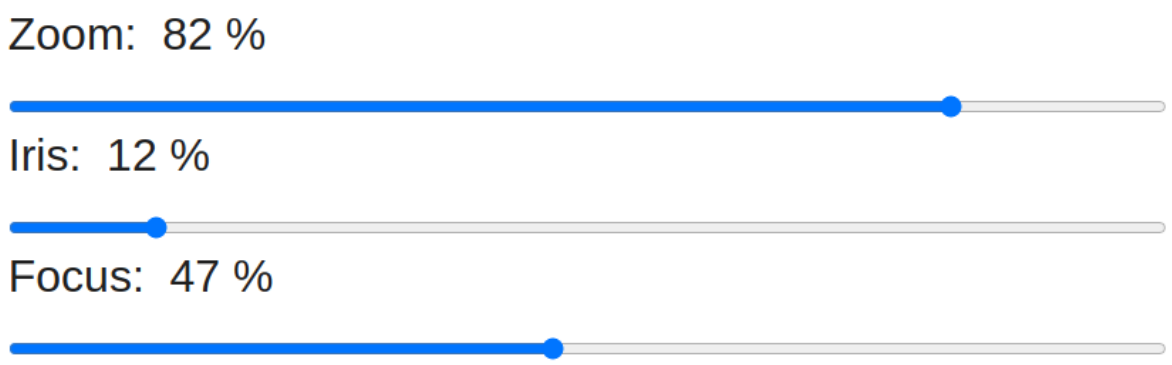


Figure 61: Zoom, focus and iris control

6.4.3. Pan/tilt control in Velocity and Position mode

Pan and Tilt axes can be controlled either in Velocity or in Position mode. *Figure 62* illustrates how to toggle between these two control modes using the two buttons that are marked in red.

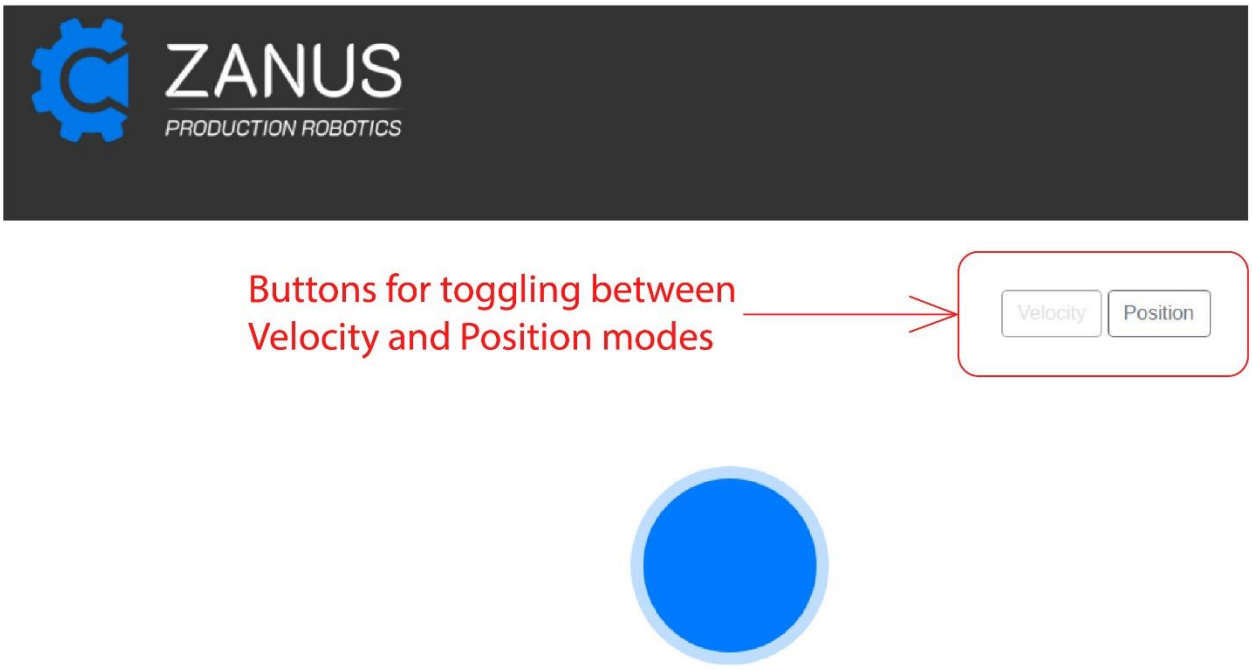


Figure 62: Buttons for toggling between the Velocity and Position control modes

6.4.3.1. Velocity control

In the Velocity mode, one can use the joystick to set the velocity for pan and tilt axes. The horizontal movement of the joystick sends the pan velocity reference, while the vertical movement sends the tilt velocity reference.

Note that the joystick automatically returns to the origin (zero pan and tilt velocity references) when released. The use of the velocity joystick is shown in *Figure 63*.

Below the joystick, its sensitivity can be set. The sensitivity that is set on the slider is the velocity reference that is sent for the maximal deflection of the joystick.

It is also possible to manually enter references under the velocity row below the sensitivity bar. To set a reference this way, one should just type in the desired axis velocity in °/s and press enter.

Below the fields for directly entering velocity references, the current axis positions are displayed in degrees.

Below the display of the axis positions, there are bars for setting the axis limits. Please note that, in order to use the sliders to set the pan and tilt limits, Pauli should first be set to the disable state (for details on disabling Pauli, please see Head state control and indication).

Below the limit bars, there are bars for setting acceleration and jerk (derivative of acceleration) limits. These limits determine how aggressively the pan and tilt axes of Pauli approach the commanded velocity references. For smaller values of acceleration and jerk, this approach is smoother but slower, while for large values the transition to a newly commanded reference is fast but very aggressive. Having low jerk and high acceleration could help in situations when the mechanical setup is not ideal and there could be shaking in the tripod or on the camera components when moving the axes fast. In this case, relatively fast movement without oscillations could be achieved by leaving the acceleration limit high but reducing the jerk limit. In this way, the motion of the head axes would not excite the modes of the surrounding mechanical parts and would not cause oscillations.

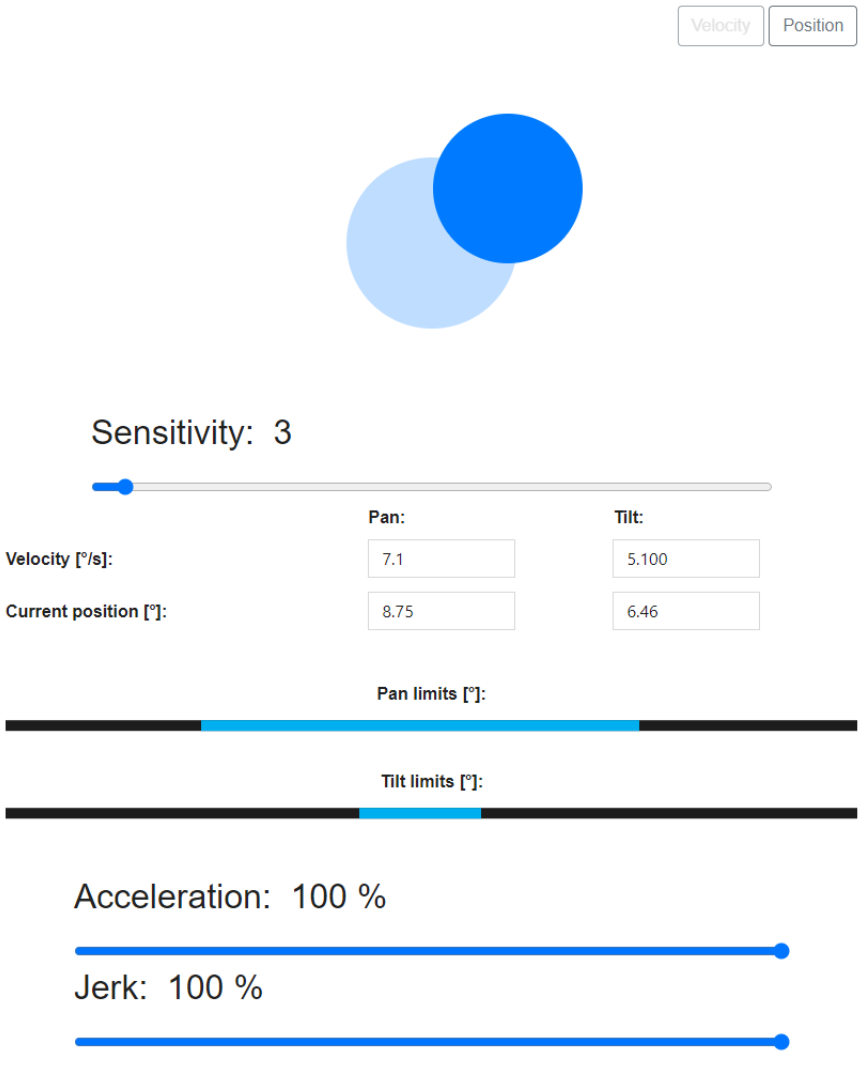


Figure 63: Pan and tilt velocity control

6.4.3.2. Position control

For controlling the head in the position mode, one can use the positioning joystick. It is given as a mesh indicating pan and tilt positions (horizontal for pan and vertical for tilt). The blue ball indicates the current position of the pan and tilt axis. By clicking on the position of the matrix, the blue ball will reallocate to that place and the pan and tilt positions will follow. For a better resolution, zooming in or out in the mesh using the mouse scroll allows making the raster finer or cruder. The positioning joystick is shown in *Figure 64*.

Below the joystick, there are fields that display pan and tilt axes velocities in degrees per second.

Below the fields that display pan and tilt velocities, there are fields that can be used to manually set the pan and tilt positions in degrees. Desired position value in degrees can be typed in and after pressing enter, the head would execute the command.

Below the fields for manually entering the position references, there are the fields for displaying the current head position in degrees.

Below the position display fields, there are bars for setting the axis limits. Please note that, to use the sliders to set the pan and tilt limits, Pauli should first be set to the disable state (for details on disabling Pauli, please see Head state and control indication).

At the bottom of the tab, there are sliders for setting the velocity and acceleration limits. These limits determine how aggressively the pan and tilt axis of Pauli approach the desired position. For smaller values of velocity and acceleration, this approach is smoother but slower, while for large values the transition to a new axis position is fast but very aggressive.

