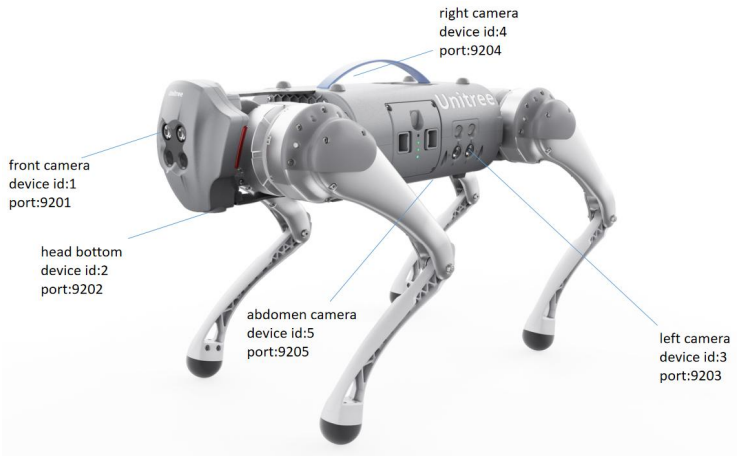
elopment and use of Go1 binocular fisheye camera

Introduction

The head and body of Go1-Edu are distributed with 5 sets of binocular fisheye cameras, and we provide the corresponding UnitreeCameraSDK for developers to use.

1. hardware

Five groups of cameras are distributed in the front face, chin, left and right sides of the fuselage and abdomen. Hardware, the front face camera and chin camera are connected to the head Nano (192.168.123.13), the cameras on both sides of the body are connected to the body Nano (192.168.123.14), and the abdomen camera is connected to the main body Nano or NX (192.168.123.15). The schematic diagram is as follows.



In the system of each motherboard, device IDs (dev IDs) are assigned to the cameras:

- Head Nano (192.168.123.13), front-facing camera dev ID=1, chin camera dev ID=0.
- Body Nano (192.168.123.14), left camera dev ID=0, right camera dev ID=1.
- Body main Nano (192.168.123.15), abdominal camera dev ID=0.

- For the convenience of the receiving program, we define ports (Port ID) for each camera as the table shown below:

PORTS for cameras:

Nano	dev ID	Port ID	Position
Nano（192.168.123.13）	1	9201	Front
Nano（192.168.123.13）	2	9202	Head bottom（chin）
Nano（192.168.123.14）	3	9203	left

Nano（192.168.123.14）	4	9204	right
Nano（192.168.123.15）	5	9205	abdomen

Camera hardware parameters:

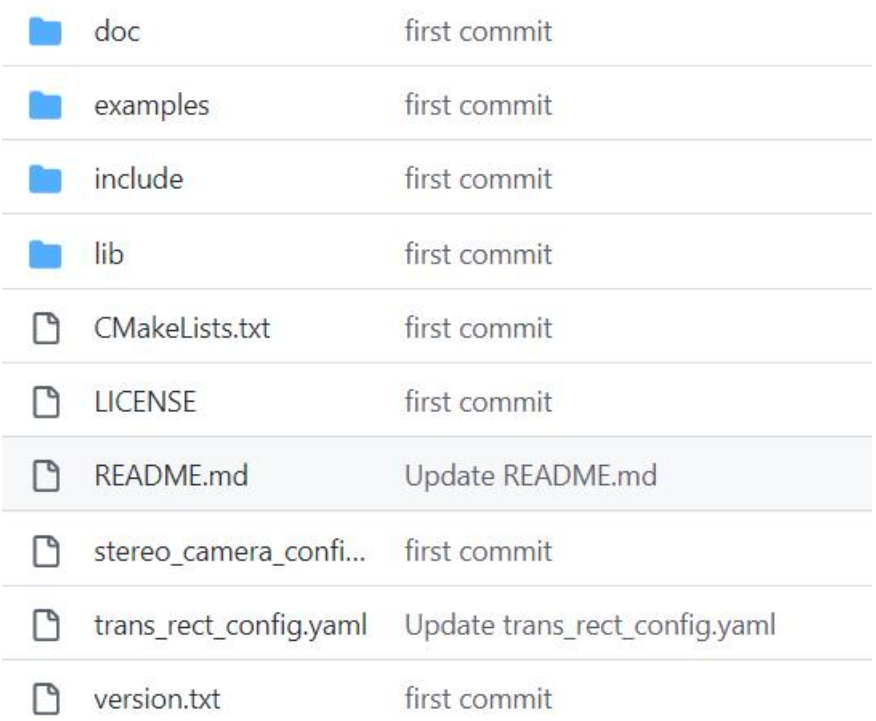
RGB	RGB frame resolution:	1856x800（stereo）
	RGB frame rate:	30fps
	RGB sensor technology:	Global Shutter
	RGB sensor FOV:	222°
Depth	Depth technology:	Stereoscopic
	Effective depth range:	10cm~85cm
	Depth Field of View:	< 180°
	Depth output resolution:	adjustable（default464x400）
	Depth frame rate:	≤30fps

