Documentation for the remote usage of the installed H-alpha camera at the wsg

December 2023

1 Introduction

This Documentation describes the remote usage of a QHY5III 200M camera[1] connected to a Raspberry Pi and a Coronado H-alpha solar telescope[2]. Following the steps of this documentation it is possible to automatically capture pictures of the sun in the H-alpha wavelength range and access those image from a shared folder in the network.
Together with this documentation comes a folder called `Webcam1` with all necessary files to run the CMOS-camera on a Raspberry Pi.

For questions about this documentation you can contact: bbrack@student.ethz.ch

2 Remote access to the raspberry pi

1. To access the Raspberry Pi, it needs to be turned on manually (the easiest way to do so is to plug out and in the power cable of the raspberry pi). The raspi is currently located at the wsg as you can see in Fig. 1

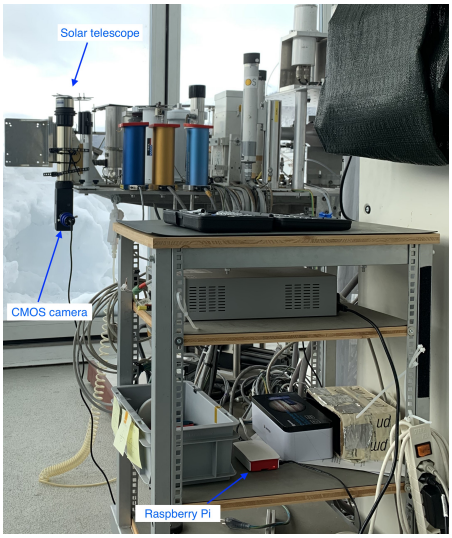
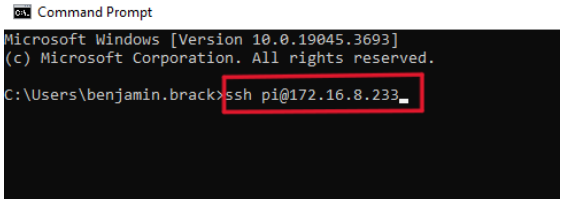


Figure 1: The setup of the Solar telescope with the attached CMOS camera which is connected to the Raspberry Pi. If you want to look through the solar telescope by eye there is an eyepiece located next to the raspberry pi which you can swap with the camera.

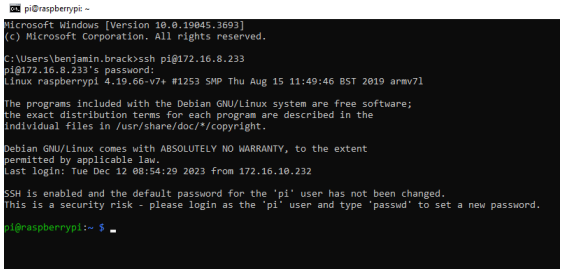
[1] Camera manual: `https://www.qhyccd.com/qhy5iii200m/`
[2] Telescope manual: `https://www.meade.com/downloadEntityFile/assets/product_files/instructions/14-2686-40_PST_20211008.pdf`

2. Open a terminal on a computer which is connected to the network and enter the following command [3] [4]:

```
ssh pi@172.16.8.233
```



3. If you access the raspberry pi for the first time it will ask you if you trust the connection and you will need to enter: `yes`
4. Enter the password: `raspberry`
5. Now you will see the terminal of the raspberry and can access it remotely from your computer.



3 Configurating the raspi

3.1 Webcam1 directory

The most important directory on the raspi is the directory `Webcam1`. It needs to be located at `/home/pi/Schreibtisch/Webcam1`. You can test that by entering the following command after login: `cd Schreibtisch/Webcam1`. If you don't get any error message it means that you have entered the `Webcam1` directory. With the command `ls` you can then see the content of the directory. If the `cd` command does not work, you need to setup the `Webcam1` folder at the right place which is described in Section 5.1.

