

RootCam GFP Manual

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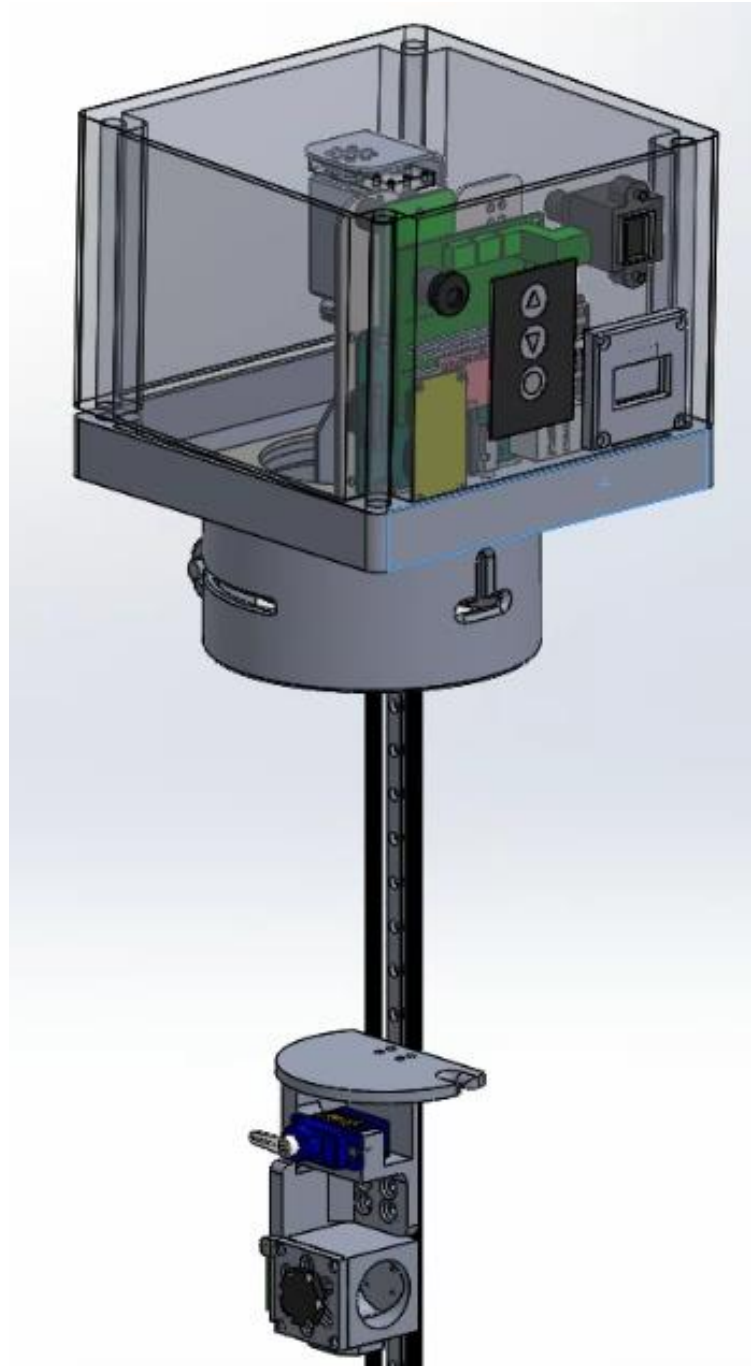
mechanical – rotating sled.

software version – 32

version - 4

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1 – Introduction.

RootCam is a state-of-the-art minirhizotron device designed for monitoring plant roots in situ. By using a transparent tube RootCam captures detailed images of roots.

