



COMPOLYTICS

We see light differently.

Macrobot Imaging System

Hardware Release 2.0 (NextGen)

Software Release 4.0

Documentation 2.1

May 2026

Haftungsausschluss (Disclaimer)

Der Macrobot als Gesamtsystem ist kein kommerzielles Produkt, sondern ein maßgeschneiderter wissenschaftlicher Prototyp für den Einsatz im Labor und die Bedienung durch qualifiziertes und eingewiesenes Personal.

Gegebenenfalls ist eine gesonderte Gefährdungsbeurteilung durch den Auftraggeber unter Berücksichtigung der spezifischen Einsatzbedingungen durchzuführen.

Bei den eingebauten Einzelkomponenten handelt es sich typischerweise um handelsübliche Module, die beispielsweise über eine entsprechende CE-Kennzeichnung verfügen. Compolytics übernimmt keine Garantie oder Gewährleistung, weder für die Hardware noch für die Software. Als wissenschaftlicher Kooperationspartner werden wir auftretende Probleme nach guter wissenschaftlicher Praxis und nach bestem Wissen und Gewissen beheben und mit dem Projektpartner zusammenarbeiten.

Eine allgemeine Übersicht über die grundlegende Funktionalität des Macrobot befindet sich auf der Compolytics Webseite unter: <https://compolytics.com/macrobot/>.

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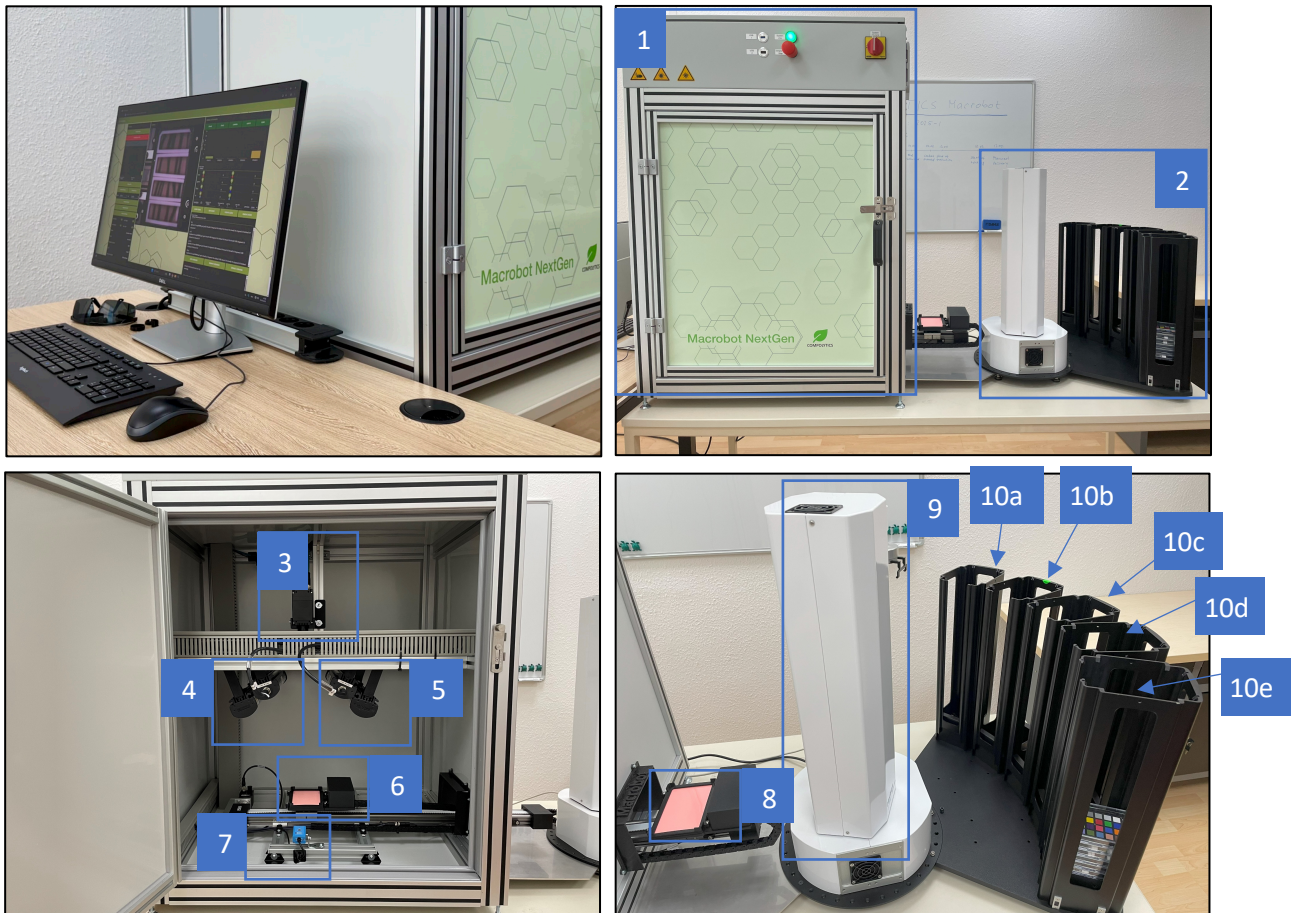
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Hardware Overview

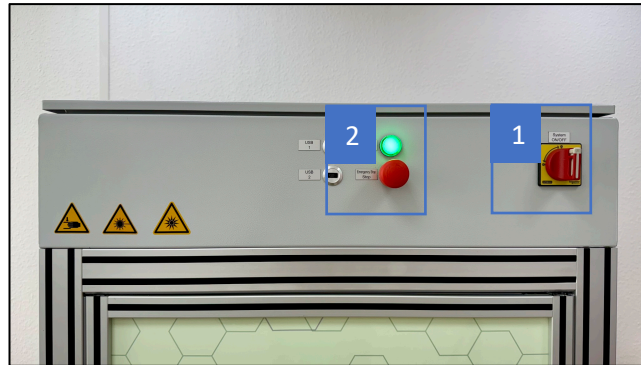
The Macrobot system primarily consists of an imaging box (1) and a plate crane system (2) to feed standard well plates to the imaging system.



Item	Description
1	Imaging box
2	Plate crane system
3	UV-VIS camera system
4	Lights left hand side (UV, RGB)
5	Lights right hand side (RGB, UV)
6	Plate carrier with backlight at camera position on translation stage
7	Barcode reader
8	Plate carrier with backlight at crane position on translation stage
9	Plate crane system for transporting well plates from five supplied stacks to carrier
10	Well plate stacks (a) stack 1, (b) stack 2, (c) stack 3, (d) stack 4, (e) stack 5

