Application Note

BMVM Depth Previewing Tool Linux SDK

Revision: 1.1

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1.0 Introduction

The main purpose of this Depth Previewing Tool for Linux SDK is to explain on how to generate a depth image and transfer from each resolution mode, including the usage of basic functionality application. This is about the introduction of Linux SDK (The reference version is **4.0.2** or above one).

The application note will cover how to open the program, how to configure the settings, and how to generate 3D Point Cloud Image. This application note applies to Linux operating systems.

The BMVM depth cameras are empowered by State-of-the-Art series processor to provide depth map data along with color image. This document is the user manual that covers following sections:

- System requirements
- BMVM-OS series depth camera setup

Note: (*RS): Rolling Shutter and (*GS): Global Shutter

1.1　System Requirement

To evaluate the full features and performance of BMVM series depth camera, the minimum system requirements as listing below are suggested,

- Supported operating system
  - Ubuntu16.04 or 18.04 64bit

- CPU type
  - X86, ARMHF, ARMEL

- Memory
  - 2GB RAM or greater

- Display resolution
  - 1366x768 (1600x1050 or higher recommended) with True Color

- Display card
  - NVIDIA GeForce GTX 1050 Ti(or above)

- Computer interface
  - USB2.0 Type A
  - USB3.1 Gen1 Type A
  - USB3.1 Gen1 Type C

2.0   Linux SDK Utility Environment Setting

2.1   Build Environment

* Type command in terminal

(1). sudo apt-get update

(2). sudo apt-get upgrade

(3). sudo apt update

(4). sudo apt upgrade

(5). sudo apt-get install build-essential qtcreator qt5-default libudev-dev

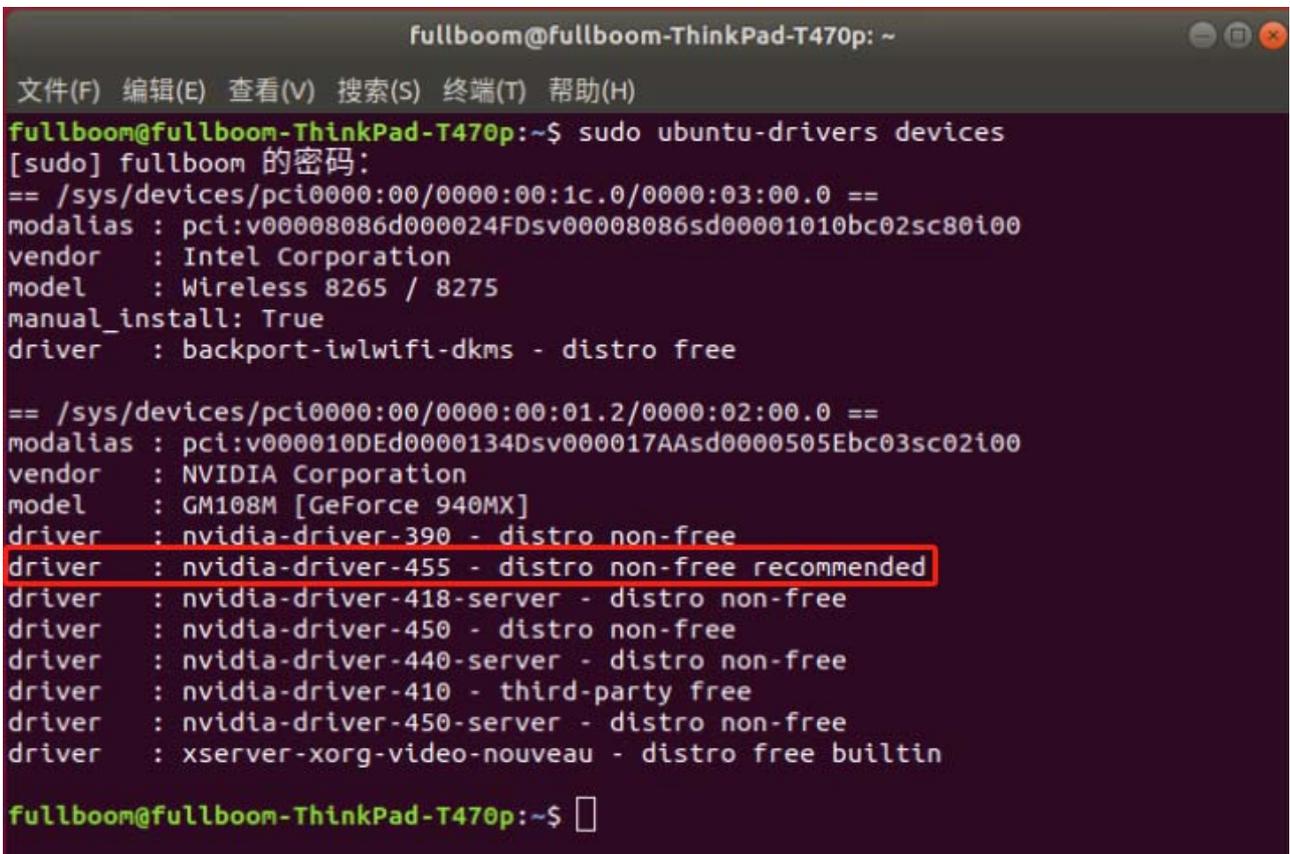### 2.2   OpenCL library support(Nvidia)

