

CA378-AOIS for Raspberry Pi 3 Software Setup Guide

Version 1.0.3

Dated: 2018/11/22

Home Page <http://www.centuryarks.com/en/>

| Date | Version | Comment |
|------------|---------|--|
| 2017/12/21 | v1.0.0 | Initial Release |
| 2018/02/07 | v1.0.1 | Fixed missing of procedure manual Added optical black correction for RAW to DNG conversion Added color management adjustment for still image capturing |
| 2018/11/07 | v1.0.2 | Update Installation Guide |
| 2018/11/22 | v1.0.3 | Added Raspbian configuration procedure |

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1. Environment configuration

1.1. Procedure for using SSP library installed Raspbian image

Raspbian Stretch with desktop

Release date: 2018-10-09

SSP Library: 1.31

(1-1) Please download the following image.

<https://www.centuryarks.com/images/product/sensor/2018-10-09-raspbian-stretch-CA378-AOIS.zip>

(1-2) Follow the installation guide of Raspbian.

<https://www.raspberrypi.org/documentation/installation/installing-images/README.md>

1.2. Manual installation procedure of SSP library

(2-1) Please download the latest image of Raspbian from the following site.

<https://www.raspberrypi.org/downloads/raspbian/>

(2-2) Follow the installation guide of Raspbian.

<https://www.raspberrypi.org/documentation/installation/installing-images/README.md>

1. Environment configuration

(2-3) Update the Raspberry Pi firmware to the specific version.

```
$ sudo rpi-update e37295d7a8f9f28eda5b6af35eb0fd4c9341a3e0  
$ sudo apt-get update  
$ sudo apt-get upgrade
```

(2-4) Register as user at Vision Processing Community.

https://www.visionproc.org/login_new_account.php?lang=en

(2-5) Download “SSP library 1.31” and “HexaVisionControl 0.92” from the following site.

<https://www.visionproc.org/download.php>

(2-6) Extract the downloaded file.

```
$ tar zxvf libssp-1.31.tar.gz  
$ tar zxvf HexaVisionControl-0.92.tar.gz
```

(2-7) Install Qt development package and RAW development software

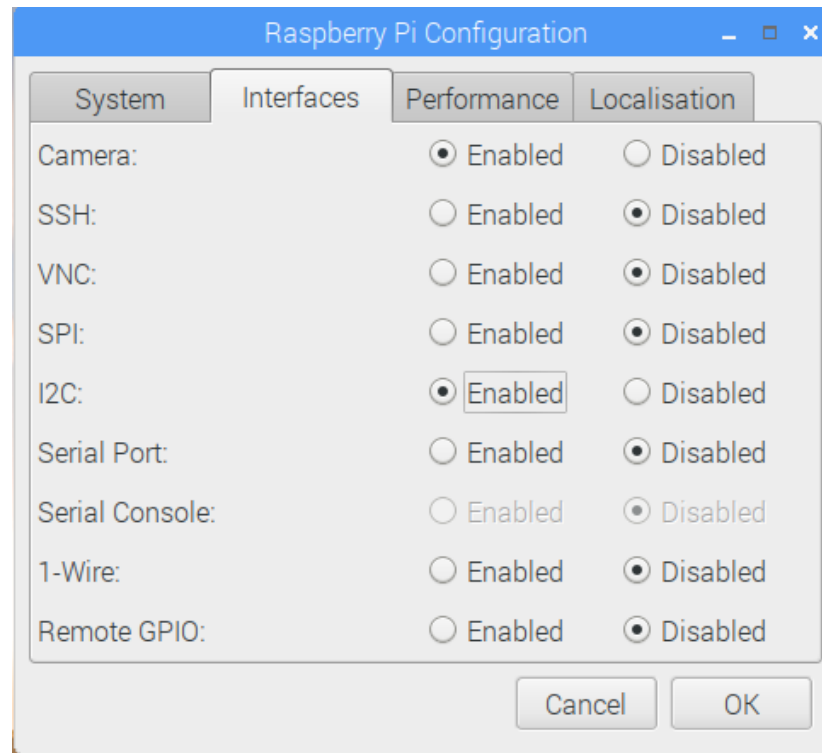
```
$ sudo apt-get install libopencv-dev  
$ sudo apt-get install qt4-dev-tools  
$ sudo apt-get install ufw
```

2. Software install

Please set up Raspbian configuration as follows.

(1-1) Select Raspberry Pi Configuration from Raspbian's start menu.

(1-2) Set Camera and I2C in the Interfaces tab to Enabled.



(1-3) Click the OK button.

2. Software install

The following settings are for Raspberry Pi 3 only.

For the settings of other Raspberry Pi versions, please see below.

https://www.visionproc.org/ssp_usage.php

(1-4) Open /boot/config.txt with the following command and add it to the last line of the file.

```
$ sudo nano /boot/config.txt
```

(1-5) For Raspberry Pi 3, add the following line to the end of the /boot/config.txt file.

```
dtoverlay=i2c1-bcm2708,sda1_pin=44,scl1_pin=45,pin_func=6
```

(1-6) Restart with the following command after setting above.

```
$ sudo reboot
```

2. Software install

Please install by the following procedure.

· Installation procedure

1. Download "demo_v1.0.3_pi3.tar.gz" from the following site.

<https://github.com/centuryarks/Sample/releases>

```
$ wget --no-check-certificate https://github.com/centuryarks/Sample/releases/download/v1.0.3/demo_v1.0.3_pi3.tar.gz
```

2. Unzip the "demo_v1.0.3_pi3.tar.gz" file.

```
$ tar zxvf demo_v1.0.3_pi3.tar.gz
```

3. Execute "Install.sh" in the extracted folder.

```
$ cd demo  
$ ./Install.sh
```

4. A shortcut is created on the desktop.

Demo.sh

Hispeed.sh

3. Demonstration functions

3.1. Focus & OIS

3.2. High-speed video recording

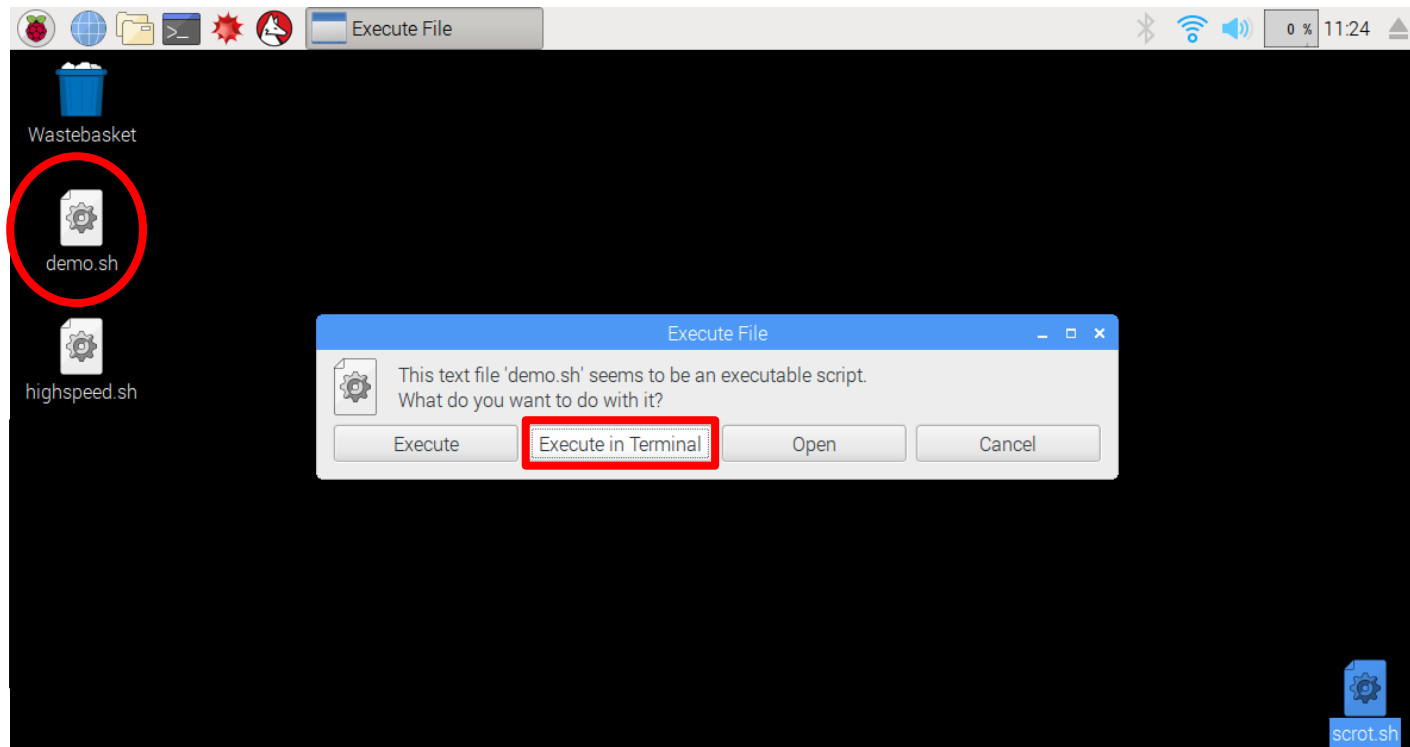
3.3. 4K3K-resolution(12Mpixel) still image capturing