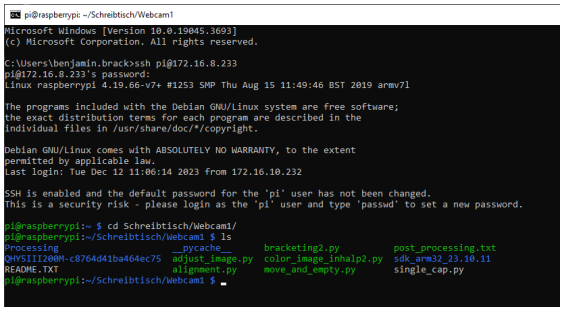


Figure 2: The content of the `Webcam1` directory which can be seen after entering it with the command `cd Schreibtisch/Webcam1/` and then inserting `ls` into the terminal.

[3] If you connect the raspi with another internet port, the ip address will change. You can get the new ip of the raspberry pi by connecting it to a screen and typing in the following command in the raspi terminal: hostname -I

[4] To access the raspi after turning it on, you will need to wait approx. 2 min until you can access it remotely.

3.2 Shared Folder

To access the captured pictures from the network a shared folder needs to be initialized. The QHY5III200M-c8764d41ba464ec75 folder should already be a shared folder and you can access it by entering the following command into the Network:

```
\\raspberrypi\Sun_Images_ha
```

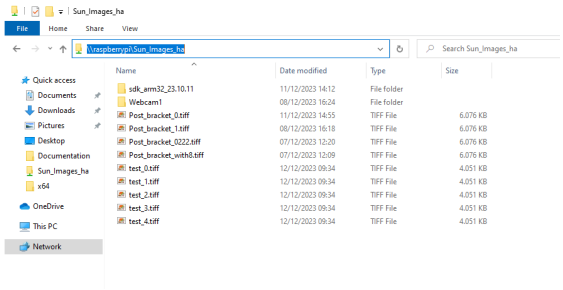


Figure 3: To access a shared folder on a Windows computer, go to the Network in the File Explorer and enter the command `\\raspberrypi\access_name`. How to setup such a folder is shown in the next steps.

To create or change the settings of a shared folder you can follow these steps:
1.Access samba with the command[5]:

```
sudo nano /etc/samba/smb.conf
```

2. Scroll down to the end of the file and insert

```
[Sun_Images_ha]
   comment = Shared Folder
   path = /home/pi/Schreibtisch/Webcam1/QHY5III200M-c8764d41ba464ec75
   read only = no
   browsable = yes
   guest ok = yes
   force user = pi
```

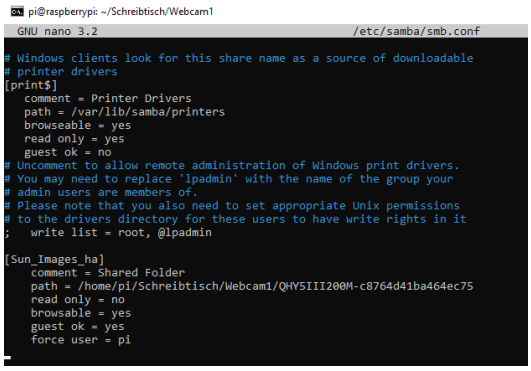


Figure 4: Example of a shared folder with access name: `Sun_Images_ha` and the path where it is located on the raspberry pi. To create another shared folder you can just copy paste this folder and change the access name as well as the path to the folder you want to share.

3. To change the access name change the interior of [...] and with path = ... you can choose which folder on the raspberry pi you want to share.

[5]if samba is not yet installed you can run: `sudo apt update && sudo apt install samba` and after that retry with step 1.

4 Handling the camera

4.1 Most important scripts

The main scripts are the `post_processing.txt` and `set_focus.py`. Both files are located in the `Webcam1` directory and can be run via the commands

`python3 post_processing.txt` | `python3 set_focus.py`

4.1.1 `set_focus.py`

If the focus of the camera is not set correctly you can use this function to try to find the best focus. In order to do that, you need to be in the `Webcam1` directory and run `python3 set_focus.py` The program will then capture a picture every 3 seconds and save it to the shared folder `\\raspberrypi\Sun_Images_ha` under the name `focus_test.tiff`. When you open this image, it will reload every 3 seconds the new image over it. Now you can try to adjust the focus of the telescope on the small wheel of the telescope. It should not be necessairy to change the position of the focus ring on the CMOS-Camera.

If the sun is over or underexposed you can access the program via the command: `nano set_focus.py` and then change the exposure time at the beginning of the document. An exposure time around 300 μs should be good.

To abort the program you can press: Ctrl + C.