2. SDK

The camera SDK is listed on the Yushu GitHub repository, so you can download it and use it yourself. The camera SDK provides video streams in color and depth, as well as internal calibration information, and also provides point clouds and depth images aligned with the color images.

https://github.com/unitreerobotics/UnitreecameraSDK

The SDK document includes the following:



doc—document
examples—examples code
include-- head File
lib-- libriary
CmakeLists.txt—cmake Document
stereo_camera_config.yaml-- Point cloud map, depth map read configuration file
trans_rect_config.yaml-- transfer configuration file
these two red yaml document is very important for you to get the picture from your robot

	Document Name	Function
1	example_getCalibParamsFile.cc	Get camera calibration parameters
2	example_getDepthFrame.cc	Get the camera depth map
3	example_getPointCloud.cc	Get the camera point cloud
4	example_getRawFrame.cc	Get the camera's unprocessed image
5	example_getRectFrame.cc	Get the processed image of the camera
6	example_getimagetrans.cc	receive images from the network
7	example_putImagetrans.cc	Send images over the network
8	example_share.cc	Shared memory code routines, not open to users

Among them, the first five are local calls to the camera, which can be compiled and run directly; the two transmission samples, one sending and one receiving, need to be run separately.

3. SDK Usage examples

Before the SDK use, you need to kill the program that comes with the call to the camera in order to successfully obtain the image. There are four programs related to the camera: point_cloud_node, mqttControlNode, live_human_pose , rosnode, these can achieve point cloud image, picture transmission, human body recognition. You can use the ps -aux command to query the status,. And you can kill these processes before use to lift the camera occupation, release arithmetic.

Ps-aux

```
ps -aux | grep point_cloud_node
ps -aux | grep mqttControlNode
ps -aux | grep live_human_pose
Kill
ps -aux | grep point_cloud_node | awk '{print $2}' | xargs kill -9
ps -aux | grep mqttControlNode | awk '{print $2}' | xargs kill -9
ps -aux | grep live_human_pose | awk '{print $2}' | xargs kill -9
```

For your understanding, let's take the example of getting the image of the dog's head camera on your own computer.

3.1 Acquire a single image from the camera in front of the head

3.1.1 Download

```
git clone https://github.com/unitreerobotics/UnitreecameraSDK.git
```

3.1.2 Stop the process related to the camera that comes with the board

Kill

```
ps -aux | grep point_cloud_node | awk '{print $2}' | xargs kill -9
```

```
ps -aux | grep mqttControlNode | awk '{print $2}' | xargs kill -9
ps -aux | grep live_human_pose | awk '{print $2}' | xargs kill -9
ps -aux | grep rosnode | awk '{print $2}' | xargs kill -9
```

As mentioned at the beginning of this section, we need to kill the point_cloud_node, mqttControlNode, live_human_pose, and rosnode processes (not all processes exist, for example, live_human_pose only exists on the main body Nano). After killing, you can use the command to query the process, and then confirm whether the process was successfully killed.