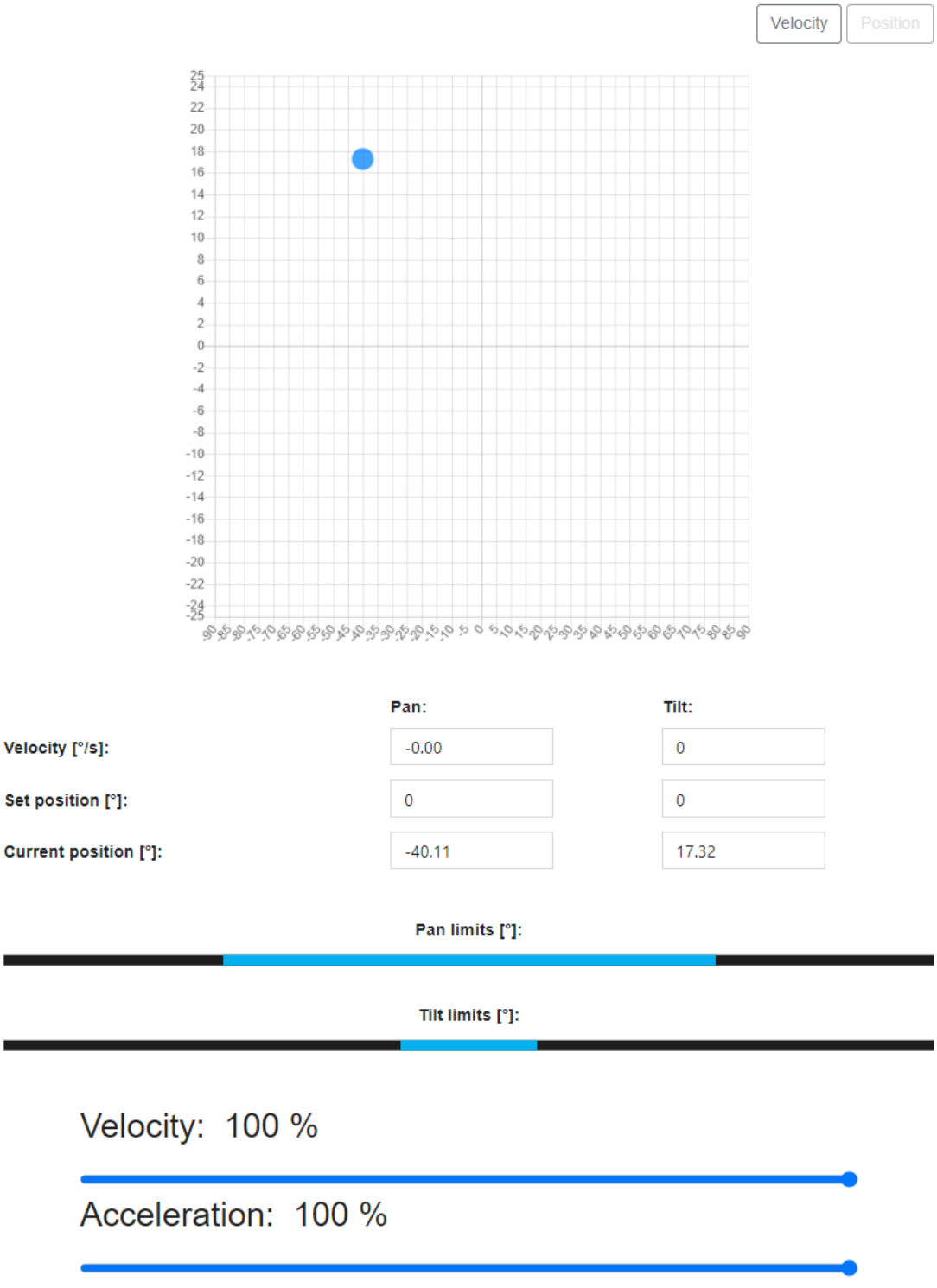


Figure 64: Pan and tilt position control

6.4.4. Preset add button

To add a preset in the application, click on the Add preset button below the Zoom, Focus and Iris sliders. The window will pop up as shown in *Figure 65*.

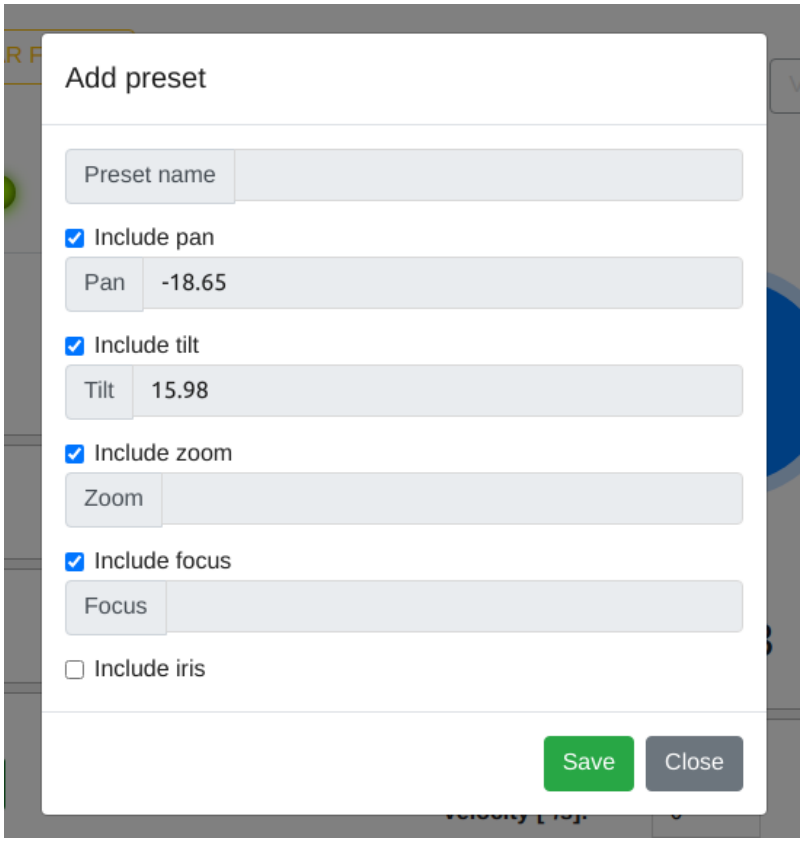


Figure 65: Adding a preset

Pauli reads the current positions of the pan and tilt axes as well as the positions of the zoom focus and iris and offers to record these values as presets. By default, all axes apart from the iris are included. By checking or unchecking the box before the axis name, one can include or exclude the given axis for the preset. When an axis is not included in the preset it is not actuated when that preset is called and can be manually actuated in parallel to the preset execution. *Figure 66* shows the situation in which only pan and zoom are included in the preset.

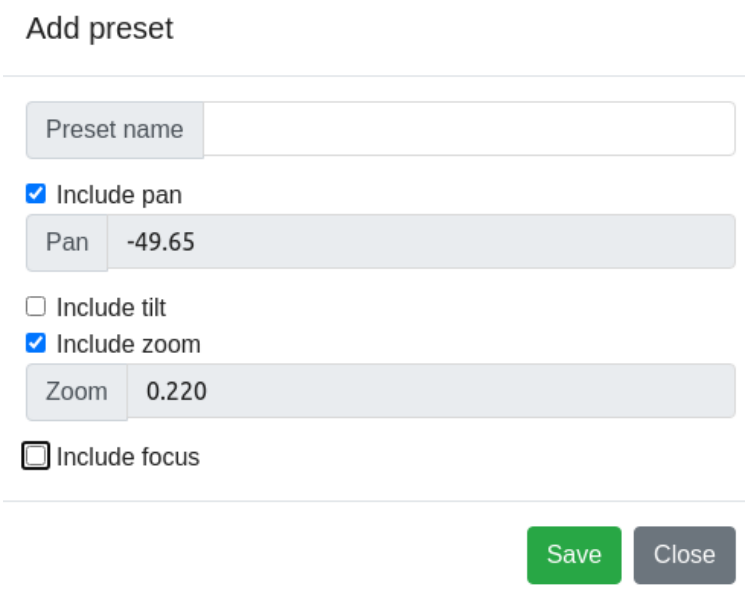


Figure 66: Preset adding options

After entering the name of the preset, it can be saved using the Save button. A notification will pop up upon the successful saving (*Figure 67*). All the saved presets can be found in the Presets tab of the application, where they can be recalled as described in the Presets tab.

Figure 67: Successful preset saving notification

6.5. Presets tab

Any preset that is saved using the Add preset button in the Position or Velocity mode of the Controls tab (as described in the Preset add button), can be recalled from the Presets tab of the main menu. All recorded presets are listed under the Presets tab as shown in *Figure 68*.

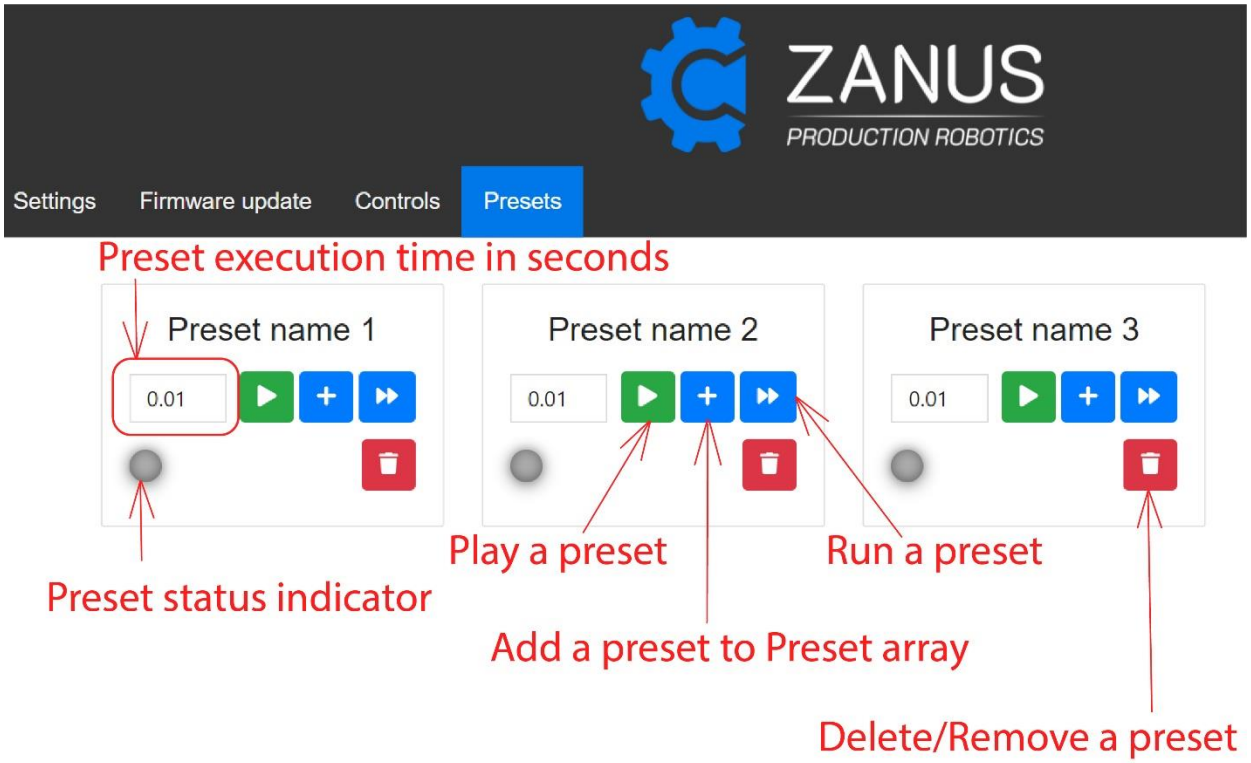


Figure 68: Content of the Presets tab

Each preset has its unique name, which can be changed by clicking onto it and typing a new one. In addition, for each preset there are options to play and run a preset, to add a preset to a list of preset arrays and to delete a preset (as indicated in *Figure 68*).

Play option executes a preset during a specified time that the user enters in an input field for preset execution time (in seconds). Run option makes Pauli move to the defined position in the shortest possible time. Option to add a preset to an array of presets adds the corresponding preset with the desired execution time to an array of presets that can later be executed. This option will be explained in detail in one of the following paragraphs. Lastly, the button for deleting a preset removes that preset and it is no longer visible under the Presets tab and cannot be recalled.

Each defined preset has its indicator (labeled with Preset status indicator in *Figure 68*) showing the status of the preset as described in the following:

1. Light gray color indicates the preset is currently inactive
2. Green color indicates the preset is currently being executed and that it will be reached in the desired time
3. Yellow color indicates the preset is currently being executed, but that it will take longer to reach it than the desired. This may happen because the settings for velocity and acceleration limits in the position mode have priority. If fast preset execution is required, these limits should be set to maximal values. Note that then, the time in which a preset can be reached is limited with the maximal velocity and acceleration of the Pauli head.
4. Red color indicates that the error occurred during a preset execution.

These preset status indicators are shown in *Figure 69* and *Figure 70*.

