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# 1. Dynamic标定

Dynamic Calibration 只能标定相机的外参，其中采用左相机坐标系作为世界坐标系，

	Factory Calibration	OEM Calibration	User Custom Calibration	Dynamic Calibration
Intrinsic	x	x	x	
Extrinsic	x	x	x	x

## 1.1. 外参

Extrinsic includes

- RotationLeftRight - rotation from right camera coordinate system to left camera coordinate system, specified as a 3x3 rotation matrix
- TranslationLeftRight - translation from right camera coordinate system to left camera coordinate system, specified as a 3x1 vector in millimeters
- RotationLeftRGB - rotation from RGB camera coordinate system to left camera coordinate system, specified as a 3x3 rotation matrix
- TranslationLeftRGB - translation from RGB camera coordinate system to left camera coordinate system, specified as a 3x1 vector in millimeters

## 1.2. 动态标定类型

1. 校正双目深度相机极线；
2. 深度尺度标定

## 1.3. 安装标定软件

### 1.3.1. 安装依赖库

```
sudo apt-get update
sudo apt-get install libusb-dev libusb-1.0-0-dev
sudo apt-get install libglfw3 libglfw3-dev
sudo apt-get install freeglut3 freeglut3-dev
sudo apt-get install libpng12-dev
```

### 1.3.2. 注册公钥

```
sudo apt-key adv --keyserver keys.gnupg.net --recv-key C8B3A55A6F3EFC
DE || sudo apt-key adv --
```

```
keyserver hkps://keyserver.ubuntu.com:80 --recv-key C8B3A55A6F3EFCDE
```

### 1.3.3. 添加仓储表

```
sudo add-apt-repository "deb http://realsense-hw-public.s3.amazonaws.com/Debian/apt-repo xenial main" -u
```

### 1.3.4. 删除旧的记录

```
sudo rm -f /etc/apt/sources.list.d/realsense-public.list  
sudo apt-get update
```

### 1.3.5. 安装标定包

```
sudo apt-get install librscaleibrationtool  
sudo apt-get install librscaleibrationapi
```

### 1.3.6. 测试安装

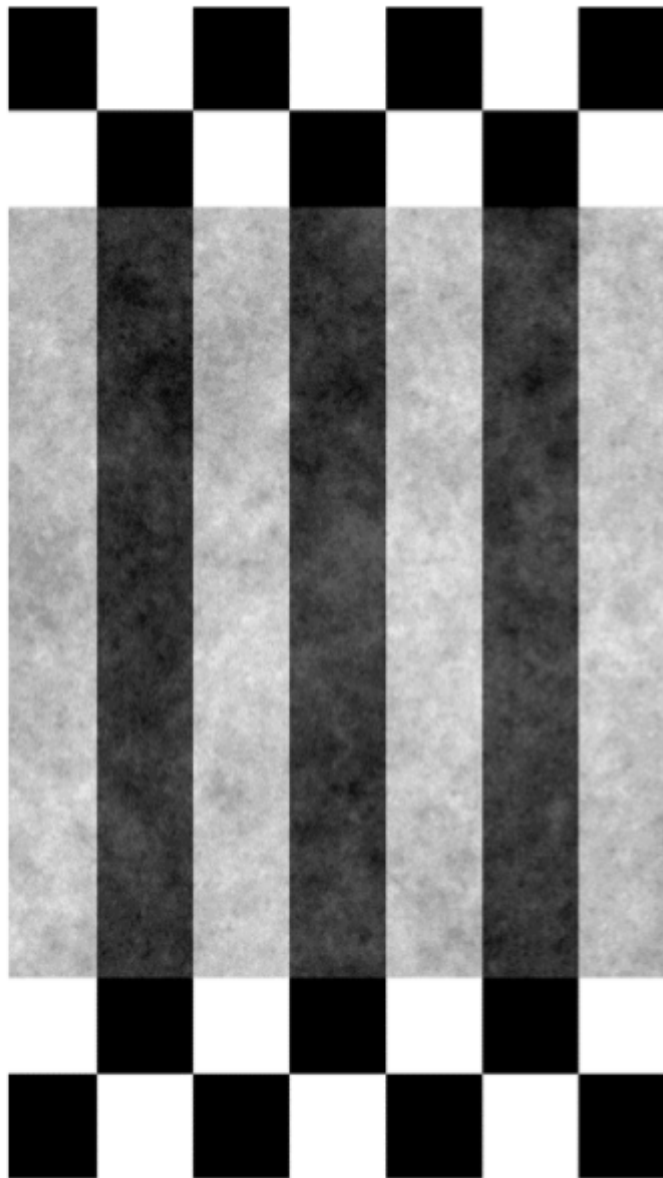
```
# 查看版本号  
leon@leon-ThinkPad-T430s:/usr/bin$ Intel.Realsense.DynamicCalibrator  
-v  
2.6.8.0  
# 是否能检测出设备  
leon@leon-ThinkPad-T430s:/usr/bin$ Intel.Realsense.DynamicCalibrator  
-list
```

