Embedded Linux
3D Sensing

Minnowboard meets RealSense

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Agenda

- 3D Sensing overview
- Intel® RealSense™ Technology
- MinnowBoard Max
- librealsense
- Others boards
3D Sensing overview

Camera model & intrinsic calibration values

Image sources: http://www.robots.ox.ac.uk/~vgg/hzbook/hzbook2/HZfigures.html
3D Sensing overview

- Get each camera model
- Two viewers to get a 3D point
- Disparity image

Image sources: http://www.robots.ox.ac.uk/~vgg/hzbook/hzbook2/HZfigures.html
3D Sensing overview

2010 Microsoft Kinect

Projected dotted grid
3D sensing overview

- A little big to do portable or embedded systems.

3D sensing overview

- Also to use with a drone.

Image sources: http://www.slashgear.com/kinect-quadrocopter-is-your-autonomous-ar-drone-video-06117764/
Intel® RealSense™ Technology

Short Range camera

Long Range camera

Intel® RealSense™ Technology (F200)

The F200 is Intel's first-generation coded light camera using a high-frequency MEMS mirror to project a 2D greycode pattern.
Intel® RealSense™ Technology (R200)

The R200 is an active stereo camera with a 70mm baseline.

Works in disparity space and has a maximum search range of 63 pixels horizontally.

Outdoors, the laser has no effect over ambient infrared from the sun. Furthermore, at default settings, IR sensors can become oversaturated in a fully sunlit environment so gain/exposure/fps tuning might be required.
## Camera specifications

<table>
<thead>
<tr>
<th></th>
<th>R200</th>
<th>F200</th>
<th>SR300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor Range</td>
<td>0.7 m - 3.5 m</td>
<td>0.2 m - 1.0 m</td>
<td>0.2 m - 1.5 m</td>
</tr>
<tr>
<td>Outdoor Range</td>
<td>10 m</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Depth FoV (DxWxH)</td>
<td>70 x 59 x 46</td>
<td>80 x 68 x 54</td>
<td>80 x 68 x 54</td>
</tr>
<tr>
<td>Depth FPS</td>
<td>30, 60, 90</td>
<td>30, 60</td>
<td>30, 60</td>
</tr>
<tr>
<td>IR FPS</td>
<td>30, 60, 90</td>
<td>30 - 300</td>
<td>30 - 300</td>
</tr>
<tr>
<td>Depth method</td>
<td>Active Stereo IR</td>
<td>Coded light IR</td>
<td>Coded light IR</td>
</tr>
<tr>
<td>Minimum F/W</td>
<td>1.0.72.04</td>
<td>2.60.0.0</td>
<td>3.10.10.0</td>
</tr>
</tbody>
</table>
MinnowBoard Max
Size matters
Librealsense

- Is a cross-platform library (Linux, OSX, Windows)
- Capturing data from the Intel® RealSense™ F200, SR300 and R200 cameras.
- Only encompasses camera capture functionality without additional computer vision algorithms.
- To support researchers, creative coders, and app developers
  - Robotics, virtual reality, and the internet of things (IoT).

https://github.com/IntelRealSense/librealsense
Librealsense

- This project is separate from the production software stack available in the Intel® RealSense™ SDK
- Librealsense is experimental and not an official Intel product.
- Does not currently provide functionality to upload new firmware

Principal Developers
- Dimitri Diakopoulos
- Sterling Orsten
Compatible Devices

1. RealSense R200
2. RealSense F200
3. RealSense SR300
Compatible platforms

It is developed and tested on the following platforms:

1. Windows 8.1 (Visual Studio 2013 Update 5)
2. Ubuntu 14.04.03 LTS x64 (GCC 4.9 toolchain)
3. Mac OS X 10.7+ (Clang toolchain)

It may be possible to compile and run librealsense on other platforms.
Supported Languages and Frameworks

- librealsense is written in standards-conforming C++11
  - C - Core library API exposed via the C89 ABI
  - C++ - Single header file (rs.hpp) wrapper around C API, providing classes and exceptions
Functionality

1. **Native streams**: depth, color, infrared
2. **Synthetic streams**: rectified images, depth aligned to color and vice versa, etc.
3. **Intrinsic/extrinsic** calibration information
4. Majority of hardware-specific functionality for individual camera generations (UVC XU controls)
5. Multi-camera capture across heterogeneous camera architectures (e.g. mix R200 and F200 in same application)
How it works?

- librealsense communicates with RealSense™ devices directly via the UVC and USB protocols.
- A kernel patch is needed.
Integrations

librealsense has been integrated with a number of third-party components and operating systems.

- Robotic Operating System (Intel Supported, R200 Only)
  - [https://github.com/intel-ros/realsense](https://github.com/intel-ros/realsense)
- Yocto / WindRiver Linux
  - [https://github.com/IntelRealSense/meta-intel-librealsense](https://github.com/IntelRealSense/meta-intel-librealsense)
- Arch Linux
  - [https://aur.archlinux.org/packages/librealsense/](https://aur.archlinux.org/packages/librealsense/)
- Clear Linux Project for Intel® Architecture
  - [https://clearlinux.org/](https://clearlinux.org/) (coming soon)
Simple capture
3D cloud point
Drone setup

- 6 rotor drone
- GoPro 4
Drone setup

- 6 rotor drone
- Minnowboard
- R200 RealSense camera
Other boards

- Intel Compute Stick (BOXSTK1AW32SCR)
- Kangaroo MD2B
- UP Board
How to get one?

Developer kits containing the necessary hardware to use this library are available for purchase at http://click.intel.com/realsense.html.
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