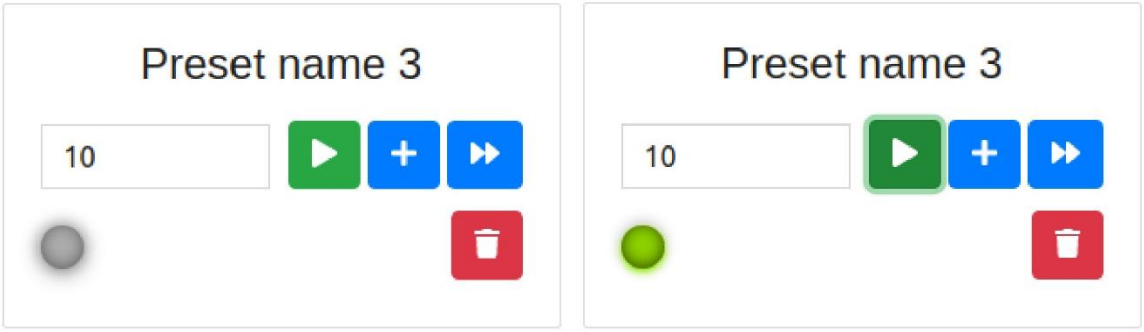


Figure 69: Inactive and active preset indicator

Figure 70: Active and error preset indicator

Additionally, there is an option to execute an array of presets. To do this, insert the preset execution time for a certain defined preset and click the Add button for the same preset to add it to the array. One can do this multiple times for different presets in order to make an array. If the head should remain still in a certain position for some time, one can just enter the same preset consecutively with the time that the head should remain in that state as the time of the second preset entry in the list. A list of presets appears above the presets in the same tab, and each time a new preset with execution time is added, this list of presets is updated (illustrated in *Figure 71*). Each listed item consists of the preset name and its duration. Below this list, there are two buttons

to Play the series and to Clear the series. The Play series button executes the array of presets as they are named in the list. The Clear series button deletes the whole array of presets.

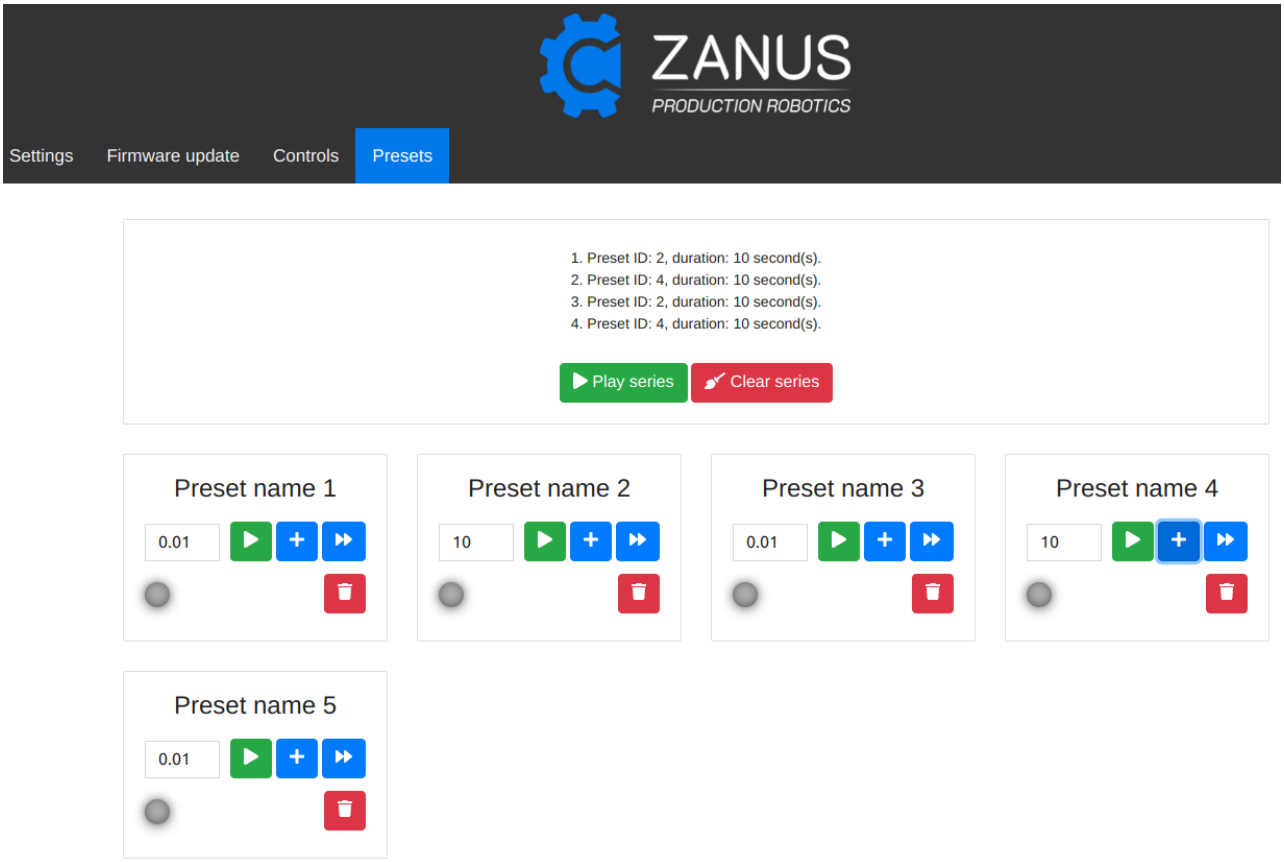


Figure 71: Preset array with execution times

When executing an array of presets, the list of presets with their names and duration times would show their current status by changing its color (as shown in *Figure 72*):

1. Yellow color indicates the preset is currently being executed, but that it will take longer to reach it than the desired. This may happen because the settings for velocity and acceleration limits in the position mode have priority. If fast preset execution is required, these limits should be set to maximal values. Note that then, the time in which a preset can be reached is limited with the maximal velocity and acceleration of the Pauli head.
2. Green color text indicates the preset is currently being executed and that it will be reached in the desired time.
3. Light gray color indicates that the preset has already been executed.
4. Black color indicates the preset has not yet been executed.

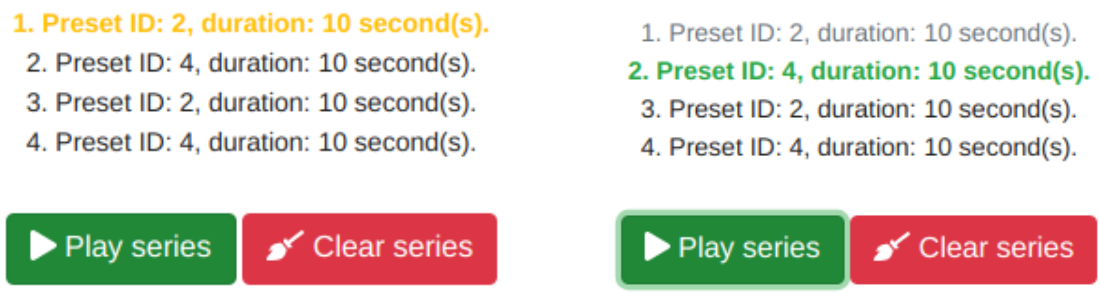


Figure 72: Preset series status indication

7. Joystick control

Another way of controlling Pauli is with a joystick. For optimal user experience, it is recommended to use the configurable Skaarhoj PTZ Extreme joystick. Additionally, Pauli can also be controlled with any joystick that has VISCA over IP protocol.

7.1. Control with Skaarhoj PTZ Extreme

Skaarhoj PTZ Extreme is a configurable joystick that can be used to control various products from different manufacturers. For it to be used for controlling Pauli head, it first needs to be configured. If supplied by Zanus together with Pauli, the PTZ Extreme joystick comes already preconfigured. In case it is obtained from some other source, it first needs to be configured, manually. For instructions on manual configuration, please see Manual PTZ Extreme configuration.

Properly configured Skaarhoj joystick should first be attached to a power supply and then connected to a Pauli head (or to multiple Pauli heads as explained in Connecting and controlling multiple heads) by an Ethernet cable. The head (or heads) and the joystick should be connected to the same local network. Once this is done, the controller will automatically turn on and it will be ready for use. The controller console will light up which is a signal that it is ready to be used. Joystick buttons and knobs all have indicators that help the user to operate the joystick with ease. *Figure 73* shows how the joystick panel looks like when it is turned on. It also identifies the main button and knob groups that will be explained in detail:

- Activation buttons
- Sensitivity knobs
- Zoom, focus and iris control
- Pan/tilt joystick control
- Direction control
- Preset control
- Active camera control

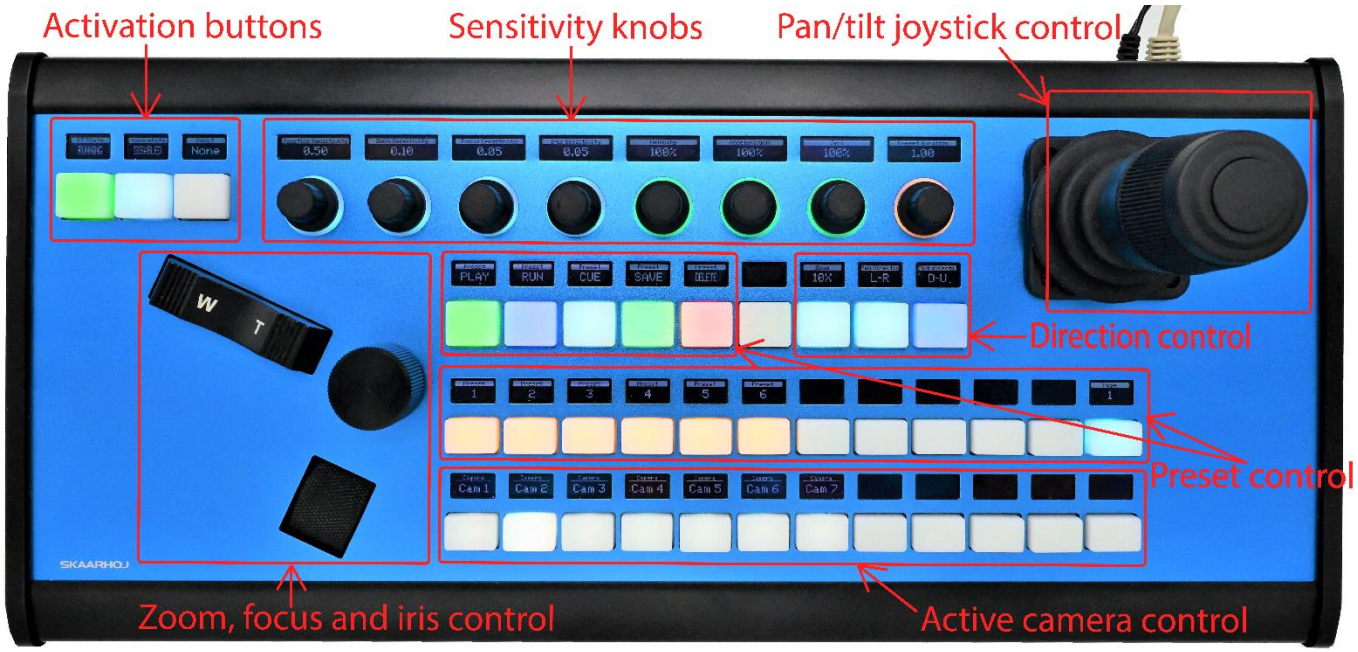


Figure 73: Skaarhoj PTZ Extreme controller functionalities overview

7.1.1. Activation buttons

The Activation buttons section includes three buttons in the top left corner of the keyboard, which are used for initializing the control of the Pauli. The closer look of this section is shown in *Figure 74*.

Figure 74: Activation buttons

These buttons enable the following control options:

1. Using the first button from the left that has Disabled written on it when the console is first turned on, it is possible to loop through the head states similarly as it was described in Head state control and indication. There are two states that can be interchanged, these are Disabled and Running. By pressing the button, the state can be changed. The button has different colors depending on the states so it would be white for Disabled state and green for Running state. *Figure 74* shows how the button looks like when the head is in the disabled state and *Figure 75* shows how it looks when the head is in the Running state.