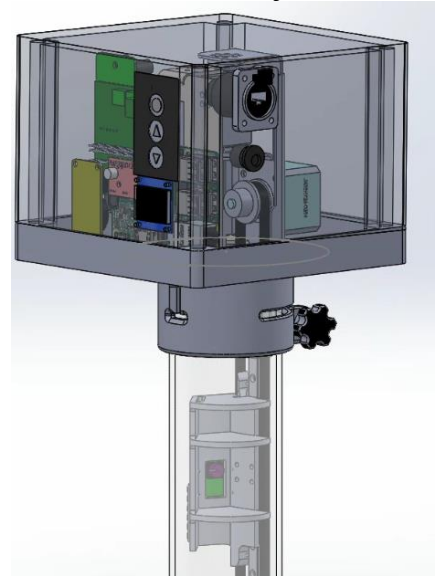
Camera Movement: A small camera travels along the tube on a rail, capturing images every 20 mm with a high resolution of approximately 0.01 mm (2592 x 1944 pixels, 2500 DPI).

Image Storage: Images are stored on a Raspberry Pi device, which can be accessed via the internet or uploaded automatically to a cloud folder.

Power Supply: The system is powered by a 12V DC converter.

Remote Control: The Raspberry Pi allows for remote operation and control of the RootCam, including setting intervals and manual operation. A preview window aids in real-time adjustments.

RootCam allows researchers to investigate the roots rate of growth, resistivity to climate changes, nutrition changes and much more. RootCam slide can be rotated at up to 180 deg to get a stitched image of approximately 250deg of the tube surface. RootCam allows for 3 wavelength of light and acquires images using RGB format. Operating as a standalone or remotely controlled device RootCam uses a variety of settings to cater for different types of research.



2 – Installation.

Installing RootCam research device requires transparent Plexiglas tubes buried in the ground. Insert RootCam into the tube for an image acquisition session.

2.1 – Tubes installation.

RootCam requires a 100cm tube, external diameter of 60mm and internal diameter of 54mm. The tube bottom must be sealed to prevent moisture intake. Tube should be capped while RootCam is not inserted for the same reason.

Tubes can be installed in a variety of directions. Vertical, horizontal or any other direction.

If installed in a field we advise to dig a hole and install the tube filling the ground and pressing it lightly so roots can grow as close to the surface of the tube. Drilling a hole for the tube is optional however installing tubes in a drilled hole might leave air gaps which might prevent root growth.

2.2 – RootCam insertion.

RootCam should be inserted into the tube carefully as the camera and lights are exposed and fragile. Tighten the black knob to set RootCam's position. On the first insertion, mark RootCam's position using a marker in the upside down T on the side of RootCam's tube connector. On the following sessions align the marking to get to the same position.

3 – Operating.

Standalone operation requires connecting RootCam to a power source. When the Oled screen is lit RootCam is ready. Press the down button to trigger a photo cycle. If RootCam is stationary, set a cycle time to operate at preset intervals.

3.1 – Power.

RootCam requires a power source capable of sustaining 12Vdc at 5Amp. A lower grade power source may cause unpredicted behavior. Please consult CrystalVision if you change the power source.

3.2 – Network and remote control.

RootCam is equipped with a Lan and WiFi networks.

If in standalone mode RootCam can operate without a network connection. RootCam will show on its Oled screen any network it is connected to as an IP number. If RootCam is connected to a network cable or WIFI and you can't see an IP number on the Oled screen please contact RootCam support for help.

There are two methods you can connect and control your RootCam from a computer or the network browser.

VNC: To connect to RootCam using vnc install the software from [realvnc](#). Set your computer to the same network on an available IP and connect using VNC you can find RootCam's IP number in the setting chapter.

Consult your setting doc for the user and password

Raspberry pi connect: to connect using raspberry pi connect, use your browser to go to <https://connect.raspberrypi.com/sign-in>. Find your RootCam by the serial number and sign in using RootCam's email. Using the (Connect via) button select Screen sharing. This method is in beta stage but it is the official Raspberry pi connection.

If you purchased RootCam with a built in modem you will need the help of one of CrystalVision staff to install a sim and set your network for you. Contact us at ofer@crystalvision.co.il

3.3 – Software.