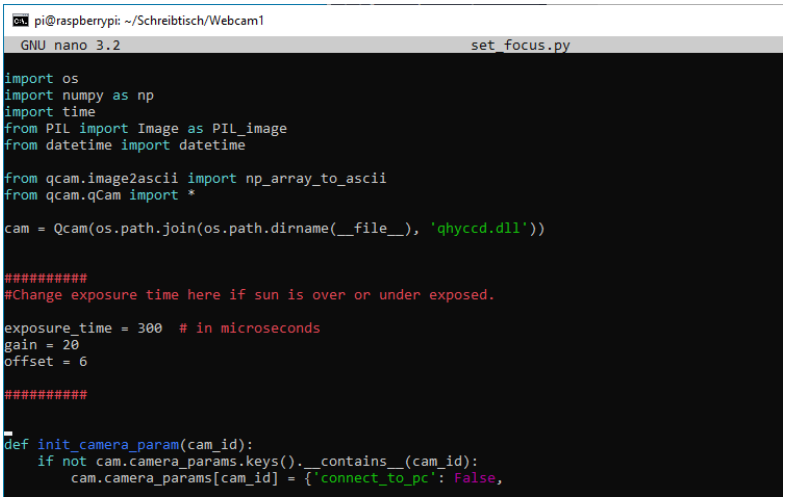


Figure 5: When you open the set_focus.py file with the command `nano set_focus.py` you will see within the red hashtags, that you can change the camera settings accordingly. To save the file enter Ctr + O and to close the file Ctr + X.

4.1.2 `post_processing.txt`

This function continuously captures 5 pictures of the sun between a minimum exposure time and a maximum exposure time, aligns them to each other and merges the pictures together to create a HDR image. The gray scaled HDR image is then colored in red and can additionally be adjusted. The final image is saved in the shared folder `QHY5III200M-c8764d41ba464ec75`, which can be accessed from the network. The interval between such an exposure series is set to 60 seconds. To adjust one of the used parameters you can access the file with the command:

```
nano post_processing.txt
```

Where to find the values: At the beginning of the `post_processing.txt` script there is an explanation on which exact line you can change the parameters.

Exposure time: is an `np.linspace(min, max, n)` array with

- min = minimum exposure time in μs
- max = maximum exposure time in μs
- n = number of frames per exposure series

Remark: Usually with an exposure time interval between 200 - 3000 μs you should be able to see the structure on the surface of the sun as well as the prominences on the edge of the sun. But depending on the filter setting more/less light enters the telescope and you need to shift the interval to lower/higher values. The exposure time can be set from $15\,\mu s - 900\,s$.

Offset & Gain: Both can be set to integer values (offset $\in [0 - 255]$ and gain $\in [0, 1258]$). An offset of 6 was found to be ideal to get the best dynamical range. I did not examined the gain much but I think a low value is better than a high gain, as we have less noise and we do not need to amplify the signal of the sun because it is already strong enough.

Adjust Brightness, Exposure, Contrast of the final image: The values for these three parameters can be set between [-100,100], where the value 0 means no change at all. To get a more beautiful picture you can increase the contrast a little whereas decrees the brightness and exposure to a value around (contrast $\approx$ 70, brightness $\approx$ -10, exposure $\approx$ -30)

Change Path: To change the location where the final image should be saved you can adapt the path to your desired folder on line 47.

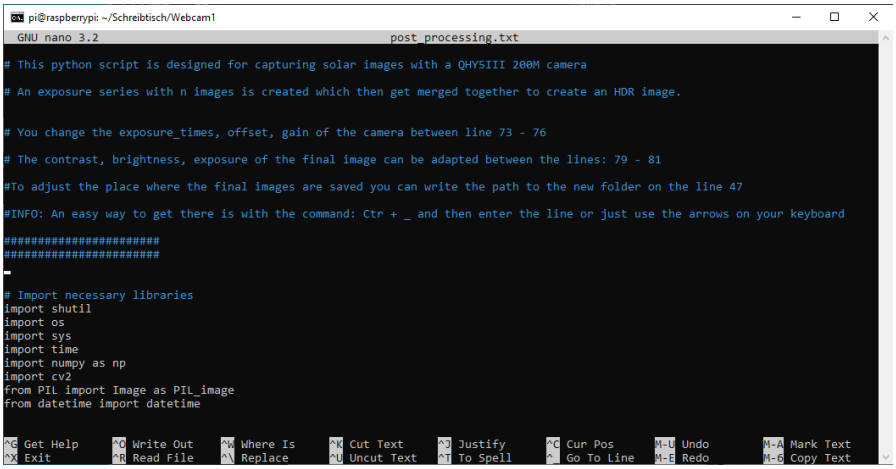


Figure 6: The explanation at the beginning of the `post_processing.txt` where you can change the main values.