Figure 75: Activation buttons state change

Figure 76: Toggling between zoom, focus and iris axes

2. The second button from the left is used to initialize the use of zoom, focus and iris controls. The four sides of this button are sensitive and by pressing them different functionalities can be achieved. By pressing the right or left corner of this button, one can toggle between different axes to have control of either zoom, focus or iris (*Figure 76*). These axes can also be in the Disabled and Running state. After switching to the desired axis, the user should press the top or bottom corner of this button to loop through the states available and reach the desired one (*Figure 77*).

Figure 77: Zoom, focus or iris state change

3. The third button from the left is there to show possible errors. In case of an error, this button would turn red (*Figure 78*). In this case, the user should press this button to clear the fault. In case the error is still there, the user should restart the Pauli.

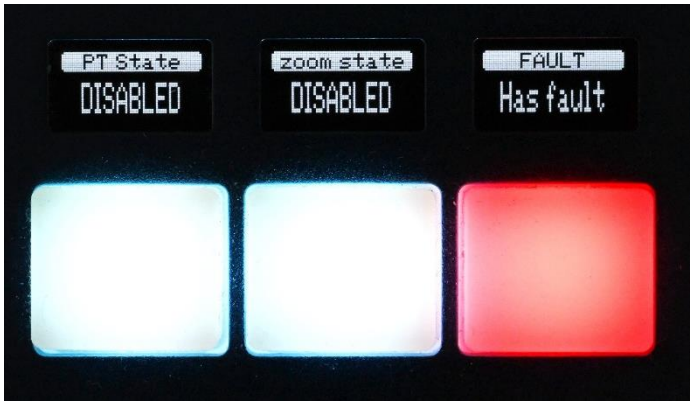


Figure 78: Fault occurrence

NOTE: Upon turning on the controller, the user should put the head state to Running and put the zoom, focus and iris to Running for those axes that will be used.

7.1.2. Sensitivity knobs

The Sensitivity knobs section includes eight knobs. They are the knobs for setting the sensitivity of axes control, knobs for limitations of velocity, acceleration and jerk, and knob for setting the preset execution duration. Sensitivity knobs are shown in *Figure 79*.

Figure 79:Sensitivity knobs

Each of the values related to the corresponding knobs is displayed on the OLED screen above that knob (some of them are shown in *Figure 80*). This value can be increased by turning the corresponding knob in the clockwise direction or decreased by turning it in the counterclockwise direction. Change of the values is for 0.1 or 0.01 and the user can toggle between these resolutions by vertically pressing the knob.

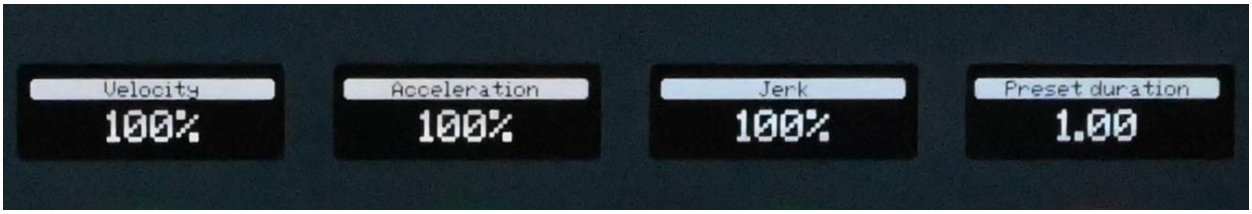


Figure 80: Example of Sensitivity knobs OLED displays

Functionalities of the knobs are as follows:

1. The first knob from the left (part of Axes sensitivity knobs in *Figure 79*) represents the pan/tilt joystick sensitivity (joystick is positioned in the top right corner of the controller and its functionality is described in Pan/tilt joystick control). The sensitivity that is set using this knob, is the velocity reference that is sent for the maximal deflection of the joystick. *Figure 81* gives a closer look at this knob.
2. The following three knobs from the left (part of Axes sensitivity knobs in *Figure 79*) represent zoom, focus and iris sensitivity. These sensitivities indicate how zoom, focus and iris would respond when the user is controlling them from the Skaarhoj controller as it is described in Zoom, focus and iris control. If the sensitivity value is higher, one can turn zoom, focus and iris faster to the desired value. A closer look at these knobs is given in *Figure 81*.

Figure 81: Sensitivity knobs for axes control

3. The three Limit knobs shown closely in *Figure 82*, can be used to reduce the velocity, acceleration and jerk limits of the pan and tilt axes. If set to 100%, the maximal possible limitations would be taken, but it is also possible for the user to reduce some of these limits to lower values. By reducing these values motion performance of the pan and tilt axes can be influenced as explained in detail in section Pan/tilt control in Velocity and Position mode

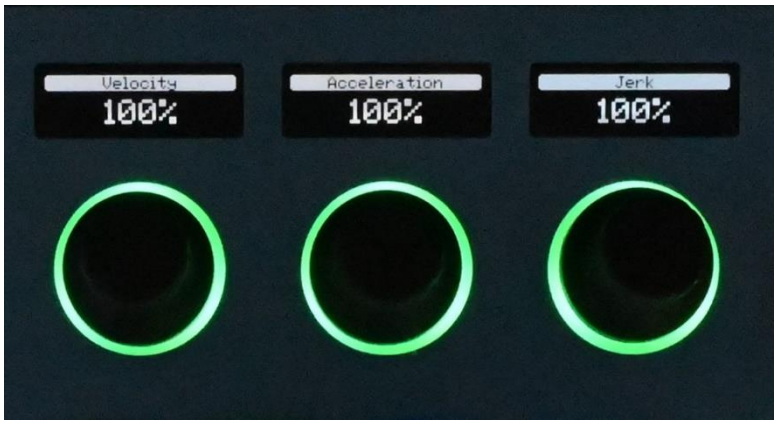


Figure 82: Limit knobs

4. The last knob looking from the left (named Preset duration knob in *Figure 79*), can be used to set preset execution time in seconds. It represents the time that the user defines and for which the preset would execute. The use of this knob will be clearer after reading the section Preset control.

7.1.3. Zoom, focus and iris control

The Zoom, focus and iris control section is shown in *Figure 83*.

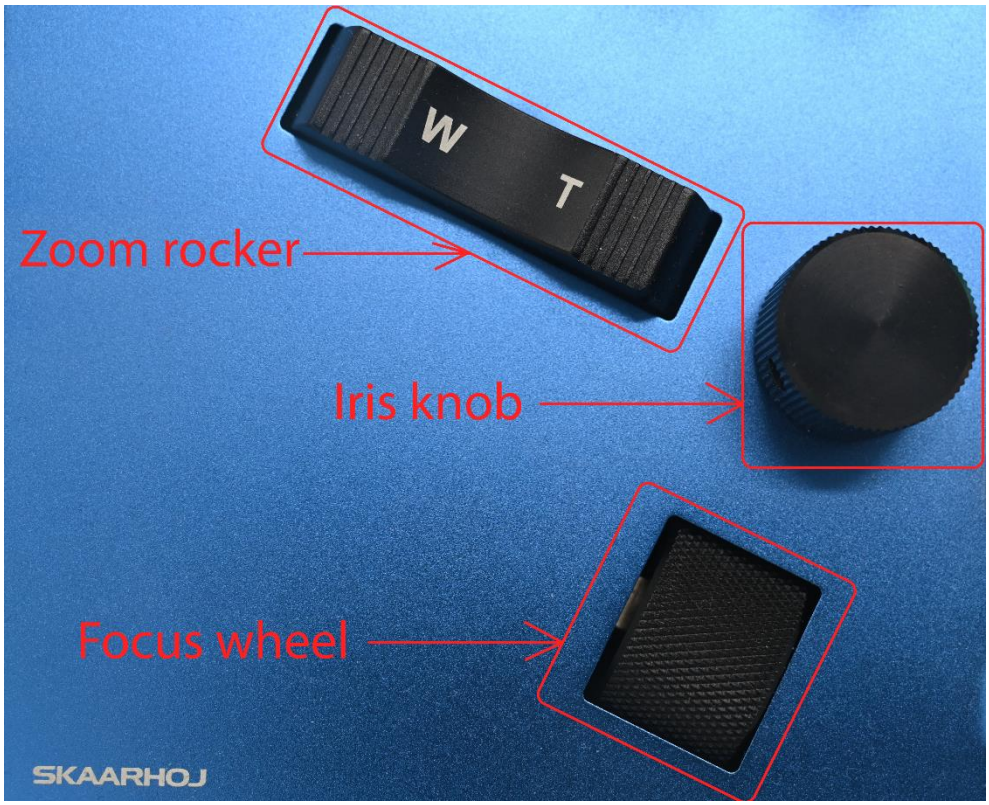


Figure 83: Zoom, focus and iris control

This section allows to control the following:

1. Control the zoom of the camera by pressing and holding the sides of the zoom rocker (the side that has written “W” is for zooming out while the one with “T” is for zooming in).
2. Control focus by scrolling the focus wheel.
3. Control iris by turning the iris knob.

Note that the sensitivity of each of these controls can be set as described in the section Sensitivity knobs. Additionally, the user can control the zoom using the Pan/tilt joystick as described in the section Pan/tilt joystick control.

7.1.4. Pan/tilt joystick control

The Pan/tilt joystick control section of the Skaarhoj controller consists of a 3-axis joystick used for setting the velocity references for pan and tilt axes. The horizontal movement of the joystick sends the pan velocity reference, while the vertical movement sends the tilt velocity reference (as illustrated in *Figure 84*). Joystick axis orientation (whether pushing the tilt of the joystick up moves the tilt of the head up or down for example) is adjustable and the way to adjust it is described in detail in section Direction control.

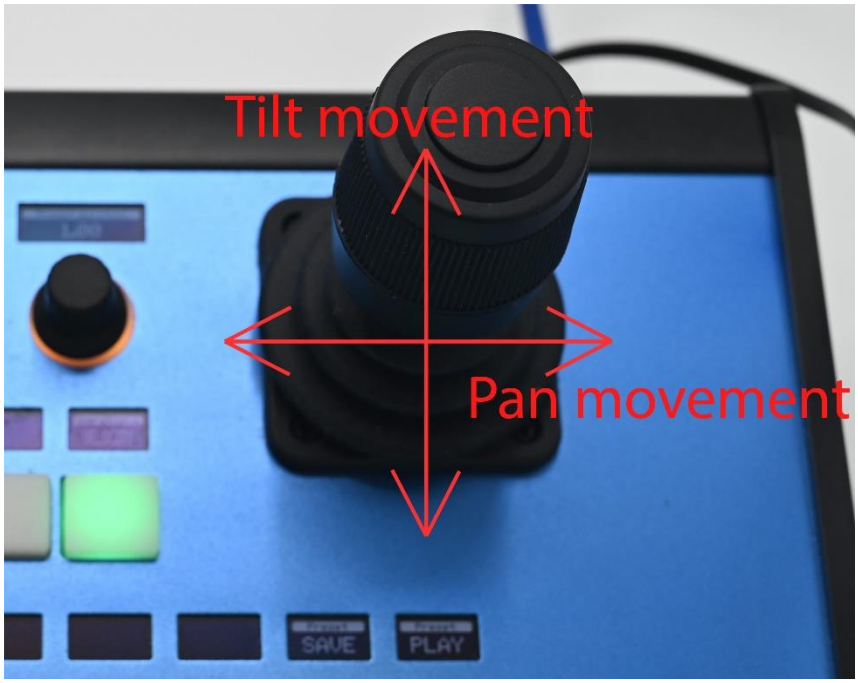


Figure 84: Pan/tilt joystick

When released, the joystick automatically returns to the origin (zero pan and tilt velocity references). Additionally, the 3rd axis represents the zoom functionality that can be achieved by turning the joystick clockwise for zooming in or counterclockwise for zooming out.

7.1.5. Direction control

The Direction control section is shown in detail in *Figure 85*.

