Camera Network Documentation

Release 1.0.0

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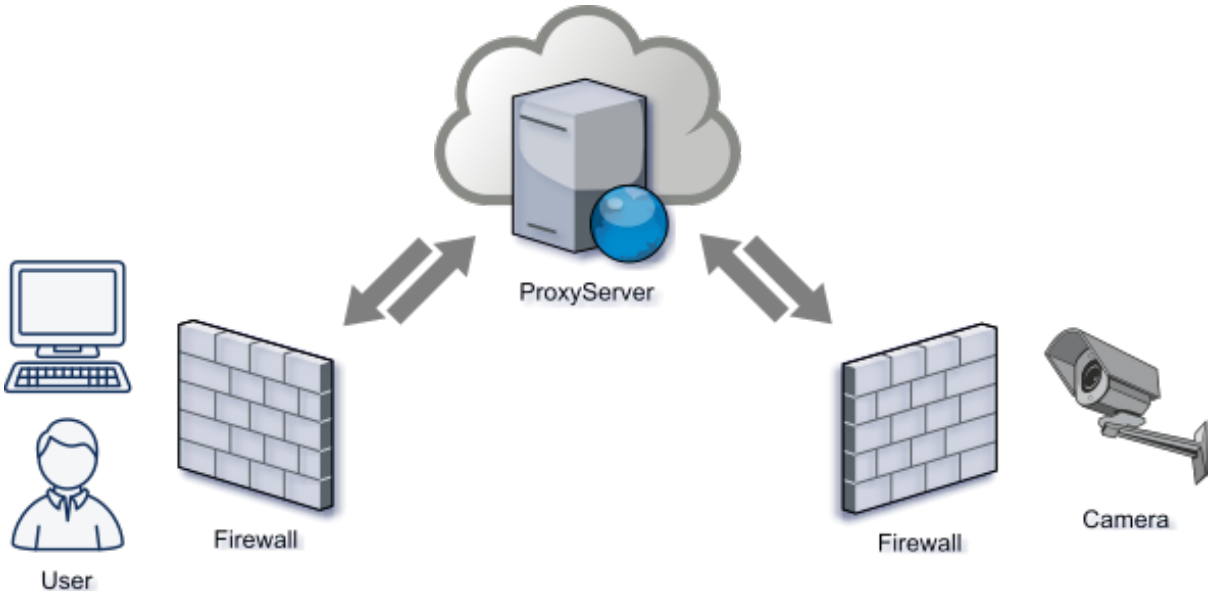
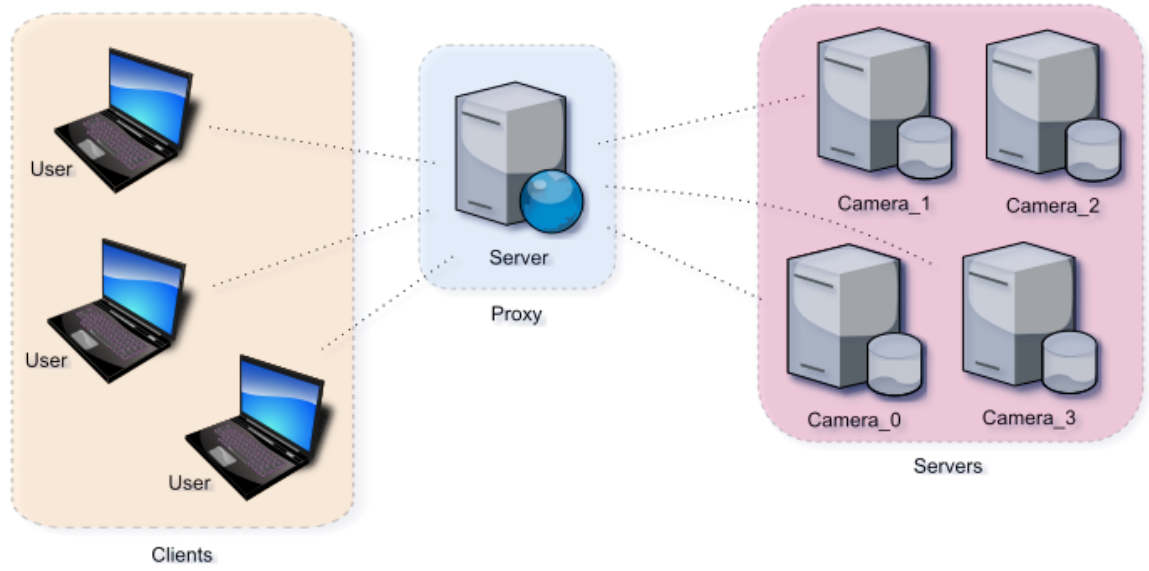
Contents

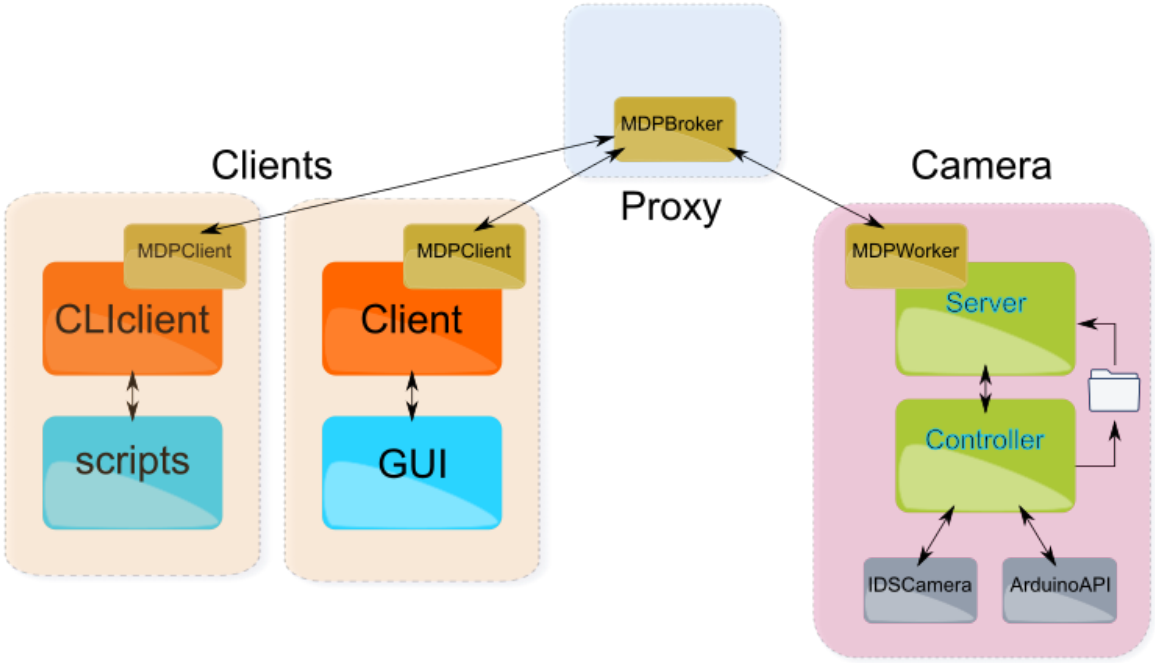
Contents:

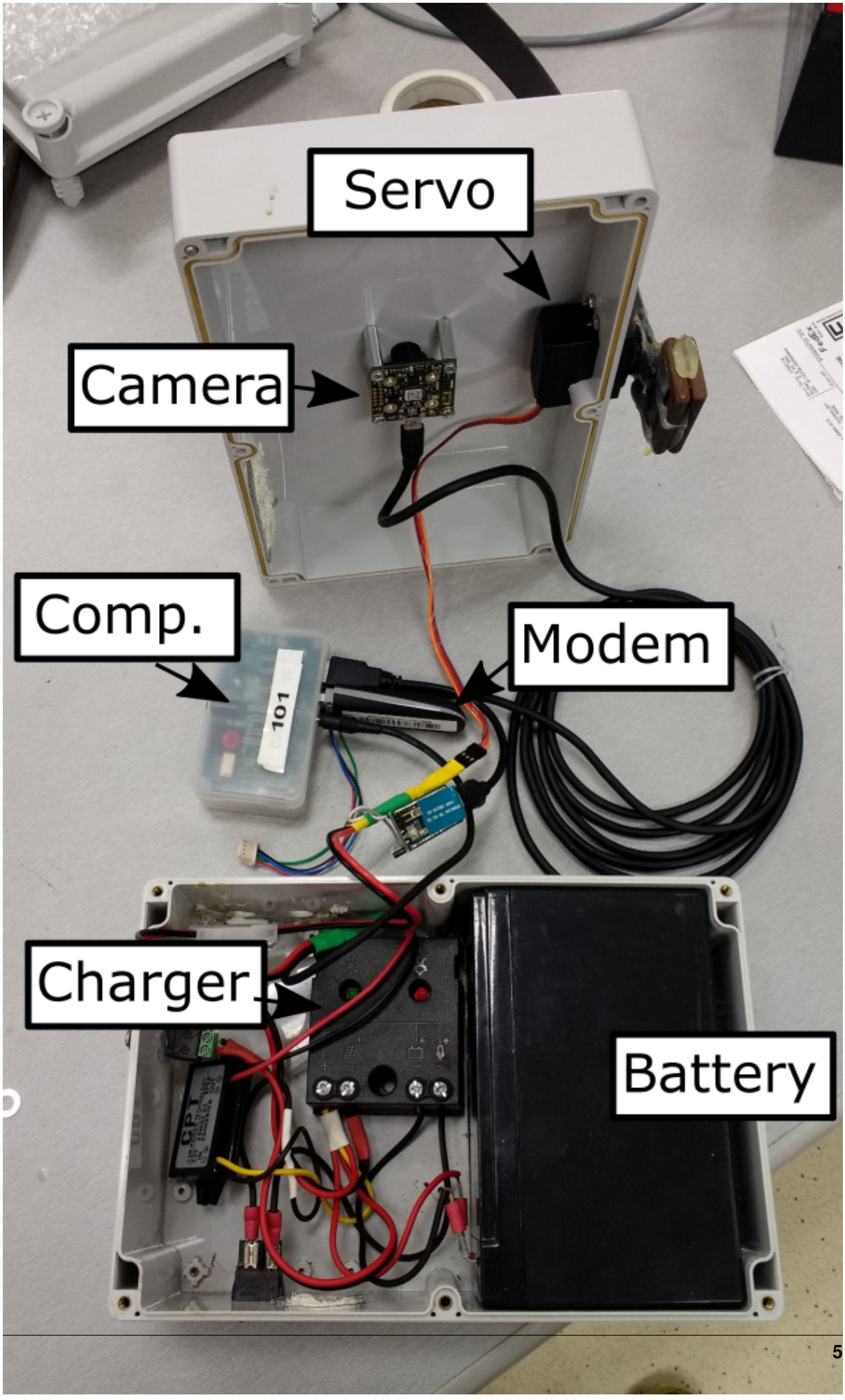
CHAPTER 1

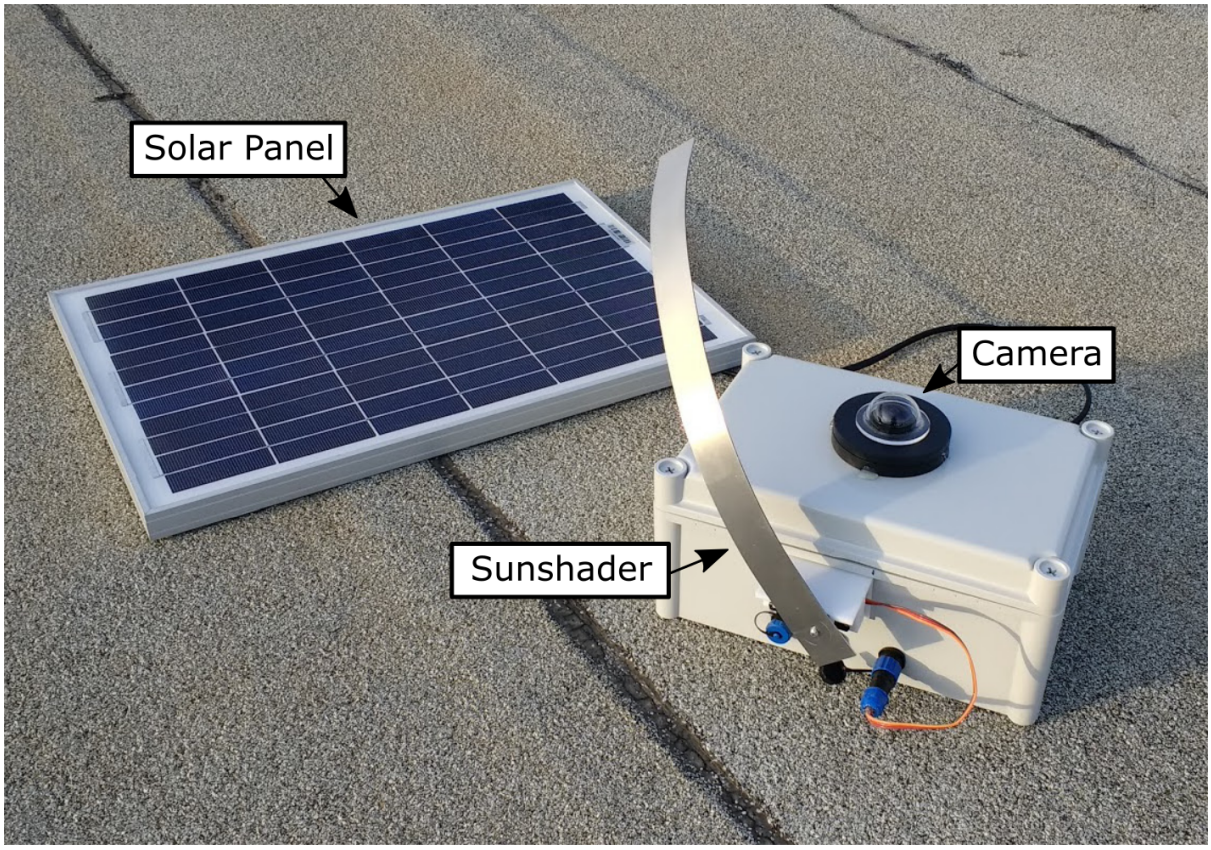
Introduction




User
User
User
Clients
Server
Proxy
Camera_1
Camera_2
Camera_0
Camera_3
Servers


MDPBroker
Clients
Proxy
Camera
MDPClient
CLIclient
scripts
MDPClient
Client
GUI
MDPWorker
Server
Controller
IDSCamera
ArduinoAPI