* Type command in terminal

(1). sudo apt-get install nvidia-opencl-dev

2.3   Graphics driver support(Nvidia)

* Type command in terminal

(1). sudo ubuntu-drivers devices

Figure 2-1. Graphics driver list

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(2). sudo apt-get install nvidia-driver-455 (recommend option)

(3). sudo reboot

2.4   Run EtronDI Utility

* Type command in terminal

(1). Open terminal in [HD-DM-Linux-SDK-4.0.2/bin]

(2). Type sudo sh run_DMPreview_X86
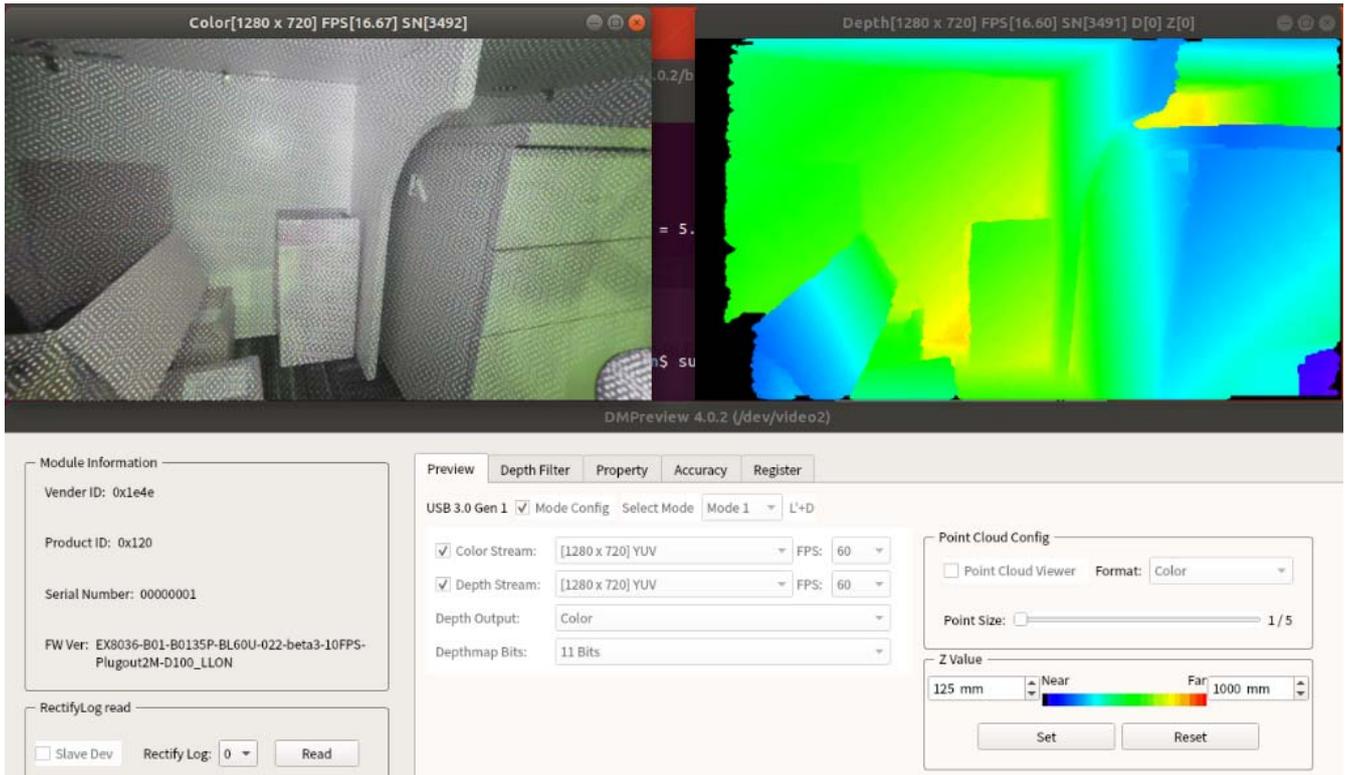
Figure 2-2. DM preview

2.5   Build DMPreview Project (DMPreview utility)

* Type command in terminal

(1). Open Qt Creator

(2). Click [File] -> [Open file or project]

(3). Select [HD-DM-Linux-SDK-4.0.2/DMPreview/DMPreview.pro]

(4). Click [Configure Project]

