Prosilica Gigecamera Stereo Vision

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Abstract

This document discusses how to use Prosilica GC 1020 cameras for stereo vision. The first section includes the hardware setting steps for two cameras. The second section provides the codes developed with this system. The code is open source and available at `https://github.com/ljc19800331/BTL_Stereo`. This document can be applied to other Gige camera systems.

1 Introduction

This document aims to help users set up Prosilica GC 1020 cameras for stereo vision. All the tutorials for dual-camera system can be used for one-camera setting. The codes are open source and some demo videos are available (please contact the author to get the demo videos by email).

For stereovision, the hardware of the stereo vision system:

- Two Prosilica GC 1020C 1024 x 768 color cameras with 1/3" sensors
- Two 12 mm C-mount lens

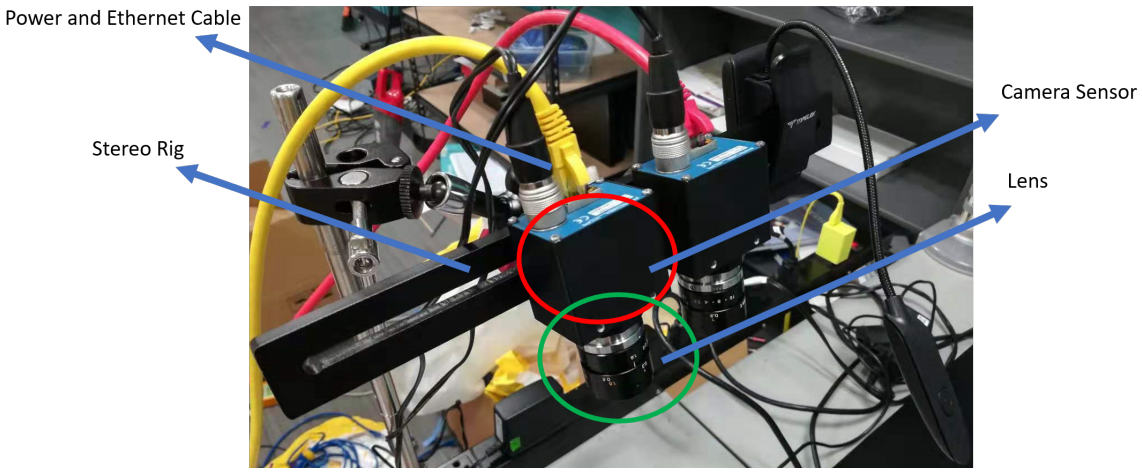


Figure 1: Stereovision System

The hardware and software sections are mainly discussed herein. The calibration and 3D reconstruction codes were uploaded on the Open Source Github repository (`https://github.com/`

ljc19800331/BTL_Stereo). All the analysis and codes were developed based on Allied Vision official tutorials and open source example codes. For starting, users are recommended to download the three tutorials online:

- Allied Vision Gige Cameras Installation Manual
- Allied Vision Prosilica GC Technical Manual
- Allied Vision Vimba c++ Manual

2 Methods

Please follow the 10 steps to set up the camera system. These steps enable you to set up the camera system without handling unnecessary hardware issues. Red texts are important for successful setting.

2.1 Hardware

2.1.1 Operating system: Windows 10 (recommended)

- Windows 10 is recommended for starting since Linux setting is more complicated for Gige Camera. The Prosilica official guide also provides Linux tutorial for users.
- If user wants to use the camera in linux, please refer to https://www.alliedvision.com/en/products/software.html. The Linux setting is not discussed in this document.

2.1.2 Download the Vimba Camera SDK

- Download the SDK with Vimba Viewer, Vimba Driver Installer, Vimba Firmware Updater from the link: https://www.alliedvision.com/en/products/software.html.
- Important: Download the GigeFirmwareLoader from the link: https://www.alliedvision.com/en/support/firmware.html. This is important for updating the firmware of your camera before using with Python and MATLAB. Otherwise the system cannot detect the cameras.
- After installing all the SDK and firmware updating loader, you can easily follow the instructions in these software to set up your camera. For other problems, please refer to "Allied Vision Installation Manual".
- The SDK enables you to get access to all the hardware setting in the cameras. If you are not familiar with the camera setting, keeping all in default is recommended.