System Startup

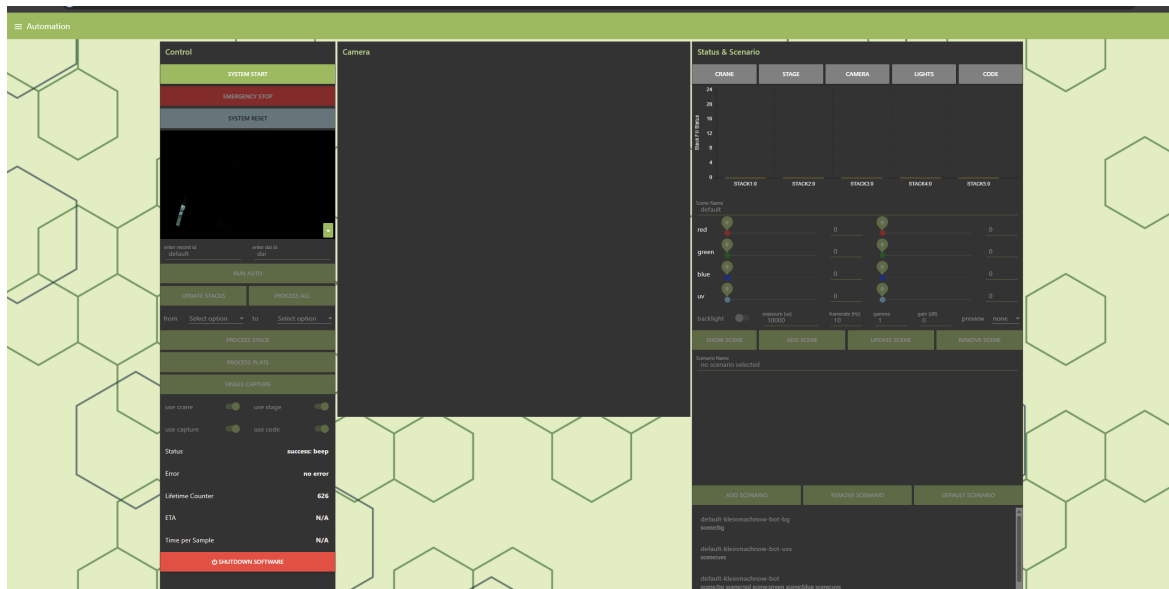
Please enable the main power supply by using the **power switch** (1) on the Macrobot's front plate. If power is on, the green **"Power On"** LED will indicate so. Make sure that the **emergency stop** (2) is disengaged by turning it and pulling it out.



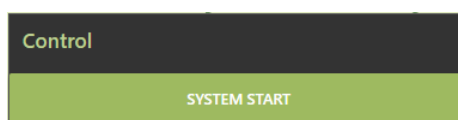
The system computer will boot up on **"Power On"**. Please let the system boot and log in to the Windows operating system. Start the Macrobot system software via the programme icon on the desktop:



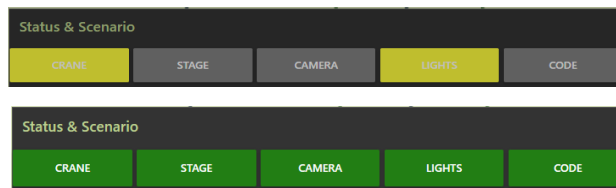
This will open a terminal window to run the software in the background. Please keep this window open. The user interface is implemented as a web application, designed to run in a standard web browser. Clicking the startup icon will also open a web browser and display the graphical user interface.



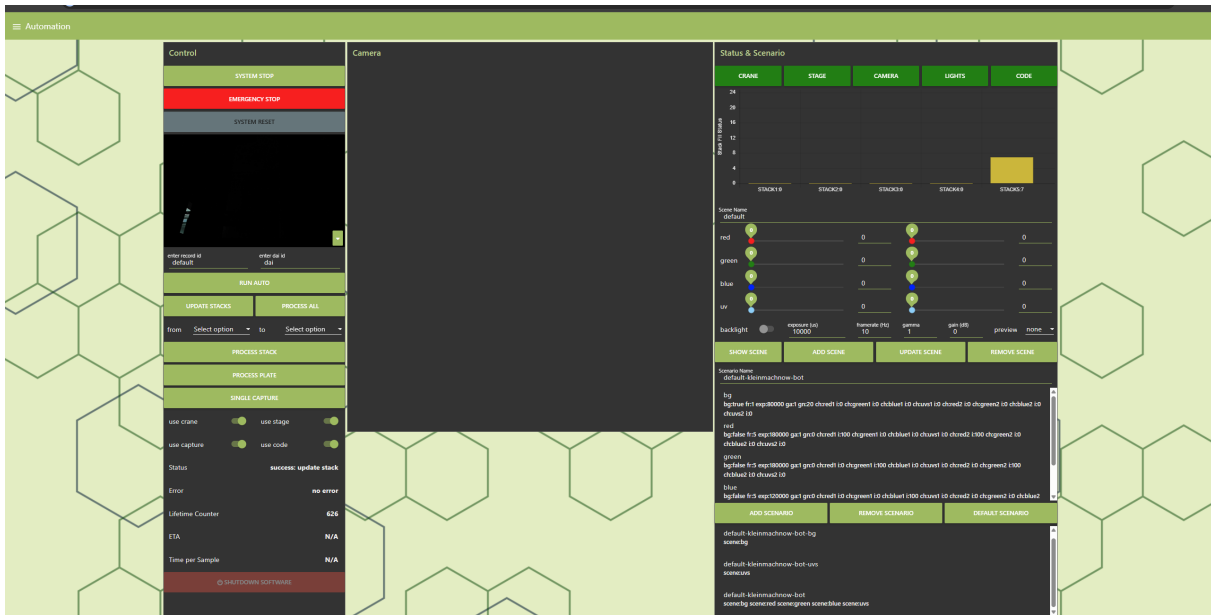
In order to start the system, press **"System Start"**.



The system will now initialise and test all hardware components. Components that are being tested are indicated in yellow. After the process, the status of all hardware elements should be green.

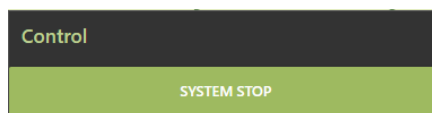


Now the system is ready to be used, and the graphical user interface is unlocked for interaction.

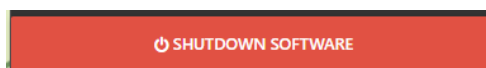


Shutting Down the System

For the system to shut down, the **“System Stop”** button will move all hardware components into a save parking position. Therefore, please do not just close the software but run **“System Stop”** first.

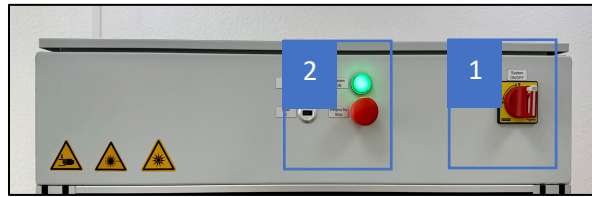


After the **“System Stop”** process has finished, please shut down the software with the displayed button. This will safely close the terminal window that runs the system software. Afterwards, you can close the browser window.



Please shut down the Windows PC via the operating system’s shutdown function. After that, disconnect the power via the **main power switch (1)**.

Please note: The **hardware emergency stop** (2) is meant for **emergency only**; it will only cut power to lights and moving parts but will keep the system PC running.



Loading Plates

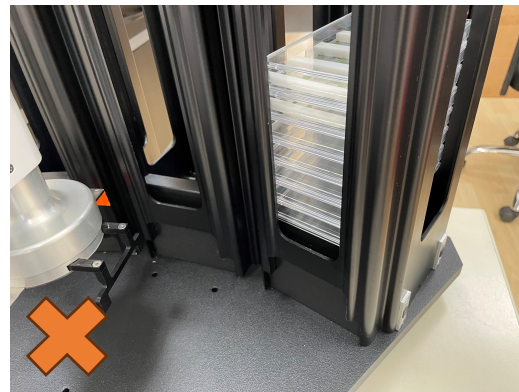
Each of the five plate stacks can hold up to 24 standardised well plates (with lid). For automatic plate handling, **one stack must remain empty** to offload processed plates.

Please load the plates so the bar code on the flat short side is pointing towards the plate crane.

Correct placement of plates!

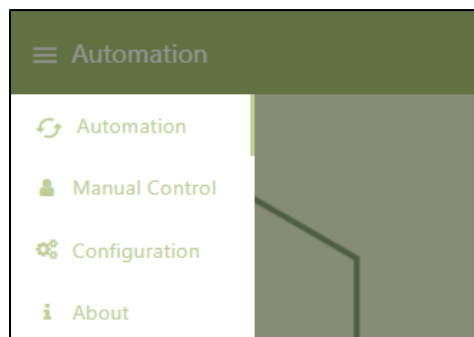


Incorrect placement of plates!