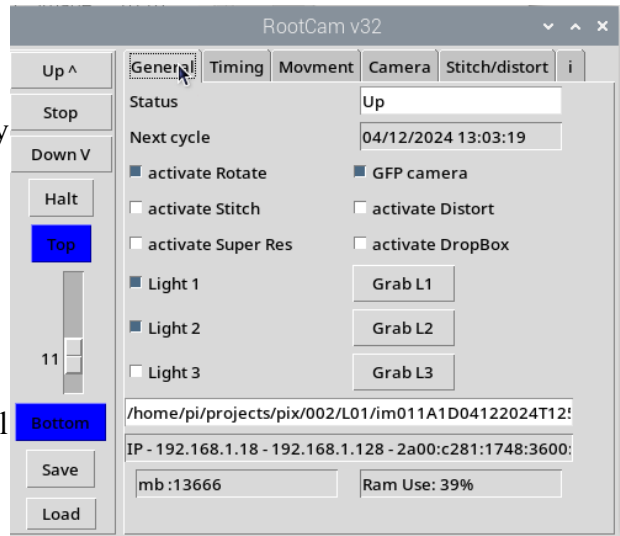
RootCam software consist of three windows. A terminal for the software low level, a preview window showing the image as seen by the camera and the user interface window.

3.3.1 – Main window (user interface).

RootCam's main window is divided into two parts.

A *constant panel*, showing the main operations and sensors.

And a *tabbed screen*, where each tab contains all the parameters of of this aspect of the camera.



Main operation constant panel.

Here you can find the status of your RootCam. The up, down and stop buttons correspond to the hardware buttons on the box. Pressing up will move the camera to the next image (do not use it when the camera is in a cycle).

Pressing the down button will start a cycle. The camera will move to the bottom position and start a photo session all the way to the designated top position.

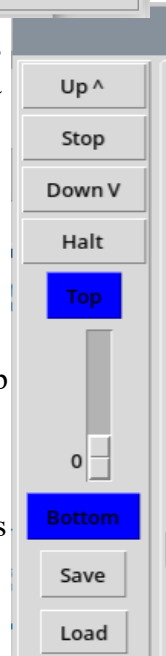
Pressing stop (as the name suggests :) will stop the camera. This might take a while if the camera is in the process of rotating.

Halt button will pause the camera allowing for maintenance if needed.

Pressing the halt button again will resume operation.

Top and bottom brackets will light in red if RootCam's camera reached the top or bottom position. When powered on, RootCam does not know its position. To orientate itself RootCam moves to the bottom position and reset the camera position to zero at the bottom.

Save and load buttons will save and load all RootCam's settings into a settings file.



The general tab:

The general tab shows RootCam main features and status. The Status bar will show RootCam's operating status and warnings. Consult this line first when you check for a problem.

You can find the next cycle (if you use the camera in a single tube) here.

RootCam's main features can be activated from the General pane: Rotate, GFP, Stitch, Super resolution, Distort image and upload images with Dropbox. To use Dropbox you will need your own account. Please contact Crystal Vision for details. The super resolution position will be shown if applicable.

RootCam support 3 sources of led lights. Although we now send our cameras with only 2 lights (white and UV) there is an option for a third color. Setting each light will acquire an image while the light is on. The buttons (GrabL1,2,3) will save an image instantly to the ManualPix directory on your RootCam file manager, lighting the image with the corresponding led light.

At the bottom of the panel you will find the amount of memory you can still use to store your images (Please consult this and move images to your computer as soon as possible as RootCam will stop its operation if memory is full) and a Ram usage.

