F

Operation and calibration manual

F.1. Calibration

Accurate water-level detection requires that the optical axis and algorithm parameters be tuned to the installed reference object. With the enclosure sealed and the reference board fixed, calibration proceeds in two stages: physical alignment and parameter extraction.

First, a live preview is used to finalize camera orientation. In GUI mode (using RealVNC), `Camera_preview.py` (in `wd__Calibration/`) is launched so that the system orientation can be adjusted to the reference object. Once the mount is locked in place, the preview window is closed.

Next, rotation and crop parameters are determined by running `get_crop_angle_parameters.py`, which guides the user through three interactive clicks:

1. Rotation: two clicks on the waterline (left then right) compute the angle required to horizontalize the image.
2. Cropping: four clicks define the rectangular region of interest around the board.
3. Preview: a final overlaid image confirms that the waterline is level and the crop box fully encloses the board.

Once the rotation and crop values are confirmed, they are entered into `wd__config_cycle.py` under `"processing_params"` and `"crop_params"`. Additionally, the interval between measurement cycles governed by the `cycle_rest_seconds` parameter in `wd__config_cycle.py`, should be reviewed and adjusted to suit the deployment requirements (9 minutes in this research). This ensures that the system waits the correct amount of time between successive captures without needing manual intervention.

Verification is then performed by executing a single detection cycle, ideally from within the Thonny IDE (standard Python terminal on RPI OS) so that the initial processing output can be observed. All results (captured images, overlay plots, and CSV logs) are saved to `wd__directory/wd__results/`, and Thonny's console displays informational and error messages to facilitate debugging.

After calibration is confirmed, the Pi must be switched to a CLI mode (text-console) to save power. This is accomplished by running `sudo raspi-config` in a terminal, navigating to:

```
Sudo raspi-config
System Options
Boot
Console Text Console
```

Next, select "Finish" and agree to reboot by selecting "Yes".

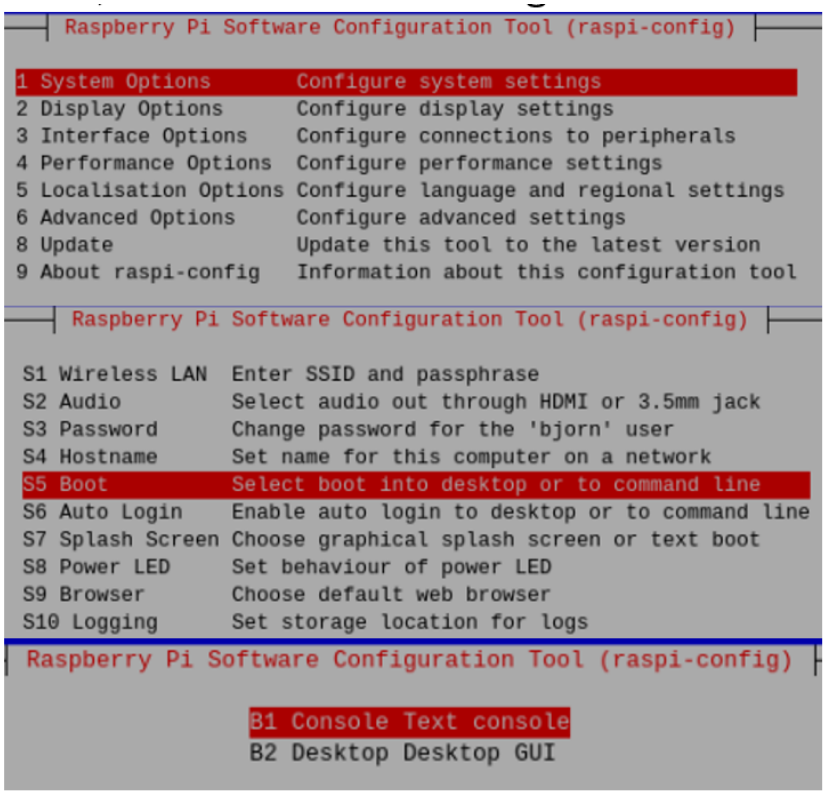

Figure F.1: Switching RPI boot-up configuration

Once the system restarts, SSH access via PuTTY (see Section 5.2.5) restores terminal control. The status and activity of the detection service may then be checked with the appropriate `systemctl` commands, and if network posting is enabled, successful uploads can be verified on the OpenRiverCam server.