3.1.3 编译运行 example_getRectFrame

- Build

```
cd UnitreecameraSDK
mkdir build
cd build
cmake ..
make
```

- Run

After the compilation is completed, the bins folder will be generated in the UnitreecameraSDK directory, and the sending program will be run.

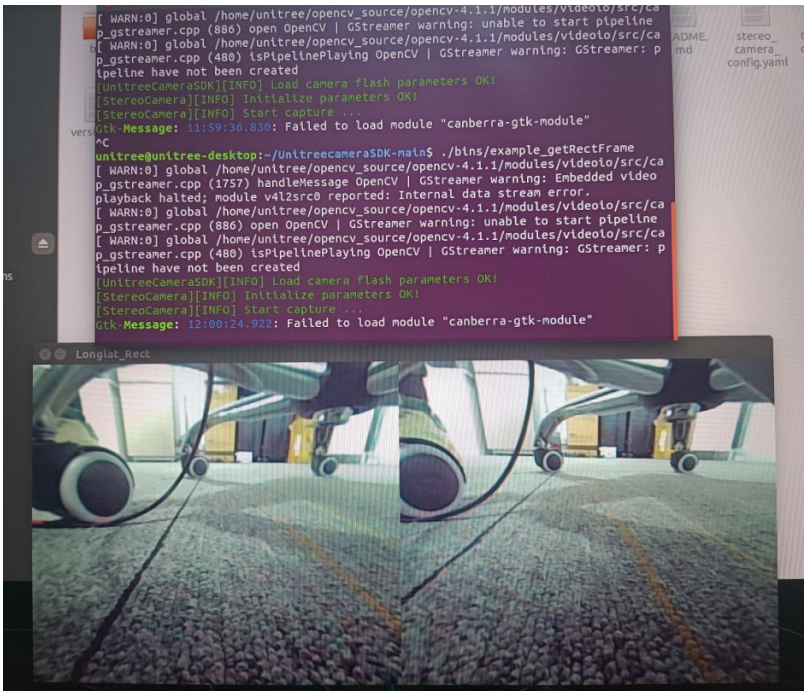
```
cd ..
./bins/example_getRectFrame
```

3.1.3 Connect your own PC to the dongle via cable and configure the network

The following is an example of configuring a local IP segment, please follow the actual situation.

```
sudo ifconfig eth0 192.168.123.100/24
sudo ifconfig eth0 up
ifconfig
```

Note: Do not cd to bins for running, it will lack dependencies
The operation is successful as shown in the following figure:



3.2 Image transmission between boards in the machine

3.1.3 Send camera sdk to head Nano

This section takes 15 boards to obtain forward camera images of 13 boards as an example. The 15 boards need to be connected to devices such as HDMI monitors, mouse and keyboard, and operations are performed on the 15 boards.

3.2.1 Download camera sdk

Download UnitreecameraSDK by yourself and put it on the board you need to use. git clone

```
https://github.com/unitreerobotics/UnitreecameraSDK.git
```

3.2.2 Send the camera sdk to the head Nano

If the board is connected to the Internet, you can use the git command to download the latest camera sdk.

Since the header Nano does not provide HDMI and USB for customers to use, we can send the SDK folder to the header Nano via the scp tool.

```
scp -r UnitreecameraSDK unitree@192.168.123.13:/home/unitree/
```

3.2.3 Remote connection head Nano

```
ssh unitree@192.168.123.13
password:123
```

3.2.4 Stop the camera-related processes that come with the head Nano

```
ps -aux | grep point_cloud_node | awk '{print $2}' | xargs kill -9
ps -aux | grep mqttControlNode | awk '{print $2}' | xargs kill -9
ps -aux | grep live_human_pose | awk '{print $2}' | xargs kill -9
ps -aux | grep rosnode | awk '{print $2}' | xargs kill -9
```

As mentioned at the beginning of this section, we need to kill the point_cloud_node, mqttControlNode process (live_human_pose is only available on the main Nano of the body). After kill, you can use the query process command to confirm again if the process was successfully kill.