Device Name	Serial Number	Firmware Version
Intel RealSense D435I 255.255.255.255	912112074105	05.11.01.100

## 1.4. 操作

### 1.4.1. 打印标定板

**Figure 9-2 Target Image**



具体pdf详见附件print-target-fixed-width.pdf

### 1.4.2. 运行dynamic calibrator

```
leon@leon-ThinkPad-T430s:/usr/bin$ ./Intel.Realsense.DynamicCalibrator
```

按照要求移动相机。

## 2. 用户自定义标定

realsensor深度相机的双目输出的数据是经过校正过的。 在realsensor的ROS包中的源码可以看到如果infra1或infra2相机使能则输出rectified image。

```
86         if (_enable[stream])
87         {
88             std::stringstream image_raw, camera_info;
89             bool rectified_image = false;
90             if (stream == DEPTH || stream == INFRA1 || stream == INFRA2)
91                 rectified_image = true;
92
93             std::string stream_name(STREAM_NAME(stream));
94             image_raw << stream_name << "/image_" << ((rectified_image)?"rect ":"") << "raw";
95             camera_info << stream_name << "/camera_info";
96
97             std::shared_ptr<FrequencyDiagnostics> frequency_diagnostics(new FrequencyDiagnostics( fps[stream], stream_name, _serial_no));
98             _image_publishers[stream] = {image transport.advertise(image_raw.str(), 1), frequency_diagnostics};
99             _info_publisher[stream] = _node_handle.advertise<sensor_msgs::CameraInfo>(camera_info.str(), 1);
100
101             if (_align_depth && (stream != DEPTH) && stream.second < 2)
102             {
103                 std::stringstream aligned_image_raw, aligned_camera_info;
104                 aligned_image_raw << "aligned_depth_to_" << stream_name << "/image_raw";
105                 aligned_camera_info << "aligned_depth_to_" << stream_name << "/camera_info";
106
107                 std::string aligned_stream_name = "aligned_depth_to_" + stream_name;
108                 std::shared_ptr<FrequencyDiagnostics> frequency_diagnostics(new FrequencyDiagnostics( fps[stream], aligned_stream_name, _serial_no));
109                 _depth_aligned_image_publishers[stream] = {image transport.advertise(aligned_image_raw.str(), 1), frequency_diagnostics};
110                 _depth_aligned_info_publisher[stream] = _node_handle.advertise<sensor_msgs::CameraInfo>(aligned_camera_info.str(), 1);
111             }
112         }
```

在对相机内参进行标定是则通过修改图像的格式，来改变是否输出原始的图像数据。

The Intel® RealSense™ D400 series modules supply unrectified calibration frame formats for use in custom calibration. The device hardware provides unrectified left/right images in Y12I format and RGB sensor images in YUY2 format (on modules with RGB sensor). If user application streams through LibRealSense, the left/right images are transformed into Y16 format.

