CeleX-5 SDK User Manual

CelePixel Technology Co. Ltd.

Content

1 User Steps of CeleX-5 SDK

1.1 Install MIPI to USB3.0 Driver

1.1.1 Windows

Please install the driver from following folder:

Drivers/Windows

Installation Steps:

(1) Connect the CeleX-5 Sensor to the PC via the USB cable, double-click “**zadig-2.4.exe**” to pop up the interface shown in Fig. 1-1.

(2) Select Options → List All Devices (Fig. 1-2), then select device FX3 (Fig. 1-3).

(3) Click “**Install Driver**” or “**Reinstall Driver**” (Fig. 1-4) to install the driver. After the installation is successful, Figure 1-5 will be shown.

Notes: The data cable must be connected to the USB 3.0 port on the PC.

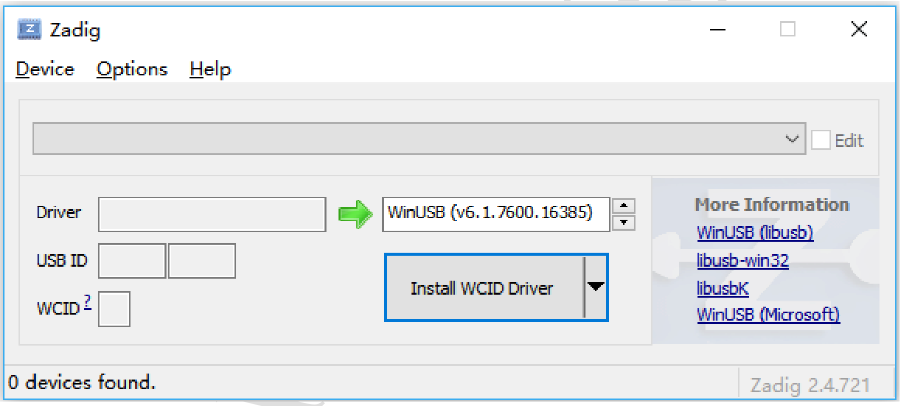


Fig. 1-1

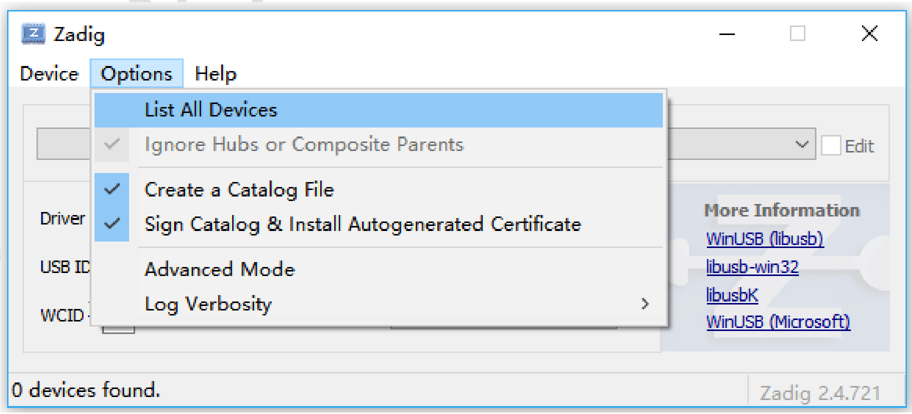


Fig. 1-2

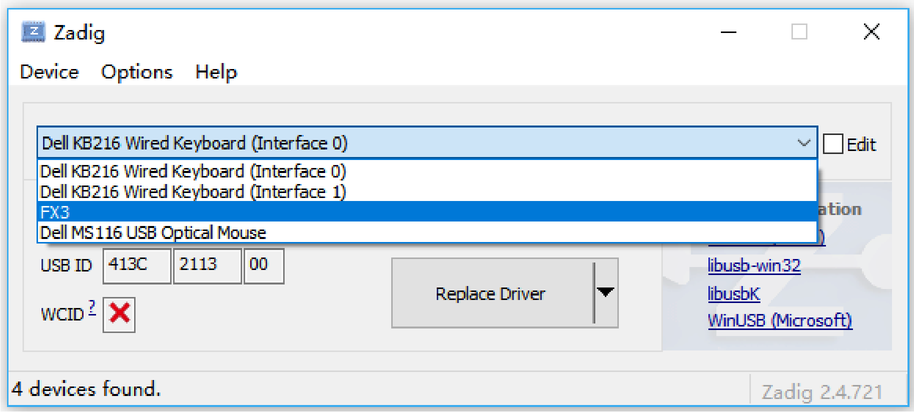


Fig. 1-3

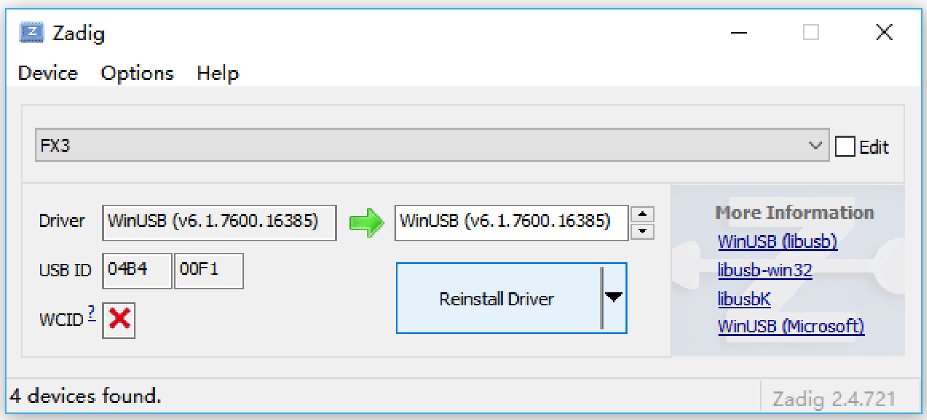


Fig. 1-4

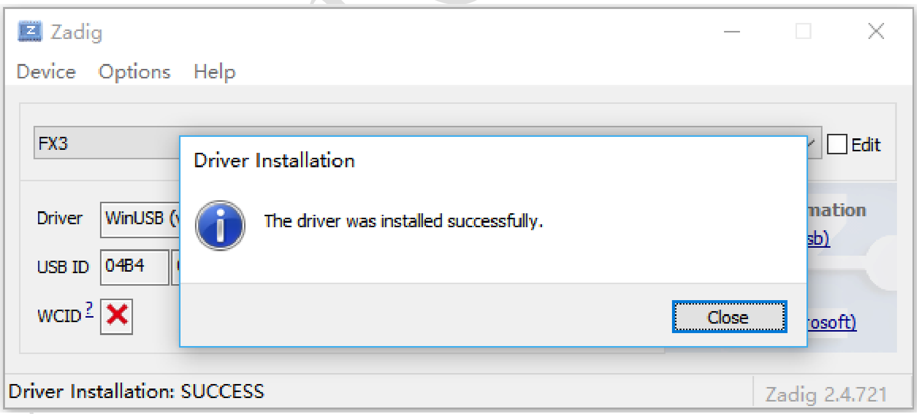


Fig. 1-5

1.1.2 Linux

Please install the driver from following folder:

Drivers/Linux

To install the driver for CeleX-5 Sensor on Linux， extract *CeleDriver-Ubuntu16.04LTS-x64.tar.gz*. after extracting, users will see the following two files:

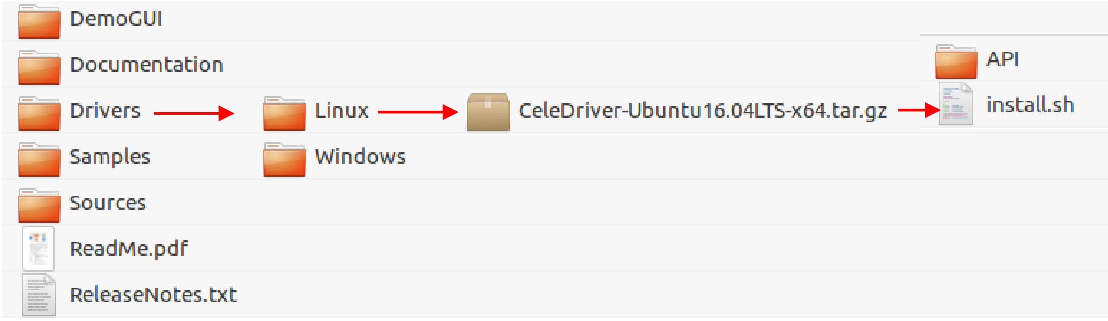


Fig. 1-6

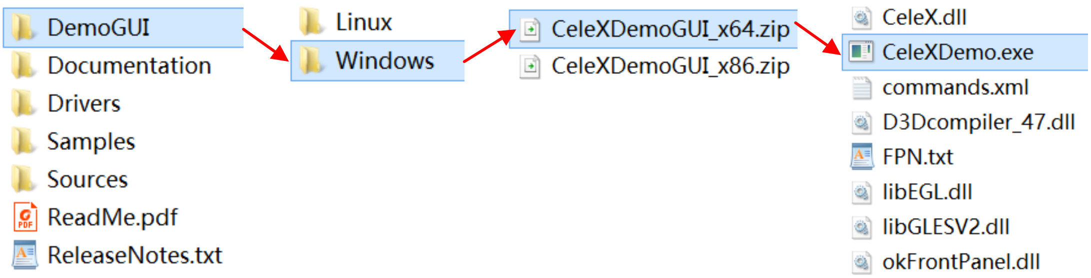
```
sudo sh ./install.sh
```

Fig. 1-7

1.2 Run CeleX Demo GUI

1.2.1 Windows

After installing the Driver, user could open the Demo GUI from following folder:

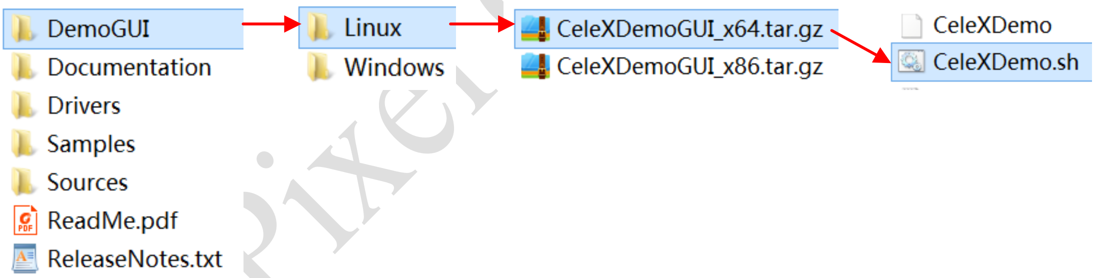


Double-click "CeleXDemo.exe" to open the CeleX-5 Demo GUI, as shown in Figure 2-2 in Chapter 2.

Note: If the software cannot be opened and some windows message box popped out saying some dynamic library files was missing, which may be caused by lacking of Visual C++ supporting package. You can install the "***vc_redist.x64.exe***" under the folder <*Drives/Windows*> and try it again, the software should be working properly.

1.2.2 Linux

After installing the Driver, user could open the Demo GUI from following folder:



Open a terminal and enter the following command to open the Demo GUI， as shown in Figure 2-2 in Chapter 3.

```
$ sudo sh CeleXDemo.sh
```

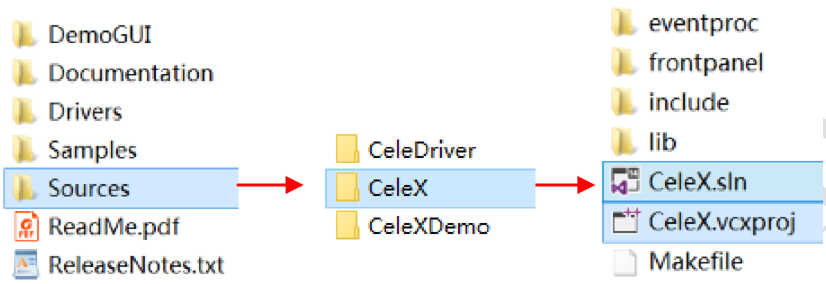
Note: Since we need to read and write the usb driver, we need to open the Demo with root privileges. Without the root permission, the usb device may fail to open.

1.3 Compile CeleX-5 Library Source Code

The OpenCV library (Version 3.3.0) is involved in the CeleX-5 API to develop some interfaces, so you need to install OpenCV and configure its development environment before compiling the source code of CeleX-5 library.

1.3.1 Windows

On the Windows platform, a VS2015 project file is provided to compile the source code, and the build library (CeleX.dll and CeleX.lib) will be imported into the directory *build/Windows*.



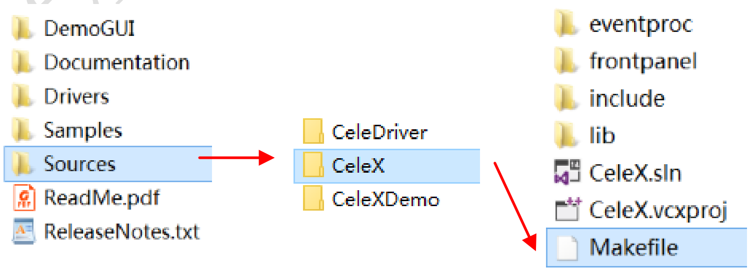
Note:

(1) You need to modify the settings of the OpenCV Include and Lib paths in the project properties. Otherwise, the compilation will fail because the OpenCV header files and libraries are not found.

(2) After the compilation is completed, a build/Windows directory will be automatically created in the directory where the project is located, and the compiled library files (CeleX.dll and CeleX.lib) will be automatically imported into this directory.