3.2.5 Modify the transfer configuration parameters file trans_rect_config.yaml

You may not be used to vim for the first time, you can go to the Internet to find a tutorial

```
cd UnitreecameraSDK
vim trans_rect_config.yaml
```

The trans_rect_config.yaml are as followed:

```
%YAML:1.0
---
# [pls dont change] The log level
LogLevel: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 1. ]
# [pls dont change] The threshold is applied to detecd point cloud
Threshold: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 190. ]
```

```
#[pls dont change] it's a switch for a algorithm in the process of computing stereo
disparity
Algorithm: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [1. ]
#UDP address for image transfer   192.168.123.IpLastSegment
IpLastSegment: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 15. ]
# This place needs to be changed to the actual receiving IP
##########################################
#DeviceNode
DeviceNode: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 1. ]
# To change the device number to the one you need, you can refer to the above
##########################################
#fov (perspective 60~140)
hFov: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 90. ]
#image size ([1856,800] or [928,400])
FrameSize: !!opencv-matrix
   rows: 1
   cols: 2
   dt: d
   data: [ 1856., 800. ]
#rectified frame size
RectifyFrameSize: !!opencv-matrix
   rows: 1
   cols: 2
   dt: d
   data: [ 928., 800. ]
#FrameRate, it gives the limitation for transmission rate(FPS)
```

```
FrameRate: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 3e+01 ]
#0 ori img - right  1 ori img - stereo  2 rect img - right  3 rect img - stereo   -1 不传图
Transmode: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 2. ]
#Here transmode, 0 and 1 can not be used, to set 2 or 3##########################################
#Transmission rate(FPS) in the UDP transmitting process. <= FrameRate
Transrate: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 3e+01 ]
# [pls dont change]  It's a switch in distortion process of fisheye camera. 1 represents "Longitude and latitude expansion of fisheye camera";  2 represnets "Perspective distortion correction".
Depthmode: !!opencv-matrix
   rows: 1
   cols: 1
   dt: d
   data: [ 1. ]
 # empty reserved IO
Reserved: !!opencv-matrix
   rows: 3
   cols: 3
   dt: d
```

3.2.6 Compile and run example_putImagetrans

- Build

```
cd UnitreecameraSDK
```

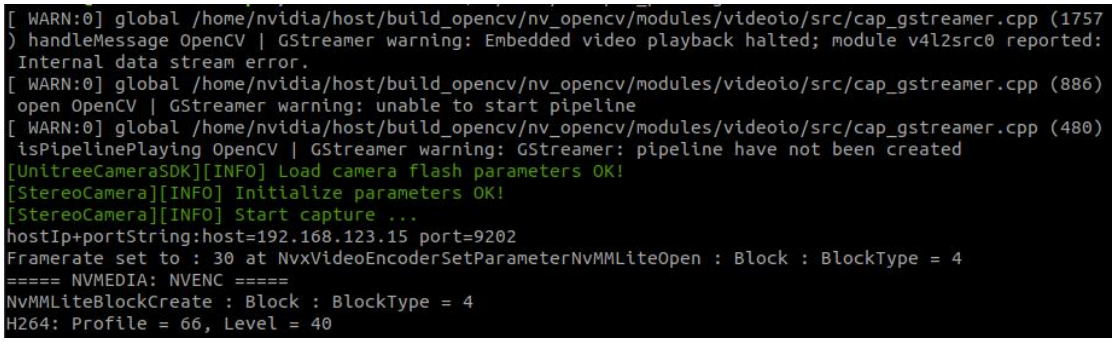
```
mkdir build
cd build
cmake ..
make
```

- Run

  Once compiled, the bins folder will be generated in the UnitreecameraSDK directory to run the sending program.

```
./bins/example_putImagetrans
```

Note: Do not run in cd to bins, this will be missing dependencies
Run successfully as shown below:



Note: When we recompile and run the sending program, sometimes it will report an error, which may be related to the sending process not kill clear.
In this case, you can kill the following program and try again.
ps -aux | grep send_image_client | awk '{print $2}' | xargs kill -9