(5). Click [Run] or [Build] icon
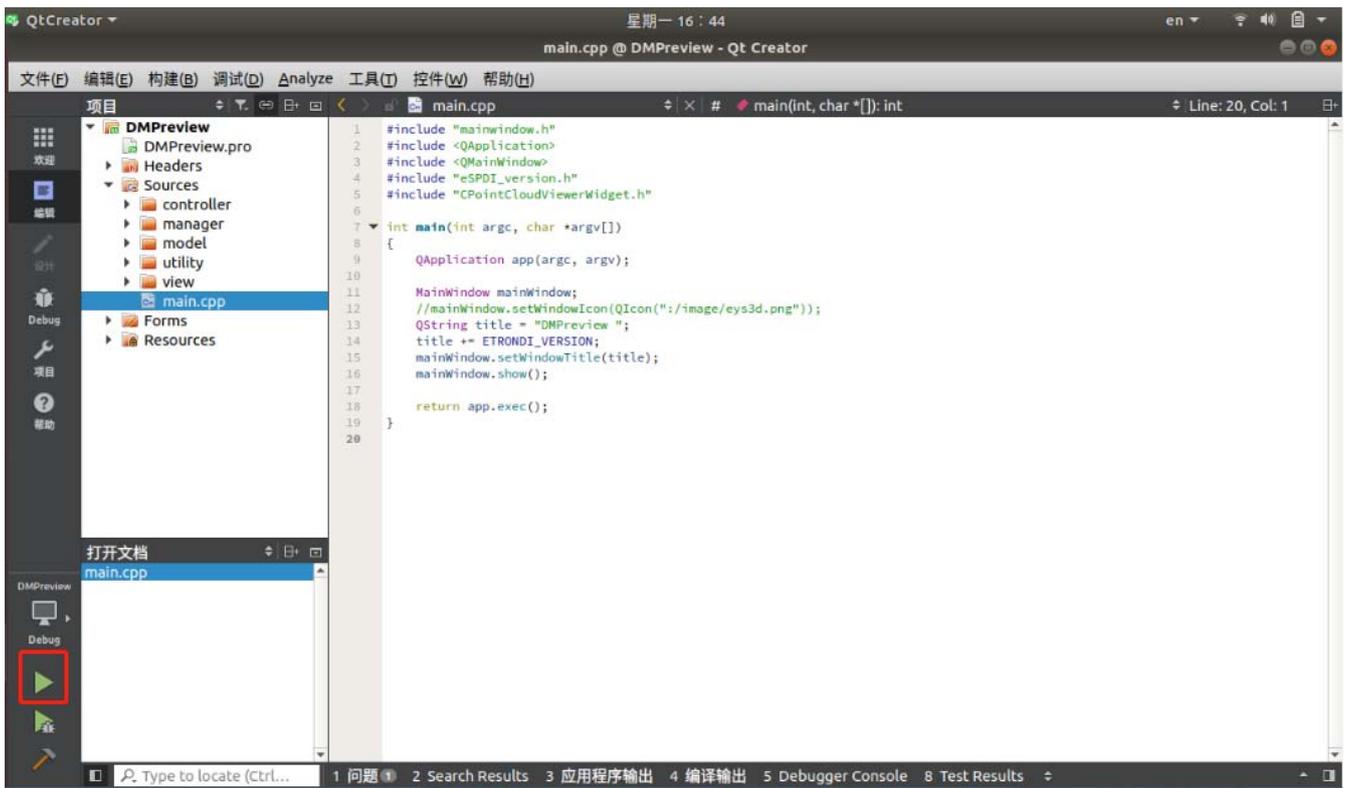
Figure 2-3. Qt Creator run&build

3.0   Setting up the Depth Previewing Application

1. Connect the USB3.1 Gen1 (Micro-B or Type C) or USB 2.0 (Micro-B) cable to the depth camera.
2. Then connect the other end of the USB3.1 Gen1 (Type A or Type C) cable to the USB port of your computer.
3. For more detail setup instruction, please refer to the Quick Start Manual enclosed in the camera package.

Note:
If the camera is connected to the computer via an USB2.0 interface, the supporting resolution or frame rate may not reach its best performance. Setup the camera to USB3.1 Gen1 connectivity is highly recommended.

Depth Camera

USB3.1 Gen1/2.0 cable

Laptop

Figure 3-1. Depth Camera to PC Connection

3.1   Connecting the 3D Camera Module

In order to generate Depthmap and 3D Point Cloud image data file, you will need to *connect* the BMVM depth module to a PC or laptop with Windows operating system through a USB 3.1/2.0 cable.

3.2   Open DMPreview

To open terminal in [HD-DM-Linux-SDK-4.0.2/bin], type: sudo sh run_DMPreview_X86,This will open the camera module's configuration window.

3.3   Camera Module Configuration Window

To open the settings window, the first window that opens will prompt you to select a device when plug in multiple modules; otherwise the color, depth-map image are automatically opened when plug in one module.

Figure 3-3. Camera Module Configuration Step 1 – Select Device

Once the device has been selected the main configuration settings window will appear:

The default Mode will be enabled automatically and User can select any mode in Spec. to show the color, depth-map or the color with depth-map image, it is not necessary to re-set the color, depth stream and bit parameter by manual.
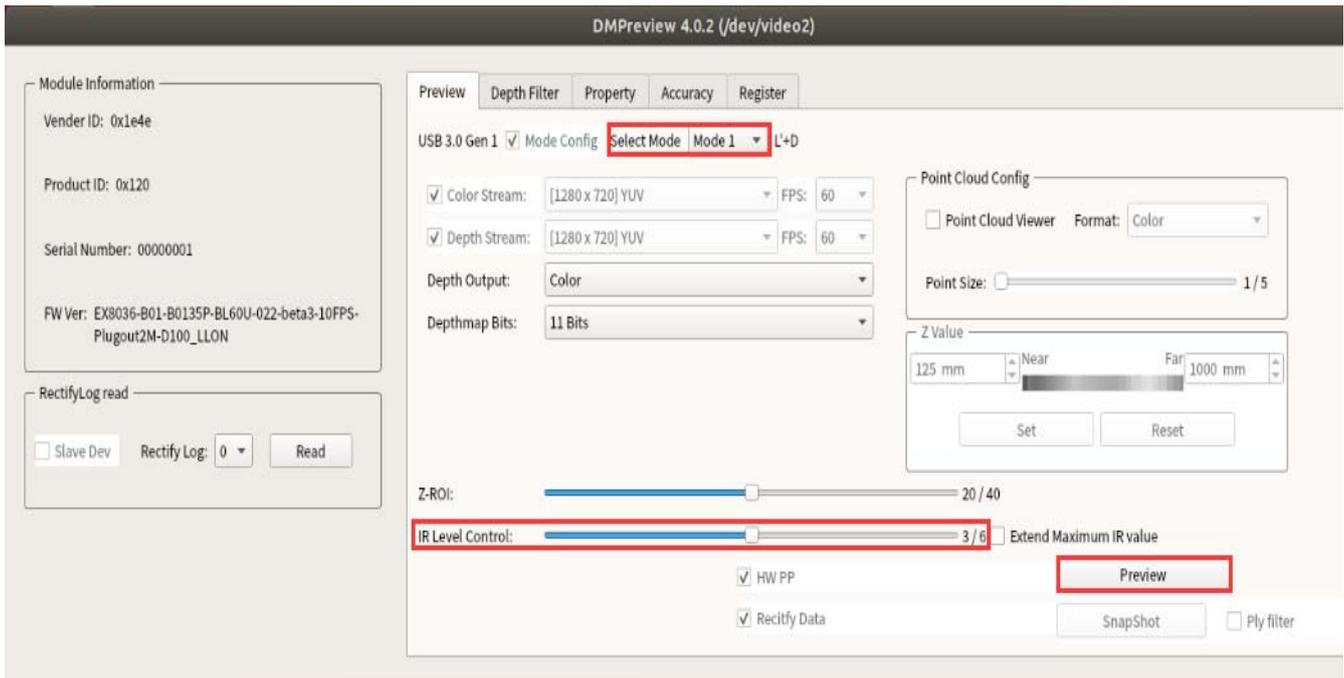
Figure 3-4. Camera Module Configuration Step 2 – Main Setting

3.4   Optimal Setup for Generating an Image Data

To generate a 3D point cloud image data file, the optimal settings need to be applied first. If the compatible settings are not applied the image generated may not be of optimal quality. The settings can be found in the **Camera Module Configuration main setting**.

Color Stream and **Depth Stream:** Both the **Color Stream** and **Depth Stream** doesn't need to be selected apart from the engineering mode is opened. Due to the engineering mode, the manual control is released and the **YUYV** for both needs to be set at 1280 x 720 which can be selected from the drop down menu. **HW PP (e.g. hard post processing) is selected by default to enhance depth-map image quality.**

Figure 3-5. Color and Depth Stream Settings

Depth Output: From the drop down menu, select **Color Image (default)** from the options of: **Color** and **Gray Image**. User can select different Depthmap output format.
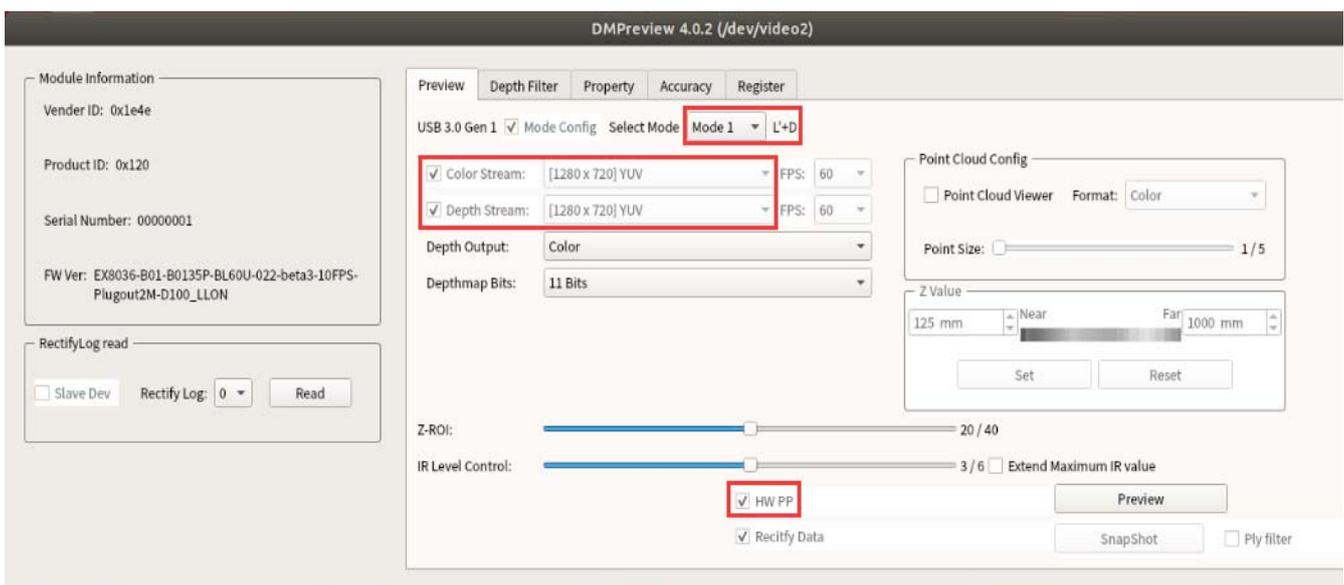