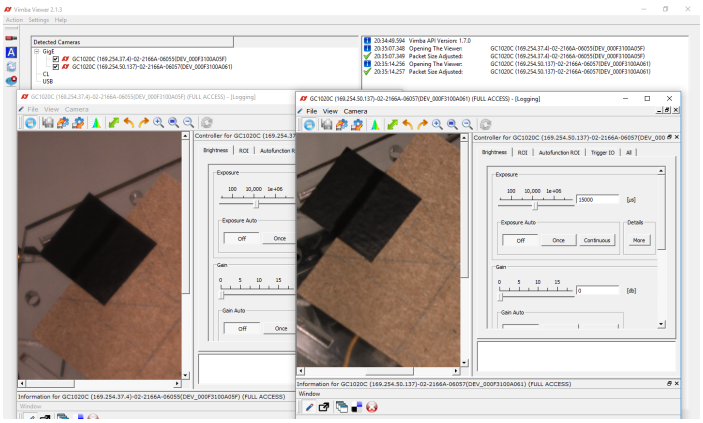


Figure 2: Vimba SDK: Vimba Viewer

2.1.3 Download GigeIPConfig and GigeViewer

- These are very important tools for checking IP and connection of the cameras.
- Please refer to the link: `https://www.alliedvision.com/en/support/software-downloads`.
- GigeIPConfig is a convenient tool to adjust and check the IP address of the camera.
- GigeViewer is a simple tool to check the connection of the camera. This is different from the GigeSDK in that GigeSDK can change the setting while GigeViewer only target at the connection of both cameras. This is a good method for fast checking the connectivity of the cameras. Please refer to "Allied Vision Installation Manual" for more information.

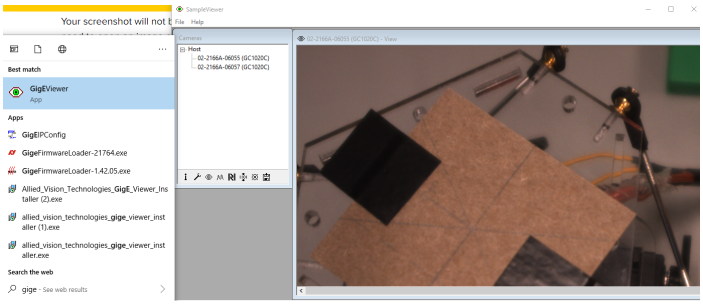


Figure 3: Vimba Gige Viewer

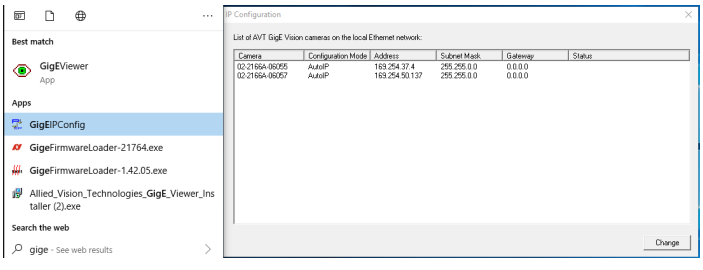


Figure 4: Vimba Gige IP Configuration

2.1.4 Check the firmware version

- This is important if you want to use the code in Python and MATLAB.
- This can be finished with the "Vimba Firmware Updater". Please check the "Download section".

2.1.5 Check the firewall

- Important: Close the firewall in windows 10, since this might block the incoming traffic from the camera. For tutorial, please refer to "Allied Vision Installation Manual" in the attached documents. For the setting, please refer to "Allied Vision Installation Manual". Windows 10 user can easily close all the firewall with several steps.

2.1.6 Check the Ethernet cable

- Please make sure that the Ethernet cable connected with the cameras are CAT6, RJ45, 500Mhz (or better). The Ethernet cable is very important for stereo vision setting since it limit the streaming traffic between the PC and camera. A wrong cable will cause data streaming issue. Please refer to the link for purchase: Monoprice Cat6 Ethernet Patch Cable - Network Internet Cord - RJ45, Stranded, 550Mhz, UTP, Pure Bare Copper Wire, Crossover, 24AWG, 7ft, Red.

2.1.7 Ethernet Port Setting

- Method 1: Two Ethernet port setting (PC only). Gige camera connects the PC with the Ethernet cable and you could buy two PCI Adaptors which enable the camera to use the entire Gigabit interface bandwidth.
    1. Two PCI adapter: Intel Gigabit CT PCI-E Network Adapter EXPI9301CTBLK (recommended choices)
    2. This method requires the PC to have two PCI adapter port, which is not common in most PC settings.
- Method 2: Two Ethernet USB port setting (PC and Desktop)
    1. This is targeted for Laptop and PC user can also use this setting.
    2. USB 3.0 port is recommended for data streaming. Laptop only has USB 3.0 port.
    3. The whole architecture is similar to the Two-PCI-Adapter setting.
- Method 3 (recommended): Gigabit Ethernet Network Switch (recommended and PC and Desktop compatible)
    1. Single Ethernet Port: This setting is recommended for both PC and Laptop user since it only requires one connection port to the computer.