Overview of User Software

The Macrobot control software consists of four different dashboards that can be selected from the “Hamburger menu” at the top left.



Automation

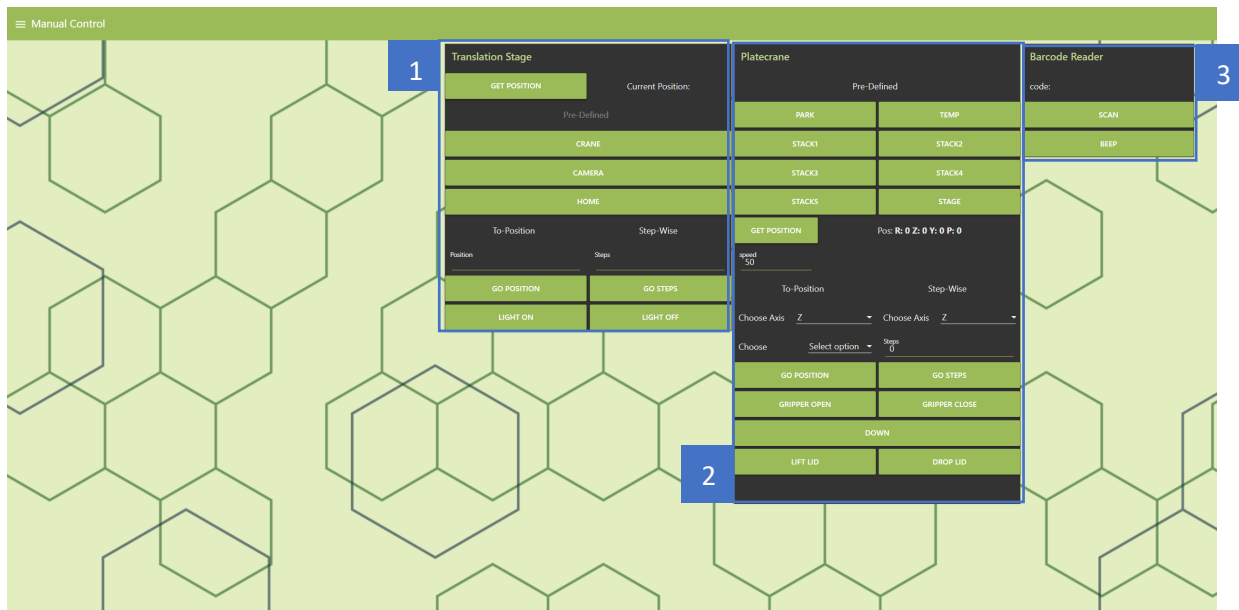
This dashboard is used to set up and organise imaging parameters, display a live camera view and control automated plate processing with a range of control options.



Section	Description
1	System Startup / Shutdown, Soft Emergency Stop, System Reset
2	Control for web camera inside of imaging box
3	Control for fully automated plate handling, single stack or single plate handling, as well as single capture
4	Switches for selectively enable/disable hardware components while in automated processing
5	Various information about system operations: status – displays current action, error – shows error message, lifetime counter – counts number of plates imaged in total over the system’s lifetime, ETA – estimated end of current run, time per sample – shows time elapsed to process one plate
6	Camera image preview with indicator (red) for pixel saturation
7	Status indicator of connected hardware
8	Stack fill status diagram
9	Currently used imaging parameters
10	List of imaging scenes, list of imaging scenarios (scenario = list of scenes)

Manual Control

The Manual Control dashboard offers functionality to control the Macrobot hardware manually, for example, to move the translation stage or calibrate the plate crane if needed.



Section	Description
1	Control for translation stage with plate carrier
2	Control for plate crane well for plate handling
3	Control for barcode reader

Translation Stage

Option	Description
CRANE	Moves plate carrier to position for placement of plate by the plate crane
CAMERA	Moves plate carrier to position defined for image capture and barcode reading
HOME	Moves plate carrier to home position, also used to calibrate translation stage
GO POSITION	Moves plate carrier to the above specified absolute position on the translation stage (input allowed 0-62000)
GO STEPS	Moves plate carrier a specified number of steps. Can be positive or negative (positive=movement towards camera, negative=movement towards plate crane)
LIGHT ON	Switches background light of plate carrier on
LIGHT OFF	Switches background light of plate carrier off

Plate Crane

Option	Description
Pre-Defined	Moving the Plate crane into pre-defined positions: a) STACK 1-5: Move crane to stack positions and down the stack b) STAGE: Moves crane above drop-off position for plates on carrier c) TEMP: Moves crane to temporary waiting position d) PARK: Moves crane into save parking position
GET POSITION	Updates the positioning data, is also updated with each manually performed move
Speed	Sets speed of movement
GO POSITION	Goes to the axis value (choose axis) of the pre-defined position (choose position)
GO STEPS	Moves plate crane along a specified axis (choose axis) for a set number of steps
GRIPPER OPEN	Opens plate crane gripper
GRIPPER CLOSE	Closes plate crane gripper
DOWN	Moves plate crane down along Z-axis until mechanical resistance is detected
LIFT LID	Manually lifts well plate lid, please only perform when plate is placed on carrier
DROP LID	Manually drops well plate lid, please only perform when plate is placed on carrier

Barcode Reader

This section is used to manually test the barcode reader in case it has to be readjusted. Please make sure the plate carrier is in the **CAMERA** position, a well plate with a barcode label is facing the reader, and the lid is taken off the well plate.

Option	Description
SCAN	Manually read the barcode, code is shown above
BEEP	Give me a beep, Vasili. One beep only 🗣️


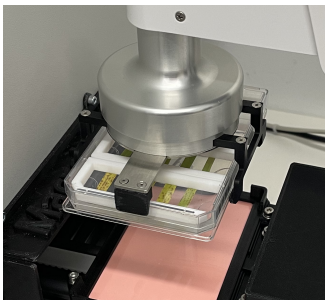
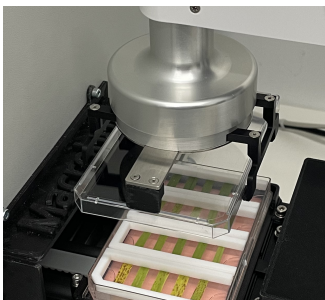
Plate Crane Axis Movement

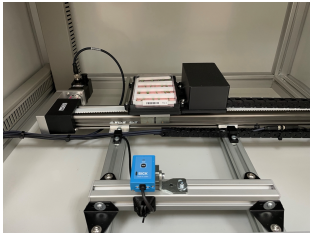
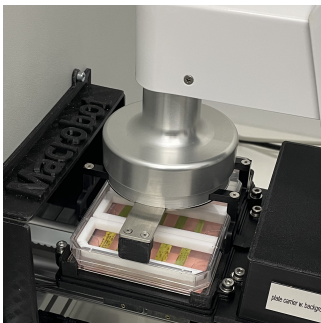
Axis	Description
Z	Moves plate crane arm vertically
Y	Extends or detracts plate crane arm
R	Rotates plate crane around its vertical axis
P	Rotates plate crane gripper around its vertical axis

Manual Control

The following steps show how to manually perform all the steps that are normally performed automatically to pick a plate from the stack, place it on the plate carrier, move it to the imaging position, and reverse the process to place the plate back on the stack.