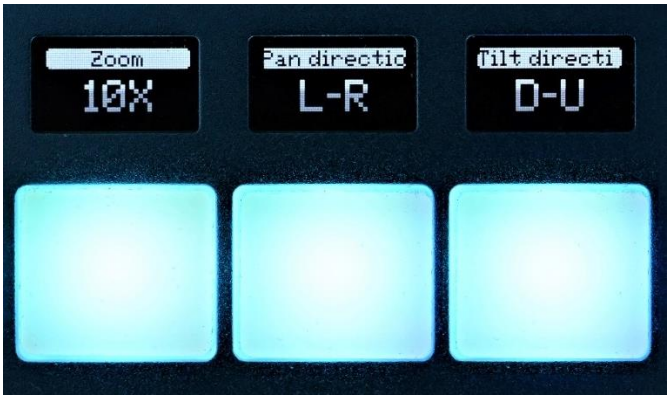


Figure 85: Direction control buttons

The buttons of this section offer the following functionalities:

1. The first button from the left allows the user to switch the default pan direction of the pan/tilt joystick (described in Pan/tilt joystick control). The two modes possible, are indicated by different button colors. The light blue color (*Figure 85*) indicates that the movement of the joystick to left also moves the head to the left, and the movement to the right moves the head to the right. Purple color (*Figure 86*) indicates that the movement of the joystick to the left moves the head to the right, and the movement to right moves it to the left.

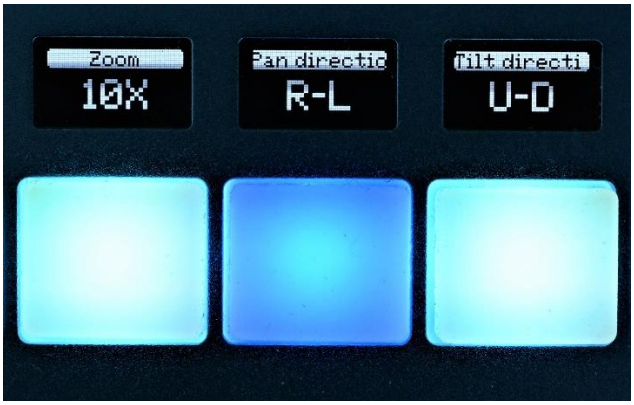


Figure 86: Pan direction button mode switch

2. The second button from the left allows the user to switch the default tilt direction of the pan/tilt joystick (described in Pan/tilt joystick control). The two modes possible are indicated by different button colors. Light blue color (*Figure 87*) indicates that the movement of the joystick up results in upward tilt movement. Purple color (*Figure 86*) indicates that the movement of the joystick up moves the tilt axes down.

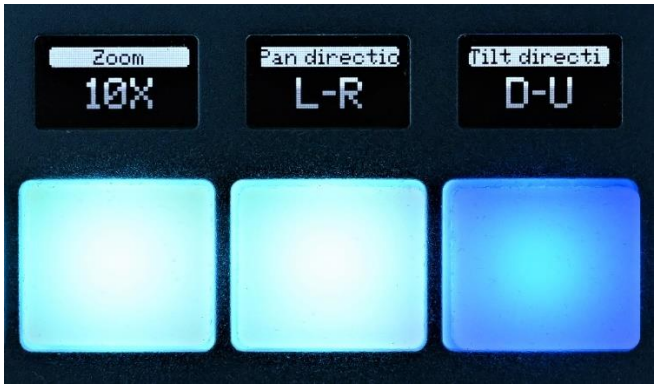


Figure 87: Tilt direction button mode switch

3. The third button from the left is configured to zoom in 10 times when its top edge is being pressed (illustrated in *Figure 88*) and configured to zoom out 10 times when its bottom edge is being pressed (illustrated in *Figure 89*). This button allows faster transitions of zoom and adjustment od frames.

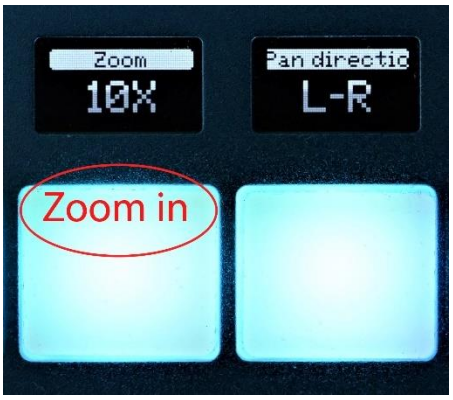


Figure 88: Zoom in 10x

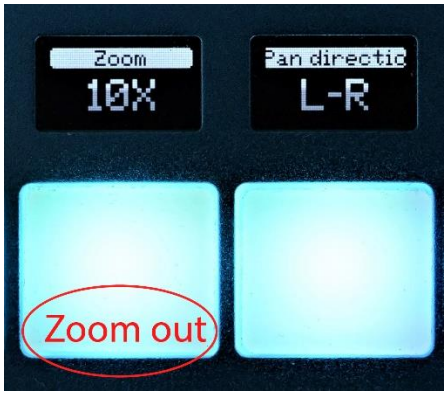


Figure 89: Zoom out 10x

7.1.6. Preset control

The Preset control section includes multifunctional buttons that can be divided into two parts, a part for preset control (*Figure 90*) and a part for preset overview and selection (*Figure 91*).

Figure 90: Preset control buttons

Figure 91: Preset overview and selection buttons

Among the buttons for preset overview and selection, there are 11 buttons available for saving and later executing presets and one button for navigating through them.

After being saved (it will be explained how in the following paragraphs), each preset is shown in the list of presets and initially beams with orange light. There can be up to 99 presets stored with 11 of them being visible on the board. Additionally, each preset gets its ID (the first available number from 1 to 99) that is shown in the OLED display above that preset. This way, the user can follow the position of a preset.

The user can move through the presets by using the Page button. One can move to the following page with presets by clicking the top edge of the Page button or move to the previous page by clicking the bottom edge of the Page button. This is of course if such pages exist (if they are filled with presets). For example, *Figure 91* is showing how Page 1 can look like. If the user presses the upper part of the Page button, the presets that appear can look something like in *Figure 92*. However, if the user presses the upper part of the Page button at this point, nothing would happen, because there are not any presets defined on Page 3. On the other side, if the user presses the lower part of the Page button, then the presets from Page one would appear again (*Figure 91*).

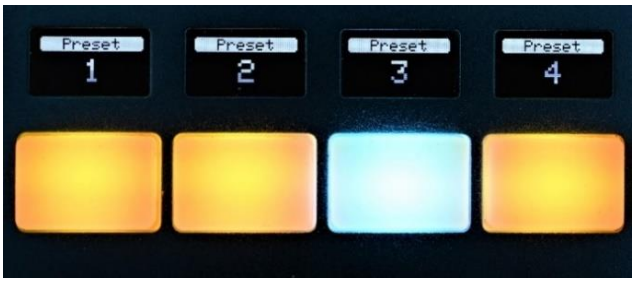
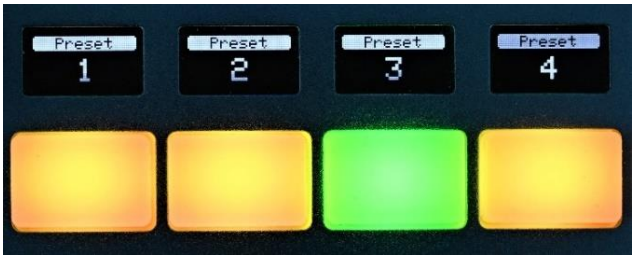
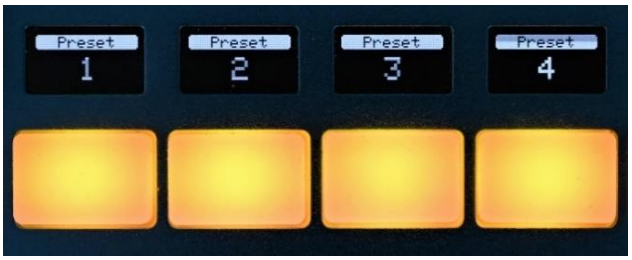
Figure 92: Example of Page 2 of presets

A preset can be selected by clicking on its button. The preset would show this selection by changing its color to white until a command has been given. To give commands, buttons for preset control are used (Play, Run, Cue, Save and Delete). Their usage based on examples is given in the following bullets:

1. The first button from the left is the PLAY button (see *Figure 90*). It is used for executing a preset that was previously saved, in a certain amount of time (it is set by the preset duration knob as explained in Sensitivity knobs). To play the preset, one should first set the preset execution time, then select the preset for execution and then click the PLAY button. During the preset execution, the preset button will turn green if the given preset can be executed in the preset execution time that was set. If this is not the case, the corresponding preset button will turn yellow showing that there is not enough time for execution taking into consideration the settings for acceleration and maximum velocity and the head will move to the corresponding preset in the shortest possible amount of time given the settings. One example of usage is shown in *Table 2*.

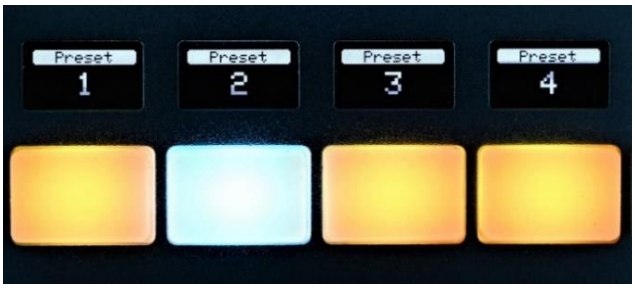
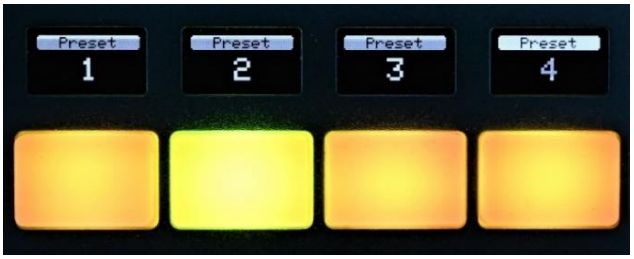
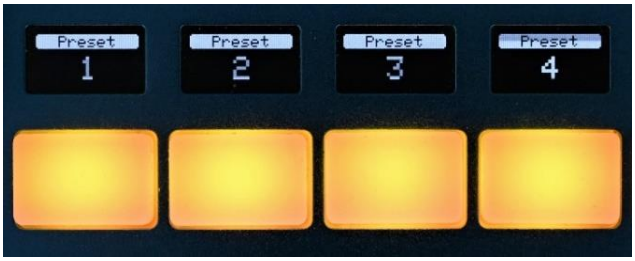
Table 2: Play button usage

Step No.	Representation	Action
1		Turn the knob to define the Preset duration time.
2		Press the preset for execution.

3		The selected preset's button becomes white.
4		Press the Play button.
5		The preset executes and becomes green during execution time.
6		When the preset has been executed it becomes orange again.

2. The second button from the left is the RUN button. It is used for executing a preset that was previously saved in the shortest possible time. To run a preset, one should select the preset for execution and then click on the RUN button. One example of usage is shown in *Table 3*.