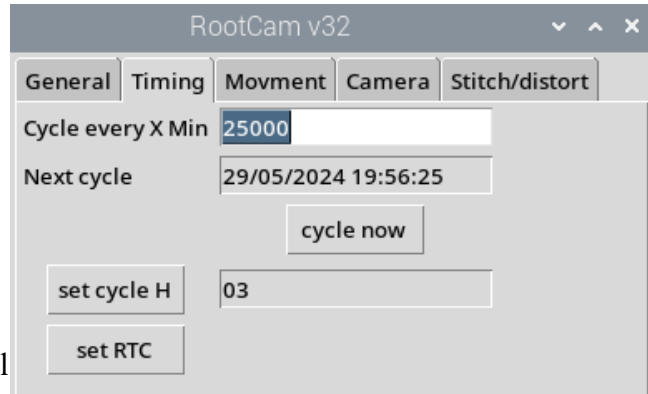


GFP – Green Fluorescent Protein – If you ordered a GFP camera it will use a set of light filters and a blue light to capture 2 types of images: an RGB image and an RGB image but only of the fluorescent light emitted by the GFP.

3.3.2 – Timing.

The Timing panel controls when will an image cycle start. You can set the number of minutes between every cycle and check when is the next cycle. The “Set cycle H” button will set RootCam’s next cycle to 3am for a midnight no light cycle.

The “set RTC” buttons will activate a software application to set the raspberry pi’s external real time clock. To set it move to the terminal black window where you will have to fill the year, date, hour and minute, each with 2 digits. At the end of the process you will see a confirmation message.



3.3.3 – Movement.

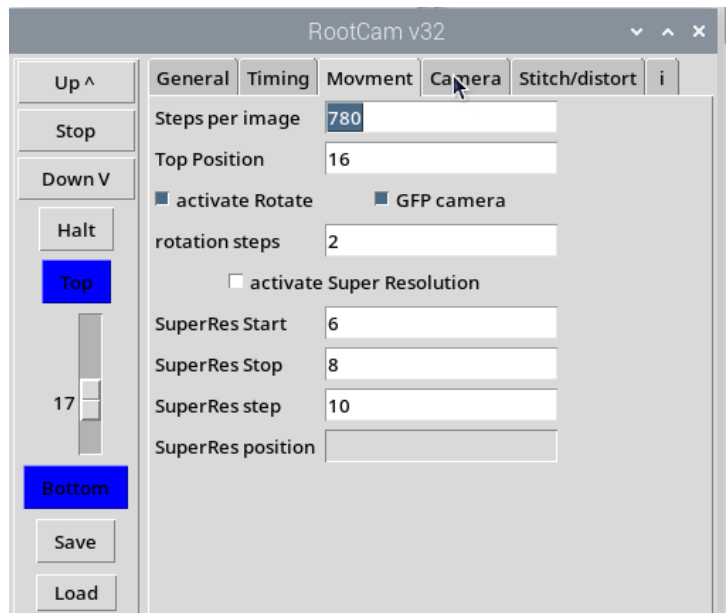
The movement panel allows RootCam users to calibrate image acquisition distances. Please save these settings if you intend to change them as they are set for each camera specifically.

Steps per image sets the number of steps the stepper motor moves up between 2 images. This allows for image overlap if needed.

Top position is the last image in the column RootCam will acquire. It is not necessarily the highest position RootCam can get because most users leave at least 20cm of tube outside the ground.

You can activate the rotation function from here and RootCam will calculate the rotation degree according to the number of steps you indicated. This means that if you asked for 3 rotation steps, RootCam will acquire an image at 0 degrees, 90 degrees and 180 degrees.

If this is a GFP camera set it here. This will set rotation to 2 automatically. Images will be sent to the L02 directory.



Super resolution.

In this panel you can activate the super resolution feature of RootCam. This allows Root cam to acquire images that overlaps each other and lend to certain algorithms the ability to get even more precise image using data from multiple images.

SuperRes Start Sets the position of the first image, *SuperRes Stop* sets the last image. *SuperRes step* sets how many steps within an image will RootCam acquire. On this example root cam will acquire:

images from position 6 to 8 (3) * 10 images per position * 5 rotation steps = **150 images**
use this option supervised as RootCam’s memory will fill out quickly.

3.3.4 – Camera.