Servo
Camera
Comp.
Modem
Charger
Battery


Solar Panel
Camera
Sunshader

CHAPTER 2

Installation

Table of Contents

2.1 Installation

The `CameraNetwork` system is made of three logical parts:

1. *Server*: The camera unit. The server performs the actual measurements.
2. *Client*: A program that enables remote control of servers.
3. *Proxy*: A program that bridges and manages the communication between the *Servers* and *Clients*.

There can be multiple *Servers* and *Clients* but only one *proxy*.

The `CameraNetwork` package contains the code for both the *Server*, *Client* and *Proxy* subsystems. This simplifies the deployment and enables code reuse. The installation procedures is similar for the three components but differs due to the different platforms.

The `CameraNetwork` is implemented completely in *Python <http://www.python.org/>_*.

2.1.1 Installation - Client

1. Install conda. Tested on conda 4.7.11
2. Clone the cameranetwork package:

```
git clone https://github.com/Addalin/cameranetwork.git
```

3. Navigate to it:

```
cd cameranetwork
```

4. Create virtual env:

   LINUX: Create conda virtual environment from *cn_client_ubuntu18.yml*

```
conda env create -f cn_client_ubuntu18.yml
```

   Note: The first line of sets the new environment's name (currently *cn_client*)

   WINDOWS (exact procedure):

```
# Create new environment with name: cn_client

conda create -n cn_client --yes

conda activate cn_client

conda config --env --set restore_free_channel true

conda config --env --append channels conda-forge

conda install python=2.7 pip paramiko cython tornado=4.5.3 futures␣
↪numpy scipy matplotlib beautifulsoup4 scikit-learn scikit-image␣
↪pyside requests ephem pandas=0.19.2 ipython pyfirmata joblib pyzmq␣
↪enaml pillow traits pyqtgraph pyopengl vtk mayavi opencv git␣
↪mercurial



# pip install pymap3d, traits-enaml and pyfisheye
# Note, this installs pyfisheye without cloning it. For development of␣
↪pyfisheye clone and install manually from https://bitbucket.org/
↪amitibo/pyfisheye (TODO: migrate pyfisheye codebase to github)

python -m pip install pymap3d==1.1.1 git+https://github.com/enthought/
↪traits-enaml.git@update-data-frame-table  hg+https://bitbucket.org/
↪amitibo/pyfisheye
```

5. Activate the environment:

```
conda activate <venv_name>
```

6. Install the cameranetwork package

```
python setup.py develop --user
```

Note: without –user it installs the scripts for all users (Windows: C:ProgramDataAnaconda2Scripts)

7. Verify successful installation by opening the GUI:

```
python scripts_client/camera_client.py
```

2.1.2 Installation - Server

The server software is run on an Odroid U3 as at the time of selection it offered a unique balance between capabilities and cost. Nonetheless it should be straight forward to install the `CameraNetwork` package and its prerequisites on other platforms like newer Oroids and even on the RaspberrPi.

In the following we detail the procedure of installing the required prerequisites and main package. Note that once the package is installed on one computer, it is much more time effective to create an image of the Odroid memory card and duplicate it as needed.

2.1.3 Installation - Proxy

Currently the code assumes that the proxy server is run on an ec2 instance. Installation on the proxy follows the same steps of installation on the client.

Before running make sure to update in the global setting the ip address: DEFUALT_PROXI_PARAMS And make sure this is updated in all end units!

To run the proxy program, do:: python ./code/cameranetwork/scripts_proxy/start_proxy.py –log_level info

or

start_proxy.py

2.1.4 Installation - Calibration Station

2.1.5 Camera setup

2.1.5.1 Arduino connections

Savox SunShader Servo pins:

1. Brown (Gnd) = Gnd
2. Red (5V) = 5V
3. Orange (Signal) = PIN NUM

2.2 Installation - OLD

2.2.1 Prerequisites

To use *CameraNetwork* several software package are needed. This can be installed using the following commands. Copy paste these to a commandline:

```
> sudo apt-get install python-pip git mercurial screen autossh
> sudo pip install paramiko
> sudo pip install cython
> sudo pip install pyzmq --install-option="--zmq=bundled"
> sudo pip install tornado==4.5.3
> sudo pip install futures
> sudo apt-get install python-numpy python-scipy python-matplotlib
> sudo pip install beautifulsoup4
> sudo pip install sklearn
> sudo pip install skimage
> sudo pip install ephem
> sudo pip install pandas
> sudo pip install pymap3d
> sudo pip install ipython
> sudo pip install pyfirmata
> sudu pip install joblib
```

To install opencv3 follow a tutorial relevant to your system, e.g. on Odroid XU4 the following tutorial was usefull opencvsh_for_ubuntu_mate.

Install the python wrappers to the ids SDK:

```
> mkdir code
> cd code
> git clone https://github.com/amitibo/ids.git
> cd ids
> sudo python setup.py install
```

Install the pyfisheye module:

```
> cd ~/code
> hg clone https://amitibo@bitbucket.org/amitibo/pyfisheye
> cd pyfisheye
> sudo python setup.py install
```

Some platforms might require the installation of modem software:

```
> sudo apt-get install network-manager
> sudo apt-get install network-manager-gnome
```

The first instal *nmcli* (used for activating the connection). The second intalls *nmcli-connection-editor* used for defining the mobile network connection.

Install a recent version of usb_modeswitch (required on raspberryPi). Follow the usb_modeswitch tutorial. To compile the above code you will need to install the *libusb-1* dev files:

```
> sudo apt-get install libusb-1.0-0-dev
```

Prepare a device reference file from the following device reference file and run it using the command:

```
> sudo usb_modeswitch -c <path to device file>
```

2.2.2 CameraNetwork Installation

Download and install the package:

```
> git clone https://amitibo@bitbucket.org/amitibo/cameranetwork_git.git␣
↪cameranetwork
> cd cameranetwork
> python setup.py develop --user
```

Note: The first command downloads a *slim* version of the code that only includes the *Server* components.