Action	Description
<p>Get plate from stack</p> 	<p>(a) Press STACK1-5 button depending on which stack to use as source</p> <p>(b) When arm is placed, press GRIPPER CLOSE</p>
<p>Place plate on carrier</p> 	<p>(a) Press CRANE button (to move translation stage) to place carrier at crane position</p> <p>(b) Press STAGE button (to move plate crane) to move plate above drop-off position on carrier</p>
<p>Lower plate and lift lid</p> 	<p>(a) Press DOWN to move plate onto the carrier</p> <p>(b) Press LIFT LID to open the plate</p>

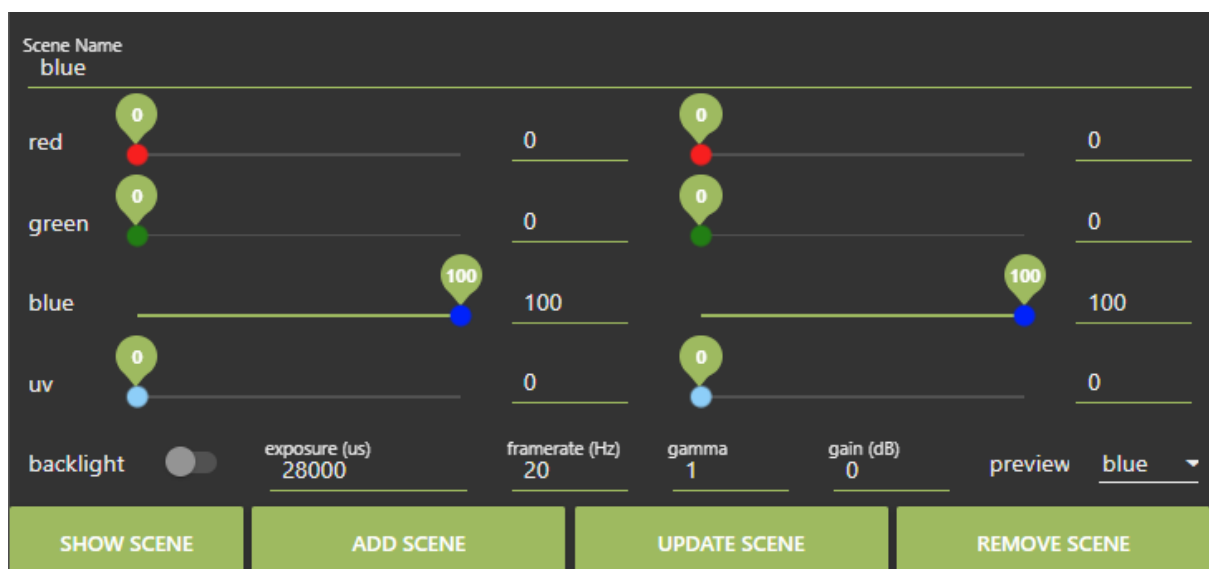
<p>Move plate to camera & back</p> 	<p>(a) Press CAMERA to move carrier to camera (imaging) position (b) Press CRANE to move carrier back to crane position</p>
<p>Move plate back to stack</p> 	<p>(a) Press DROP LID button to place lid back onto the well plate (b) Press one of STACK1-5 buttons dependent on target stack (c) Once the plate is placed back on the target stack, open the gripper with GRIPPER OPEN (d) Move crane into temporary waiting position by pressing TEMP</p>

Setting Imaging Parameters

In this section, it is described how to set up the imaging system and organise imaging scenes and scenarios for experiment-specific imaging tasks.

Generating an Imaging Scene

Camera and lighting parameters are selected from the **Automation** dashboard. The system consists of paired LED lights providing ultraviolet, blue, green, and red illumination. The camera is a monochromatic camera system, so different illumination setups are run in sequence. A single combination of LED configurations and camera parameters makes up a **scene**. A sequence of scenes forms a **scenario**.



Setting	Description
Scene Name	Name of the scene to be set up, is used in the recorded data to indicate which scene was used for imaging.
Slider “red”, “green”, “blue”, “uv”	Adjusts the intensity of the LED light. Values between 0-100 are allowed. 100 is considered the maximum illumination for that channel. Separate sliders are available for the left and right LED lights.
Backlight	Specifies if the carrier backlight is switched on or off in the scene.
Exposure	Sets the camera integration or exposure time in microseconds; the higher the number, the brighter the image. Avoid overexposing plant samples.
Framerate	Sets the camera framerate in Hz.
Gamma	Sets the value for gamma correction. Gamma = 1 means no correction.
Gain	Sets the camera gain in dB. Gain = 0 is a gain factor of 1, the gain can increase the image brightness without increasing the exposure time at the expense of increased image noise. If possible, the gain should be left at 0dB.
Preview	Select which channel in the RGB preview image should be used for the current scene. For example, this scene uses blue lighting and is set as the B (blue) channel for the RGB preview. If red, green, and blue channels are set, an RGB preview will be generated. If none are selected, this scene will be ignored when creating the RGB preview.

Generating an Imaging Scenario

Once set up, the scene can be switched on in the system by pressing “**SHOW SCENE**”. To add this scene to the scenario, press “**ADD SCENE**”.

```
Scenario Name
test-rgb-preview

red
bg:false fr:10 exp:40000 ga:1 gn:0 ch:red1 i:100 ch:green1 i:0 ch:blue1 i:0 ch:uv1 i:0 ch:red2 i:100 ch:green2 i:0 ch:blue2
i:0 ch:uv2 i:0

green
bg:false fr:10 exp:60000 ga:1 gn:0 ch:red1 i:0 ch:green1 i:100 ch:blue1 i:0 ch:uv1 i:0 ch:red2 i:0 ch:green2 i:100 ch:blue2
i:0 ch:uv2 i:0

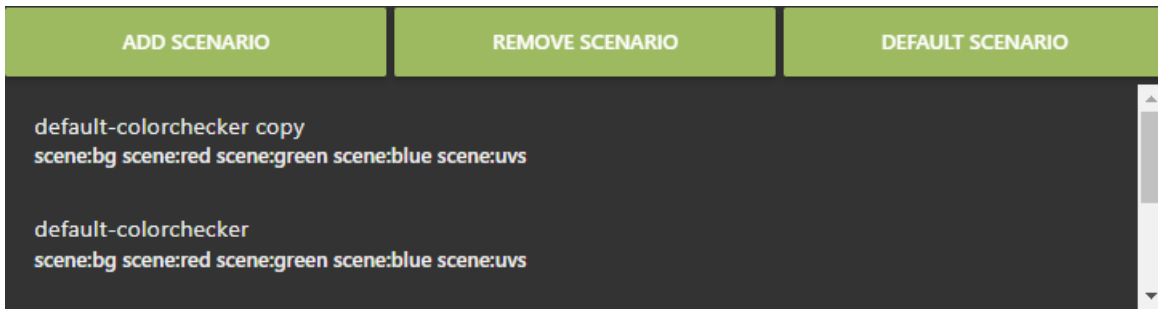
blue
bg:false fr:20 exp:28000 ga:1 gn:0 ch:red1 i:0 ch:green1 i:0 ch:blue1 i:100 ch:uv1 i:0 ch:red2 i:0 ch:green2 i:0 ch:blue2
i:100 ch:uv2 i:0
```

The Scenario view displays the set scenes. A scenario can be named under “**Scenario Name**”. When a scene is selected, the current camera and lighting settings are updated with the saved values. To reactivate the settings, press “**SHOW SCENE**”. If the camera or lighting parameters are changed, press “**UPDATE SCENE**” to make the changes permanent in the saved scene within the scenario.

Press “**REMOVE SCENE**” to delete the selected scene from the scenario. When the auto-recording is in progress, the scenes will be played in sequence in the order they are listed in the displayed scenario.

Organize Imaging Scenarios

The system allows multiple scenarios to be saved. When you have finished creating a scenario, press **“ADD SCENARIO”** to save it.



A scenario can be deleted using **“REMOVE SCENARIO”**. By pressing **“DEFAULT SCENARIO”**, a template scenario will be created which can be further set up.