Figure 3-6. Color or Gray Output Control

Depthmap Bits Selection: The Depthmap Bits Selection dropdown menu has options: **8 bits 11 bits** and **14 bits. The "11 bits"** (Default) **/ "14bits"** should be selected for a module connected with USB 3.0, and the "**8 bits**" should be selected for a module connected with USB 2.0 only. There are different selections due to each module with the specified application.

Figure 3-7. Depth Bits Selection

IR Level Control: The **IR Control** setting is a slider bar, the bar slides from 0 to 6, the default is 3. Level "0" will turn off the projector and "6" will set the strongest intensity. The IR value can be extended to 15 when Extend Maximum IR value is selected. Note that using higher power without additional heat sink may cause the system to overheat.

Figure 3-8. IR Level Control

<u>Safety Advice:</u>

Depending on the operational use of the device, the modules can emit highly concentrated non-visible infrared light which can be unsafe to the human eyes.

The illuminator is a laser product of high power infrared emission. Refer to the relevant safety regulations for protection during operation.

"Complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019"

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Z-ROI (Threshold): The Z-ROI can be changed due to the different application and the sensitivity of distance judgment user need. The bar slides from 1 to 40, the default is 20. In stereoscopic depth map calculation, depth information is obtained through a defined Region of Interest (ROI) in a scene and retrieved by mouse over to any coordinate of the depth map window dialog. This "Z-ROI Control" allows user to define the ROI size to adapt various sensing scenes.

Figure 3-9. Depth ROI Control

Z Value (Depth working range):

The Z-far value should be set at **1000** mm (default), however it should be set more than 1000mm while you need to see the point cloud data of object or depthmap of object that located distance to module is over 1000mm.

The Z-near value is set at **125** mm after image previewing, its value is different depending on module.

User could set different value to see different RGB color depending on near to far distance.

Figure 3-10. Z Far Control

Note: This control function is enabled after image previewing

Point Cloud Viewer: When selected the image previewing will display 3D dynamic point cloud image by separated pop-up window.

Format Select: <**Color**: When selected the 3D dynamic point cloud image is according depth output color mapping on depthmap data with fusion color stream . **Depth Output**: When selected the 3D dynamic point cloud image is according depth output color mapping on depthmap data without fusion color stream. **Sigle Color**: When selected the 3D dynamic point cloud image is only displaying unique color mapping on depth data without fusion color stream>.

PointCloud-PointSize: The point size of 3D dynamic point cloud image can be changed from 1 to 5 times, the default is 1.

Figure 3-11. Point Cloud Config

3.5 Previewing an image

After all the settings are selected, *click* the **"Preview"** button, this will open two new windows and one will display the color Image and the other one will display the depthmap preview. One window will show the color image as the human eye sees it, the other window will preview the depthmap information with mapped on distance translation inside the software.

Depth data (z-value) is color mapped from a [0 – 255] color palette to indicate how far an object is and its proximity relative to the camera.

- **Color Stream Status:** Information related to the camera video stream is shown at the top of the Video stream window dialog's title-bar. The information contains resolution [RES] and statistic data of averaging frame-rate [FPS] and current video frame counter [SN]. For example,
    - Color[1280 x 720]: The resolution of video stream is 1280 x 720.
    - FPS[16.66]: Averaging frame rate is 16.66 frame per second (FPS).
    - SN[1106]: The current video stream frame counter marking is 1106.
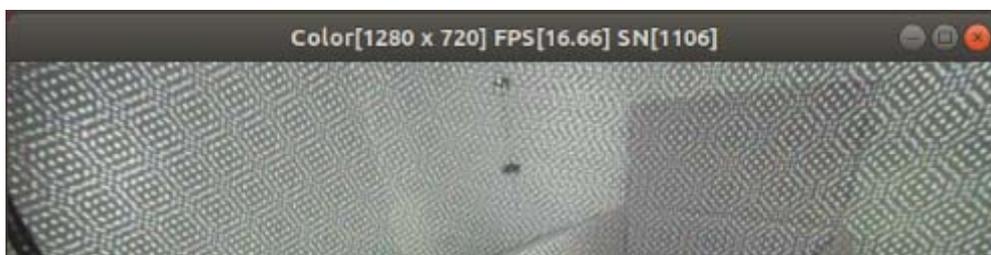