1.3.2 Linux

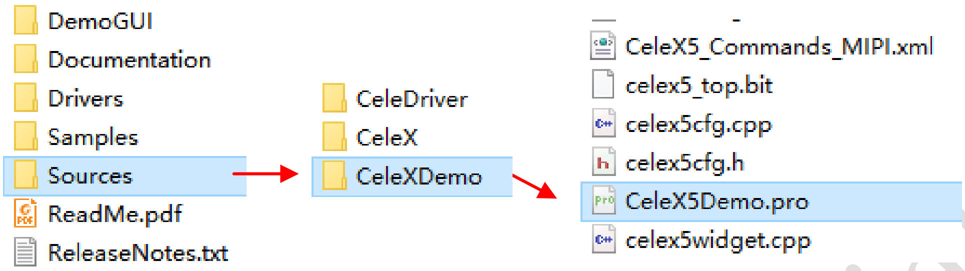
On the Linux platform, a Makefile is provided to compile the source code, and the shared library (libCeleX.so) will be generated in the current directory.



1.4 Compile Source Code of CeleX Demo GUI

Development Environment: Qt5.6.3 + OpenCV3.3.0

You could open the project in the following directory and compile it using Qt Creator easily.



Notes: It needs to modify the INCLUDEPATH and LIBS of OpenCV in the file *CeleXDemo.pro*.

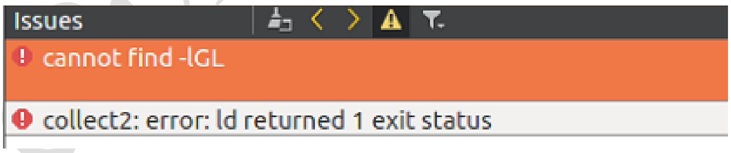
```
win32 {
    INCLUDEPATH += D:/opencv/build/include \
                   D:/Program Files/opencv/build/include/opencv \
                   D:/Program Files/opencv/build/include/opencv2
}
else {

    INCLUDEPATH += /usr/local/include \
                   /usr/local/include/opencv \
                   /usr/local/include/opencv2

    LIBS += /usr/local/lib/libopencv_highgui.so \
            /usr/local/lib/libopencv_core.so    \
            /usr/local/lib/libopencv_imgproc.so \
            /usr/local/lib/libopencv_videoio.so
}
```

Note: Problems that may occur during compilation (Linux):

(1) Cannot find -lGL

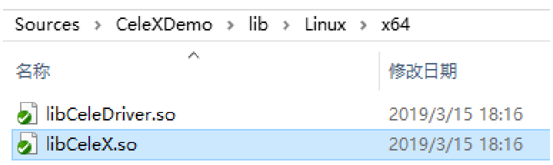


Solution:

sudo apt-get install libgl1-mesa-dev

(2) OpenCV version is not compatible (the version of OpenCV used in this SDK is 3.3.0)

Solution: Compile the API library first (see section 1.3), and then replace the ../Sources/CeleXDemo/lib/Linux/x64/libCeleX.so with the new compiled libCeleX.so. Recompile again to fix this problem.

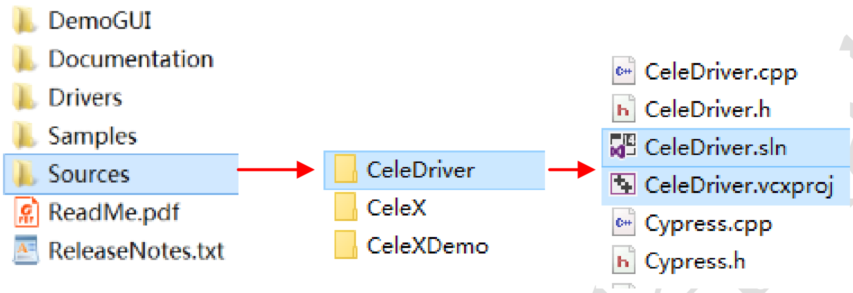


1.5 Compile CeleX-5 Driver Source Code

The CeleX-5 Driver is used to obtain data on the USB side, and the SDK then acquires data through the CeleX-5 Driver for subsequent processing.

1.5.1 Windows

On the Windows platform, a VS2015 project file is provided to compile the source code. You can enter the Driver's Source Code directory by following the illustration below:

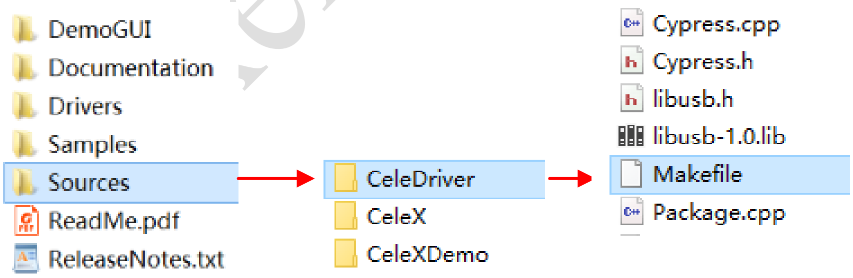


Note:

（1） After the compilation is completed, a build/Windows directory will be created automatically in the directory where the project is located. The compiled library files (CeleDriver.dll and CeleDriver.lib) will be automatically imported into this directory.

1.5.2 Linux

On the Linux platform, we provide a Makefile to compile the code, and the library file (libCeleDriver.so) will be generated in the current directory.



1.6 Generate FPN file

FPN (Fixed Pattern Noise) is the term given to a particular noise pattern on digital imaging sensors often noticeable during longer exposure shots where particular pixels are susceptible to giving brighter intensities above the general background noise. To get rid of FPN, we need to create FPN files for CeleX-5 Sensor. Each sensor requires its own FPN, and steps for generating FPN are illustrated in section 2.4.

2 Introduction to CeleX-5 Demo Kit GUI

2.1 Introduction to the working mode of the CeleX-5 Sensor

This SDK provides five operating modes for the sensor. Users can switch between the five modes via the Demo GUI. The figure below gives the name of each mode and the corresponding image.