To make the system start automatically at boot time, we use the *rc.local* script:

```
> sudo cp cameranetwork/scripts/rc.local/rc.local /etc/rc.local
```

Run the camera setup script to setup the camera environment.

> setup_camera.py

You will be asked for a camera id. Enter a unique camera id number.

2.2.3 Installing the Client

It is recommended to install python using the Anaconda distribution. Install the `CameraNetwork` package:

```
> git clone https://amitibo@bitbucket.org/amitibo/cameranetwork_git.git␣
↪cameranetwork
> cd cameranetwork
> python setup.py develop --user
```

2.2.4 Installing the Calibration Station

It is recommended to install python using the Anaconda distribution. Install the `CameraNetwork` package:

```
> git clone https://amitibo@bitbucket.org/amitibo/cameranetwork_git.git␣
↪cameranetwork
> cd cameranetwork
> python setup.py develop --user
```

2.2.5 Shubi reference

1. Create conda virtual environment:

```
conda create --name <venv_name> --no-default-packages
conda config --add channels conda-forge
conda activate cnvenv
```

2. Install prerequisites:

```
conda install python=2.7 pip paramiko cython tornado=4.5.3 futures numpy scipy␣
↪matplotlib beautifulsoup4 scikit-learn scikit-image ephem pandas ipython␣
↪pyfirmata joblib
pip install pyzmq --install-option="--zmq=bundled"
pip install pymap3d
conda install enaml pillow traits pyqtgraph pyopengl vtk mayavi opencv
```

3. Install additional modules:

```
pip install ephem
conda install -c anaconda pil
conda install -c anaconda enaml
conda install -c anaconda traits pyqtgraph pyopengl
conda install -c anaconda vtk
pip install mayavi
```

4. Install traits-enaml:

```
git clone https://github.com/enthought/traits-enaml.git --branch update-data-
↪frame-table
cd traits-enaml
python setup.py install
cd..
```

5. **Install the cameranetwork package**

    1. Navigate back to cameranetwork:

    ```
    cd ..
    ```

    2. Install the cameranetwork package:

    ```
    python setup.py develop --user
    ```

Note: without –user it installs the scripts for all users (Windows: C:ProgramDataAnaconda2Scripts)

CHAPTER 3

Calibrating the Camera Network

Calibration of the camera network is done in several stages. Part of it is done in the lab using a custom calibration setup. Another part is done in the field using the sunphotometer of the Aeronet system.

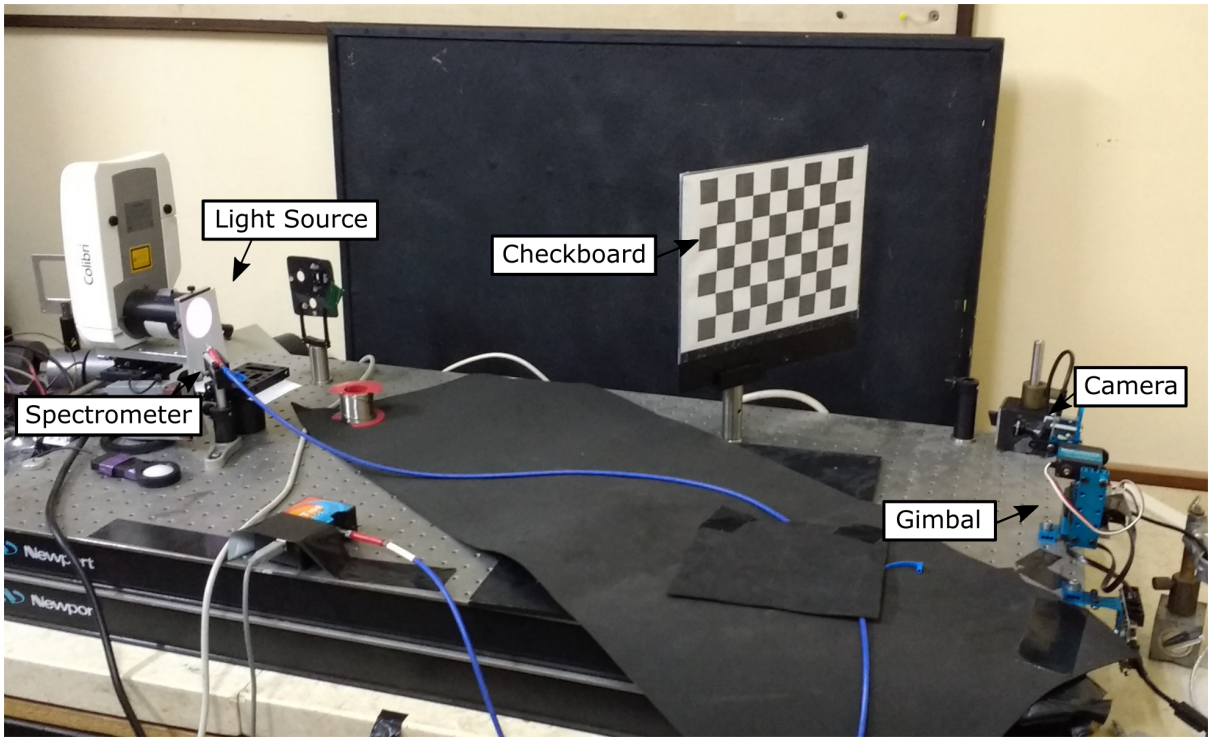


Fig. 3.1: Camera calibration setup.

3.1 Geometric Calibration

Geometric calibration is done

3.1.1 Intrinsic Calibration

Intrinsic calibration is done using a checkboard target and using the pyfisheye package which is based on the opencv fisheye calibration toolbox.

3.1.2 Extrinsic Calibration

Extrinsic calibration is the determination of the orientation of the camera in the global coordinates system. It is based on tracking the sun position.

3.2 Radiometric Calibration

Each camera is calibrated relation the a custom calibration setup (Figure **:num:‘calibration-setup‘**).