2. The general Ethernet splitter can be used for this setting: TP-Link 5 Port Gigabit Ethernet Network Switch — Ethernet Splitter — Sturdy Metal w/ Shielded Ports — Plug-and-Play — Traffic Optimization — Unmanaged (TL-SG105)

3. The architecture combines bandwidth into single cable and for general application, this is acceptable with only one Ethernet port in the PC. If you need to prevent packet collision, please refer to "Allied Vision Installation Manual" and search for "single Ethernet port".

(a) PCI Adapter

(b) Ethernet Switcher

Figure 5: Two different Ethernet Connection Methods

2.1.8 Camera IP setting

- Camera IP setting is important for the usage of multiple cameras. Please refer to document: "Allied Vision Installation Manual" and search for "using multiple cameras".

- Manual IP setting: Camera and adapter IP are recommended to manage with fixed IP addresses since each adapter IP needs to be in a unique subnet. The IP setting is completed with the "Vimba GigeIPConfig interface" downloaded before. For general setting, we have (for more information, please refer to "Allied Vision Installation Manual" and search for "Using multiple cameras") :

  1. Adapter 1: IP Address: 169.254.100.1; Subnet mask: 255.255.255.0
  2. Adapter 2: IP Address: 169.254.100.2; Subnet mask: 255.255.255.0

  Users can follow this IP setting to set up your camera system.

- Auto IP setting: This is also recommended if you are not familiar with the IP setting. The IP can automatically managed and you only need to choose the Auto Setting in "Vimba GigeIP-Config interface". By default, the IP is set automatically if you use the Vimba SDK. Note: The Vimba Viewer or Gige Viewer enable Auto IP setting and both cameras can be automatically detected once connecting successfully.

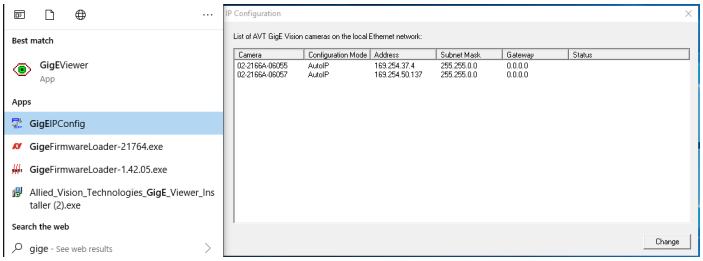


Figure 6: Vimba Gige IP Configuration

2.1.9 Stereo Rig setting: (Keep the camera safe)

- Parallel rig: This is a stereo rig to fixed both cameras and users can find the choices online. This is important for keeping both cameras in a safer position.
- Fixing rig: Recommended choice: pangshi 11inch Adjustable Articulating Friction Magic Arm and Large Super Clamp Compatible with DSLR Camera Rig, LED Lights, Flash Light, LCD Monitor.

2.1.10 Safety concern:

- Close the power when leaving. The camera will heat up if you connect the camera for a night and forgot to turn it off and plug out the power port.
- Protect the lens with the covers if you don't use it for a long time.
- Protect the camera from laser beam.
- Please read "Allied Vision Installation Manual" the safe section before using the camera.

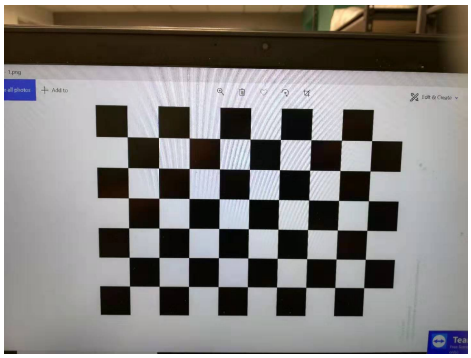
2.2 Software

2.2.1 Calibration Software

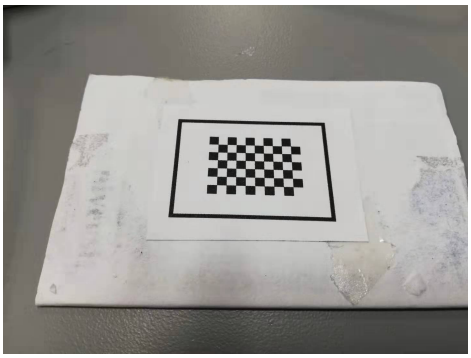
The calibration board is required to be flat so any commercial chessboard will be recommended. You can also make it by printing a chessboard on a paper, and attach the calibration board on a card (I use my student ID card). This is good for high calibration accuracy with less than 0.5 pixel (reprojection error with dual-camera calibration).

As the calibration board is required to be flat, a laptop screen can be used for calibration. For example, you can show a chessboard on a laptop screen and use it as a flat-board for calibration. As for my testing, the reprojection error is less than 0.5 pixel). In addition, an important note is that the "findchessboardcorners python" in opencv is sensitive to the size of the calibration board length. For example, the "findchessboardcorners" cannot accurately detect the corner coordinates in Vimba Calibration Board (Fig. 7) while the "StereoCameraCalibrator" in MATLAB is more compatible with all different kinds of calibration board. As both methods were written in different codes and it

is difficult to validate which is better. Thus the "StereoCameraCalibrator" is strongly recommended for stereo vision for beginners.