Figure 3-12. Color Stream Status Indicators

- **Depth map Stream Status:** Information related to the camera depth map stream is shown at the top of the depth map stream window title-bar. The information contains resolution [RES] and statistic data of distance measurement [Z] at mouse pointer, depth disparity [D], frame rate [FPS] and current depth map frame counter [SN]. For example,
    - Depth [1280 x 720]: The resolution of depth map stream is 1280 x 720.
    - FPS [16.62]: The depth map stream averaging frame rate is 16.62 frame per second (FPS).
    - SN [1106]: The current depth map stream frame counter marking is 1106.
    - D [256]: The measured depth disparity at the location of mouse pointer is 256.
    - Z [8692]: The measured distance at the location of mouse pointer is 8296 mm.
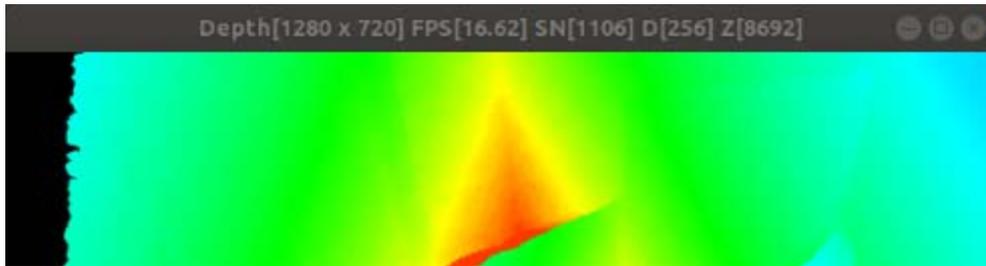
Figure 3-13. Depthmap Stream Status Indicators

3.6   Taking a Snapshot

Preview Image must be clicked before a snapshot can be taken, once **Preview** has been selected, the **Snapshot** button should now be enabled and can be pressed to capture the image from the previewed windows.

A snapshot needs to be taken before an image can be transferred to the MeshLab Software. To take a Snapshot, first check that the image in the previewed windows is capturing the preferred image, then *click* the "**Snapshot**" button in the Camera Module settings window.
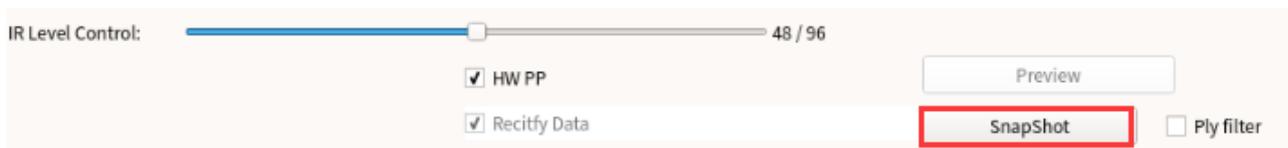

Figure 3-14. Snapshot Button

- **Capturing Color Image, Depth map and 3D Files:** Snapshot function provides the operation of capturing and saving the current image (video frame) and various depth map data formats to files. These files will be saved in the path: HD-DM-Linux-SDK-x.x.x/out/image/.

- **Capturing with post-processing filters (Ply Filter):** The depth map data will be parsed through the post-processing filters before files save, this allows enhancement of 3D depth map data by processing through hardware and software filters.

Note: The operation might take a few seconds.

   The saved files include:

   - cloud_xxxx_xxxxxxxx_xxxx.ply

   - Color_xxxx_xxxxxxxx_xxxx.bmp

   - Color_xxxx_xxxxxxxx_xxxx.yuv

   - Depth_xxxx_xxxxxxxxx_xxxx.bmp

   - Depth_xxxx_xxxxxxxxx_xxxx.yuv

3.7 Transferring 3D Point Cloud Image to MeshLab

After generating 3D Point Cloud Image data files, they need to be opened in MeshLab to view the final 3D Point Cloud view, and edit. There are three ways you can open a point cloud image in the MeshLab:

1. *Open* the folder with the 3D Point Cloud image data files, select the preferred image file and *double click* the file to open in **MeshLab**.
2. Select the preferred image and *drag and drop* it into the **MeshLab's layer dialog**.
3. *Open* the **MeshLab** software, *click* file on the **MeshLab** toolbar, then *click* **Import Mesh**

These are the three options for transferring 3D Point Cloud image data files into the MeshLab.

3.8 Dynamic 3D Point Cloud Image Viewer

After all the settings are selected, such like the above optimal Setup, you could also select the "**Point Cloud Viewer**" and then *click* the "**Preview Image"** button after, this will open one new windows and one will display the dynamic point cloud image. **User can use the mouse to drag the image to rotate the 3D point cloud object**
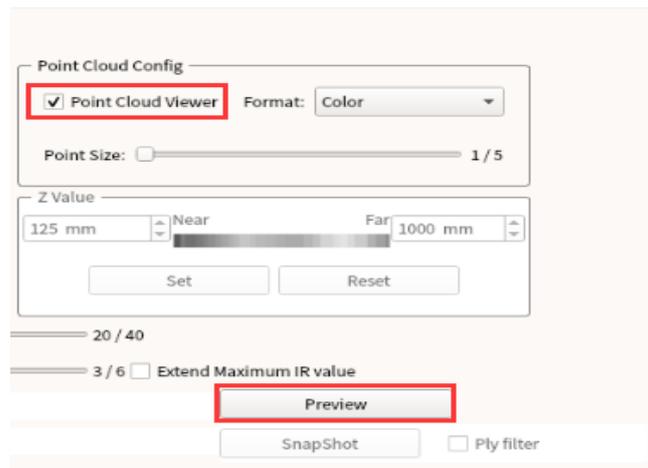

Figure 3-15. Point Cloud Viewer Mode

Figure 3-16. Dynamic Point Cloud Image Display

3.9　Manipulate Image Property

In the "Property Page", it allows user to adjust various settings, such as "Exposure Time", "White Balance Temperature", "Light source", "Low Light Compensation" and "Exposure Time / Global Gain" for the camera.