CHAPTER 4

Camera

CHAPTER 5

Using the Camera Network Package

Table of Contents

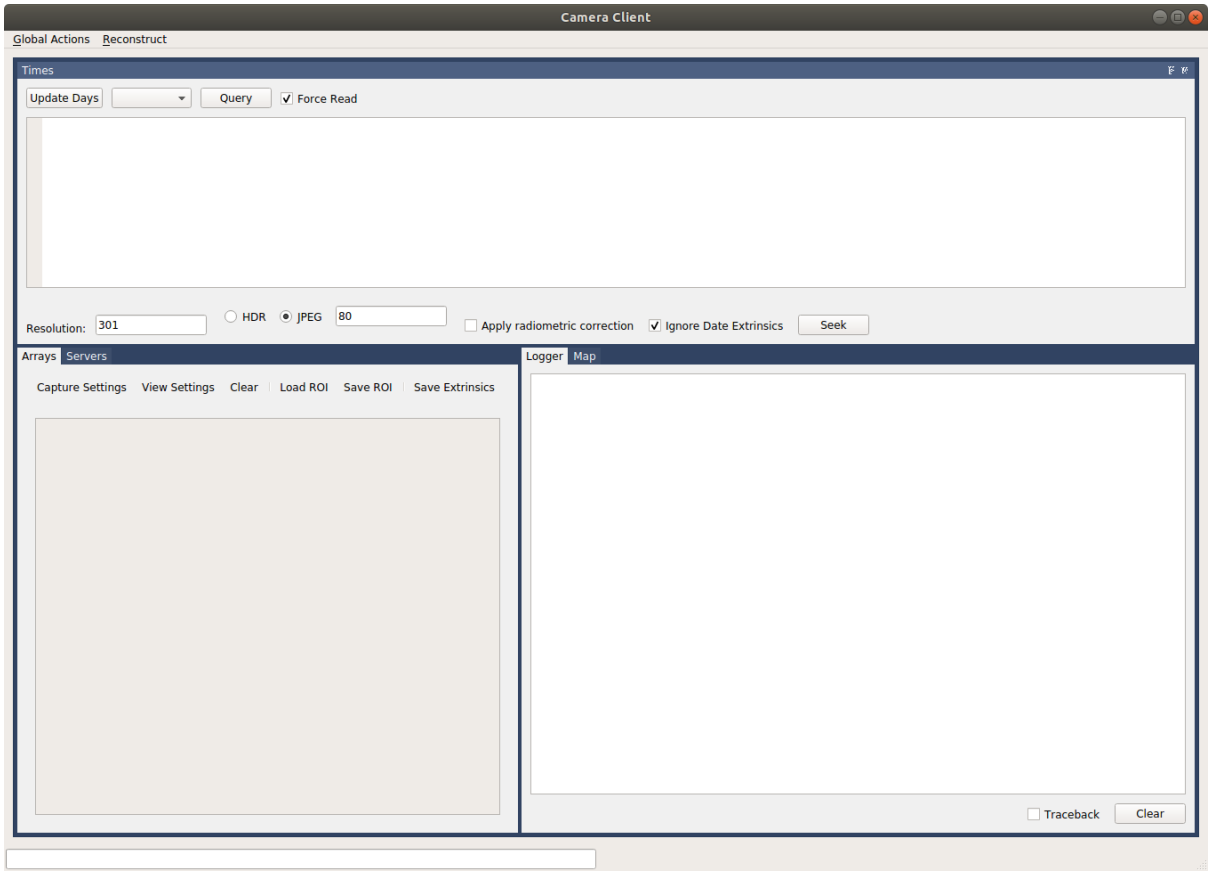
5.1 Client

After successful installation, start the Client GUI by navigating to:

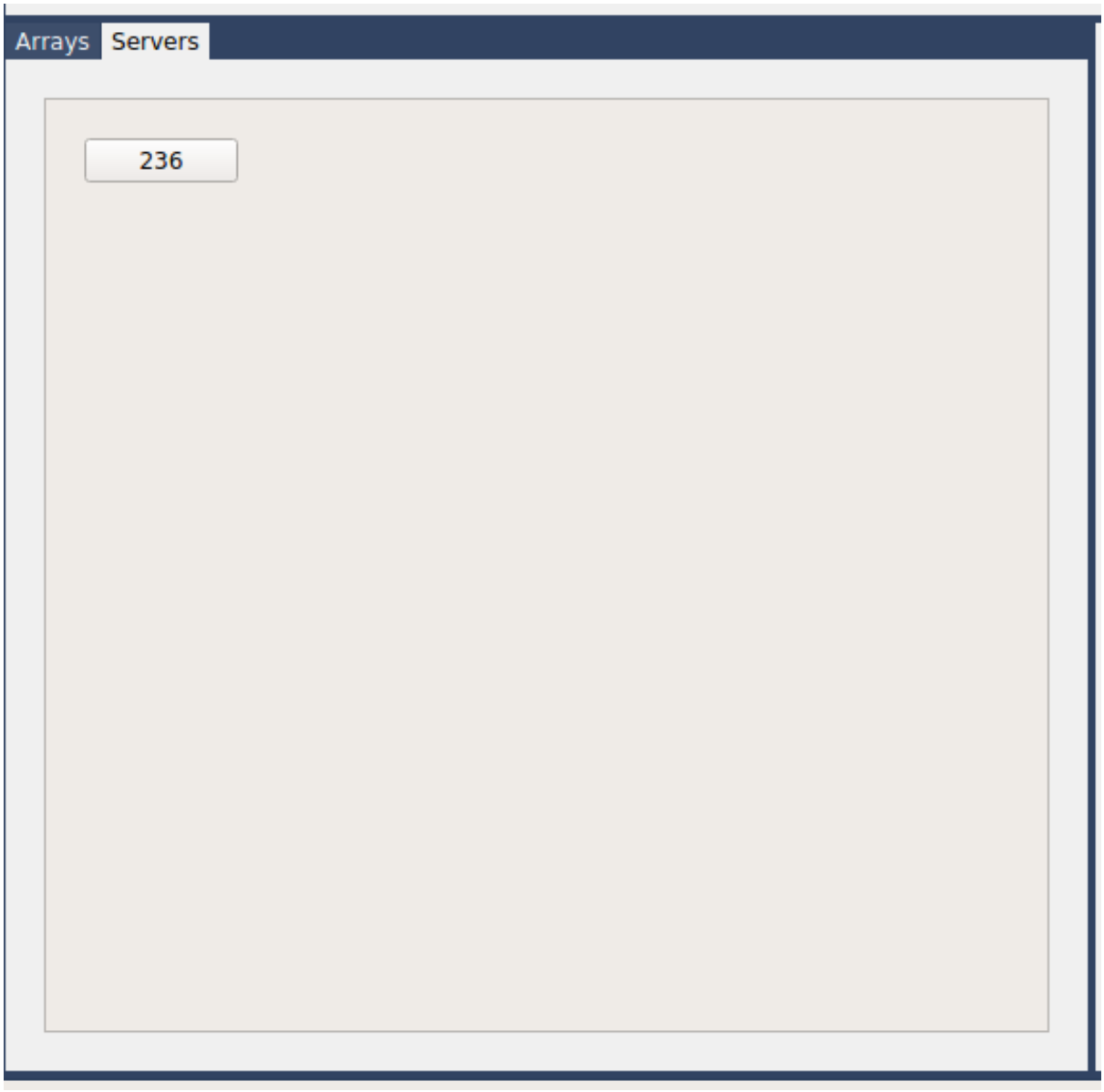
```
cd cameranetwork/scripts_client
```

then run `python camera_client.py`

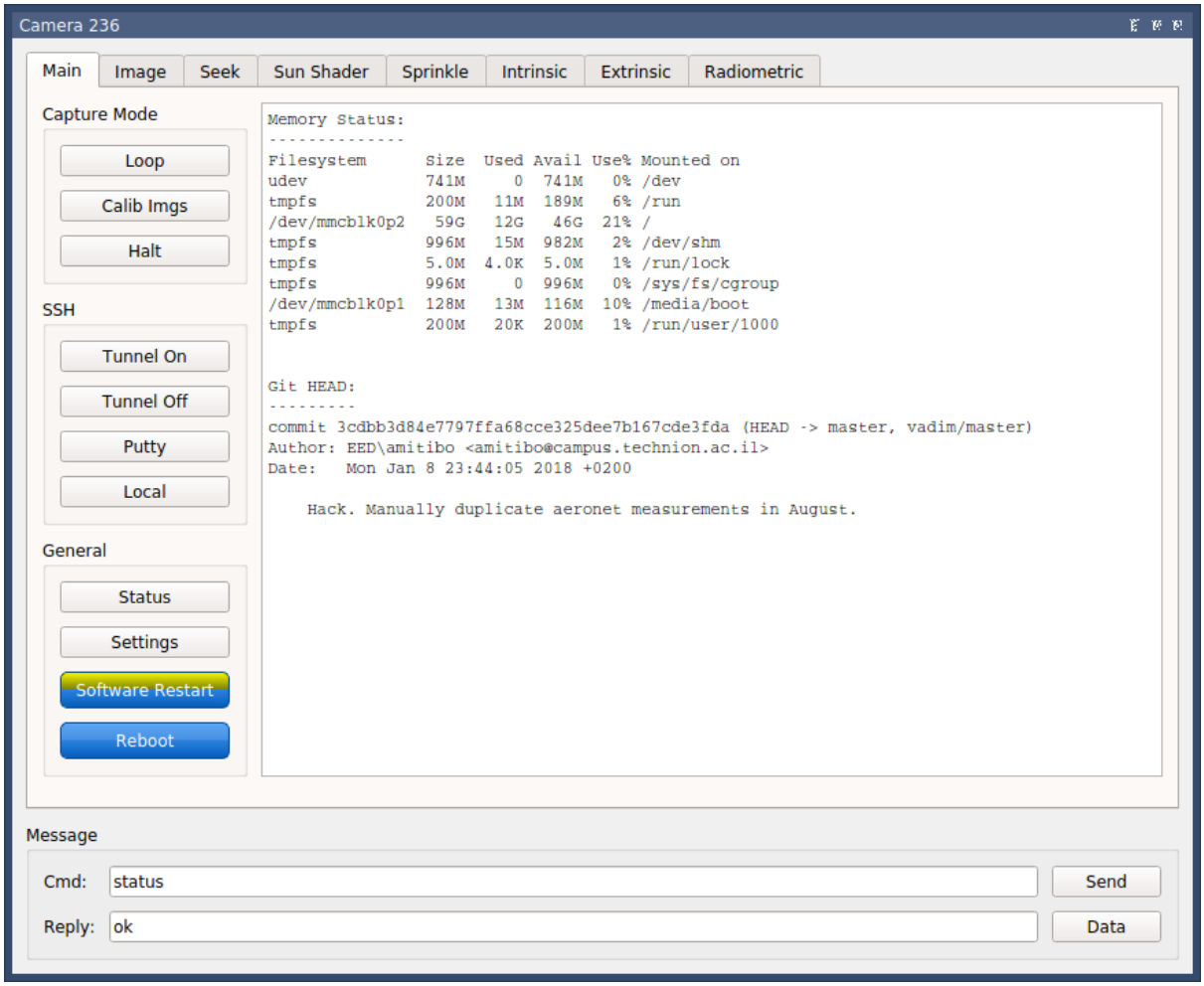
You should now see



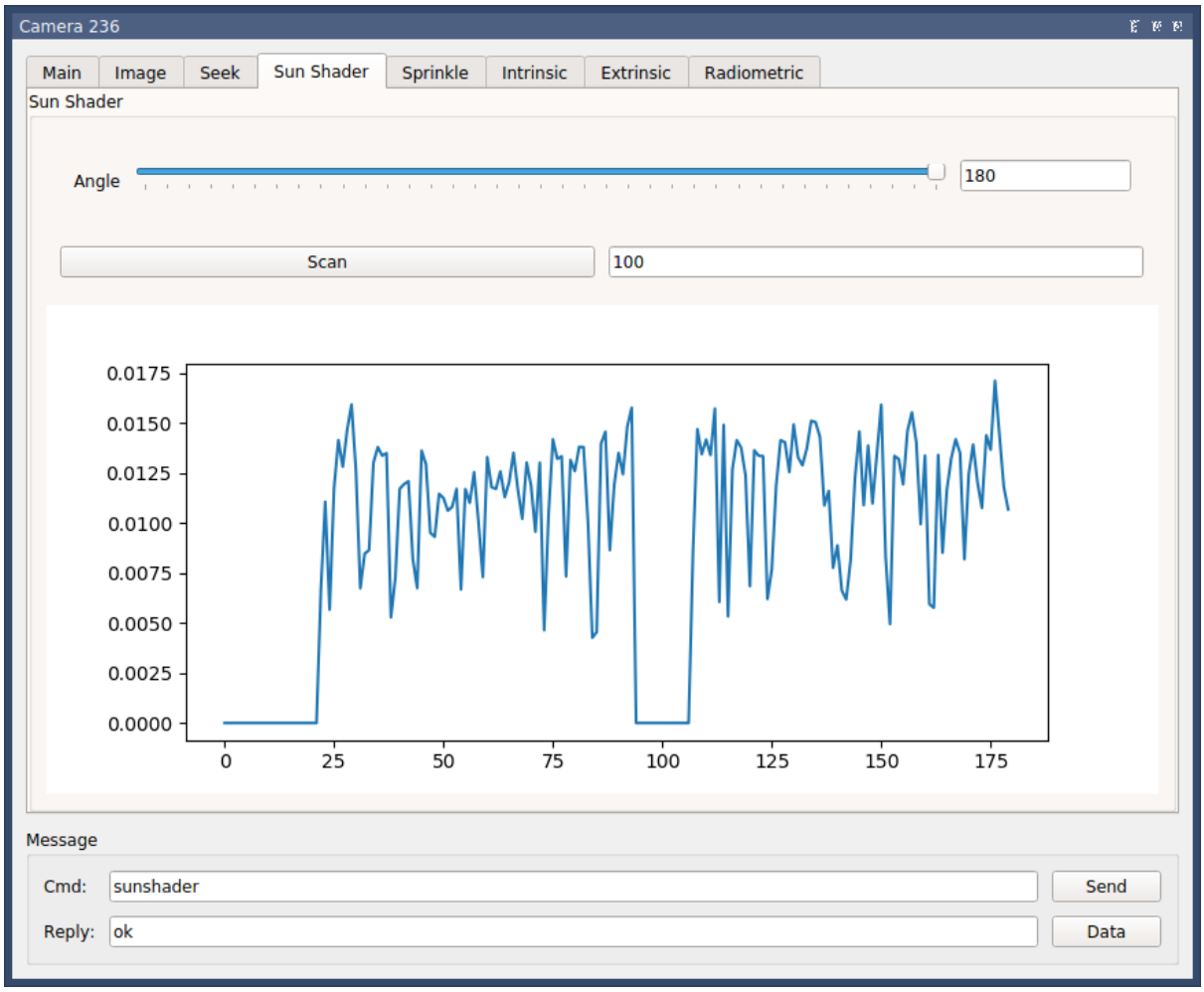
after pressing on servers, you should see all connected cameras, in this case camera id 236.