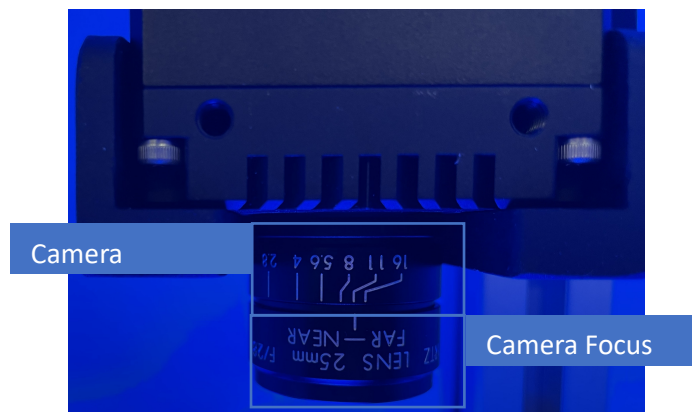
Scenario parameters are stored as a JSON formatted text file and can be saved for later use. The system reads available scenario JSON files at startup.

By default, the scenario files are stored in **D:\macrobot\scenario**

This folder can be changed in the **“Configuration”** dashboard if needed.

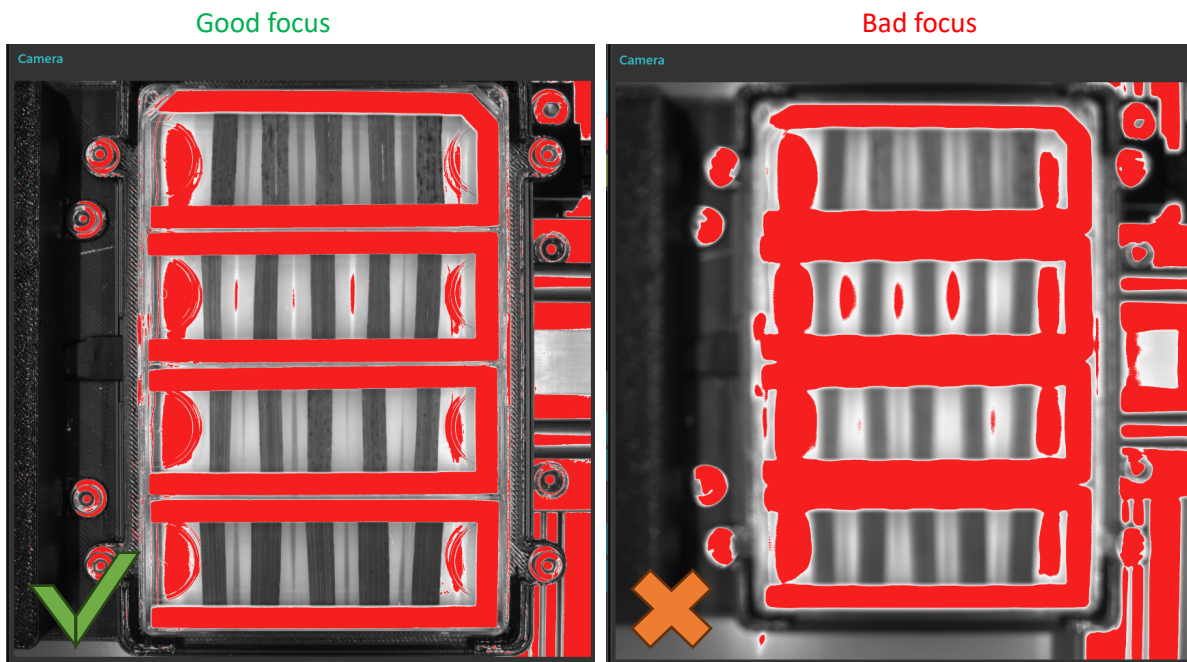
Setting up Camera Optics

Camera aperture and focus can be manually adjusted at the camera.

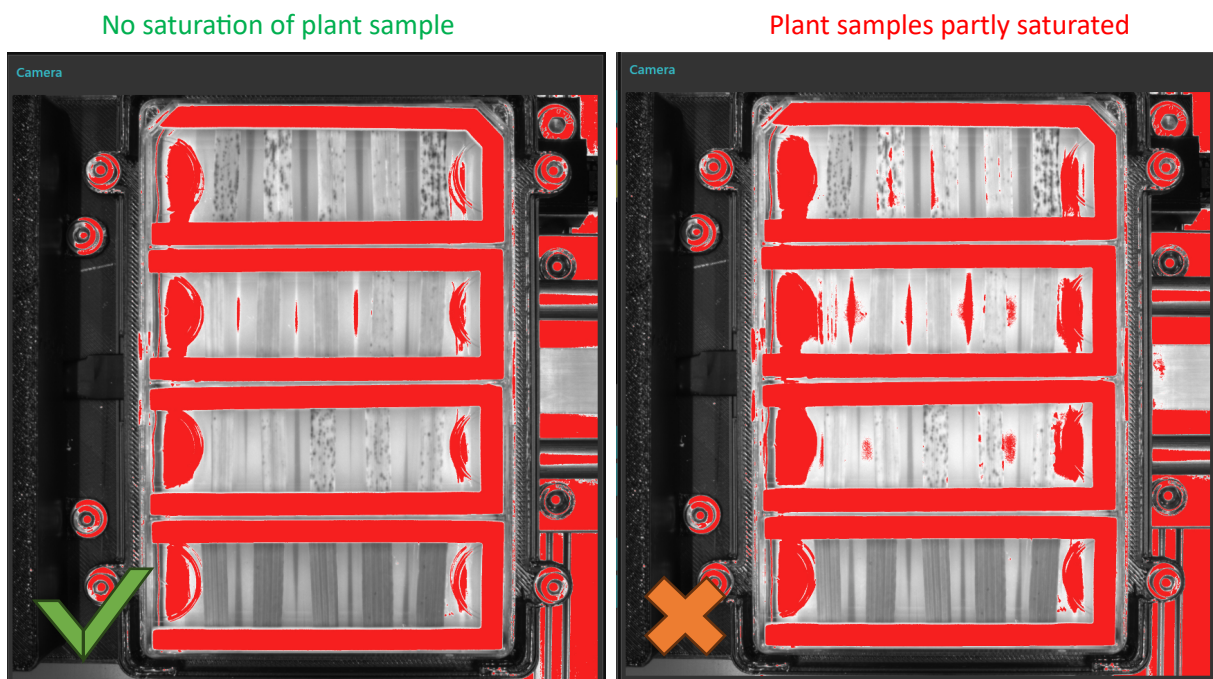


For adjusting the aperture, turn the upper ring on the camera lens. The larger the aperture, the less light is passing through to the camera but also increases the depth of field.

Adjust the focus by turning the bottom ring. Use the preview to check the focus.

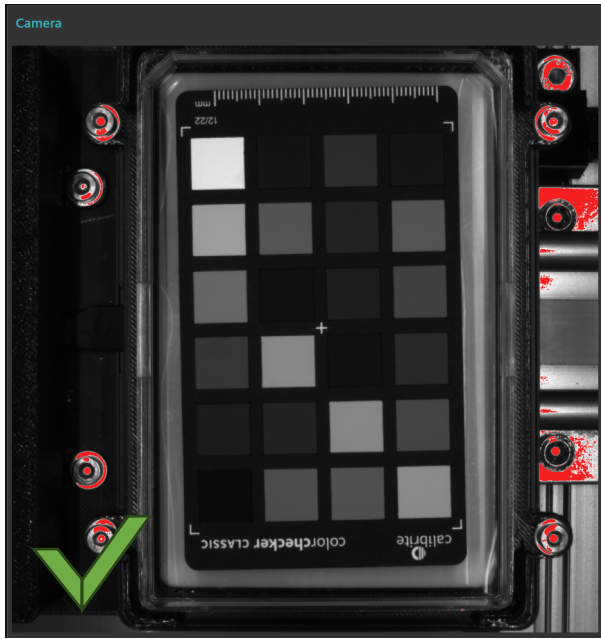


The image preview will show saturated pixels in red. Please ensure that plant samples or other areas to be analysed are not saturated. The brightness of the image can be altered by changing the camera exposure, lens aperture, or camera gain.