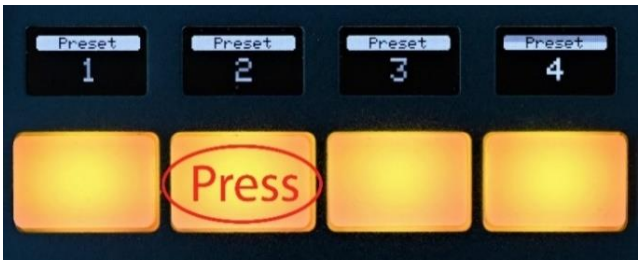
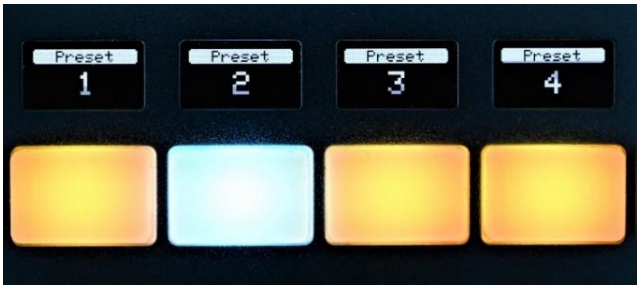
Table 3: Run button usage

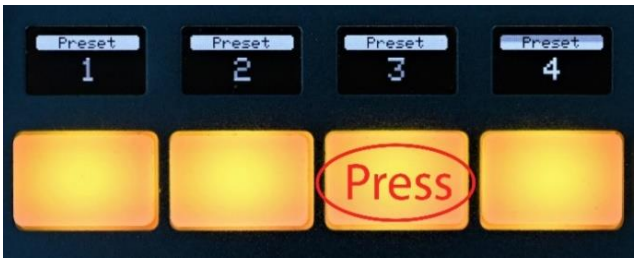
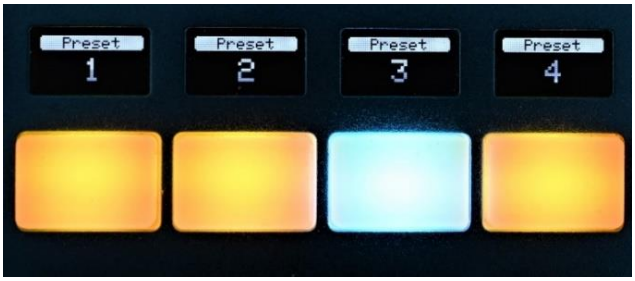
Step No.	Representation	Action
1		Press the preset for execution.
2		The selected preset's button becomes white.
3		Press the Run button.
4		The preset executes in the shortest time possible and becomes yellow the execution.
5		When the preset has been executed it becomes orange again.

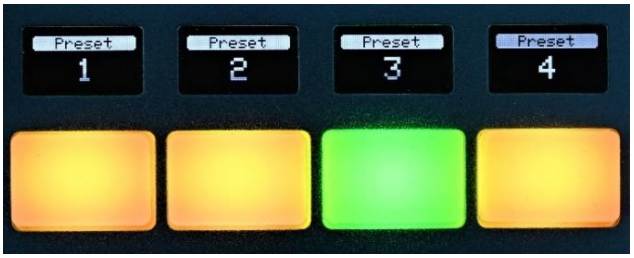
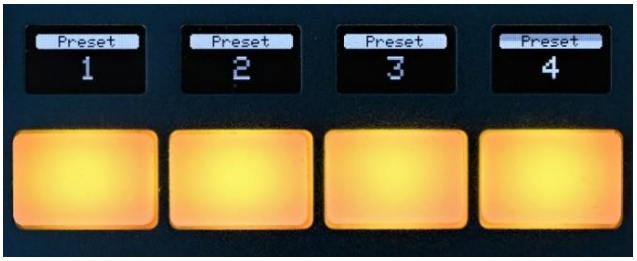
3. The third button from the left is the CUE button. It is used for making and executing an array of presets. To add the presets for execution to an array, one should first set the execution time for a certain preset (using the preset duration knob mentioned in Sensitivity knobs), select a preset for execution and then click the CUE button. This should be done for each preset that should be in the array for later execution. CUE button would change its color from light blue to purple after it is first pressed and stay like that until the array of presets has been executed.

   The array of presets that was made can be executed by pressing the PLAY button. During execution, the preset that is currently being executed will change its color to green or yellow (if there is not enough time for execution). One example of usage with two presets in the array is shown in *Table 4*.

Table 4: Cue button usage

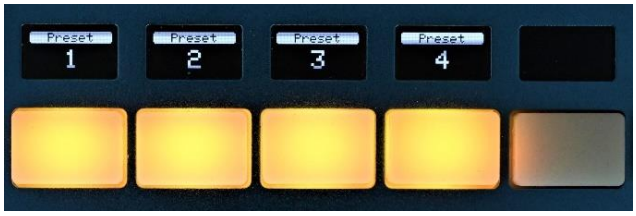
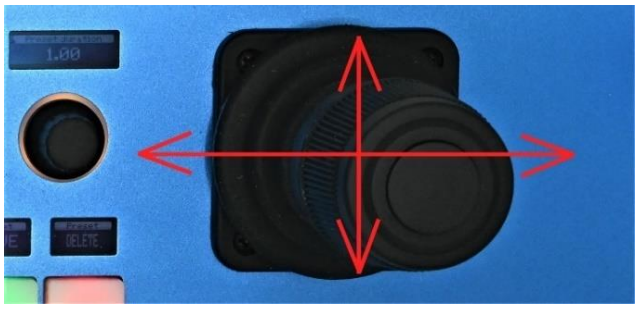
Step No.	Representation	Action
1		Turn the knob to define the Preset duration time for the first preset in the array.
2		Press the first preset that should be added to the array.
3		The selected preset's button becomes white.

4		Press the Cue button to add the preset to the array.
5		The Cue button becomes purple, which means that there is an array that can be executed
6		Turn the knob to define the Preset duration time for the second preset.
7		To add another preset, press the button of the preset that should be added to the array.
8		The selected preset's button becomes white.
9		Press the Cue button to add the preset to the array.

10		If there are no more presets to be added, the array of presets that were added can be executed by pressing the Play button.
11		The first preset from the array executes in the given preset execution time and becomes green.
12		The second preset from the array executes in the given preset execution time and becomes green.
13		The presets have been executed and become orange again.

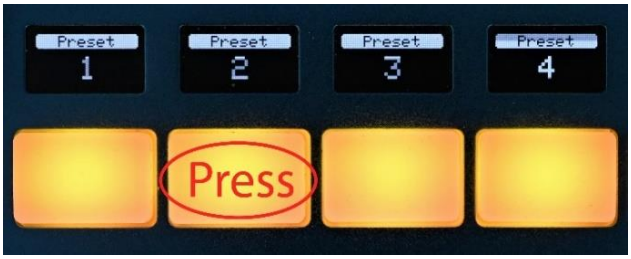
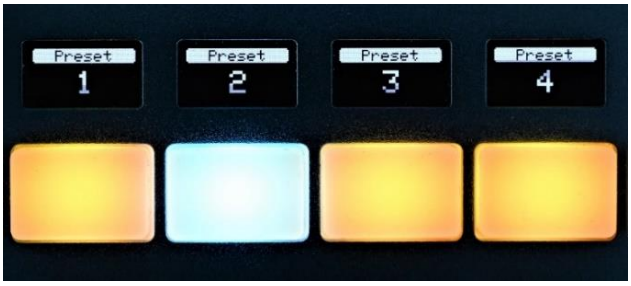
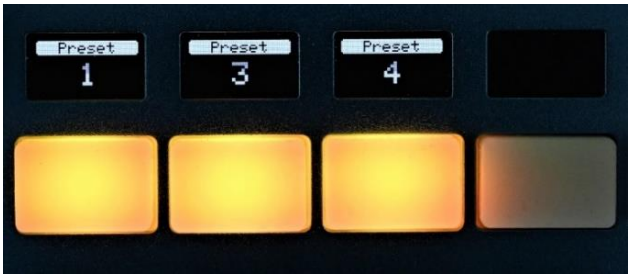
4. The fourth button from the left is the SAVE button. It is used for adding a new preset. For preset adding, the joystick described in Pan/tilt joystick control should be used to position Pauli head to the desired position. This position includes setting pan, tilt, zoom, focus and iris. Once the axes are in the desired positions, one should press the SAVE button. The preset should appear in the list of active preset buttons in the first available place. One example of usage is shown in *Table 5*.

Table 5: Save button usage

Step No.	Representation	Action
1		Preset overview before saving a preset.
2		Drag pan/tilt, zoom and focus joysticks to reach the desired position of the Pauli head.
3		Press the Save button.
4		Preset overview after saving a preset.

5. The fifth button from the left is the DELETE button. It is used for deleting a preset. To delete a preset, one should select the preset and then on the DELETE button. The user will be able to see the preset disappear (become inactive and lose its color) unless another preset was on the right side of that preset. In this case, the preset from the right would move one place to the left and take the place of the deleted preset. One example of this button's usage is shown in *Table 6*.

Table 6: Delete button usage

Step No.	Representation	Action
1		Press the preset that should be deleted
2		The selected preset's button becomes white
3		Press the Delete button.
4		The preset is deleted (become inactive and loses its color). All presets that were on the right side of the deleted preset move one place to the left.

7.1.7. Active camera control

Skaarhoj controller configuration for Pauli offers control of multiple Pauli heads from a single control point. The Active camera control section (shown in *Figure 93*) can be used to select the robotic head to be controlled with the joystick.

Figure 93: Active camera control buttons

There can be up to 7 different Pauli heads assigned with these buttons. The buttons of the assigned heads are dimly lit, with the button that corresponds to the currently selected head being brighter than the others. Default IP addresses are assigned to these buttons, starting from 10 (10.10.12.10) to 16 (10.10.12.16). For a better overview, these are listed in *Table 7*. Since the Pauli is shipped with the default IP address 10.10.12.10, this means that the first button from the left should be used to select the head with the default IP.

Table 7: Default assigned IP addresses

No.	Button overview	Default IP address
1		10.10.12.10
2		10.10.12.11
3		10.10.12.12
4		10.10.12.13

5				10.10.12.14
6				10.10.12.15
7				10.10.12.16

To activate the Skaarhoj panel for a certain Pauli head, the user should press the button in the Active camera control section corresponding to that Pauli. After doing this, the button for this Pauli head should have a bright white color and the user can start operating the corresponding Pauli head.

Apart from using the 7 predefined IP addresses for Pauli control, the user can reassign new ones. The procedure for doing this will be explained in the rest of this chapter.

Firstly, the user should install the Skaarhoj desktop application from the official webpage (https://www.skaarhoj.com/support/manuals). Depending on the user's operating system, there are downloads available for Mac, Windows or Linux OS (*Figure 94*). After clicking on the appropriate OS image, the download should start right away.

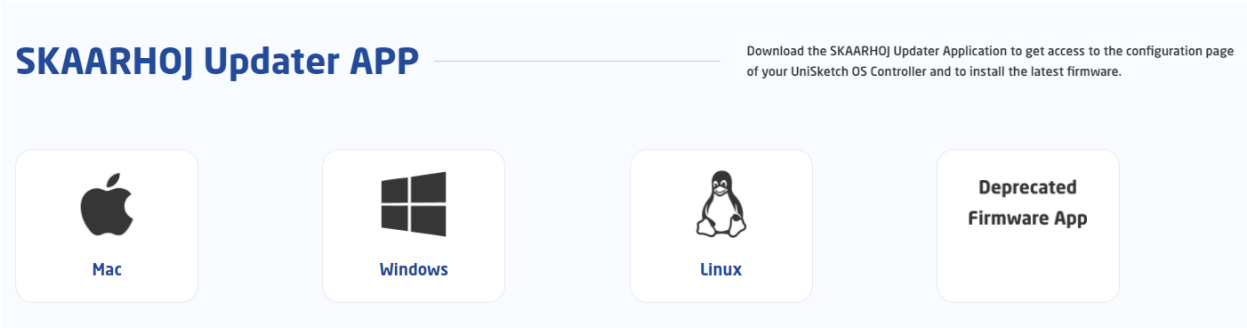


Figure 94: Skaarhoj application download

After installing and opening the application, the user should see a screen as in *Figure 95*.