Event Address Only Mode

Event Optical-flow Mode

Event Intensity Mode

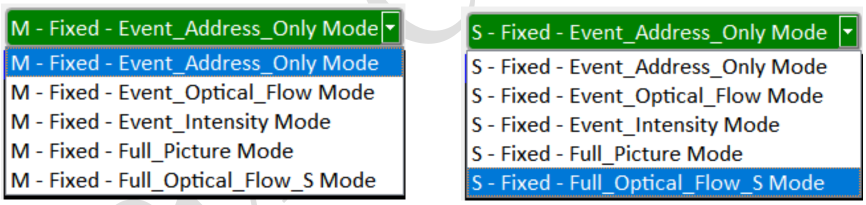
Full-frame Picture Mode

Single Full-frame Optical-flow Mode

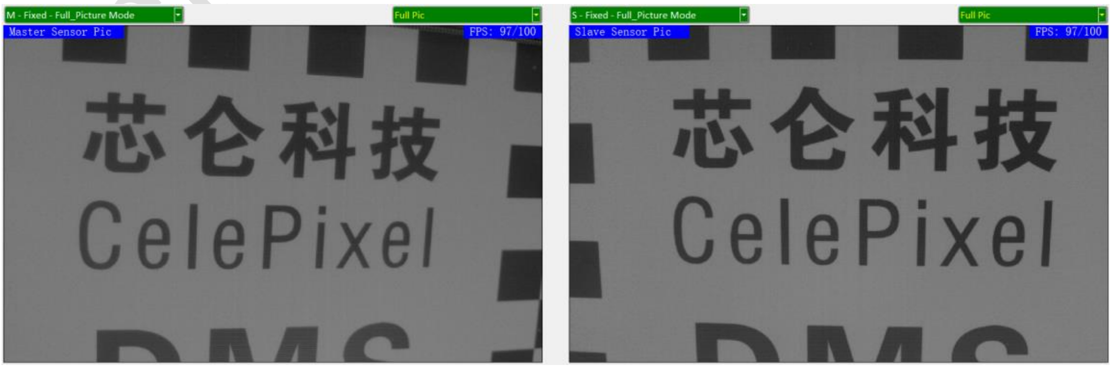
2.2 Change Sensor mode (Fixed Mode)

Since this document is for 2 Sensors, the Demo GUI will be different from the previously released version (single sensor).

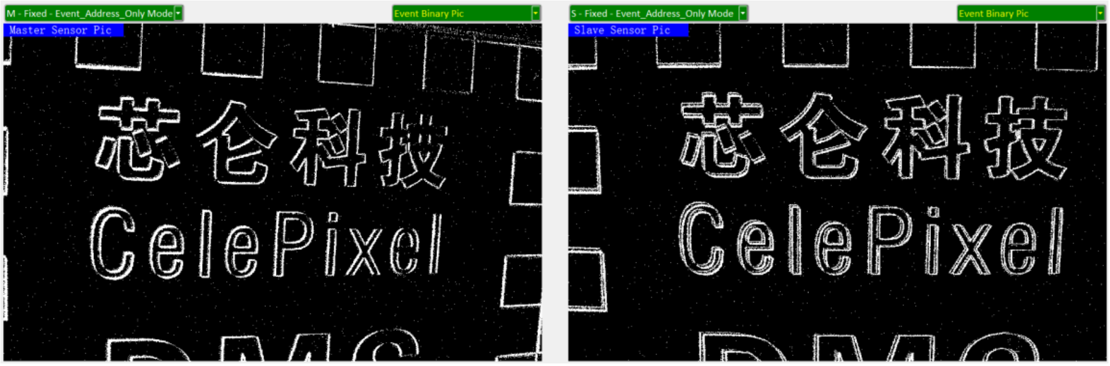
As shown in the figure below, the image on the left is the image of the Master Sensor, and the image on the right is the image of the Slave Sensor. As for how to set up the Master Sensor and the Slave Sensor, it will be introduced in Section 2.5.2.



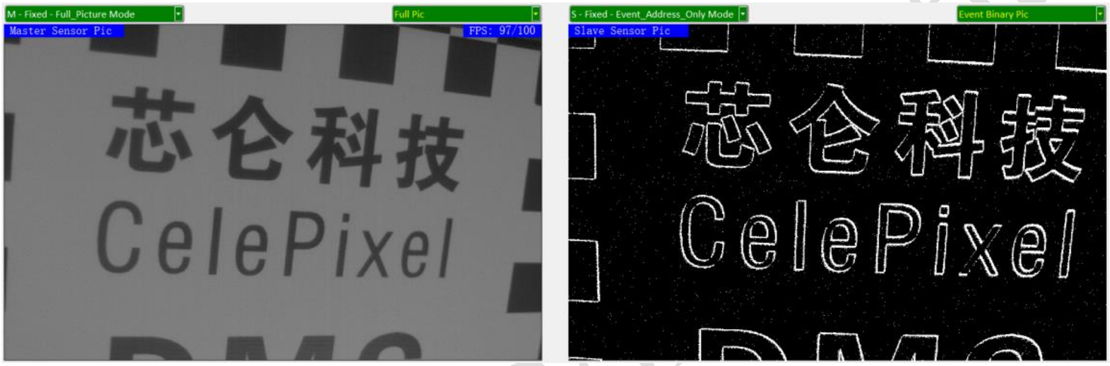
Users can switch modes by clicking on the selection box shown above. The left side corresponds to the Master Sensor and the right side corresponds to the Slave Sensor. The image display of the two sensors working in the same mode or different modes will be given below.



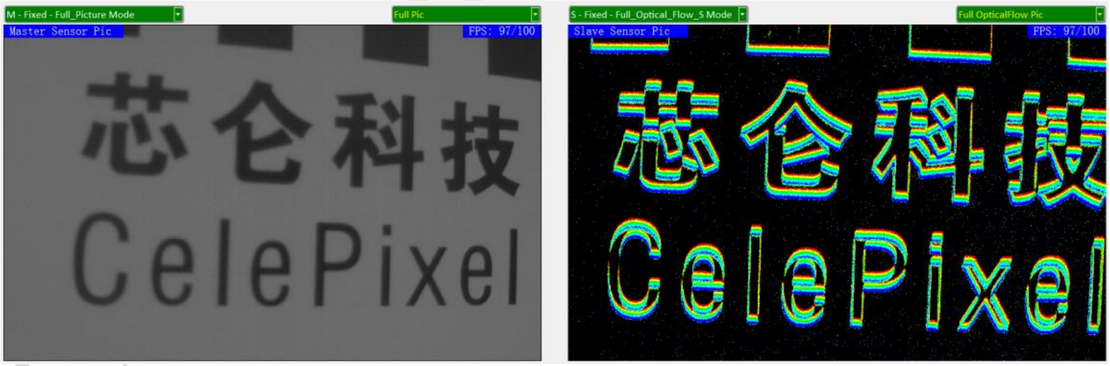
Two Sensors work in *Full-frame Picture* mode at the same time



Two Sensors work in *Event Address Only* mode at the same time



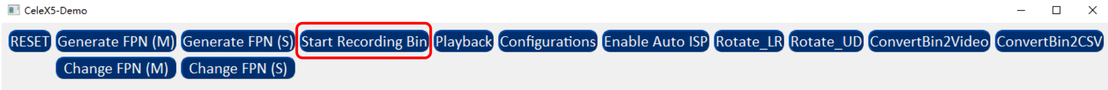
Two Sensors work in *Full-frame Picture* and *Event Address Only* modes respectively