(a) Laptop calibration board



(b) Vimba Calibration Board

Figure 7: Difference between high and low speckle noise images

2.2.2 C++

Vimba SDK provides C++ API for most common functions with the camera. After the SDK is installed, search for "Vimba SDK Examples Overview" and you are able to check each file with Visual Studio 2015 or ealier verion. If C++ is a preferable language, users are recommended to use the Vimba C++ API. An Vimba C++ tutorial is also available online provided by the official technical support team.

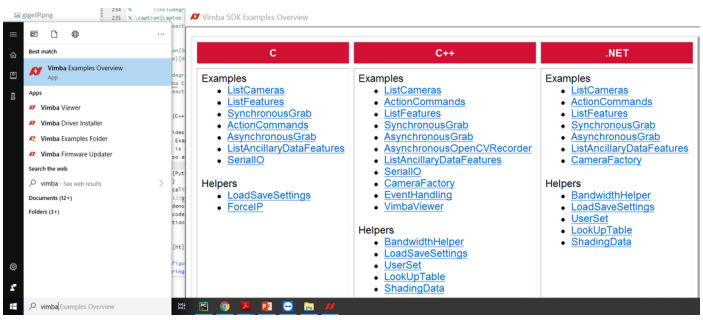
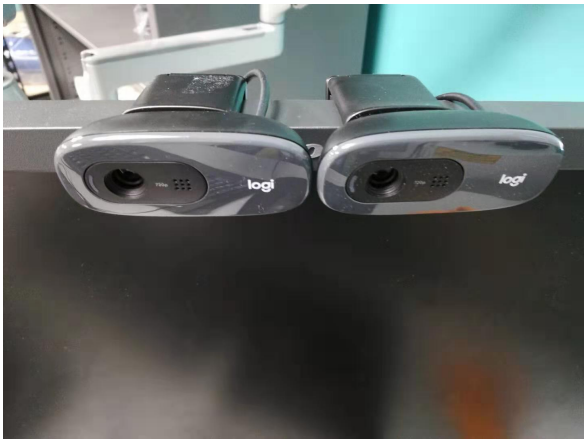


Figure 8: Vimba C++ SDK

2.2.3 Python

- The calibration and reconstruction code is available at: `https://github.com/ljc19800331/BTL_Stereo`
- The demo is available at: `https://www.youtube.com/watch?v=eqJ8CsTg79I&feature=youtu.be`.
- The code is tested with Two Prosilica GC 1020 and Two Logitech Cameras system for 3D reconstruction. The users can first test the code with two low cost Logitech C270 Cameras.

(a) 3D Reconstruction Logitech Cameras



(b) Logitech low-cost stereo vision system

Figure 9: The demo for 3D reconstruction of different stereovision systems

2.2.4 MATLAB

- Please refer to the MATLAB example code: `https://www.mathworks.com/help/vision/examples/depth-estimation-from-stereo-video.html` and `https://www.mathworks.com/help/vision/ug/stereo-camera-calibrator-app.html#`.
- MATLAB code is much easier than python opencv for implementation, but Python is good for learning the whole calibration procedure.
- The MATLAB can also provide Realtime Point Cloud visualization tools.
- MATLAB can provide Gige Camera Toolbox.
- Based on the testing, MATLAB Calibration toolbox is more robust and less sensitive to the calibration board. The computer vision toolbox provides very efficient tools for 3D reconstruction.

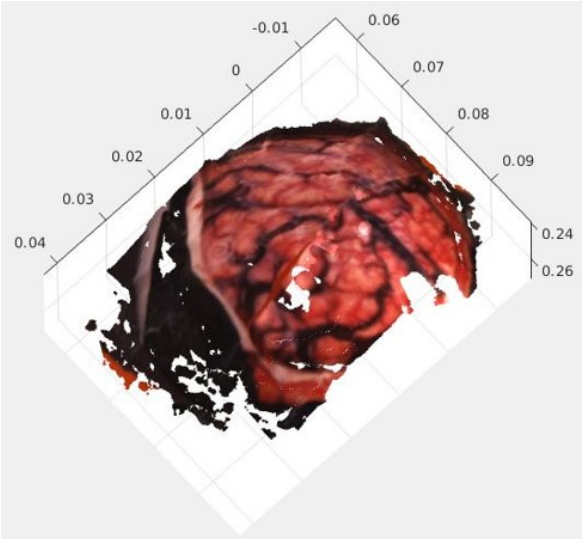


Figure 10: Reconstruction surface from Vimba Camera System with MATLAB Toolbox