F.1.1. Device setup checklist

1. Clear al data storages / charge all batteries
2. Setup mobile hotspot
   - `<host name>`, `<host password>`
   - Connect laptop with mobile hotspot
   - Turn on Raspberry Pi and seal device
3. Mount device facing Reference Object
4. Run: `Camera_preview.py` in `wd__Calibration` using Thonny
   - Adjust device orientation so that OI is in the frame
   - Secure camera orientation
   - Adapt lens focus using lens tool
   - Exit out
5. Run: `get_crop_angle_parameters.py` in `wd__Calibration` using Thonny
   - Rotation: two clicks on the waterline (left then right) compute the angle required to horizontalize the image.
   - Cropping: four clicks define the rectangular region of interest around the board.
   - Preview: a final overlaid image confirms that the waterline is level and the crop box fully encloses the board.

6. Open: `wd__config.py` in `wd__directory`
    - Insert rotation and crop parameters
    - Insert cycle wait time under the `cycle_rest_seconds` parameter
    - Save & Exit out
7. (Test)Run: `wd__main_cycle.py` in `wd__directory`
    - Check for errors
    - Check behaviour LED
    - Check cropbox file in `wd__results`
    - Check 4modes file in `wd__results`
    - Check raw images
    - Check writing to usb
    - Check sleep parameter
8. Switch to no GUI mode
    - Open terminal

```
Sudo raspi-config
1 system options
S5 boot
B1 Console Text console
Finish
```

    - Reboot now: no
9. Turn on reboot service file
    - `sudo systemctl enable wd__main_cycle.service`
    - `sudo systemctl status wd__main_cycle.service`
10. Reboot
11. Check IR led if program is running correctly
12. (optionally) Utilize a SSH connection via PuTTY to validate operation

F.1.2. Disable device checklist

1. Take down device
    - Move to safe location (dry and not above water)
2. Make SHH connection via PuTTY
3. Check, stop and disable algorithm
    - `sudo systemctl status wd__main_cycle.service`
    - `sudo systemctl stop wd__main_cycle.service`
    - `sudo systemctl disable wd__main_cycle.service`

F.2. Operation

Once calibration is complete and the Pi has been configured to boot into CLI mode, measurement cycles proceed automatically at the interval specified by the `cycle_rest_seconds` parameter in `wd__config_cycle.py`. In normal operation, the system illuminates the reference board, captures an image, runs the detection algorithm, uploads result if enabled, and then sleeps until the next cycle without any further user intervention.

If a cycle needs to be triggered on demand the detection service may be restarted manually. In the terminal, the following command forces an immediate cycle.

```
sudo systemctl restart wd_main_cycle.service
```

To confirm that the service is running correctly and view recent log entries, the operator can issue:

```
sudo systemctl status wd_main_cycle.service
```

Each cycle writes its outputs to the file system: raw photographs appear under `~/output/raw_images/`; annotated PNGs with the detected waterline are saved in `~/results/`; and a line is appended to the CSV log at `~/results/algorithm_results.csv`. These files can be investigated or retrieved remotely over the RealVNC connection by first pausing the detection service and reverting to GUI mode. To do this, stop the service:

```
sudo systemctl stop wd_main_cycle.service
```

then run `sudo raspi-config` to switch the boot target back to the GUI mode and reboot. Once the Pi restarts, connect via RealVNC and use WinSCP or a similar SFTP client to access and copy the output files. Once the transfer is complete, CLI mode is restored by reconfiguring the boot target and restarting the service:

```
sudo systemctl start wd_main_cycle.service
```

Periodic maintenance includes verifying that the battery maintains sufficient charge, inspecting the reference board for any debris or alignment shift, and checking the enclosure's seals and mounting hardware. By following these procedures, the system delivers reliable, unattended water-level measurements while still allowing straightforward manual checks and data retrieval when needed.