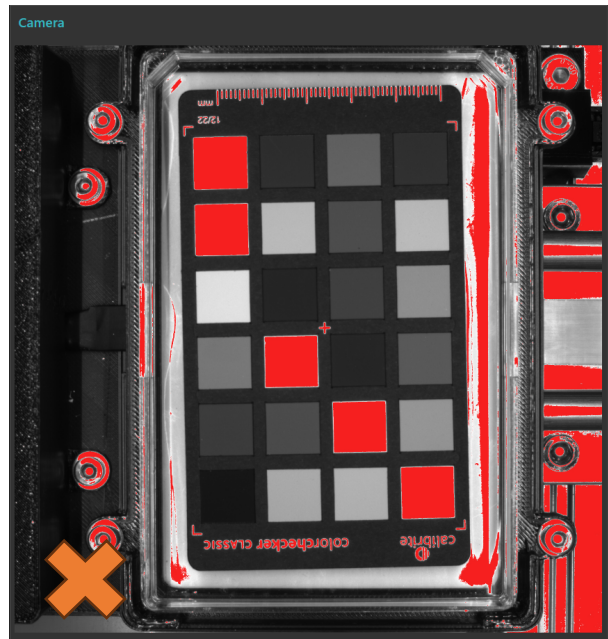


To find a good setup for each LED illumination, please use the supplied calibration pad. Place the calibration pad in an empty plate and take an image of it. Make sure that no calibration patch is shown as saturated. To get a well illuminated scene, try to find the point where only the white patch (lower right on the calibration pad) is saturated and then lower the exposure further until the saturation disappears. **For later colour calibration purposes, please image the calibration pad in each run.**

Calibration pad without saturation



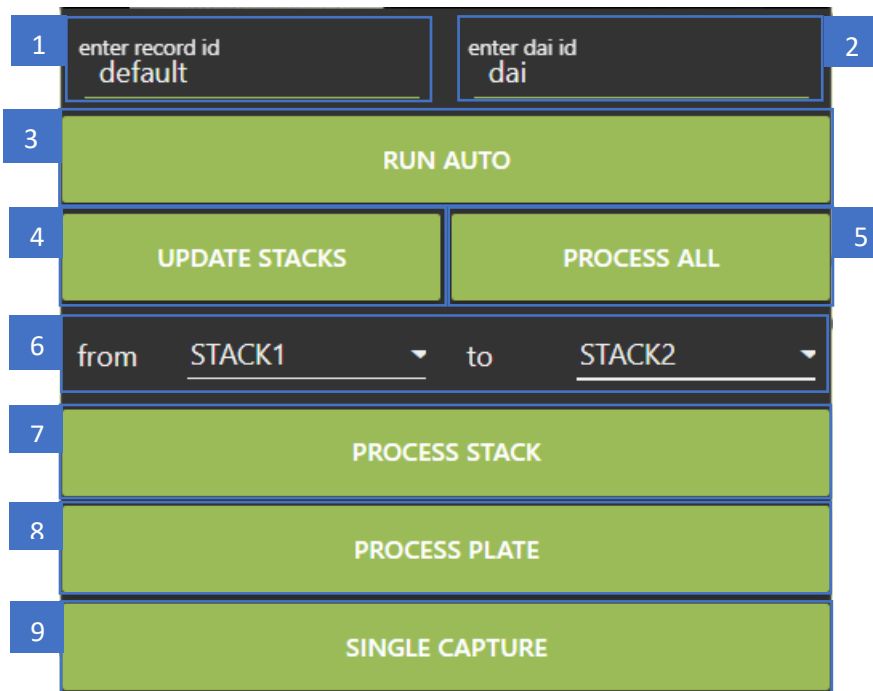
Calibration pad with saturation



Run Fully Automatic Mode

The fully automatic mode will image all stacked well plates with the selected scenario. Please ensure that the imaging parameters are set correctly and that the plates are stacked as described above.

- (1) Enter a record ID name under which the recorded images should be stored (“**enter record id**”). This corresponds to the experiment name in the Macrobot analysis software.
- (2) Enter a day after inoculation (dai) ID name (“**enter dai id**”). This corresponds to the second folder level in the Macrobot analysis software.
- (3) Start auto mode by pressing “**RUN AUTO**”.



This starts the processing mode. First, the plate crane determines the stack fill status, then the stacks are processed one at a time. **One stack must be empty in order to be able to place processed plates into it.**

It is also possible to run both steps separately:

- (4) “**UPDATE STACKS**” – Determines the fill state of the stacks, this can be run at any time.
- (5) “**PROCESS ALL**” – Will process all stacks without running a fill status test first.

Run Single Stack

In order to process all plates of a single stack:

- (6) Select a source and a target stack from the selection menu.
- (7) Press “**PROCESS STACK**”, make sure that the target stack is empty.

Run Single Plate

If you only want to image a single plate from a particular stack, please run:

- (6) Select a source and a target stack from the selection menu.
- (8) Press “**PROCESS PLATE**”, this will process the top plate of the source stack and place it in the target stack.

Run Single Capture

If you only want to image the current plate on the plate holder under the camera, run:

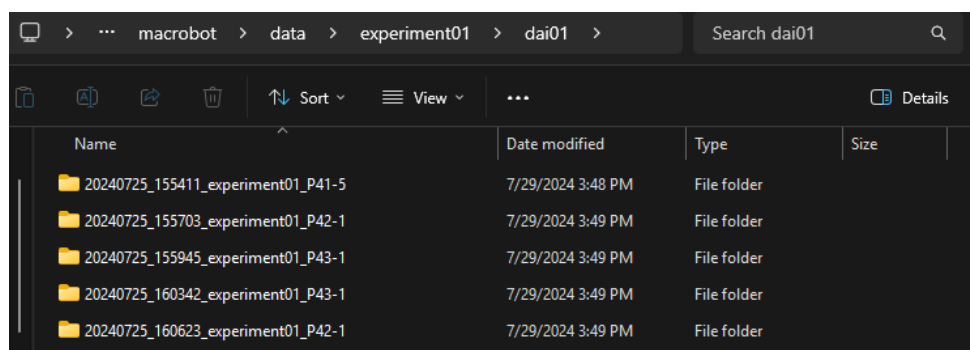
- (9) Press “**SINGLE CAPTURE**”, this will image the current camera view with the complete sequence of scenes selected with the current scenario and store the images under the record and dai ID folder structure. The barcode is read if the “**code**” option is activated. If “**stage**” option is selected, the carrier will also go to the camera position automatically before imaging and return to crane position afterwards.

Image Data Handling

All recorded data is placed in the data folder specified in the configuration dashboard. By default, this is the folder **D:\macrobot\data**. The data is placed in a folder with the record id name. The data files are given a timestamp, the record id as well as the scene they were imaged with. The files are stored in a 3-folder structure. The first folder is the experiment or record id, the second folder is the day after inoculation id, and the third folder is the individual sample folder. This folder structure is compatible with the BluVision Macrobot analysis software developed by IPK Gatersleben.

The following files per scene are stored:

- (1) ***.preview.jpg** – This file shows the imaged plate with saturated pixels highlighted. This is a preview image only for quality checking and should not be used for data analysis.
- (2) ***.tif** – This is the sample image stored as 16bit TIFF image with lossless compression. The image can be read with image analysis software and retains the full precision of the 12bit provided by the camera system. Please note that the MS Windows preview will not display the image correctly as it expects the maximum brightness to be 16bit.
- (3) ***.json** – This is a record of all the imaging parameters of the scene used to image the particular sample. This should be kept as a record in case the same setup needs to be reconfigured in a later experiment.
- (4) ***_rgb.preview.jpg** – This image shows a composite preview of using the single scenes set as the R, G, and B channel of a colour image. A scene for each channel must have been selected in the imaging parameters setup, otherwise no RGB preview is generated.