One of the "Color" sensors can be set as **"Auto Exposure"** or **"Manual"** with desired exposure time. The **"Auto White Balance"** can be turned on or controlled manually and **"Light Source"** of 50Hz or 60Hz frequency can be alternated according to the region system. Under low light environment, **"Low Light Compensation"** can be turned on to enhance the incoming image brightness for better depth map process; However supporting frame rate might not be able to reach its maximum performance, **"Exposure Time / Global Gain"** can be set manually with desired exposure time and gain to sensor for incoming image brightness when auto exposure mode is disabled.
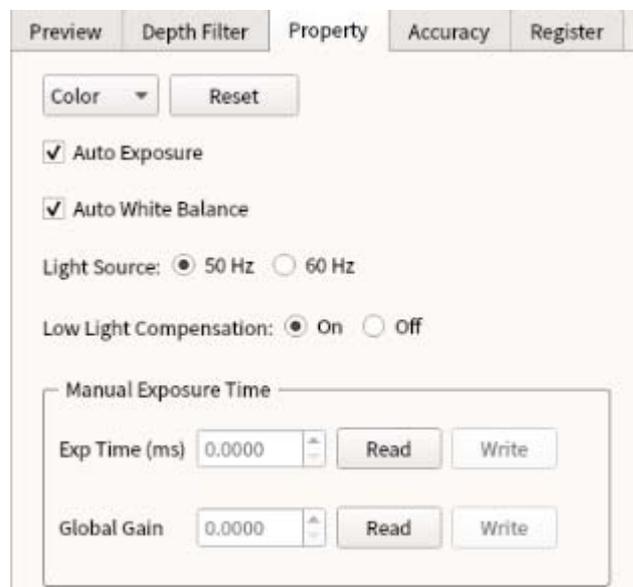

Figure 3-17. Image Property

3.10　Post Processing Filter

The post-processing filters are implemented to enhance the quality of depthmap data and reduce noise levels. All filters are developed in the library as independent blocks to be applied in custom application.
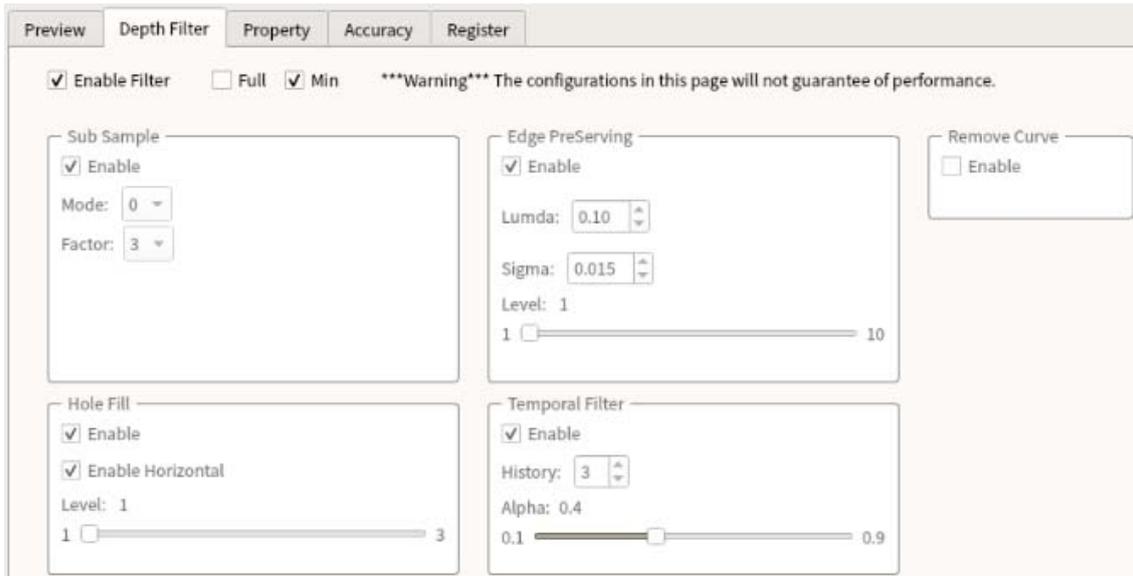
Rev. 1.1

Figure 3-18. Depth Filter

- **Sub-Sampling:** This is aim at noise removal and first level median filter on 2x2 or 3x3 disparity sub-sample domain.

- **Edge-Preservin**g: This type of filter will smooth the depth noise while attempting to preserve edges.

- **Hole Fill:** This is aim at providing fill rate enhancement by second level median filter and reduce the black holes area.

- **Temporal Filter:** This is aim at stabilize the pixel disparity on time domain.