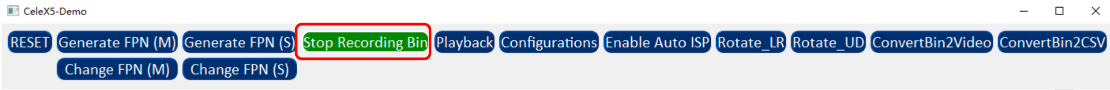


Two Sensors work in *Full-frame Picture* and *Single Full-frame Optical-flow* modes respectively

2.3 Record Raw Data of Sensor (Bin Files)

Click the "***Start Recording Bin***" button to start recording Bin data, then the text on the button will change to "***Stop Recording Bin***". Then Click the "***Stop Recording Bin***" button to stop recording Bin data





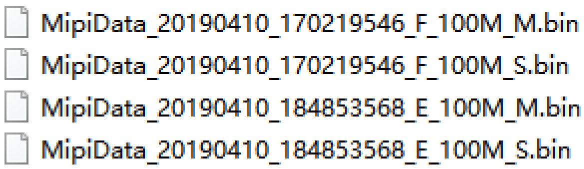
If two sensors are connected, the data of the two sensors will be recorded at the same time, and the recorded bin file will be saved in the same directory as CeleXDemo.exe.

The name of the Bin file recorded by the Master Sensor is:

MipiData_YYYYMMDD_HHMMSSSSS_SensorMode_ClockRate_M.bin

The name of the Bin file recorded by the Slave Sensor is:

MipiData_YYYYMMDD_HHMMSSSSS_SensorMode_ClockRate_S.bin



E indicates that the recorded data is in Event Address Only mode, and **F** is in Full-frame Picture mode. The following abbreviations are given in several other modes:

(1) *Event Optical-flow Mode*: EO

(2) *Event Intensity Mode*: EI

(3) *Single Full-frame Optical-flow Mode*: FO1

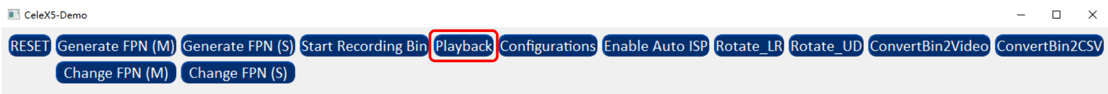
M indicates the Master Sensor or the first identified Sensor, and **S** indicates the Slave Sensor or the second identified Sensor.

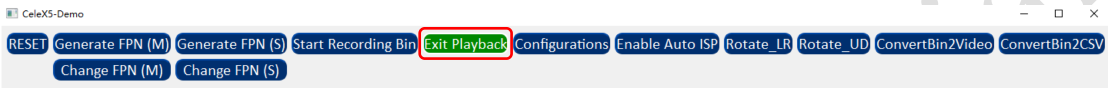
100MHz means that the Sensor operates at 100MHz.

2.4 Playback Recorded Raw Data of Sensor (Bin Files)

The ***Playback*** function supports both playing a single bin file and simultaneously playing two bin files. The specific operations are as follows:

Click the "***Playback***" button and select a bin file or two bin files. After the playback starts, the text on the button will be "***Exit Playback***". Then clicking the "**Exit Playback**" button will stop playing the Bin file and back to the real-time display.





The following figure shows two bin files playing at the same time. The image on the left shows the data of the first bin file, and the image on the right shows the data of the second bin file.

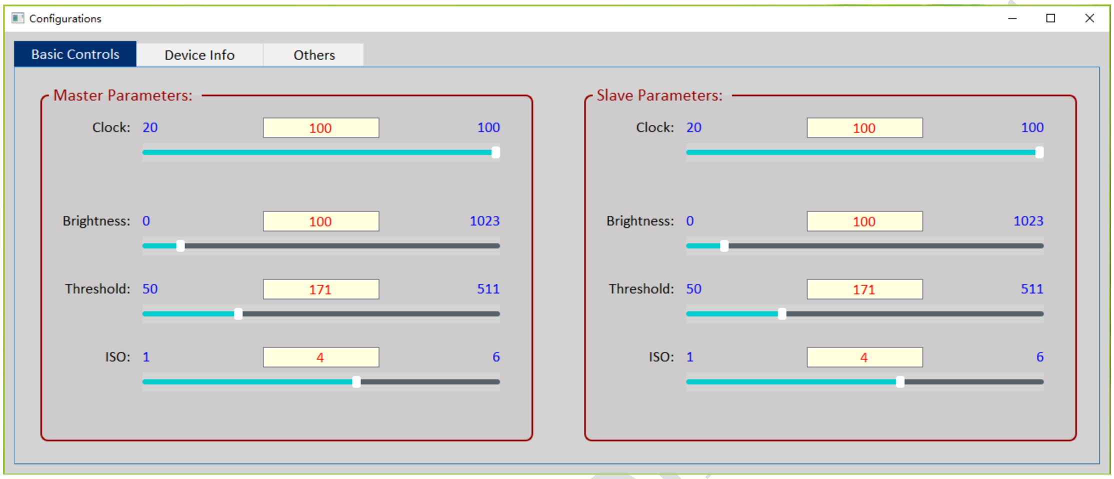
Playback also supports "***Replay***", "***Play/Pause***", ***saves the picture*** (divided into saving the picture from the current playback position and saving the picture from the beginning). Buttons are in the yellow frame area shown above.

Users can select various Pic modes of the bin file for display (shown in red in the figure above) and can also modify parameters such as ***Frame Time*** or ***Display FPS*** (shown in the blue box in the figure above).

2.5 Configurations

Click the "***Configurations***" button to open the configuration interface. Some hardware functions or software functions could be configured in this interface.

2.5.1 Basic Control Parameters (Basic Controls)



This set of parameters is hardware parameter that controls the Sensor and only works when displayed in real time, they are not need to be adjusted during Playback.

When there is only one sensor connected, then you only need to adjust the Master Parameters on the left. When there are two Sensors connected, parameters on the left correspond to the Master Sensor, and parameters on the right correspond to the Slave Sensor.

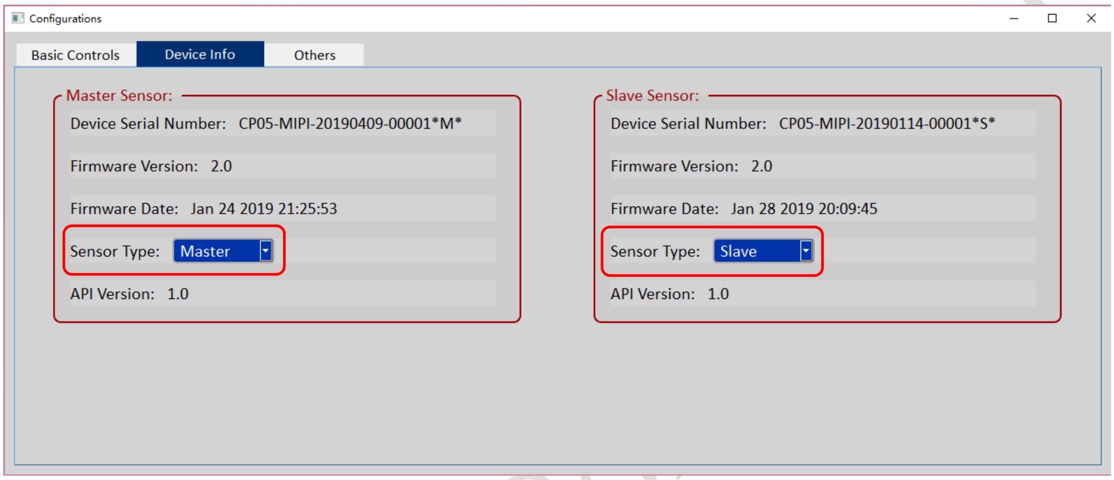
How to distinguish between Master Sensor and Slave Sensor will be introduced in the next section (2.5.2 Sensor Device Information).