pressing on the camera ID should lead to the camera interface screen

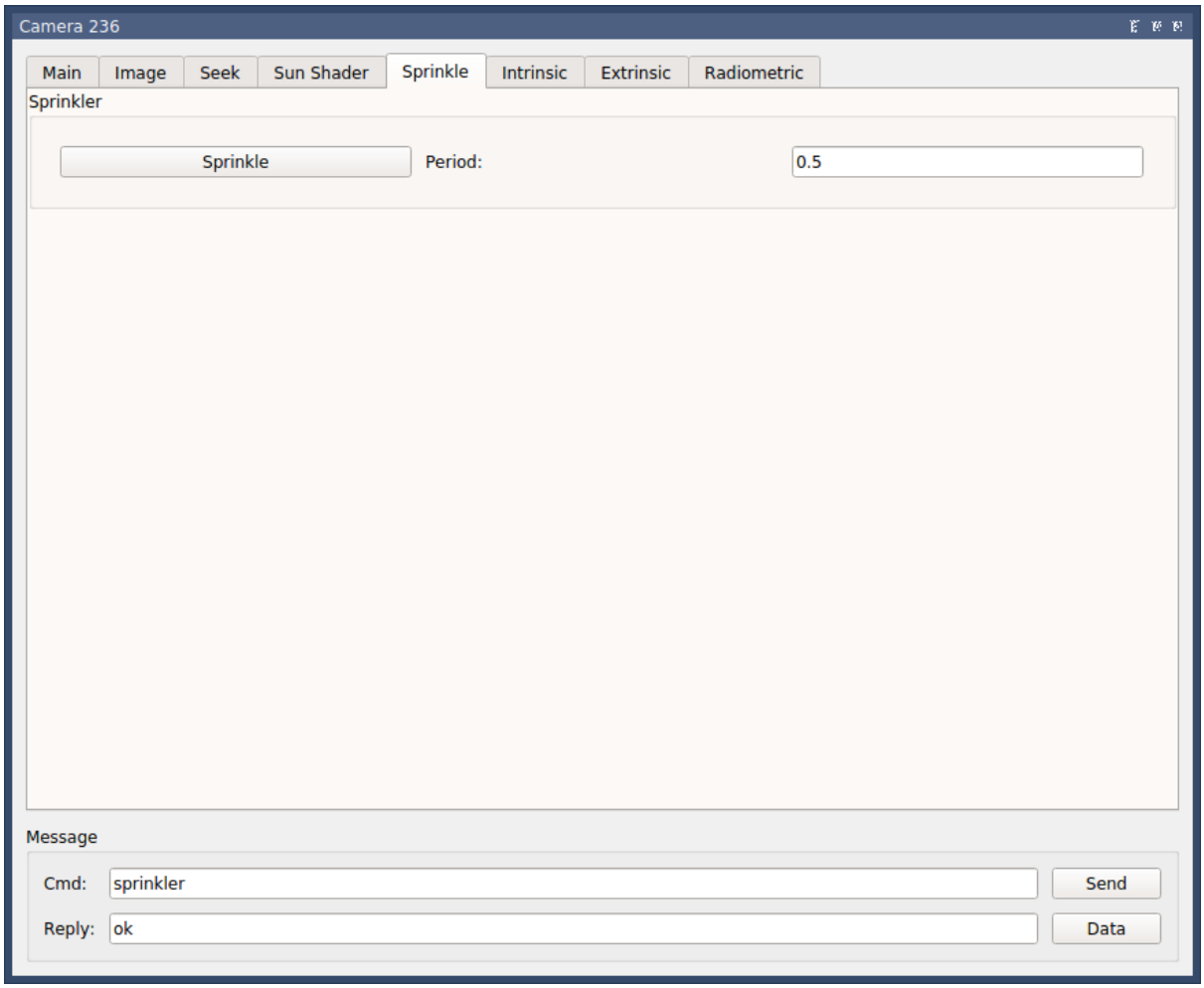

Camera 236
Main
Image
Seek
Sun Shader
Sprinkle
Intrinsic
Extrinsic
Radiometric
Capture Mode
Loop
Calib Imgs
Halt
SSH
Tunnel On
Tunnel Off
Putty
Local
General
Status
Settings
Software Restart
Reboot
Memory Status:
Filesystem Size Used Avail Use% Mounted on
udev 741M 0 741M 0% /dev
tmpfs 200M 11M 189M 6% /run
/dev/mmcblk0p2 59G 12G 46G 21% /
tmpfs 996M 15M 982M 2% /dev/shm
tmpfs 5.0M 4.0K 5.0M 1% /run/lock
tmpfs 996M 0 996M 0% /sys/fs/cgroup
/dev/mmcblk0p1 128M 13M 116M 10% /media/boot
tmpfs 200M 20K 200M 1% /run/user/1000
Git HEAD:
commit 3cdbb3d84e7797ffa68cce325dee7b167cde3fda (HEAD -> master, vadim/master)
Author: EED\amitibo <amitibo@campus.technion.ac.il>
Date: Mon Jan 8 23:44:05 2018 +0200
Hack. Manually duplicate aeronet measurements in August.
Message
Cmd:
status
Send
Reply:
ok
Data

5.1.1 sun Shader



The angle slider allows manual setting of sunshader angle. The scan button moves the sunshader throughout it's whole range, then according to the point with least sunlight (as shown in the graph) determines the sunshader optimal angel.

5.1.2 Sprinkler



The Sprinkle tab and corresponding button allows to manually activate the sprinkler system in order to clean the camera len dome. Period Refers to activation time in seconds.

5.2 Camera (server)

5.2.1 Field Deployment

1. Verify Case Screws fully tightened.
2. Verify plugs fully screwed.
3. Verify sprinklers are pointing in the right direction
4. Verify camera alignment with north-south

5.2.2 Code

After changing any global_setting.py parameter, need to run setup_camera.py again.

5.2.3 Connection

There are options to connect to the camera

5.2.3.1 Serial connection

On the Client's PC, from cameranetwork folder:

`bash scripts/listusb.sh` to list all connected usb devices and to find the relevant one. Should be /dev/tty/USB0 (replace '0' with relevant number)

1. Follow driver installation instructions by Odroid.
2. Linux: Run `sudo minicom` in Client PC's terminal. Windows: Use Teraterm.
3. Enter odroid username
4. Enter odroid password

5.2.3.2 SSH

1. Via SSH

5.2.3.3 GUI

1. Via GUI (as mentioned in the client section)

5.3 Proxy

5.3.1 To connect to the proxy

`sudo ssh -i <path_to_key> ubuntu@<proxy_ip>`

Note: `sudo chmod 400 <path_to_private_key>` if permission error is encountered.