3.4. HDR still image capturing

3.1. Focus & OIS

Procedure of starting Focus & OIS:

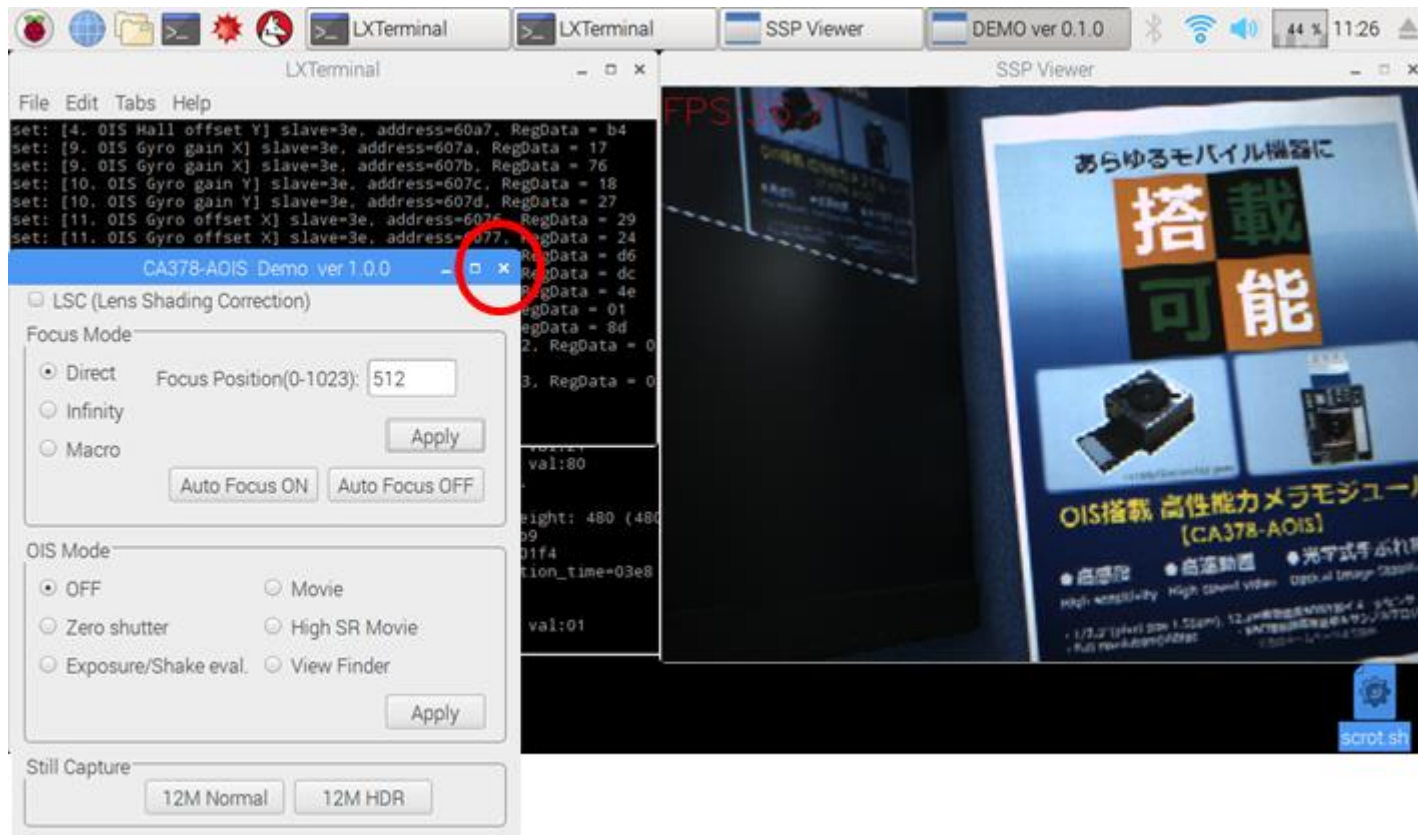
1. Click "demo.sh" on the desktop.
 2. Click [Execute in Terminal].
 3. After a while the GUI screen will be displayed.
 4. Please change the distance of the object, or move the camera, confirm the function.
- * For details of functions, refer to page 12-13.



3.1. Focus & OIS

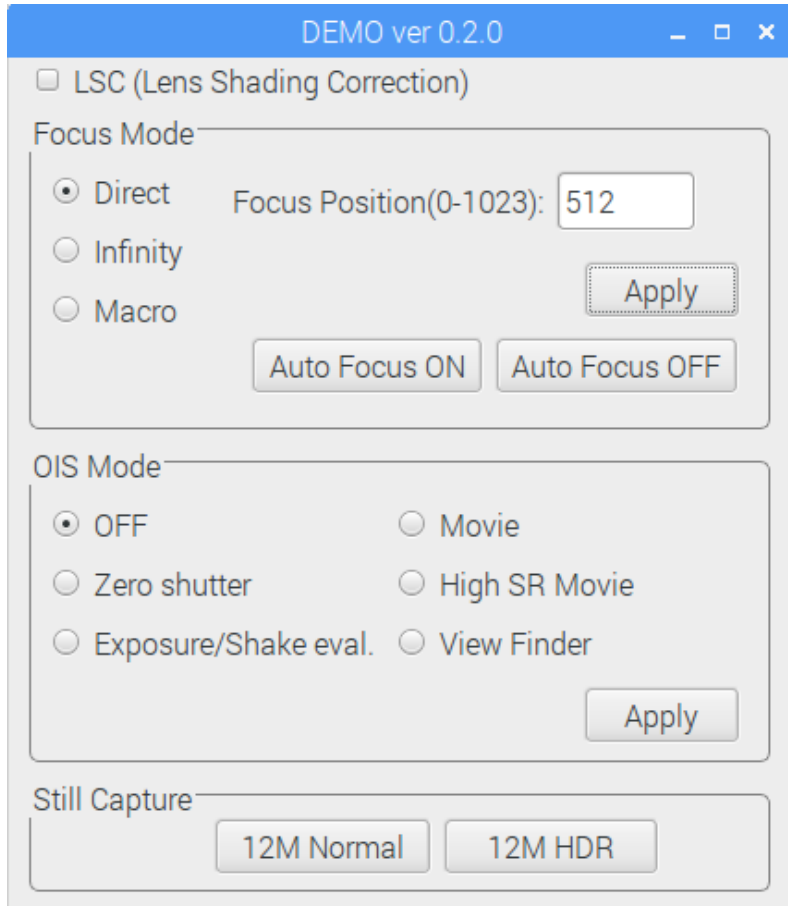
Procedure of finishing Focus & OIS:

1. Click the [x]



3.1. Focus & OIS

The following section describes each function of Focus & OIS.