The function and meaning of each parameter in basic control

Clock	Adjust the operating frequency of the Sensor. The default value is 100MHz. The larger the value, the faster the Sensor will detect. Works for all modes.
Brightness	Adjust the brightness of the image, the larger the value, the darker the image will be. Works Only for Full-Frame Picture and Event Intensity
Threshold	Adjust the threshold value associated with the number of triggered events. Under the same conditions, the larger the value, the smaller the number of triggered events. Works for Event Address Only, Event Optical-flow, Event Intensity, and Single Full-frame Optical-flow.

ISO	Adjust the value associated with image contrast and dynamic range. The higher the value, the lower the contrast and the higher the dynamic range. If the value is modified, it needs to regenerate the FPN (please refer to section 2.6). This SDK will automatically use the new FPN file corresponding to the ISO value. Works only for Full-Frame Picture and Event Intensity

2.5.2 Sensor Device Information (Device Info)



In addition to the Sensor Type, all other information in this set of parameters is read-only. The table below gives the specific meaning of each message.

Device Serial Number	Device serial number, each sensor has a unique serial number.
Firmware Version	Firmware version number.
Firmware Date	Release date of the firmware.
Sensor Type	It is used to distinguish whether a sensor is a Master or a Slave. By default, all Sensors are Masters. Users can modify the Master and Slave property of the Sensor through the selection box shown above.
API Version	API version.

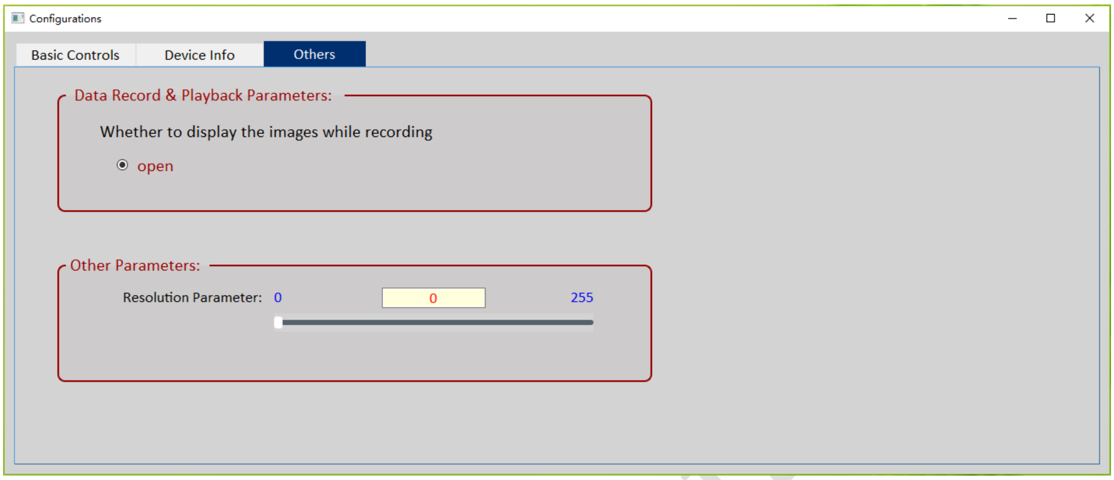
When only one sensor is connected, the device information is displayed in the "***Master Sensor***" on the left and the "***Slave Sensor***" on the right is empty.

When there are two sensors connected, if users have not modified the "***Sensor Type***", the left side shows the first identified Sensor device information, and the right side shows the second identified Sensor device information. The "***Sensor Type***" on both sides is Master.

Note: The order in which the devices are recognized is independent of the chronological order in which the Sensor is connected. It is related to the port location of the connected USB.

It needs to set the Master Sensor's “***Sensor Type***” to "***Master***" and the Slave Sensor's “***Sensor Type***” to “***Salve***” according to the connection status of the two Sensors, and then restart the program. This ensures that the Master Sensor image will be displayed on the left and the Salve Sensor image will be displayed on the right each time it is launched.

2.5.3 Other Parameters (Others)

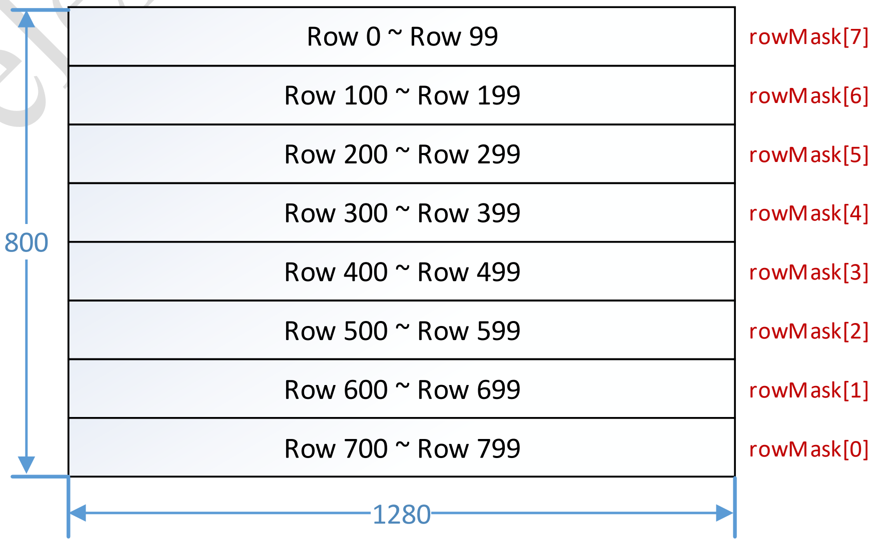


When recording a Bin file, you can choose to turn off the screen display to ensure the integrity of the data (due to the time-consuming analysis of the data when displaying, it may result in data loss).

In addition, the resolution can be modified in this interface. Some lines could be disabled by modifying the "***Resolution Parameter***".