5 Remarks

5.1 Setting up the `Webcam1` folder on a Raspberry Pi

To setup the `Webcam1` folder at the correct location first make sure that you are connected to the raspi which is shown in Section 2. You should be at the directory `pi (pi@raspberry)` in your terminal.Then you can follow these steps:

1. Enter the command: `ls`. If you see a directory called `Schreibtisch`, enter this directory via `cd Schreibtisch`. If you don't see such a directory, you can create a new directory with this name using the command: `mkdir Schreibtisch`.

2. Share the `Schreibtisch` directory according to the explanation in Section 3.2.

3. Now you can copy the `Webcam1` folder from your computer via the Network into the `Schreibtisch` directory where it should be.

5.2 Dust on detector

Unfortunately there is probably some dust on the detector.

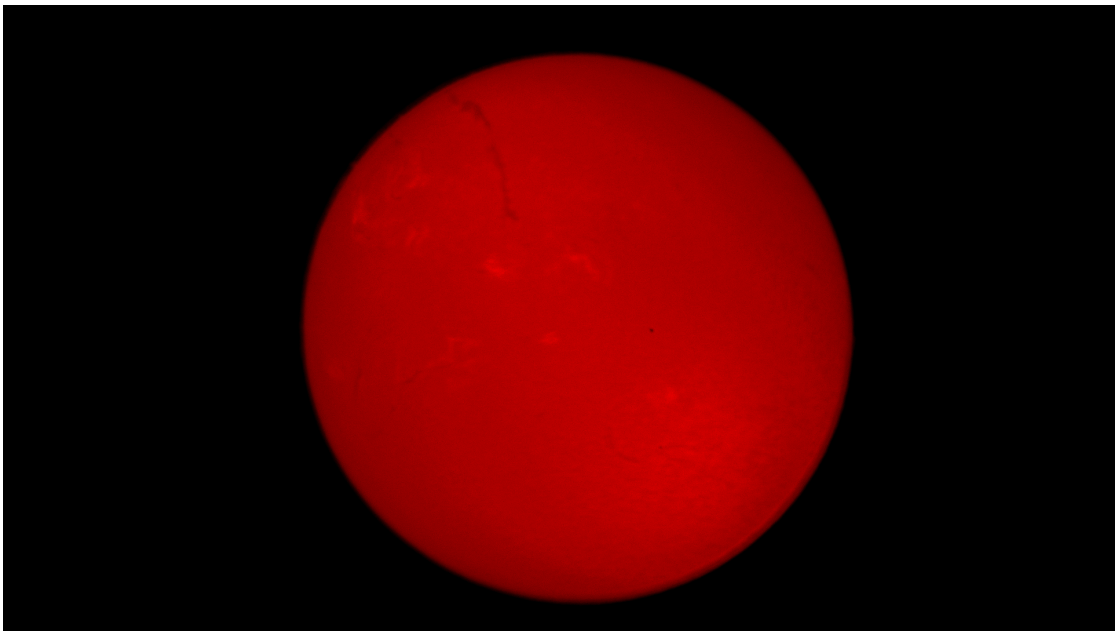


Figure 7: Picture of the sun taken with the setup described in this documentation on the 18.12.2023 at 13:00. The black spot slightly to the right of the center (around pixel values (1118,518)) is probably dust on the detector.

5.3 Transmission rate error

I tested the camera once to capture pictures for a longer time and after 36 min and 1 exposure series per minute (and therefore 36 successful images) the transfer rate of the camera only returned 0 intensity at all pixel values. I think this error could result from the fact that the camera is connected to an USB 2.0 port, however for a correct data transfer it should be connected to an USB 3.0 port. After rebooting the raspberry pi resp. disconnecting and connecting again the camera it worked normal again.