DEMO ver 0.2.0

☐ LSC (Lens Shading Correction)

Focus Mode

☒ Direct Focus Position(0-1023): 512

☐ Infinity

☐ Macro

Apply

Auto Focus ON Auto Focus OFF

OIS Mode

☒ OFF ☐ Movie

☐ Zero shutter ☐ High SR Movie

☐ Exposure/Shake eval. ☐ View Finder

Apply

Still Capture

12M Normal 12M HDR

| Function | Description |
|---------------|--|
| LSC | Check to enable shading correction. ※ Theoretical values have been set. |
| Focus Mode | Direct: Directly specify the focus position. Infinity: Set the focus position to infinity. Macro: Set the focus position to the short distance. Focus Position: Focus position. Apply: Apply the settings. Auto Focus ON: Enable auto focus. Auto Focus OFF: Disable auto focus. * Current debug control is for demo. |
| OIS Mode | OFF: Disable OIS. It corresponds to each OIS mode. Zero Shutter Exposure / Shake eval. Movie High SR Movie View Finder Apply: Apply the settings. |
| Still Capture | 12M Normal: Capture 12Mpixel normal still image. 12M HDR: Capture 12Mpixel HDR still image. |

3.1. Focus & OIS

Description of the script file:

It describes about the “script/preview.sh”.

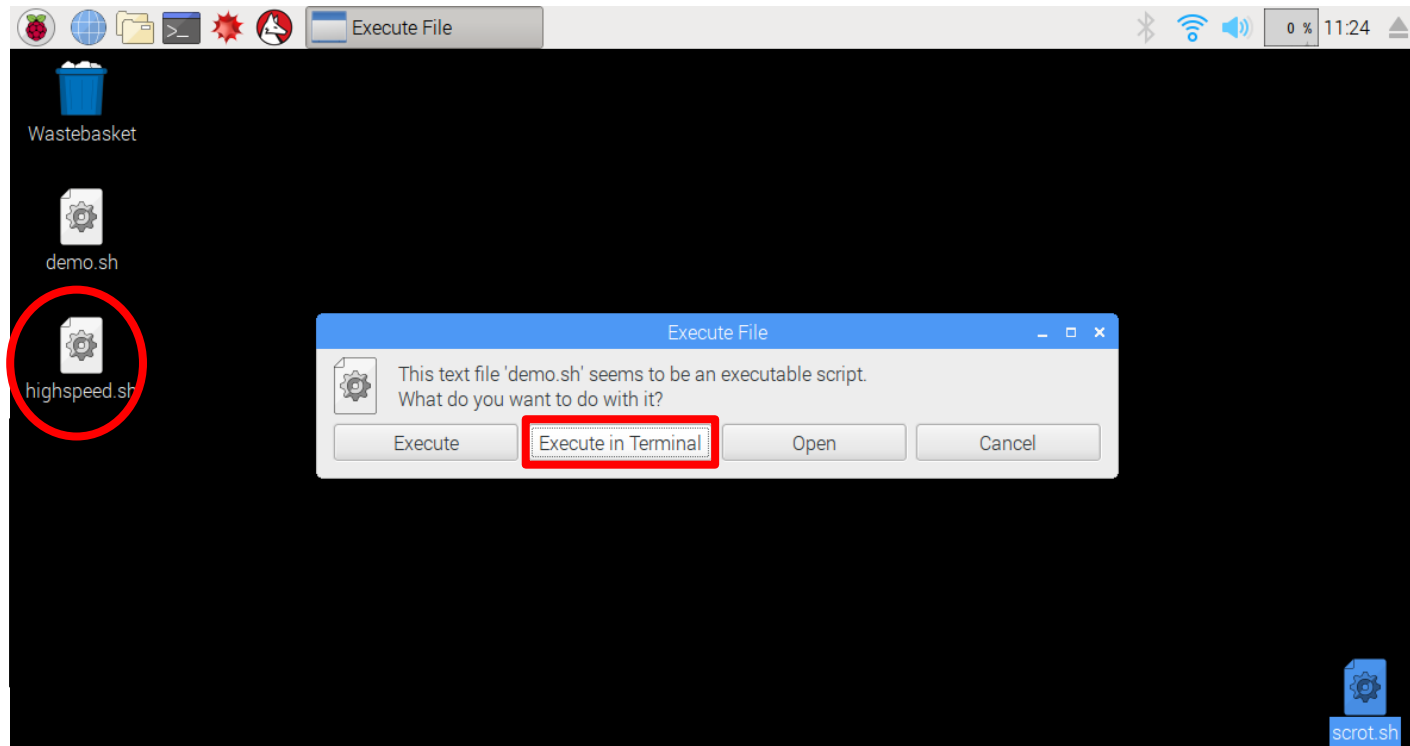
```
#!/bin/sh
cd /home/pi/demo
./bin/highspeed ./profile/IMX378_640x480_4x4.xml 953 256 2372 IMX378
```

| Function | Description |
|---------------------|---|
| The first argument | Specify the VPF profile. |
| The second argument | Specify the analog gain. Range: 0 – 978 Analog Gain = $1024 / (1024 - \text{value})$ |
| The third argument | Specify the digital gain. Range: 256 to 4057 Digital gain = $\text{value} / 256$ [times] |
| The fourth argument | Specify the shutter speed. |
| | Conditions: Long exposure: None COARSE_INTEG_TIME = 500 (fourth argument) LINE_LENGTH_PCK = 3000 (specified in the profile of the first argument) Pixel rate [pixels / s] = 210 [MHz] * 4 Example: Exposure time = $(500 * 3000) / (210 \text{ [MHz]} * 4) = 1.785$ [msec] Frame rate = 560 [fps] * Please understand that Frame rate does not rise only by changing shutter speed. |
| The fifth argument | specify IMX 378 |

3.2. High-speed video recording

Procedure of starting high-speed video recording:

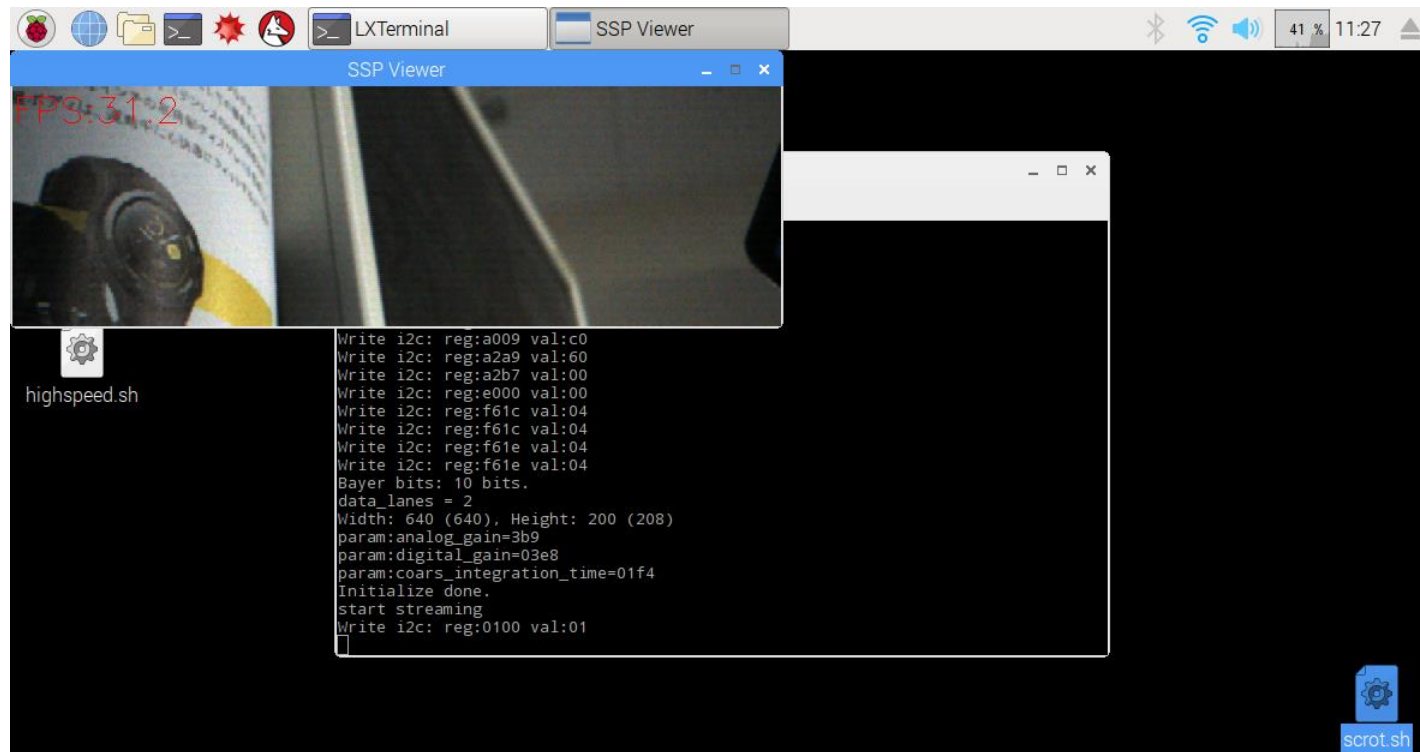
1. Click "highspeed.sh" on the desktop.
 2. Click [Execute in Terminal].
 3. Preview will start automatically when you start up.
 4. Press the [r] key on the keyboard at the timing you want to shoot.
- * For detailed operation, refer to page 17



3.2. High-speed video recording

Procedure of finishing high-speed video recording:

- (1) If you press any of [w], [W], [a] on the keyboard, you can save captured data in the specified format.
([w]: uncompressed, [W]: Motion JPEG, [a]: MP 4)
- (2) Press [q] on the keyboard.
(* It does not exit even if clicking the [x] button.)
- (3) Saved image data can be edited / played with general software.



3.2. High-speed video recording

Description of the script file:

It describes about the “script/highspeed.sh”.

By exchanging the third and fourth rows,
You can change the image size and frame rate.

```
#!/bin/sh
cd /home/pi/demo
#./bin/highspeed ./profile/IMX378_640x480_250fps_10bit_2lane.xml 978 384 1000 IMX378
./bin/highspeed ./profile/IMX378_640x200_500fps_10bit_2lane.xml 978 768 500 IMX378
```

| Function | Description |
|---------------------|---|
| The first argument | Specify the VPF profile. |
| The second argument | Specify the analog gain. Range: 0 – 978 Analog Gain = $1024 / (1024 - \text{value})$ |
| The third argument | Specify the digital gain. Range: 256 to 4057 Digital gain = $\text{value} / 256$ [times] |
| The fourth argument | Specify the shutter speed. |
| | Conditions: Long exposure: None COARSE_INTEG_TIME = 500 (fourth argument) LINE_LENGTH_PCK = 3000 (specified in the profile of the first argument) Pixel rate [pixels / s] = $210 \text{ [MHz]} * 4$ Example: Exposure time = $(500 * 3000) / (210 \text{ [MHz]} * 4) = 1.785 \text{ [msec]}$ Frame rate = 560 [fps] * Please understand that Frame rate does not rise only by changing shutter speed. |
| The fifth argument | specify IMX 378 |

3.2. High-speed video recording

The following section describes the functions of high-speed video recording.
Activate SSP Viewer and correspond to the following key command.

| Command | Description |
|---------|--|
| q | Quit |
| r | Go to recording mode |
| v | Go to real-time preview mode |
| w | Movie file output (uncompressed) |
| W | Movie file output (Motion JPEG format) |
| a | Movie file output (MP4 format) |
| p | Pause |
| s | Jump to start frame |
| e | Jump to end frame |
| z | Export current frame |
| x | Export entire frames |
| t | Toggle show / hide message |

| Command | Description |
|---------|--|
| 0 to 5 | Adjust preview speed |
| 9 | Play with skipping 5 frames |
| 8 | Play without skipping |
| [Space] | Show next frame |
| m | Show back frame |
| f | Forward 100 frames |
| b | Back 100 frames |
| F | Forward 200 frames |
| B | Back 200 frames |
| c | Perform simple white balance gain adjustment |

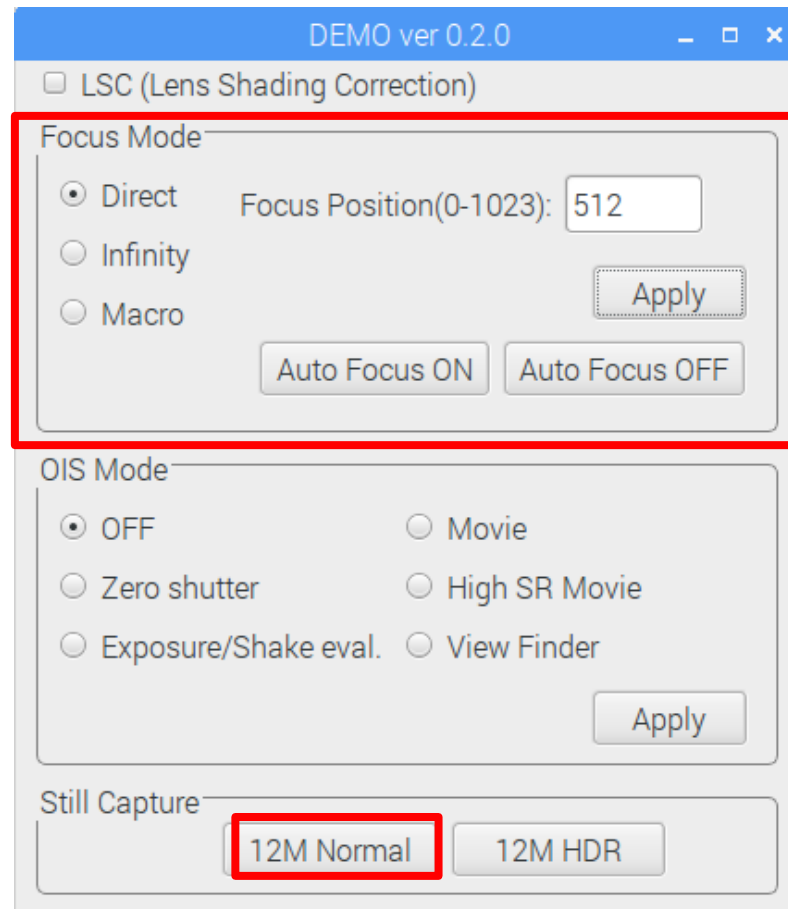
3.3. 12Mpixel still image capturing

Procedure of capturing 12Mpixel still image:

1. Adjust the focus.

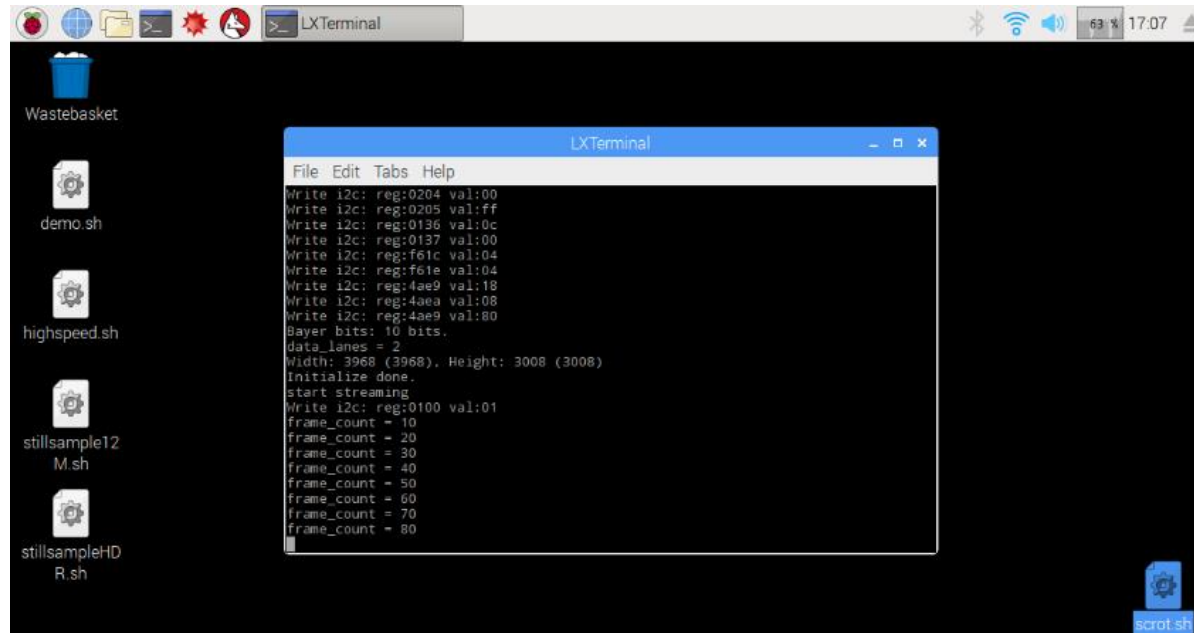
(It is useful to turn on Auto Focus and turn Auto Focus OFF when focus is on)

2. Click the [12M Normal] button



3.3. 12Mpixel still image capturing

3. The image is taken at the timing when Frame count becomes 20 (initial setting).
(Currently you can use only in the countdown system, manual push is planned for the future.)



The screenshot shows a Raspberry Pi desktop with a black background. On the left, there is a vertical dock with icons for a Wastebasket, a gear icon labeled 'demo.sh', another gear icon labeled 'highspeed.sh', a gear icon labeled 'stillsample12 M.sh', and a gear icon labeled 'stillsampleHD R.sh'. In the center, an LXTerminal window is open, displaying the following text:

```
File Edit Tabs Help
Write i2c: reg:0204 val:00
Write i2c: reg:0205 val:ff
Write i2c: reg:0136 val:0c
Write i2c: reg:0137 val:00
Write i2c: reg:f61c val:04
Write i2c: reg:f61e val:04
Write i2c: reg:4ae9 val:18
Write i2c: reg:4aea val:08
Write i2c: reg:4ae9 val:80
Bayer bits: 10 bits.
data_lanes = 2
Width: 3968 (3968), Height: 3008 (3008)
Initialize done.
start streaming
Write i2c: reg:0100 val:01
frame_count = 10
frame_count = 20
frame_count = 30
frame_count = 40
frame_count = 50
frame_count = 60
frame_count = 70
frame_count = 80
```

The terminal window has a blue title bar with 'LXTerminal' and standard window controls. The desktop also shows system status icons in the top right corner, including Bluetooth, Wi-Fi, and battery level (63%), and the time 17:07.

4. The display method is explained in the following procedures.
- (1) How to adjust color management (*Please skip, if you do not adjust.)
 - (2) How to display still images with Raspberry Pi
 - (3) How to display still images in environments such as PCs and smartphones.

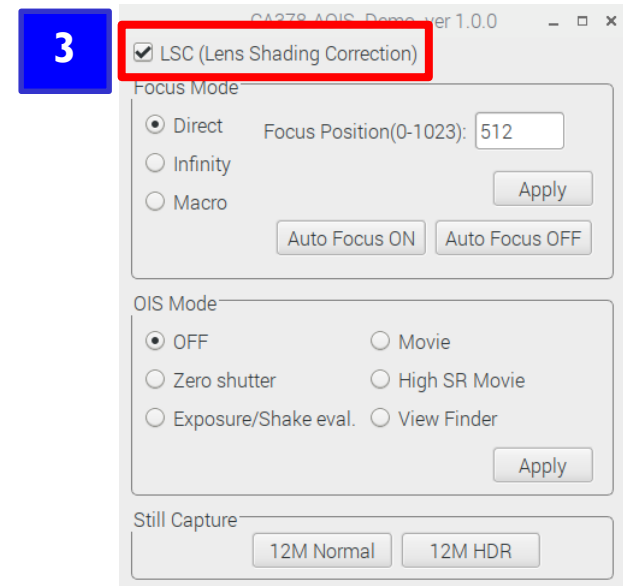
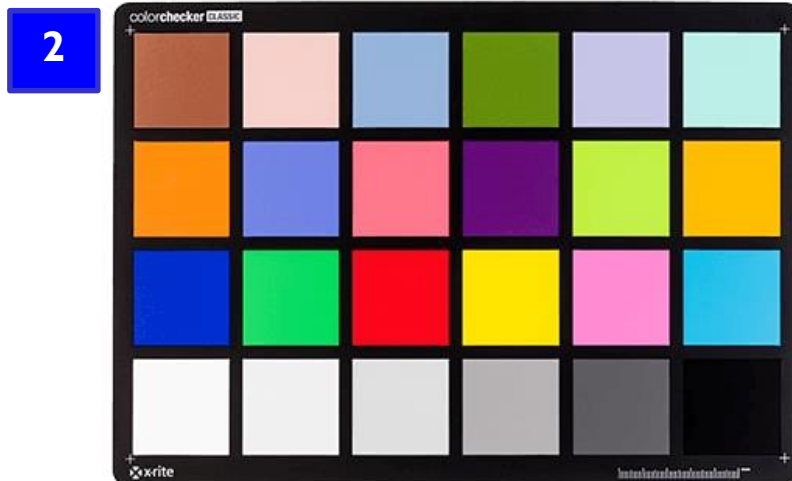
3.3. 12Mpixel still image capturing

- (1) How to adjust color management
(*Please skip, if you do not adjust.)

1. Install color management tool.

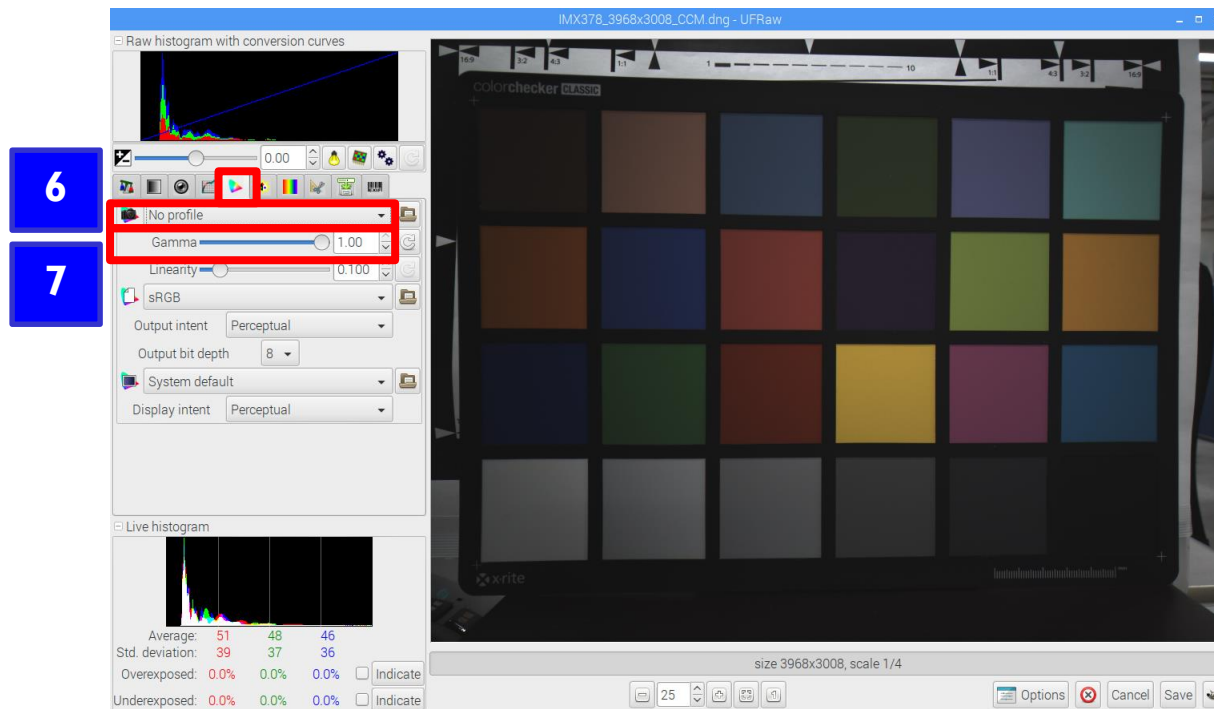
```
$ sudo apt-get update  
$ sudo apt-get install argyll
```