Note: <*path_to_key*> is the path and name of the proxy's private key <*proxy_ip*> is defined in *global_settings.py*. Currently *3.123.49.101*

If this is the initial setup of the proxy server:

```
screen -S session_name
python ./code/cameranetwork/scripts_proxy/start_proxy.py --log_level info
```

Should be run from the root of the server, otherwise the logs would be put in a different location each time. Screen is used to be able to detach and retrieve when ever needed.

- Press *ctrl+a* then *ctrl+d* to detach the *start_proxy.py* from the terminal
- `screen -ls` to see detached processes. then `screen -r <name>` to bring it back.

5.3.2 Noticable stuff

tunnel_port_<camera_id>.txt stores the odroid's password and tunnel_port (random int between 20,000 and 30,000).

/proxy_logs/cameralog_<date+time of ____ initialization>_proxy.txt is a log. Mainly shows Heartbeats from connected cameras and notification of message transmissions to/from the client.

5.4 Others

5.4.1 Image Acquisition flow

On Odroid: rc.local –> main(start_server.py) –> start(server.py).278 –> loop_timer(server.py) –> handle_loop(controller.py) –> safe_capture(controller.py) –> IDSCamera.capture (cameras.py)

5.4.2 Useful commands

- `ps -ef | grep python` to view running python processes (should see start_proxy.py!)
- `sudo netstat -a -nlp -o | grep 198` to see status of relevant ports
- adding ssh key to ssh-agent.
- How to use scp to transfer files. For example to retrieve proxy log from proxy to client: `scp ubuntu@3.123.49.101:/home/ubuntu/proxy_logs/cameralog_190929_092735_proxy.txt /home/shubi/Desktop/log`
- gparted for microsd / eMMC partitioning & direct copying.
- `sudo dd if=/dev/sdb of=~/xu4_lab.img status=progress` to create an image of odroid
- etcher to flash image onto the SD card
- **`grep -a -e "Unregistering worker 236" -e "Registering new worker 236" cameralog_190`** to see connections and disconnections. replace log.txt with * for all logs in folder.
- `du -ah --max-depth=1 | sort -hr` to see size of all subfolders and files

5.4.3 Data Structures

When looking at a specific camera, under *captured_images*, for each that the camera recorded a folder *<%Y-%M-%D>* is created. Inside, the images are stored as *.mat* files. In addition there is a thumbnail *.jpg* version, add metadata as *.pkl*. The name is *utctime_date+exact time*. The *.pkl* file stores the following data:

```
img = pd.read_pickle('~/captured_images/2019_10_02/1570011900.0_2019_10_02_10_25_
↪00_3.pkl')
```

```
▼ img_data = {DataObj} <CameraNetwork.utils.DataObj object at 0x7f0ebb338590>
    altitude = {int} 229
  ▼ camera_info = {dict} {'global_shutter': False, 'sensor_name': 'UI155xLE-C', 'I... Vi
      'global_shutter' (139701247260352) = {bool} False
      'sensor_name' (139701247256304) = {str} 'UI155xLE-C'
      'hw_version' (139701247012960) = {str} 'V1.0'
      'color_mode' (139702319758912) = {str} 'Bayer'
      'master_gain' (139701247013056) = {bool} True
      'max_height' (139701247256832) = {int} 1200
      'blue_gain' (139701247256640) = {bool} True
      'red_gain' (139701247013920) = {bool} True
      'sensor_id' (139701246946448) = {int} 39
      'max_width' (139701247015504) = {int} 1600
      'green_gain' (139701247256496) = {bool} True
      'manufacture_date' (139701247259960) = {str} '16.01.2017'
      'serial_num' (139701247013296) = {str} '4103098529'
      'type' (139701247013104) = {str} 'USB uEye LE'
      'id' (139701246972672) = {int} 1
      'pixel_size' (139701247256544) = {float} 2.8
      'manufacturer' (139701247260296) = {str} 'IDS GmbH'
      __len__ = {int} 17
  ▶ capture_time = {datetime} 2019-10-02 10:25:04.264311
    color_mode = {unicode} u'raw'
    exposure_us = {float} 522.64
    gain_boost = {bool} True
    gain_db = {long} 0
    latitude = {float} 32.775776
    longitude = {float} 35.024963
  ▶ name_time = {datetime} 2019-10-02 10:25:00.001113
```

In addition, one *database.pkl* is created and stored per day:

```
database = pd.read_pickle('~/captured_images/2019_10_02/database.pkl')
database.head()

Time                  hdr   path                                                    ␣
↪                          longitude  latitude   altitude  serial_num
2019-10-02 00:00:00 0     /home/odroid/captured_images/2019_10_02/1569974400.05_
↪2019_10_02_00_00_00_0.mat  35.024963  32.775776  229        4103098529
2019-10-02 00:30:00 0     /home/odroid/captured_images/2019_10_02/1569976200.05_
↪2019_10_02_00_30_00_0.mat  35.024963  32.775776  229        4103098529
2019-10-02 01:00:00 0     /home/odroid/captured_images/2019_10_02/1569978000.05_
↪2019_10_02_01_00_00_0.mat  35.024963  32.775776  229        4103098529
2019-10-02 01:30:00 0     /home/odroid/captured_images/2019_10_02/1569979800.05_
↪2019_10_02_01_30_00_0.mat  35.024963  32.775776  229        4103098529
2019-10-02 08:48:03 0     /home/odroid/captured_images/2019_10_02/1570006083.33_
↪2019_10_02_08_48_03_0.mat  35.024963  32.775776  229        4103098529
```

5.4.4 Analyzing Results

On Client PC:

```
cd /cameranetwork/scripts_client
python start_local.py <path_to_experiment_data>
```

Note:

- Make sure to activate environment beforehand: `conda activate cn_client`
- -l flag is used for local proxy (instead of real proxy server)
- -d flag is for opening gui separately.

workflow + data structure:

#. Run `python start_local.py -d ~/experiment_23_09_2019` in the background where *experiment_date* is a folder containing *cam_ID* folder for each camera involved. Each *cam_ID* should consist of

1. *captured_images* folder which stores inside a folder with images(.jpg, .mat & .pkl versions) and database.pkl for each day that the camera recorded.
2. *dark_images* folder
3. *sun_positions* folder, containing a folder with .csv containing the positions of the sun (and moon!) with format: timestamp, object, pos_x, pos_y, sunshader_angle, row each 6 minutes for sun and every 1 minute for moon.
4. Additional pkl's and json's and other (important!) files.

1. Run `python camera_client.py`
2. You should see a list of all real & virtual cameras.

CHAPTER 6

Indices and tables

- genindex
- modindex
- search