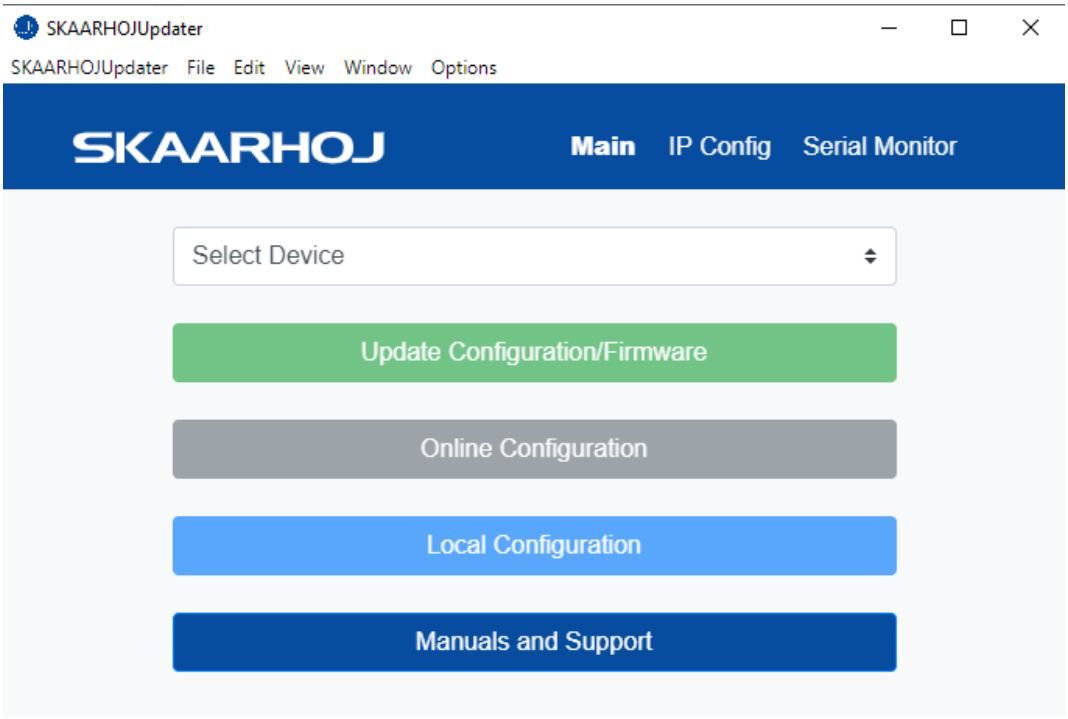


Figure 95: Skaarhoj Updater app homepage

To start using this application, Skaarhoj needs to be connected to the user's computer with a USB cable that comes with the controller. After it is successfully connected, the user should see the Skaarhoj device in the Select Device dropdown list. The user should select the Skaarhoj PTZ Extreme controller from the list.

To assign new Pauli IP addresses to the selected Skaarhoj controller, one should click on the IP Config tab in the application menu. The tab that opens will look like the one shown in *Figure 96*. In the Device Cores section, it is possible to see the list of IP addresses that are currently set for each of the 7 buttons in the Active camera control section. They can be changed by editing the corresponding fields and clicking the Save Settings button to finish the process.

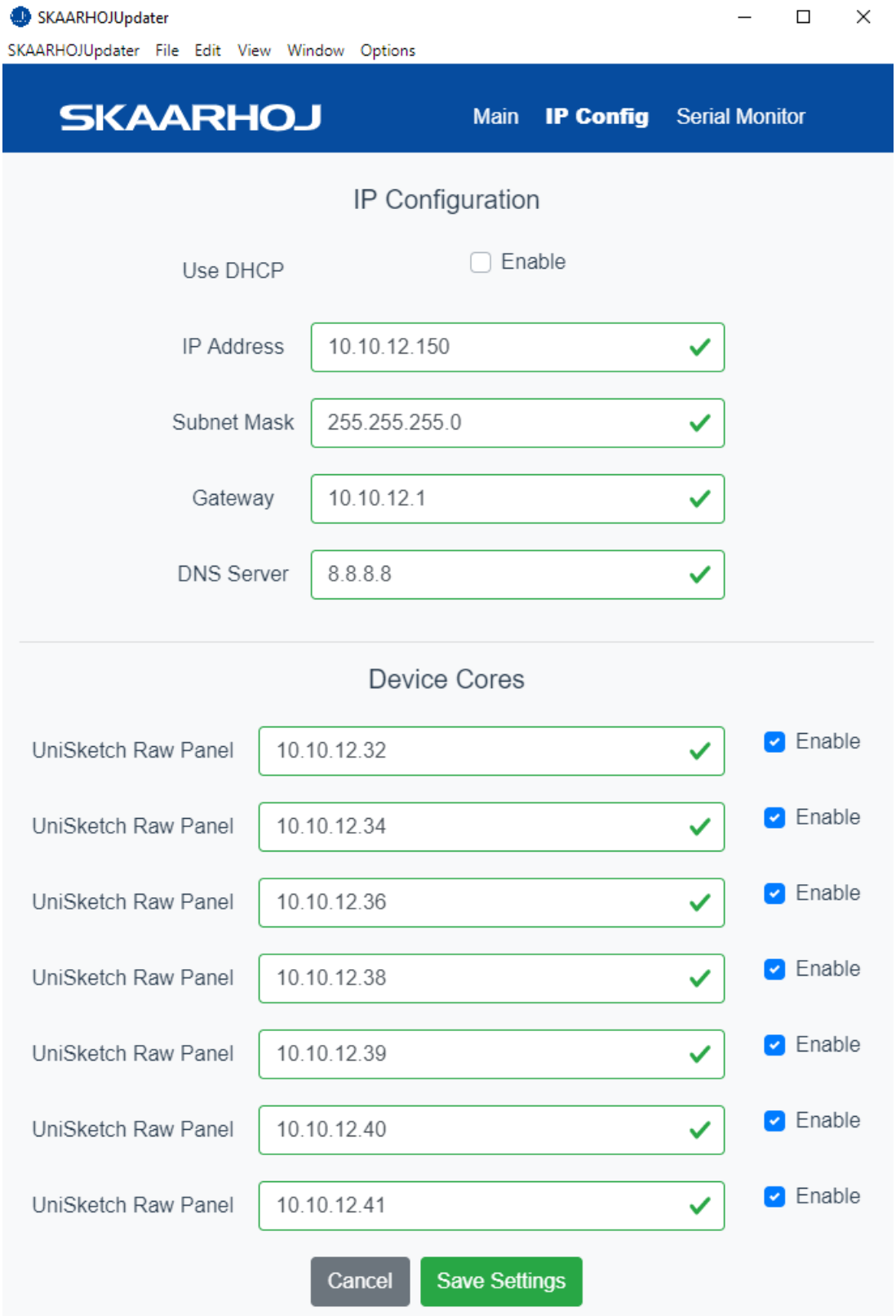


Figure 96: IP address configuration

7.1.7.1. Connecting and controlling multiple heads

As already stated, it is possible to connect multiple Pauli heads and control them from a unique control point. There are several options of connecting Pauli heads with the controller, but it is important that all Pauli heads are in the same local network. Then, the user can assign the IP address of each Pauli to the controller (as explained in Active camera control). Nevertheless, one way of connecting the heads and the Skaarhoj controller is particularly handy – it is to daisy chain the heads.

To daisy chain the heads, one should connect each Pauli head with the next one using the Ethernet cables (as shown in *Figure 97* where the Ethernet cables are highlighted in blue). Then, one of these Pauli heads should be connected to the Skaarhoj controller and the controller connected to the power supply. After the connection has been established, Pauli heads can be controlled after their IP addresses have been assigned to the Skaarhoj controller raw panel buttons.

Figure 97: Pauli Daisy chain

7.1.8. Manual PTZ Extreme configuration

To start with manual configuration, the user should first open the official SKAARHOJUpdater application that was previously installed as explained in section Active camera control. Make sure the controller is connected to the computer with this application as it was described in the same section. After selecting the Skaarhoj device from the Select Device dropdown, one should click the Online Configuration button (shown in *Figure 95*). A webpage would open as illustrated in *Figure 98*.

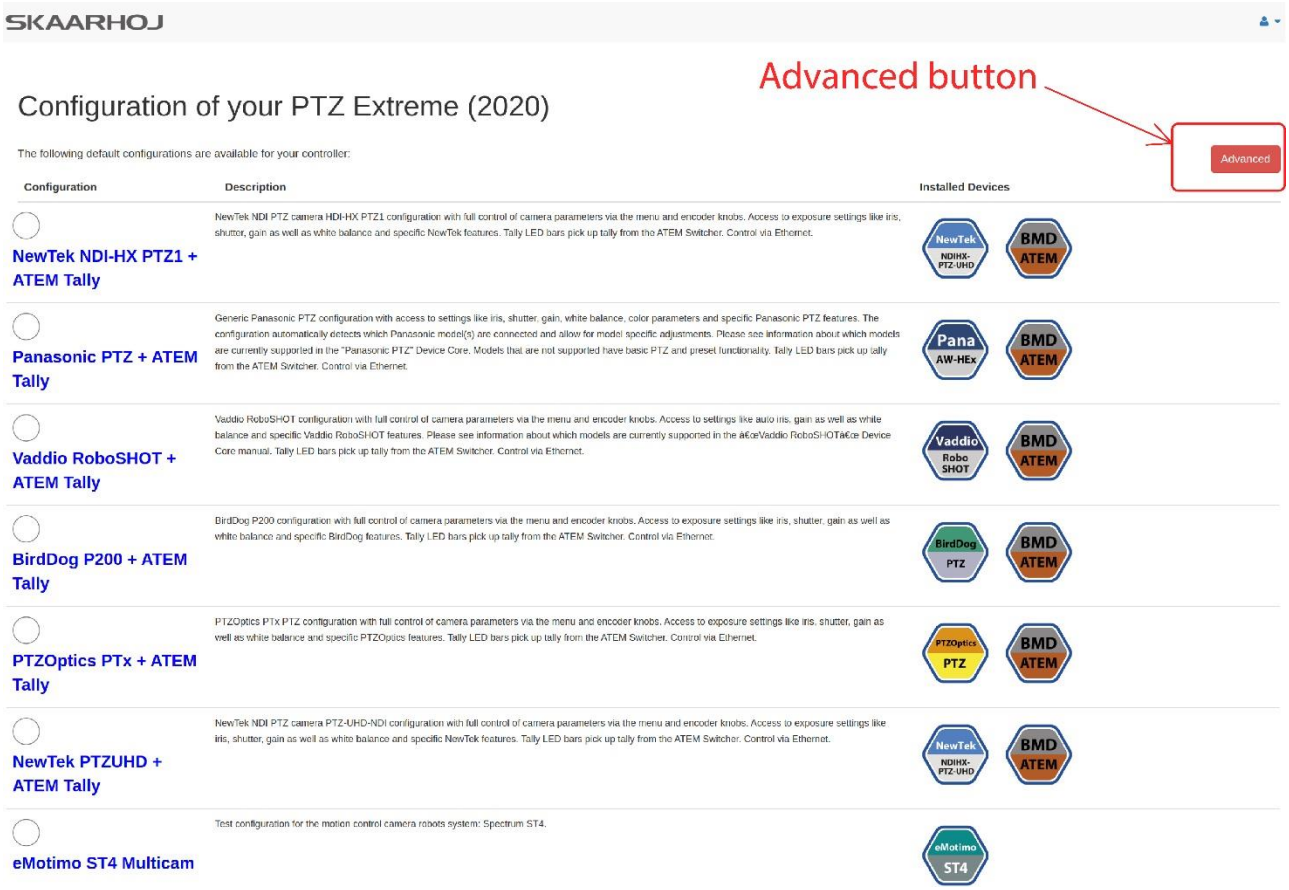


Figure 98: Online configuration homepage

The user should click on the Advanced button (shown in *Figure 98*) and then on the Manage Configurations in the menu on the left side of the screen (*Figure 99*).