The camera panel enables fine tuning the camera settings. You can see here the last image path and name. Control shutter speed, gain (all, red and blue). Set camera focus here and press “set camera” button to activate camera using these values.

To use the auto focus and white balance options of the camera:

- 1 - move the camera to your preferred location in the tube
- 2 - check the “auto” box.
- 3 - Press “GrabL1” button. Notice the change in the preview window.
- 4 - Check the image captured in manual pix directory to see if it is sharp and well lit.

Please make sure you are looking at the image in full resolution [1] as the image resolution is larger than the screen resolution.

5 – if all is well press the “camera status” button, this will set the current values to the corresponding settings.

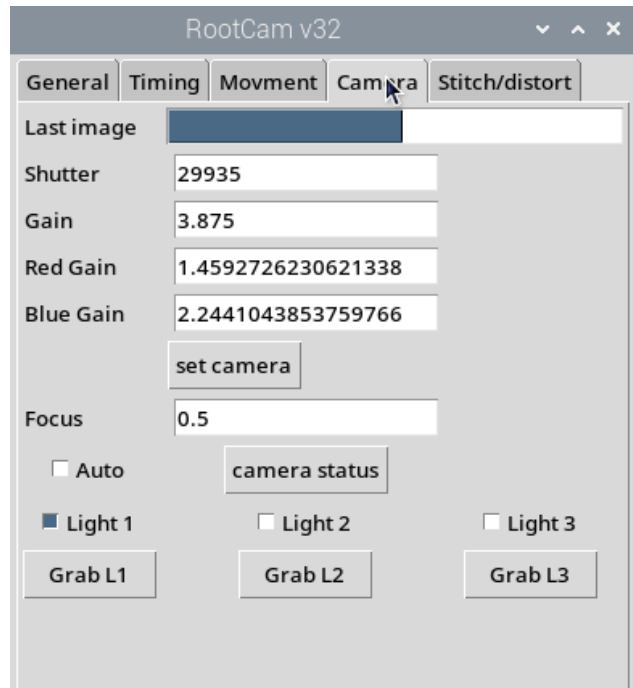
6 – save the new settings in the main pane,

please notice that using this option will set these lighting settings for all of the next images!

Checking the “light1,2,3” check boxes will save images using corresponding light in the next cycle.

Use “GrabL1,2,3” buttons to acquire an image using the corresponding light.

The “auto” checkbox is not saved and will reset to off every time RootCam is turned off.



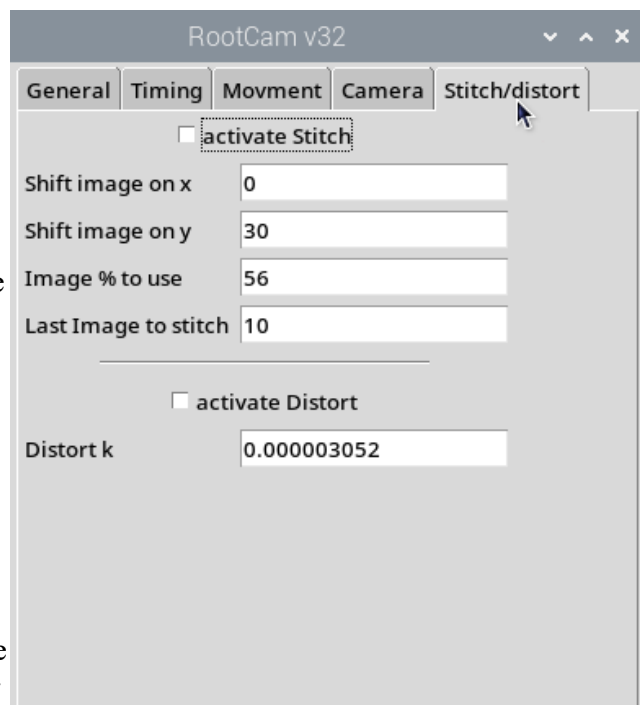
3.3.4 – Stitch/Distort

Activate the stitch option to get a single image of the roots in the tube. Stitch is not automatic. you need to set the number of steps in the movement panel and then determine the amount of overlap you use to get the correct image.