- **Remove Curve:** This is removal of invalid flying pixels.

3.11   Region Accuracy Observation

The primary characteristics of depth camera image quality can be described by: depth data accuracy, depth data coverage, and its spatial and temporal noise (or uniformity). Each metric may be computed over any desired ROI within the camera's FOV. Collectively, these metrics describe the primary depth-related performance of the camera, yet are each independent of the others.

- **Region of Interest:** The depth ROI can be changed due to the different application and the sensitivity of distance judgment user need. The option has 20%, 40%, 60% and 80%, the default is 80%. In stereoscopic depth map calculation, depth information (Distance) is obtained through a defined Region of Interest (ROI) in a scene.
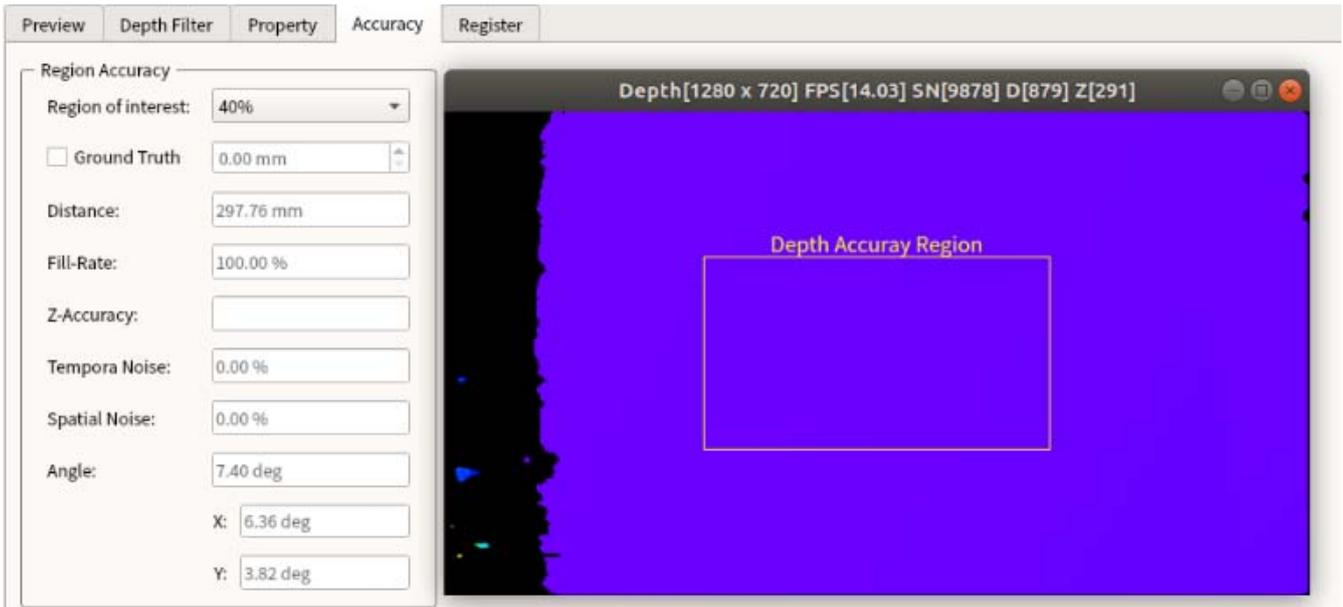
Figure 3-19. Region of Interest

- **Ground Truth:** "Ground Truth" refers to information collected on location allows image data to be related to real material on the ground. "Ground Truth" means a set of measurement that is known to be much more accurate than measurements from the system are testing.

- **Distance:** The distance average of valid depth values over depth ROI.
- **Fill-Rate:** Measures the portion of the depth image containing valid pixels (non-zero depth values) within depth ROI.

    Fill Rate = Valid pixel / All pixel * 100%

- **Z-Accuracy:** Measures the reported depth values are to the actual distance (Ground Truth).

    Z-Accuracy = (distance average – ground truth) / ground truth * 100%

- **Temporal Noise:** Measures the total temporal noise for each valid pixel of the depth image over depth ROI.

- **Spatial Noise**: Measures the total spatial noise for each valid pixel relative to a best fit plane.
- **Angle**: The value of RMS angle X and angle Y.
- **Angle X / Y:** This is the angle between the wall and the line of projection from the camera, refer to Figure 3-20.
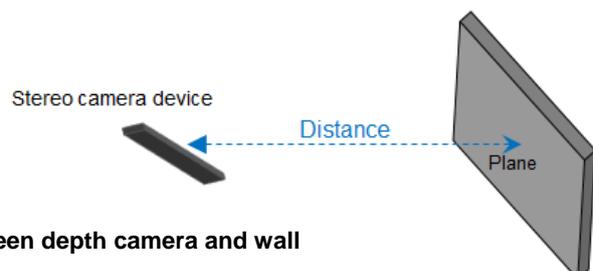

Figure 3-20. Position between depth camera and wall

4.0   API Settings

For more details on Linux SDK API Functions informations, please refer to the following document:

Path: HD-DM-Linux-SDK-xx.xx.xx/doc/ API Document HD-DM-LINUX-SDK-x.x.x.x