As shown in the figure below, the default resolution of CeleX-5 Sensor is 1280*800, which can be divided into 8 blocks by row. The size of each block is 1280*100, and each block has a corresponding Control bits (rowMask[7] to rowMask[0] from top to bottom).

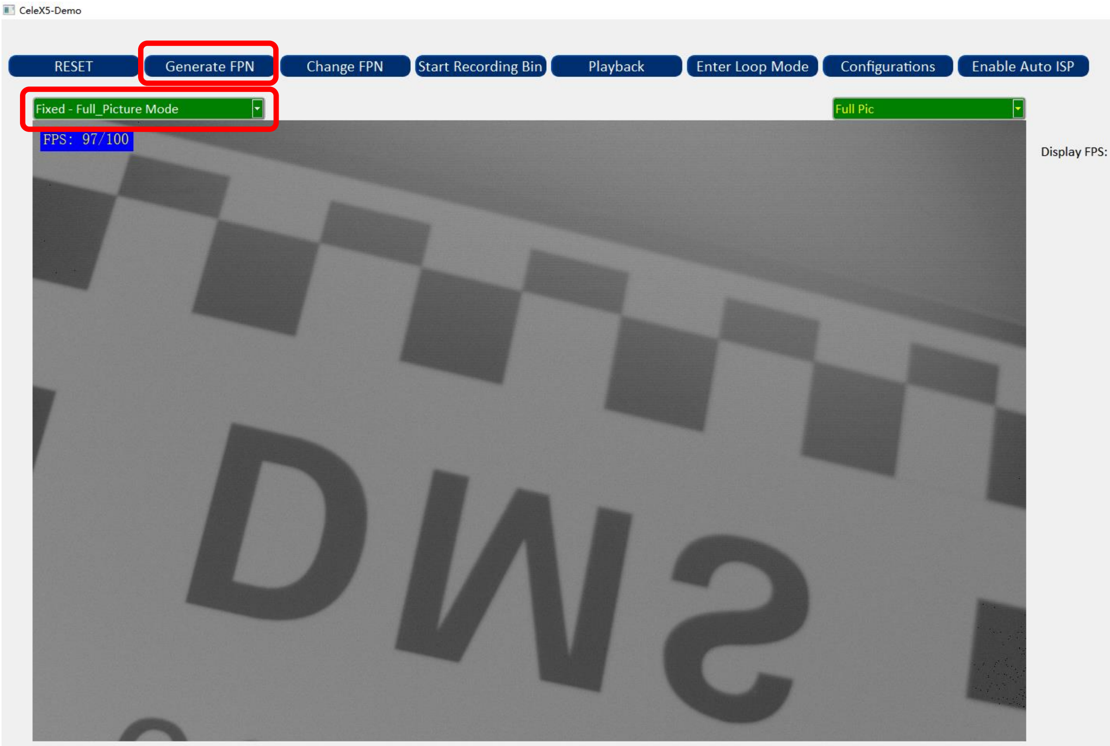
For example, to disable the top 100 rows, simply set rowMask[7] to 1, and set the other control bits to 0, that is, the value of Resolution Parameter is set to 128 (b’10000000).



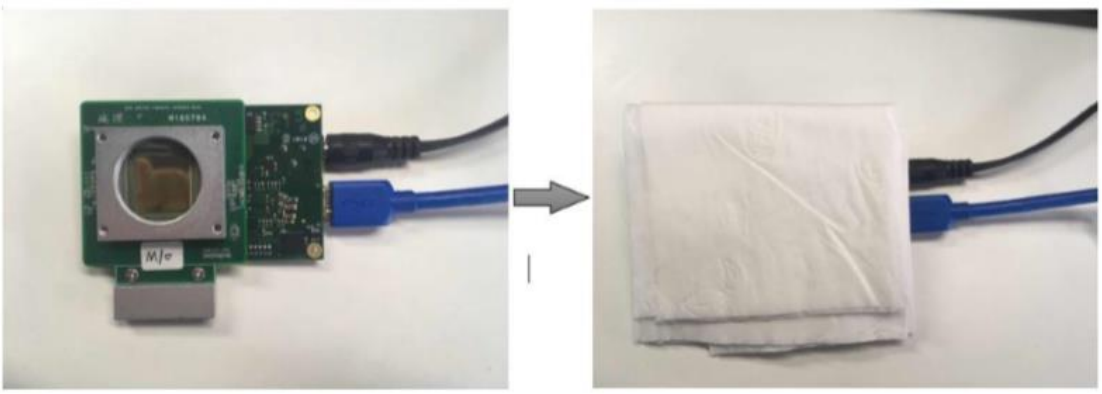
2.6 Generate FPN file

Each sensor requires its own FPN, and steps for generating FPN are illustrated as below:

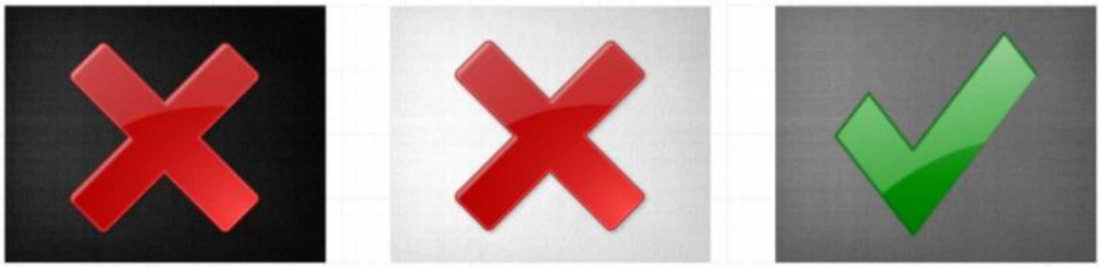
1) Switch the Sensor operating mode into "Full-frame Picture Mode".



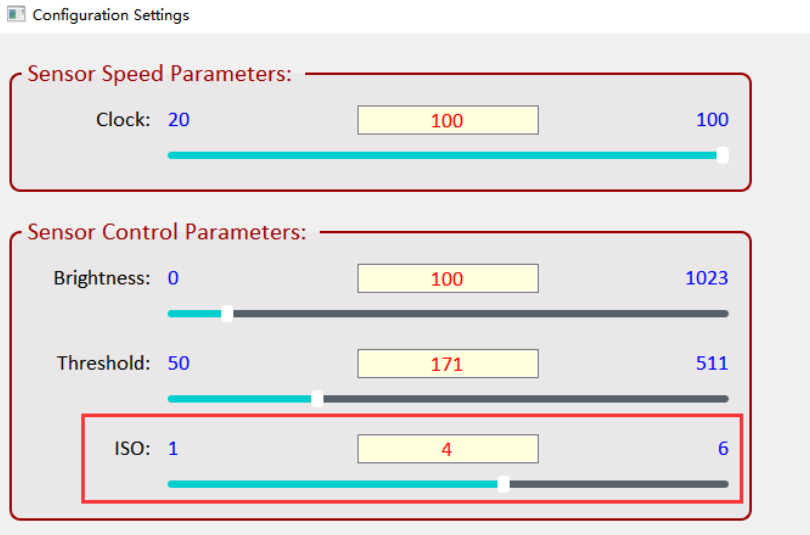
2) Since the FPN should be conducted under the condition of uniform illumination, we could use the way of removing optical lens and covering a piece of white paper (thin tissue or A4 paper) over the exposed Sensor. Make sure that paper completely covers the sensor and sheet is stationary. **NOTE: the effect will be better if you operate in natural light rather than the LED lamp.**