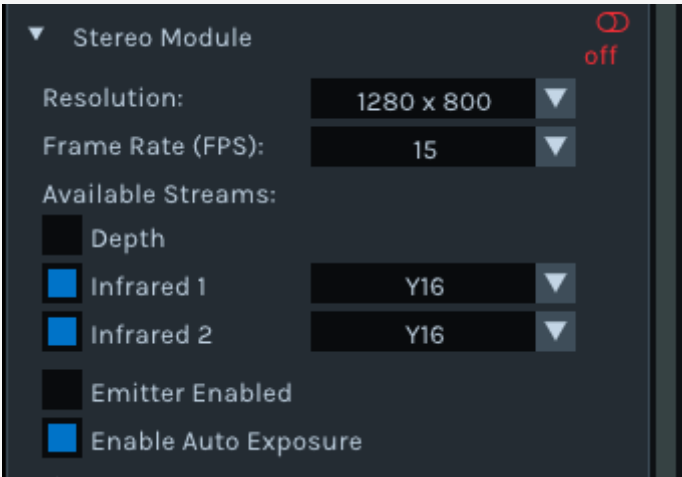
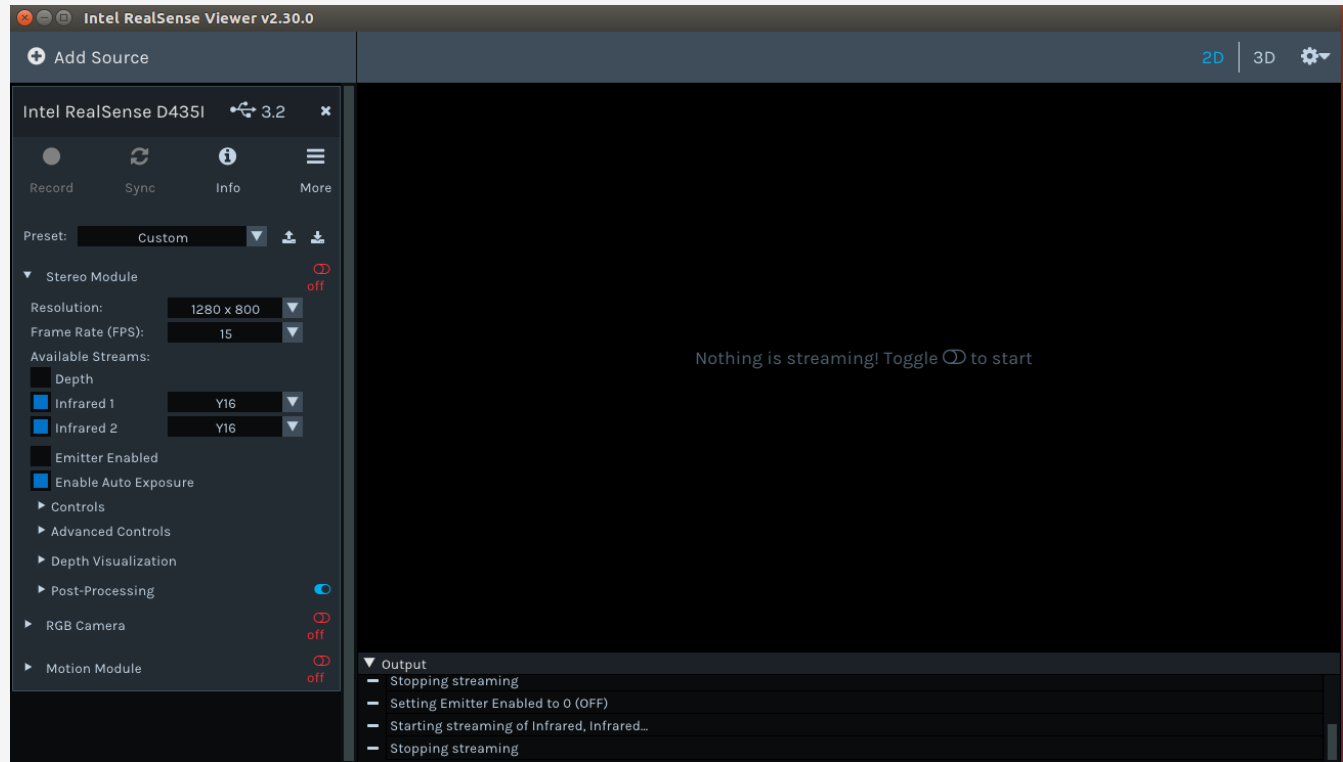
The Custom Calibration Sample App example uses LibRealSense for streaming from the device and the following image formats for calibration.

**Table 2-1. Frame Formats Used in Custom Calibration\***

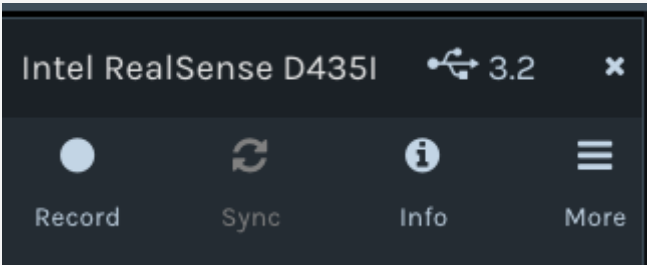
Format	SKU	Used	Comment
Y16 (16-bit)	D400	Left and Right Sensors: 1920x1080 @ 15 FPS	Intel® RealSense™ Camera D400, D410, D415
	D410		
	D420	Left and Right Sensors: 1280x800 @ 15 FPS	Intel® RealSense™ Camera D430 D420, D435, D435i
	D430		
YUY2	D415	RGB Sensor: 1920x1080 @ 15 FPS	Intel® RealSense™ Camera D415, D435, D435i
	D435		