Shift image on x should be 0 but might be a small number (0-30) if the camera is tilted in the casing.

Shift image on y is a derivative of the steps per image (movement panel) as it decides the amount of overlap between two images on the y axes (bottom to top movement). increase if you see the same pixels twice, decrease if some parts of the image are missing.

Image % is used when you stitch with rotation. This determines the percentage of image used for stitching. It is calculated from the center



of the image so a 1000x1000 image using 50% will yield the image (250:0 to 750:1000). the image percentage is represented on the preview window as 2 faint vertical lines.

Distorting the image is not a simple task. The camera is located as far from the tube surface as we could to get a better field of view. To calculate the distortion we used [opencv](#) algorithm and it is not the optimal distortion. The variable you can control is the K variable. Use it at your own discretion. If you do find a better algorithm please let us know.

3.3.5 – **Image preview.**

The image preview window shows the image the camera sees at the current moment. Most of the time it will be black as there is no light in the tube. While on cycle you can see the image. please note that this is a small window and the acquired image will have much more details. Open the images from their directory (double click) then use the [1] icon to get the full resolution.

This image can be In a floating window (for sci camera) or in a dedicated tab for usb cameras.

3.3.6 – **Terminal.**

On your screen you will see a terminal window. It is where the application is running. Some actions are recorded in it and it is helpful in case of errors. If you encounter a problem do not forget to add a picture of the terminal to your report. Setting the real time clock is done through the terminal.

4 – Maintenance.

RootCam rarely need any mechanical maintenance. The most common source for problems is failing to move your images from the raspberry pi to your computer. Please do that regularly. As every delicate electronics device RootCam might fail because of a loose wire. Please check wiring if you encounter a problem.

WARNING: do not update raspberry pi software.

RootCam depends on several python libraries. Updating the raspberry pi through the automated process might brake the links between these libraries and render RootCam useless!

4.1 - File system.

RootCam is operated from the raspberry pi file system.

The common folder is /home/pi/projects. This is where the application resides. Please do not change it!

Here is the file tree form:

```
/home/pi/projects      #main folder
  Doc                  # where this file dwells
  FindRoot             # some python algorithms to search for roots in an image
  gpiotest             # software redundancies
  ManualPix           # images you aquired using GrabL1,2,3 buttons
    L0                 # those images in light 1 – normally white
    L1                 # UV Light
    L2                 # images with no light – unless you ordered a 3 light RootCam
  pix                  # images acquired in a regular cycle
    001                # cycle number 1
    002                # cycle number 2
      L0               # images of light 1 – normally white – of cycle 2
      L1               # UV light
      L2               # images with no light
    003                #cycle number 3 – you get where it is going :)
```

image file format is as follows :

im001A0D06052024T105813.jpg where:

im is a prefix

001 – height from bottom of tube.

A0 – step of rotation. Divide 180 by rotation steps to get angle if you need.

Dddmmyyyy – date of image day month year.

Thhmmss – time of image hour minute second.

4.2 – Uploading/downloading.

RootCam uses Raspberry pi as its computer. To get your file into a windows computer use WinScp to connect to the Ip of your RootCam and move your files. Please go to <https://winscp.net/eng/index.php> and download the program. Here is a simple explanation: https://winscp.net/eng/docs/task_download.

4.3 – DropBox.

RootCam is capable of transferring your images as soon as they are acquired to your DropBox account. if you need this option please state it when you order your RootCam so we can enable it and set you with the account. Please contact ofer@crystalvision.co.il as early as possible.

4.4 – Raspberry Pi connect

to control RootCam from any web go to <https://connect.raspberrypi.com/devices> and sign in using your email and password (located in section 5). select your device and connect via screen sharing.

5 – your settings.

Your settings can be found in the directory /home/pi/projects/Doc in the file [RootCam settings.docx](#)

notes