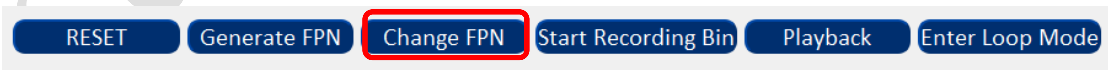
3) Before generating FPNs, please check the image screen and make sure it is normal, which is neither too dark nor too bright. Then, you could adjust the amount of paper over the Sensor or switch the "Brightness" slider in the GUI to change the luminance. **NOTE: the 3rd figure is the right luminance among the three figures below.**

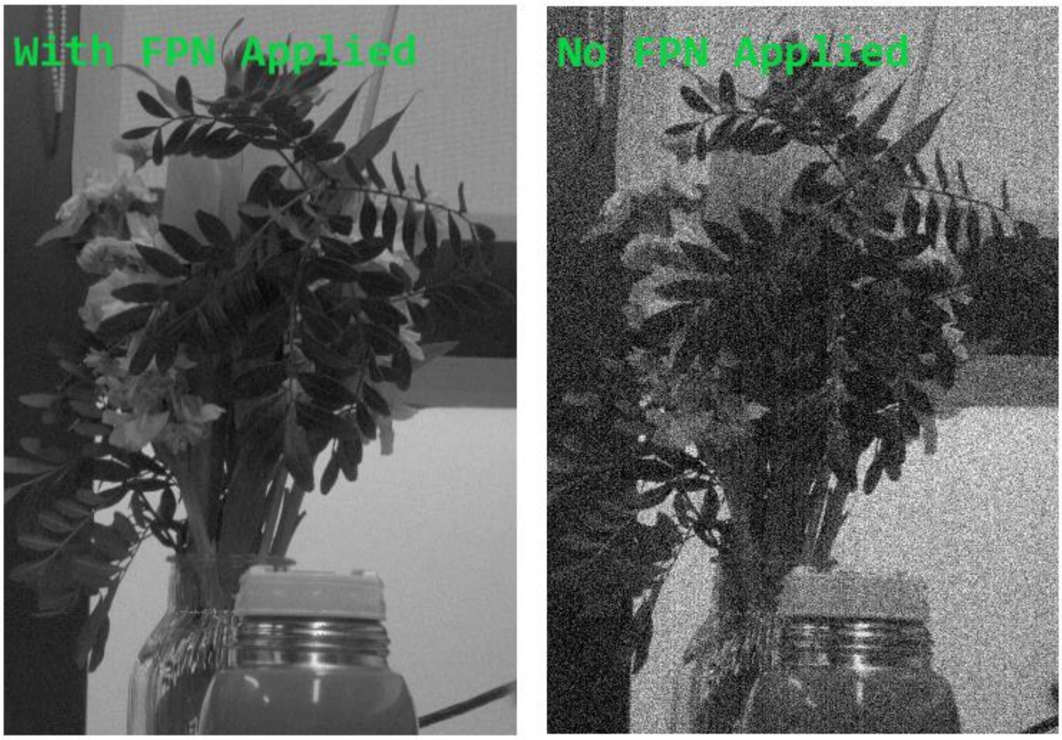


4) Click the "***Generate FPN***" button in GUI. Then, you could see the FPN_3.txt file in assigned direction after FPN file was successfully generated. **Note: Different ISO levels correspond to different FPN files. ISO has a total of six levels. The default is the third level, which corresponds to the FPN_3.txt file. The user can obtain a brighter or darker image by adjusting the ISO level in the Configuration settings.**



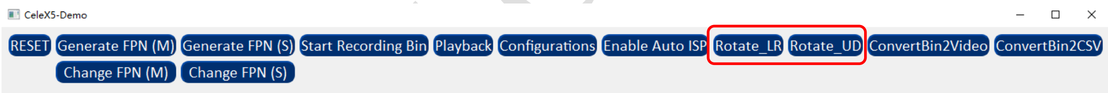
5) After generating the FPN file under the corresponding ISO settings, we can choose to switch to the corresponding FPN by clicking the "***Change FPN***" button. **Note: If the FPN file is generated according to the steps, but the image resolution is not improved after switching, check whether the current ISO corresponds to the FPN; check whether the selected FPN path contains the Chinese path.**





2.7 Flip image

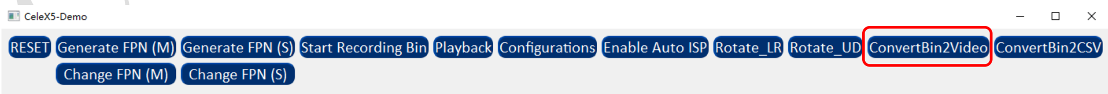
Click the "***Rotate_LR***" or "***Rotate_UD***" button to flip the image left and right or up and down.



Note: The Demo GUI currently only supports flipping images of 2 sensors at the same time. It does not support only flipping image of a sensor.

2.8 Convert bin to video

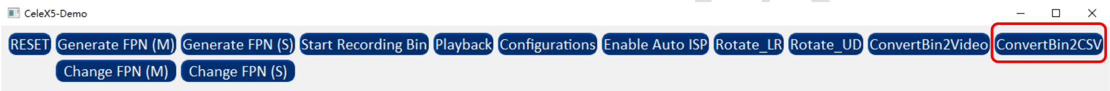
Click the "***ConvertBin2Video***" button, you can convert the recorded Bin file to a video file with the same name as the file, and only support one bin file at a time.



A video file in .mkv format is generated under Windows, and a video file in .mp4 format is generated under Linux. By selecting a different image format, you can convert the corresponding image format video of the Bin. For example, if you select the denoised image format, you can convert the Bin file of *Event Address Only* mode into the denoised image video.

2.9 Convert bin to CSV

Click the "***ConvertBin2CSV***" button to convert the recorded Bin file to a CSV file, and only support one bin file at a time.



This function only supports data recorded in event mode, and the data transferred from different event modes is also different, as follows:

(1) For *Event Address Only* mode, the data stored in the csv file is Row, Colum, and Timestamp.

(2) For *Event Intensity* Mode， the data stored in the csv file is Row, Colum, Intensity, Polarity and Timestamp.

(3) For *Event Optical-flow* Mode, the data stored in the csv file is Row, Colum, Optical-flow Info, and Timestamp.