Name	Date modified	Type	Size
20240725_155411_experiment01_P41-5_bg.json	7/25/2024 3:54 PM	JSON-Quelldatei	1 KB
20240725_155411_experiment01_P41-5_bg.preview.jpg	7/25/2024 3:54 PM	JPG File	3,030 KB
20240725_155411_experiment01_P41-5_bg.tif	7/25/2024 3:54 PM	TIF File	13,220 KB
20240725_155411_experiment01_P41-5_blue.json	7/25/2024 3:55 PM	JSON-Quelldatei	1 KB
20240725_155411_experiment01_P41-5_blue.preview.jpg	7/25/2024 3:55 PM	JPG File	3,049 KB
20240725_155411_experiment01_P41-5_blue.tif	7/25/2024 3:55 PM	TIF File	12,915 KB
20240725_155411_experiment01_P41-5_green.json	7/25/2024 3:54 PM	JSON-Quelldatei	1 KB
20240725_155411_experiment01_P41-5_green.preview.jpg	7/25/2024 3:54 PM	JPG File	3,153 KB
20240725_155411_experiment01_P41-5_green.tif	7/25/2024 3:54 PM	TIF File	12,896 KB
20240725_155411_experiment01_P41-5_red.json	7/25/2024 3:54 PM	JSON-Quelldatei	1 KB
20240725_155411_experiment01_P41-5_red.preview.jpg	7/25/2024 3:54 PM	JPG File	3,029 KB
20240725_155411_experiment01_P41-5_red.tif	7/25/2024 3:54 PM	TIF File	12,722 KB
20240725_155411_experiment01_P41-5_rgb.preview.jpg	7/25/2024 3:55 PM	JPG File	2,827 KB
20240725_155411_experiment01_P41-5_uvvs.json	7/25/2024 3:55 PM	JSON-Quelldatei	1 KB
20240725_155411_experiment01_P41-5_uvvs.preview.jpg	7/25/2024 3:55 PM	JPG File	3,900 KB
20240725_155411_experiment01_P41-5_uvvs.tif	7/25/2024 3:55 PM	TIF File	12,481 KB

Security Notes

The processing can be stopped at any time using the soft emergency stop feature. Please press **“EMERGENCY STOP”** in the **“Control”** section



This will stop processing after the last hardware motion step has been completed. Once the **“EMERGENCY STOP”** has been activated, the user can press **“SYSTEM RESET”** to reset the system. This will move the plate carrier back out of the imaging box, move the plate crane to a safe parking position and turn off all lights. Please note that for safety reasons, the gripper remains closed to prevent a plate or plate lid from being dropped.

Once the reset is complete, perform the appropriate manual steps if required, e.g., return a plate to the stack, etc. After reset, the system can be used as normal. If no reset is performed, the system will not perform any processing, even if prompted to do so.

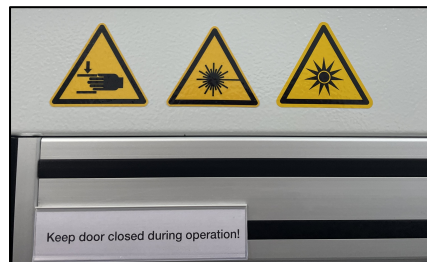
In the event of a serious emergency, the system can be stopped immediately by activating the **“hardware emergency stop”** at the front of the system.



The “**hardware emergency stop**” cuts power to the lights, the translation stage and the plate crane. The emergency stop is reset by turning and pulling the red button. After the emergency stop has been activated and reset, it is best to completely restart the software.

Please consider the following security notes:

- (1) While operating the plate crane, **keep clear of the rotating arm.**
- (2) **Wear protective glasses** when opening the imaging box with lights on. Especially the UV light can be potentially damaging.
- (3) Keep door closed during operations.



System Configuration

The Configuration Dashboard provides further control over internal system parameters.

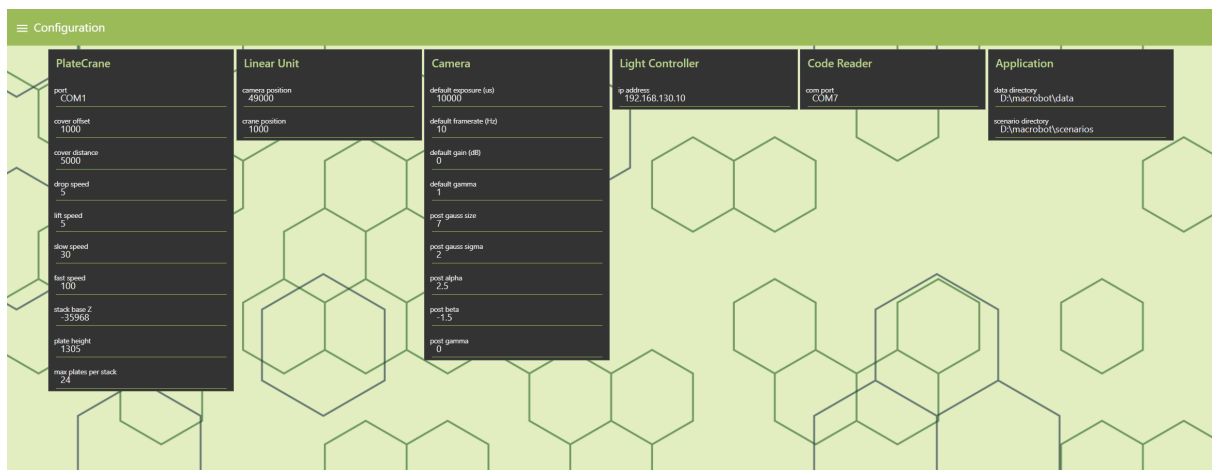


Plate Crane	Description
port	COM port for communication with plate crane
cover offset	Number of steps to move up when grabbing the lid to lift the plate cover
cover distance	Number of steps to raise the lid when lifting the plate cover
drop speed	Speed when dropping the plate cover
lift speed	Speed when lifting the plate cover
slow speed	Speed value for slow operations
fast speed	Speed value for fast operations
stack base z	Number of z-axis steps that represent the stack base
plate height	Number of z-axis steps that represent the height of a plate
max plates per stack	Maximum number of plates per stack

Linear Unit	Description
camera position	Step motor position for camera-position on translation stage
crane position	Step motor position for crane-position on translation stage

Camera	Description
default exposure	Default exposure time (microseconds) used in scene at startup
default framerate	Default framerate (Hz) used in scene at startup
default gain	Default gain (dB) used in scene at startup
default gamma	Default gamma value used in scene at startup
pos gauss size, post gauss sigma, post alpha, post beta, post gamma	Parameters for camera image handling, please use default parameters as given – do not modify