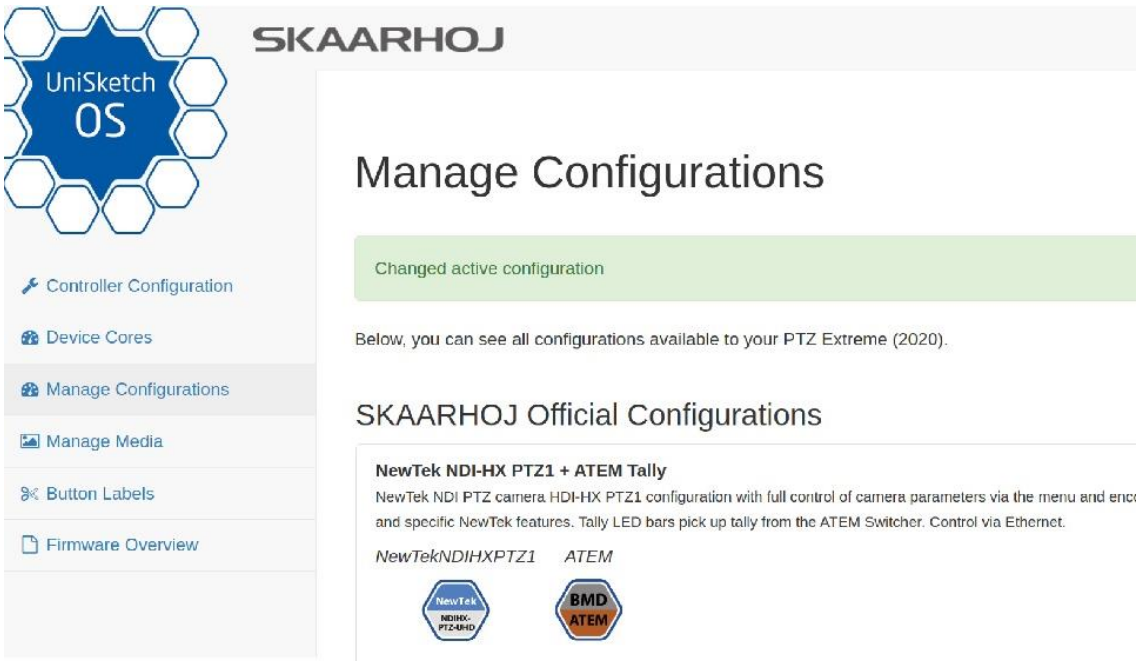


Figure 99: Manage configurations tab

To subscribe to the Zanus configuration, one should scroll to the bottom of the page and enter the Zanus subscription ID (31488) in the dedicated field and then click the Go button (as illustrated in *Figure 100*). A message should appear as in *Figure 101*.

Figure 100: Configuration subscription ID

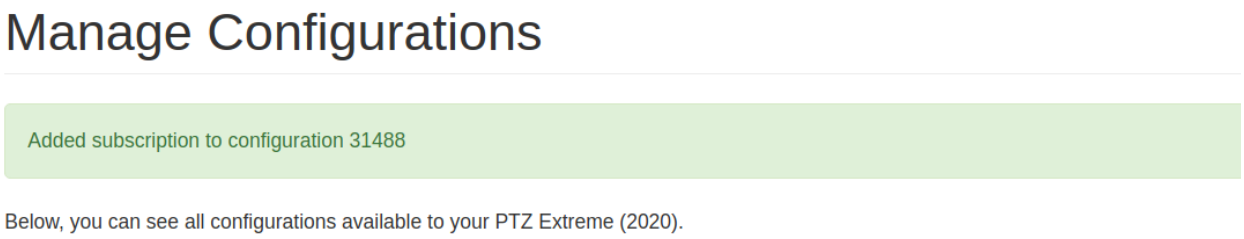


Figure 101: Subscription to configuration success message

Later, the user should find the Configuration Subscriptions section by scrolling on the same page. The Zanus user configuration should be there, named Zanus: RawPanels as in *Figure 104*. One should click on Set Active in the right corner of this configuration to activate the configuration (illustrated closely in *Figure 103*).

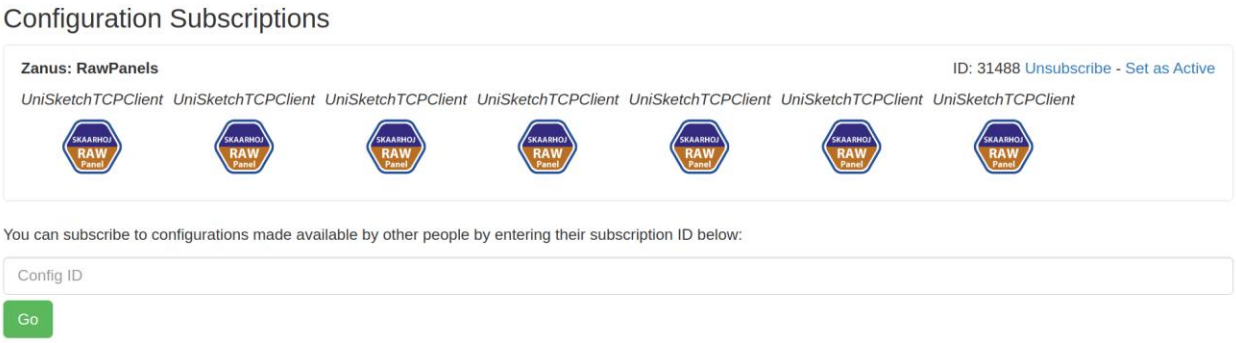


Figure 102: Zanus user configuration subscription

Figure 103: Set configuration as active

After this, the user can see the Active status next to the name of that configuration (*Figure 104*). One more thing to do is to go back to the desktop SkaarhojUpdater application and click on the Update Configuration/Firmware button (shown in *Figure 95*). This would finish the process of manually configuring the Skaarhoj PTZ device.

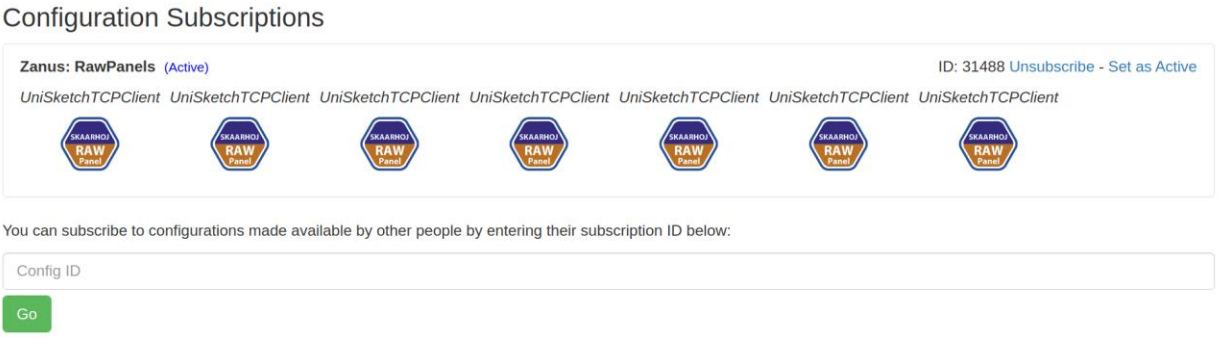


Figure 104: Active Zanus user configuration

Lastly, Skaarhoj has provided a manual for PTZ controllers called PTZ Manual on the webpage https://www.skaarhoj.com/support/manuals. It is recommended to read it to fully understand the options of using them.

7.2. VISCA over IP protocol joystick

Any joystick with VISCA over IP protocol is suitable for controlling Pauli head. This means that one can control Pauli using VISCA on a controller equipped with IP communication capabilities via LAN.

For using a controller with VISCA over IP protocol, it is important only that the IP address on the joystick and the Pauli head is the same. If it is not possible to change the IP address on the joystick, then the IP address of the Pauli can be changed to match the target IP address of the joystick as explained in the Network settings.

The following *Table 8* shows the commands that Pauli head accepts from a controller with VISCA over IP protocol:

Table 8: VISCA over IP command list

Command Set	Command	Command Packet	Comments
PAN TILT DRIVE	UP	8x 01 06 01 vv ww 03 01 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	DOWN	8x 01 06 01 vv ww 03 02 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	LEFT	8x 01 06 01 vv ww 01 03 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	RIGHT	8x 01 06 01 vv ww 02 03 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	UPLEFT	8x 01 06 01 vv ww 01 01 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	UPRIGHT	8x 01 06 01 vv ww 02 01 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	DOWNLEFT	8x 01 06 01 vv ww 01 02 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	UPRIGHT	8x 01 06 01 vv ww 02 02 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	STOP	8x 01 06 01 vv ww 03 03 FF	vv: Pan speed 0x01 (Slow) - 0x18 (Fast) ww: Tilt speed 0x01 (Slow) - 0x18 (Fast)
PAN TILT DRIVE	ABSOLUTE POSITION	8x 01 06 02 vv ww 0p 0p 0p 0p 0t 0t 0t 0t FF	Official SONY docs values except tilt, tilt has same values as pan
FOCUS	FAR	8x 01 04 08 2p FF	p: 0 (Low) - 7 (High)
FOCUS	NEAR	8x 01 04 08 3p FF	p: 0 (Low) - 7 (High)
FOCUS	DIRECT(POSITION)	8x 01 04 48 0p 0p 0p 0p FF	Official SONY docs values
ZOOM	TELE	8x 01 04 07 2p FF	p: 0 (Low) - 7 (High)
ZOOM	WIDE	8x 01 04 07 3p FF	p: 0 (Low) - 7 (High)
ZOOM	DIRECT(POSITION)	8x 01 04 47 0z 0z 0z 0z FF	Official SONY docs values

IRIS	DIRECT(POSITION)	8x 01 04 4B 00 00 0p 0p FF	Official SONY docs values
PRESET	SET	8x 01 04 3F 01 pp FF	pp: PRESET No. to set - 1 (0x00 - 0x63)
PRESET	RECALL	8x 01 04 3F 02 pp FF	pp: PRESET No. to recall - 1 (0x00 - 0x63)
PRESET	SPEED - Common	8x 01 7E 04 1C 0p 0p FF	pp: Common Speed (0x01-0x18)

The following *Table 9* shows the list of VISCA messages that Pauli returns:

Table 9: VISCA over IP inquiry command list

Inquiry command		**Inquiry Packet**	**Reply Packet**	**Comments**
PAN TILT DRIVE	POSITION	8x 09 06 12 FF	y0 50 0p 0p 0p 0p 0t 0t 0t 0t FF	Official SONY docs values
FOCUS	POSITION	8x 09 04 48 FF	y0 50 0p 0p 0p 0p FF	Official SONY docs values
ZOOM	POSITION	8x 09 04 47 FF	y0 50 0z 0z 0z 0z FF	Official SONY docs values
IRIS	POSITION	8x 09 04 4B FF	y0 50 00 00 0p 0p FF	Official SONY docs values
POWER STATUS		8x 09 04 00 FF	y0 50 0p FF	p: 2=On, 3=Standby

For more information on VISCA over IP protocol usage, it is recommended to read the official document from Sony at the link https://www.sony.net/Products/CameraSystem/CA/BRC_X1000_BRC_H800/Technical_Document/C456100121.pdf.

8. Troubleshooting

If Pauli head is not working properly there could be several reasons and solutions for it:

1. The head is not responding to commands
    i. Make sure that all the cables are in place and that the power switch is turned on.
    ii. Make sure that the status section on the head is showing green lights for Power, Active and Network states while being normally mounted.
    iii. Make sure that the status section on the head is showing green lights for Power and Network states and blue light for Active state while being in inverse mount.
    iv. If nothing works then simply turn off the power switch button, wait for a few seconds and then turn it back on.
2. The head is suddenly moving too fast (moves on its own)
    i. Disarm the system and wait for a few seconds. Turn off the disarm button and turn on the system again.
3. Errors appear in the application
    i. First, try pressing the Clear error faults button in the Controls tab of the application
    ii. Restart the head and restart the application