## 获取未标定数据

1. 打开终端运行realsense-viewer，如下图所示：



按照上图进行配置，打开图像



等图像稳定后，点击GUI左上角Record按钮，此按钮是保存rosbag数据包。默认保存文件目录在~/Document文件夹中。

## 2.1. 内参

Intrinsic includes

- Focal length - specified as [fx; fy] in pixels for left, right, and RGB cameras
- Principal point - specified as [px; py] in pixels for left, right, and RGB cameras
- Distortion - specified as Brown's distortion model [k1; k2; p1; p2; k3] for left, right, and RGB cameras

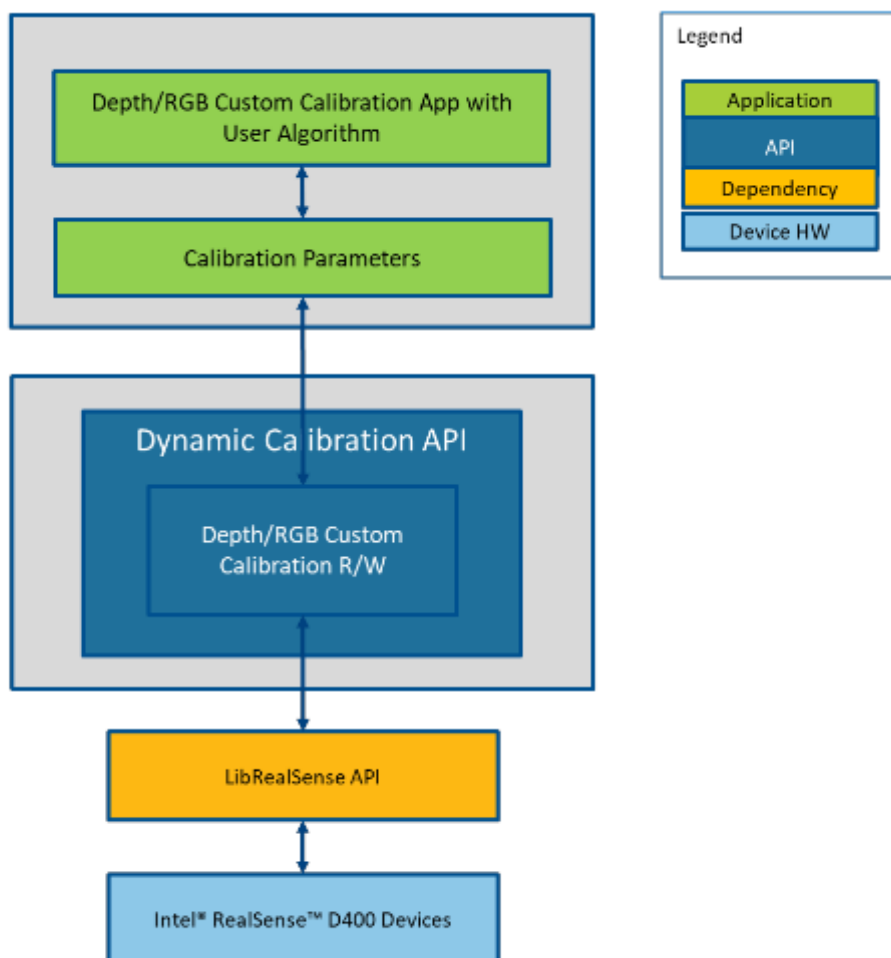
将参数用xml格式的文件写入进去

```
leon@leon-ThinkPad-T430s:/usr/bin$ ./Intel.Realsense.CustomRW
```

## 2.2. 操作示意

Intel provides a software interface in Calibration API to enable user uploading those calibration parameters to Intel® RealSense™ D400 devices and read the parameter back from device:

- WriteCustomCalibrationParameters – write parameters to device
- ReadCalibrationParameters – read parameters from device



## 3. 标定总结

### 3.1. 相机与相机的外参

有两种方法方法：

1. Dynamic Calibration
2. 用户自定标定方法，比如使用kalibr工具或着使用Opencv。

### 3.2. 相机内参：

1. 官方提供在WIN10系统下的标定例程，是基于opencv的
2. 用户自定标定方法，比如使用kalibr工具或着使用Opencv， matlab等。

### 3.3. imu内参

采用官方提供的标定方法。快捷简单。

### 3.4. 相机与IMU外参

采用kalibr工具。