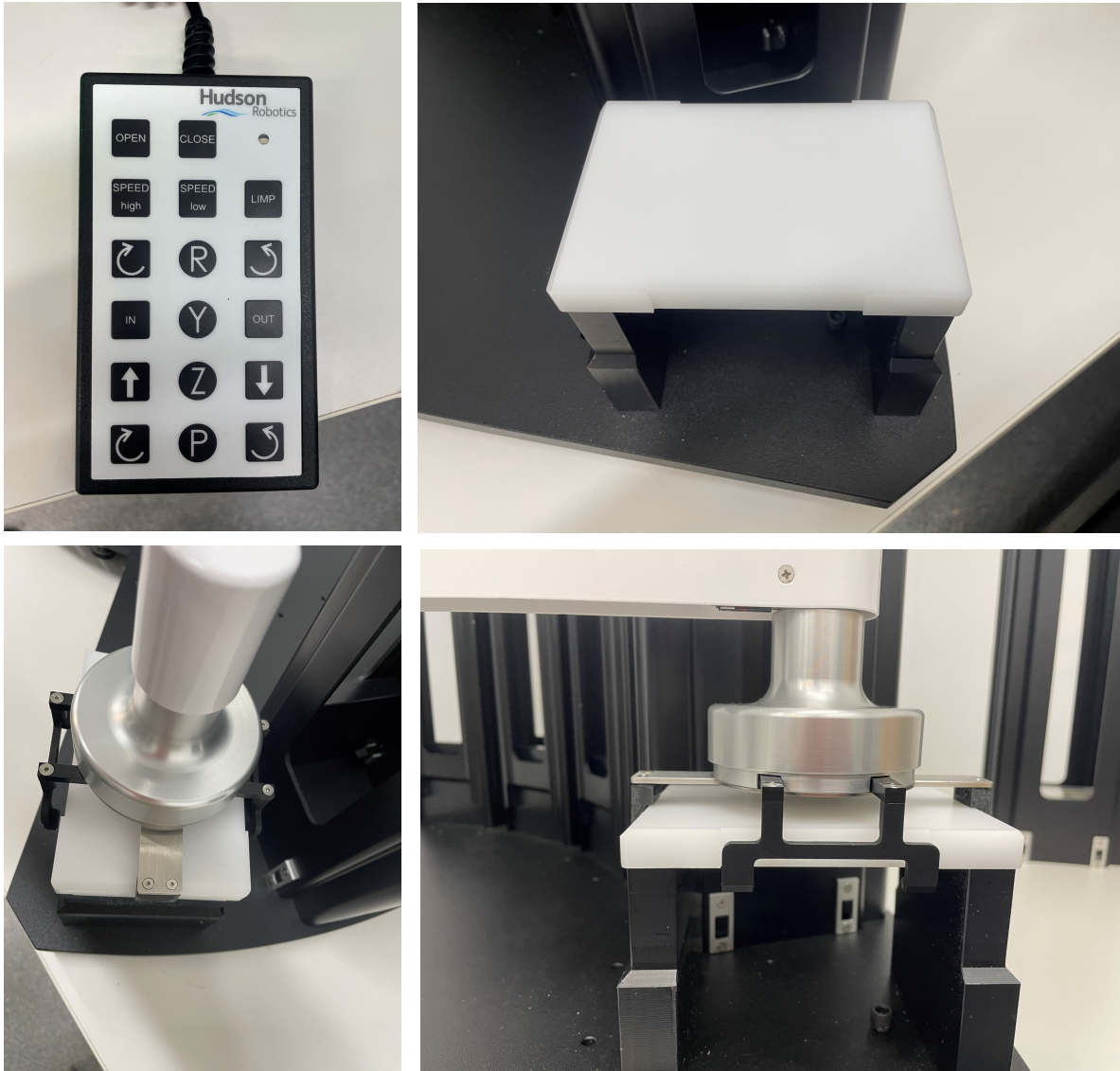
Light Controller	Description
ip address	IP address of the system's LED controller

Code Reader	Description
com port	COM port for barcode reader

Application	Description
data directory	Directory (folder) for storing sampling data
scenario directory	Directory (folder) for storing scenario descriptions

Calibrating the Plate Crane

In case there is a persistent problem with the correct placement of the plates on the tray or in the stacks, e.g., dragging of the plates on the stack metal, the pre-defined positions of the plate crane should be readjusted. This can be achieved by using the plate crane remote control supplied. Please plug the remote control into the socket on the back of the plate crane.



A white teaching plate is supplied with the plate crane to help calibrate the stack base position.

Please follow the steps below:

- (1) Switch off motor control on the plate crane by pressing “**LIMP**” on the crane remote.
- (2) You can now move the crane freely, but the position of the crane is still tracked and can be checked in the “**Manual Control**” dashboard.
- (3) Move the plate crane to the position (**STAGE** (on carrier) or **STACK1-5**) which you want to recalibrate. Use the teaching plate as reference for the **STACK1-5** position or a real plate for calibrating the **STAGE** position on the carrier.
- (4) When correctly positioned, update the displayed position by pressing “**GET POSITION**” in the “**Manual Control**” dashboard. This will show the current step position of the **R, Z, Y, and P** axes.

(5) Find and open the following text file (please create a backup first):

D:\software\flows\config\macrobot_positions_white.txt

```

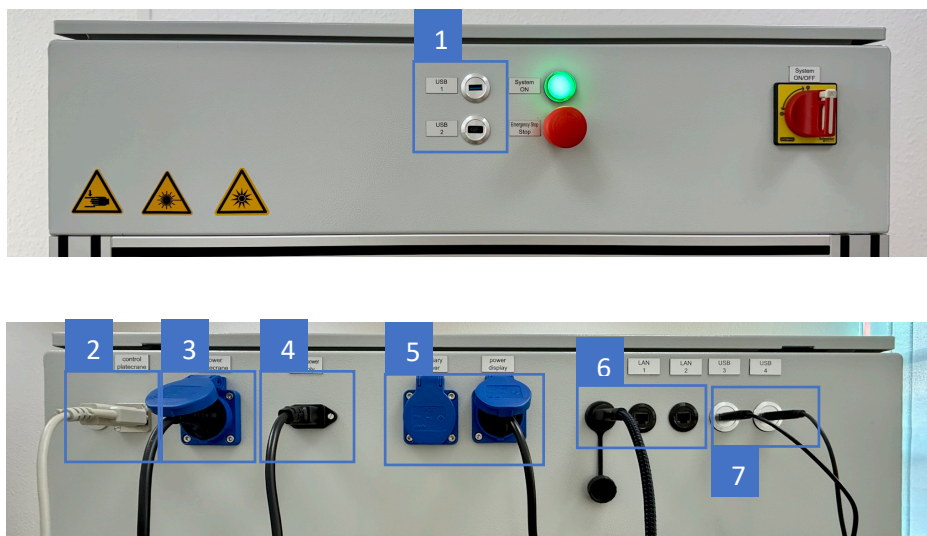
1:TEMP, 0, -2, 0, 0
2:STACK1, 27797, -34470, 5360, 523
3:STACK2, 45386, -34470, 5379, 543
4:STACK3, R 24, Z 470, Y 83, P 8
5:STACK4, 80643, -34470, 5391, 543
6:STACK5, 98233, -34470, 5382, 543
7:PARK, 70000, -36050, -400, -6000
8:STAGE, 239936, -23226, 1519, -2653
9:ROTATE, 0, 0, 5540, -5900
    
```

(6) Change the parameters for either of **STACK1-5** or **STAGE** (on the carrier) position. The values are in the order of **R, Z, Y, and P**.

(7) Please do not change Z positions for any of STACK1-5 or STAGE!

Once saved, restart the software to load the new predefined positions into the system software. Test the adjusted positions. Consider using the “**GO STEPS**” function to fine tune the positions.

System Hardware Ports



Item	Description
1	Front-facing USB ports connecting to the system computer [USB-A (1) and USB-C (2)]
2	Serial connection for plate crane
3	Power supply for plate crane
4	Power supply for the overall Macrobot system
5	Two additional power outlets, e.g., for computer display
6	HDMI connection for system computer (display) Network ports connecting to system PC [LAN (1) and LAN (2)]
7	Two additional USB ports [USB-A (3), USB-A (4)]

Troubleshooting Guide (online)

Even in carefully designed scientific instrumentation, occasional technical issues or unexpected behaviour can occur due to the complexity of hardware, software, operating conditions, and third-party components.

An online Troubleshooting Guide is intended as a continuously expanding knowledge base for users of the COMPOLYTICS® Macrobot NextGen platform. It summarises known issues, possible causes, and recommended solutions identified through internal testing and user feedback.

Macrobot Troubleshooting Guide
https://compolytics.com/macrobot-troubleshooting-guide

The guide will be updated regularly as new observations, improvements, and software updates become available.

Notes

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