2. Prepare a color checker (24 colors).
3. Check "LSC (Lens Shading Correction)".
4. Run the procedure of capturing 12Mpixel still image.



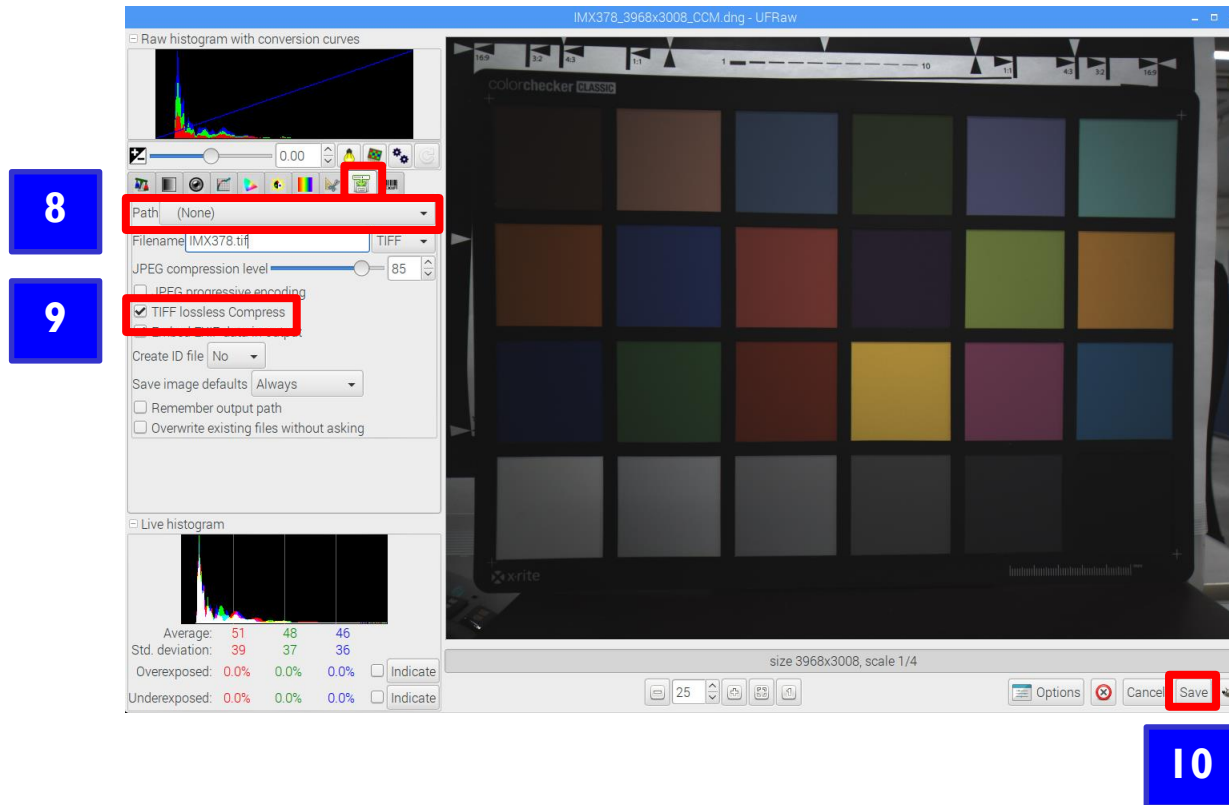
3.3. 12Mpixel still image capturing

5. UFRaw will be started when capturing is completed.
6. Set the camera profile of color management to "No profile".
7. Set Gamma to "1.0".



3.3. 12Mpixel still image capturing

8. Change "Filename" of Save to "IMX378.tif".
9. Check "TIFF lossless compress".
10. Click the [Save] button.

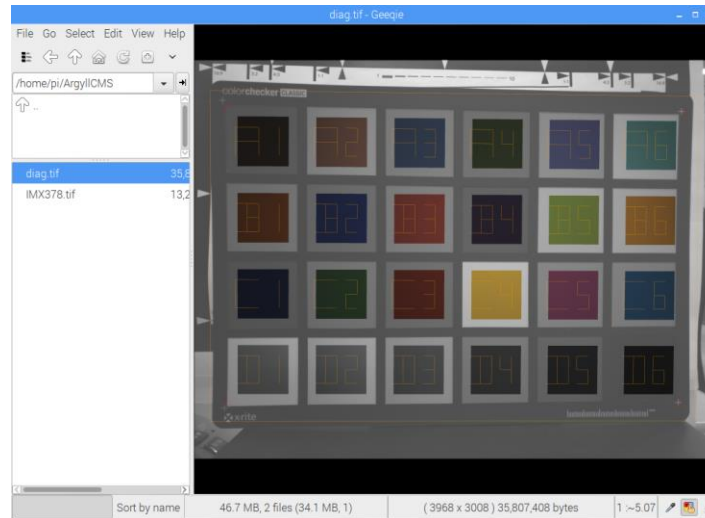


3.3. 12Mpixel still image capturing

11. Adjust the color management using Argyll.

```
$ cp -r /usr/share/color/argyll/ref/ ~/ArgyllCMS  
$ mv IMX378.tif ~/ArgyllCMS/  
$ cd ~/ArgyllCMS  
$ scanin -v -p -a -G 1.0 -dipn IMX378.tif ColorChecker.cht ColorChecker.cie diag.tif
```

12. Open the output "diag.tif" with the image viewer and confirm the measurement result.



13. If it was measured successfully, run colprof to create the .icc profile.

```
$ colprof -v -qh -am -nc -u IMX378
```

Reference URL:

<http://www.russellcottrell.com/photo/LinuxWorkflow.htm>

3.3. 12Mpixel still image capturing

(2) How to display still images with Raspberry Pi:

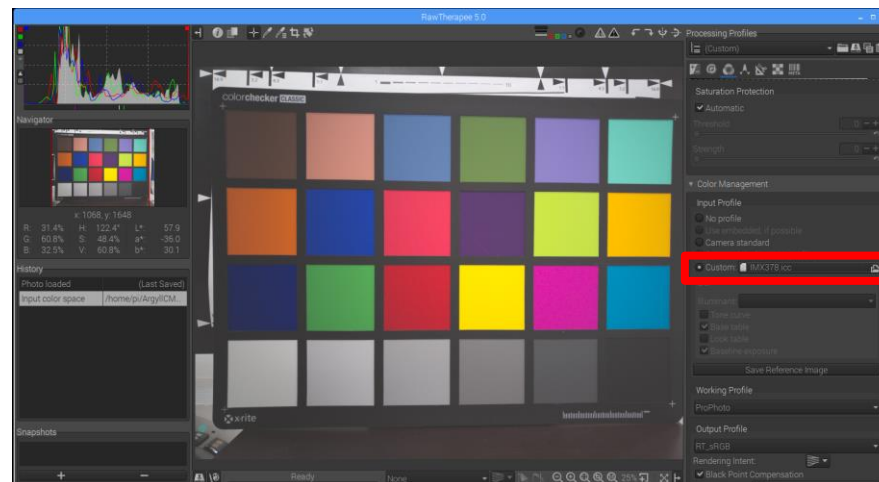
1. Install RAW development software (RawTherapee).

```
$ sudo apt-get update  
$ sudo apt-get install rawtherapee
```

2. Start RawTherapee.

```
$ rawtherapee IMX378_3968x3008.dng
```

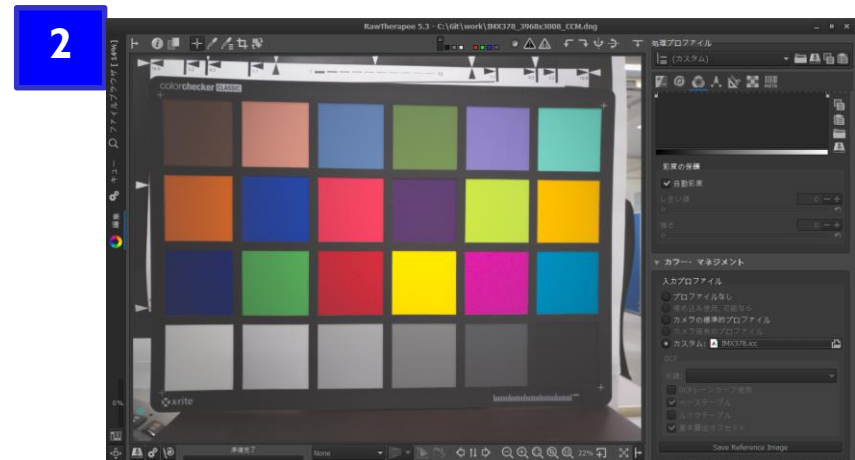
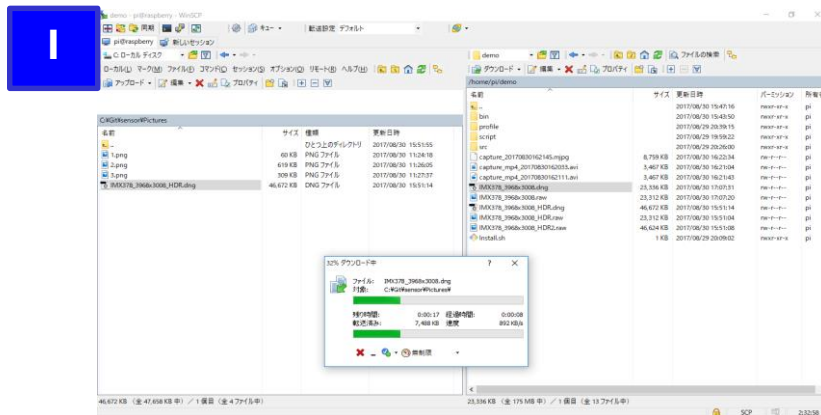
3. Specify "IMX378.icc" in the color management function profile.
(Please select "No profile" if color management adjustment is not done)



3.3. 12Mpixel still image capturing

(3) How to display still images in environments such as PCs and smartphones:

1. Please download "/home/pi/demo/IMX378_3968x3008.dng" and "IMX378.icc" on PC or smartphone with WinSCP etc.
2. Display dng file with UFRaw/RawTherapee/Adobe Photoshop Lightroom etc.
 - * Please specify "IMX378.icc" or "No profile" with the color management function.



3.4. HDR still image capturing

Procedure of capturing HDR still image:

1. Install OpenCV 3.4.

```
sudo apt autoremove libopencv3  
wget https://github.com/mt08xx/files/raw/master/opencv-rpi/libopencv3_3.4.0-20180115.1_armhf.deb  
sudo apt install -y ./libopencv3_3.4.0-20180115.1_armhf.deb  
sudo ldconfig
```

2. Install the image viewer.

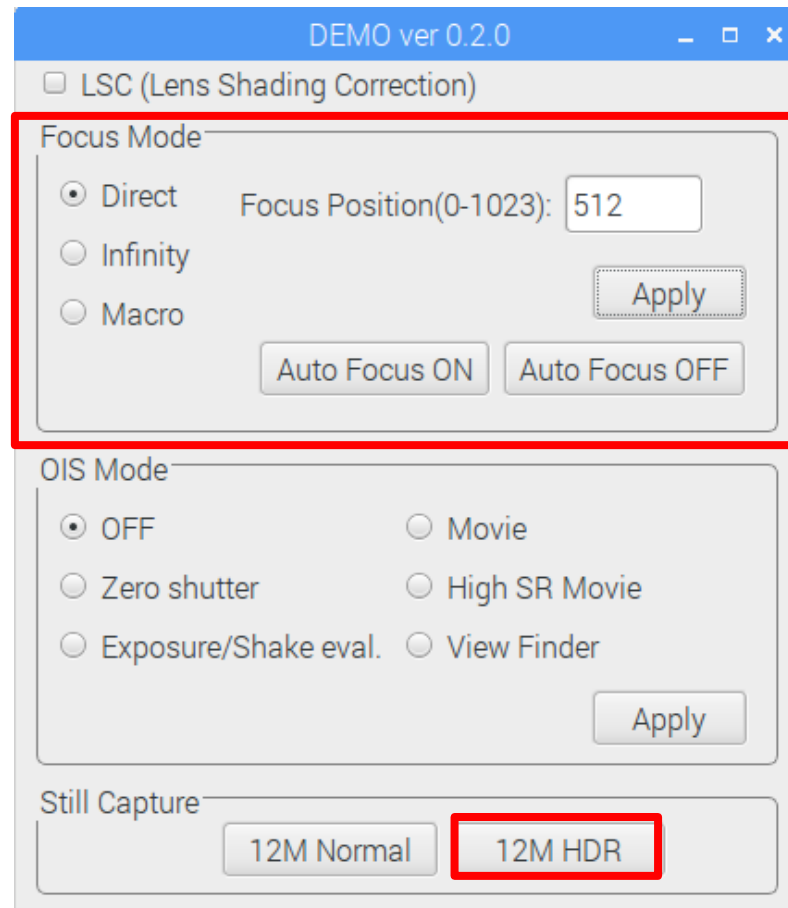
```
$ sudo apt-get update  
$ sudo apt-get install geeqie
```

3.4. HDR still image capturing

3. Adjust the focus.

(It is useful to turn on Auto Focus and turn Auto Focus OFF when focus is on)

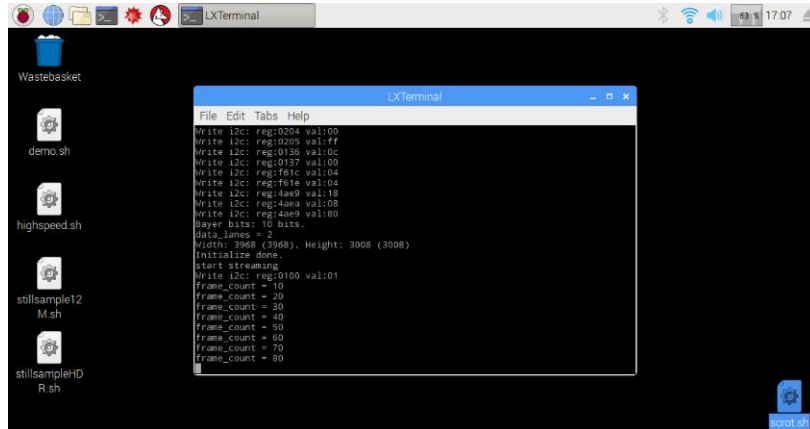
4. Click the [12M HDR] button.



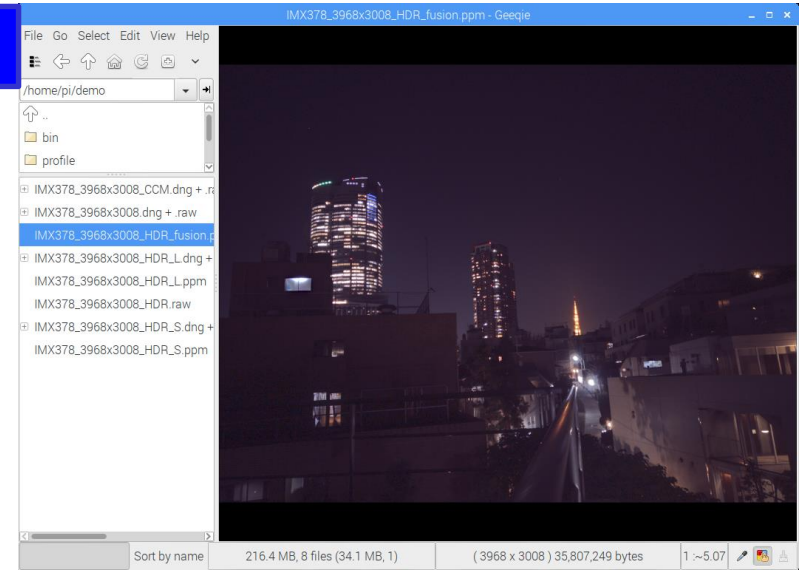
3.4. HDR still image capturing

5. The image is taken at the timing when Frame count becomes 20.
(Currently you can use only in the countdown system, manual push is planned for the future.)
6. The display method is the same as 12M still image capturing.

3



4



* Only with extracting long storage and short storage, HDR setting and tone mapping method will be described in separate document.

Appendix

A.1. About the directory structure

The following section describes the directory structure of the software.

```
demo
├── bin
│   ├── DemoGUI
│   ├── demo.ini
│   ├── highspeed
│   ├── raw2dng
│   ├── raw2hdr
│   └── stillsampleRAW16
├── Install.sh
├── profile
│   ├── IMX378_1920x1080_2x2.xml
│   ├── IMX378_3840x2160.xml
│   ├── IMX378_3968x3008_HDR.xml
│   ├── IMX378_3968x3008.xml
│   ├── IMX378_640x200_500fps_10bit_2lane.xml
│   ├── IMX378_640x480_250fps_10bit_2lane.xml
│   └── IMX378_640x480_4x4.xml
├── script
│   ├── demo.sh
│   ├── highspeed.sh
│   ├── preview.sh
│   ├── stillCapture12M_HDR.sh
│   └── stillCapture12M_Normal.sh
└── src
    ├── GUI
    │   ├── af_control.c
    │   ├── af_control.h
    │   ├── communication.h
    │   ├── communication_raspberry.c
    │   ├── debug_util.h
    │   ├── demo_control.c
    │   └── DemoGUI.pro
```

| Function | Description |
|----------|--|
| bin | DemoGUI: Demonstration software Demo.ini: Demonstration software setting file Highspeed: High-speed video recording program raw2dng: RAW to dng file converting program raw2hdr: Program that extracts HDR long storage and short storage from RAW stillsampleRAW 16: Still image capturing program |
| profile | This is a profile describing register values to send to the sensor. You can use the profile used in VPF as it is. |
| script | Script files are described. It can be customized according to specifications. demo.sh highspeed.sh preview.sh stillCapture12M_HDR.sh stillCapture12M_Normal.sh |
| src | It is a set of demo software source code. |

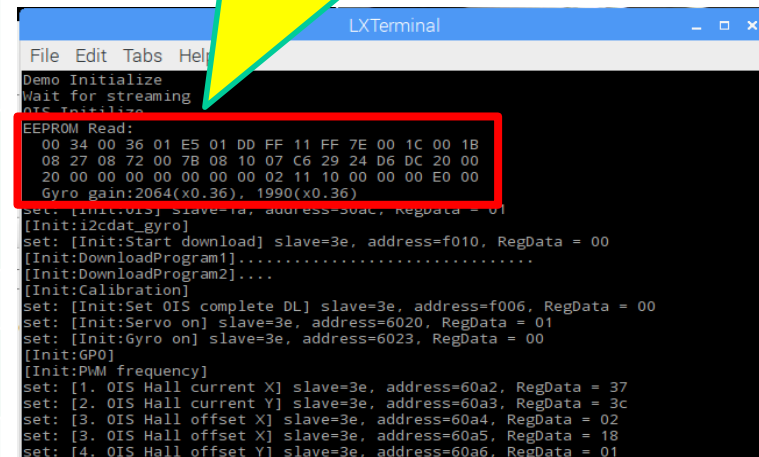
A.2. About the setting file

The following section describes the "demo.ini" of the setting file.

```
# DEMO Setting
preview = /home/pi/demo/script/preview.sh
stillCapture12M_Normal = /home/pi/demo/script/stillCapture12M_Normal.sh
stillCapture12M_HDR = /home/pi/demo/script/stillCapture12M_HDR.sh
stillCaptureFrame = 20
gyroGainRateX=1.0
gyroGainRateY=1.0
autoFocusGain=2.0
autoFocusConfidenceThreshold=10
autoFocusMoveLimit=100
```

| Function | Description |
|--------------------------------|---|
| preview | Script path for preview |
| stillCapture12M_Normal | Script path for capturing 12M normal still images |
| stillCapture12M_HDR | Script path for capturing 12M HDR still image |
| stillCaptureFrame | You can specify the countdown frame for still image capturing. * If it is set to 10 or less, it is possible to fail. |
| gyroGainRateX gyroGainRateY | It is valid only when OIS calibration result is written in EEPROM. Currently, since the value of Gyro gain is too effective, the rate is adjusted. |
| autoFocusGain | Adjust the autofocus gain. |
| autoFocusConfidenceThreshold | Specify the threshold value of the confidence level of Phase Difference. |
| autoFocusMoveLimit | Limit the amount of focus movement at one time. |

If OIS calibration is already done,
The following log is output to Terminal.



```
LXTerminal
File Edit Tabs Help
Demo Initialize
Wait for streaming
OIS Initialize
EEPROM Read:
00 34 00 36 01 E5 01 DD FF 11 FF 7E 00 1C 00 1B
08 27 08 72 00 78 08 10 07 C6 29 24 D6 DC 20 00
20 00 00 00 00 00 00 00 02 11 10 00 00 00 E0 00
Gyro gain:2064(x0.36), 1990(x0.36)
set: [Init:OIS] slave=3e, address=30a2, RegData = 01
[Init:i2cdat_gyro]
set: [Init:Start download] slave=3e, address=f010, RegData = 00
[Init:DownloadProgram1].....
[Init:DownloadProgram2]....
[Init:Calibration]
set: [Init:Set OIS complete DL] slave=3e, address=f006, RegData = 00
set: [Init:Servo on] slave=3e, address=6020, RegData = 01
set: [Init:Gyro on] slave=3e, address=6023, RegData = 00
[Init:GPO]
[Init:PMM frequency]
set: [1. OIS Hall current X] slave=3e, address=60a2, RegData = 37
set: [2. OIS Hall current Y] slave=3e, address=60a3, RegData = 3c
set: [3. OIS Hall offset X] slave=3e, address=60a4, RegData = 02
set: [3. OIS Hall offset X] slave=3e, address=60a5, RegData = 18
set: [4. OIS Hall offset Y] slave=3e, address=60a6, RegData = 01
```