3.2.7 Compile and run example_getimagetrans on your own PC

- example_getimagetrans.cc

```
#include <opencv2/opencv.hpp>
#include <iostream>
int main(int argc,char** argv)
{
    std::string IpLastSegment = "15";//Change to the IP of the current PC
    int cam = 1;//Front port is 1 (9201)
```

- Build

```
cd UnitreecameraSDK
mkdir build
cd build
cmake ..
make
```

- Run

```
./bins/examples_getimagetrans
```

The program runs normally and we can see the acquired image:

If the sender has sent, but the program cannot receive it, you can enter the following command in the terminal to test:

```
gst-launch-1.0 udpsrc port=9201 ! application/x-rtp, media=video,
encoding-name=H264 ! rtph264depay ! h264parse ! omxh264dec ! videoconvert !
autovideosink
```

3.3 The client PC obtains a single image from the camera in front of the head

This section takes the client PC to obtain the forward camera image of the 13-board card through the network cable as an example.

3.3.1 The client PC obtains a single image from the camera in front of the head

Connect the client PC and the robot dog through a network cable, and configure the PC wired network card.
The following is an example of configuring a local IP network segment, please refer to the actual situation
Note: If you remove our camera and connect it to the computer via USB, you can also configure Ubuntu to use the case code in the SDK by following the steps below

```
sudo ifconfig eth0 192.168.123.100/24
sudo ifconfig eth0 up
ifconfig
```

3.3.2 Download camera sdk

Download UnitreecameraSDK by yourself, and put it on the board and PC you need. If the board and PC are connected to the Internet, you can use the git command to download the latest camera sdk.

3.3.3 Configure the header board to send images

Refer to Sections 3.2.2 - 3.2.6, which will not be repeated here.

3.3.4 Configure the environment dependencies of your own PC

1. Install gstreamer dependencies

```
sudo apt update
sudo apt install -y libgstreamer1.0-dev libgstreamer-plugins-base1.0-dev
libgstreamer-plugins-bad1.0-dev libgstreamer-plugins-good1.0-dev
```

```
sudo apt install -y gstreamer1.0-plugins-base gstreamer1.0-plugins-good
gstreamer1.0-plugins-bad gstreamer1.0-plugins-ugly
sudo apt install -y gstreamer1.0-tools gstreamer1.0-libav
sudo apt install -y gstreamer1.0-doc gstreamer1.0-x gstreamer1.0-alsa gstreamer1.0-gl
gstreamer1.0-gtk3 gstreamer1.0-qt5 gstreamer1.0-pulseaudio
```

If the installation fails, try over the wall or change the source.

To change the source, you can try the source of ustc.edu.cn.

2. Compile and install opencv4.1.1 from source code

Download the source code of opencv4.1.1. Unzip, compile and install

```
mkdir build
cd build
cmake -D OPENCV_GENERATE_PKGCONFIG=YES ..
make -j4
sudo make install
```

If an error is reported during compilation, fatal error: Eigen/Core: No such file or directory

1. Manually install eigen3 (usually installed)

```
sudo apt install libeigen3-dev
```

2. If this error is reported after installation or installation, you can modify the path of eigen in the source code

Go to the file

件

```
~/opencv4.1.1/modules/core/include/opencv2/core/private.hpp
```

modify #include <Eigen/Core> to #include <eigen3/Eigen/Core>, and then recompile.

3.3.5 Compile and run example_getimagetrans on your own PC

Edit example_getimagetrans.cc

```
#include <opencv2/opencv.hpp>
#include <iostream>
int main(int argc,char** argv)
{
    std::string IpLastSegment = "100";// Change to the IP of the current PC
    int cam = 1;// Front port is 1 (9201)
```

Note: If the PC is AMD64 (X86) platform, you need to modify the decoder in the receiving program:

```
std::string udpstrBehindData = " ! application/x-rtp,media=video,encoding-name=H264 ! rtph264depay ! h264parse ! avdec_h264 ! videoconvert ! appsink";
```

If the PC is an ARM64 platform, just keep the original decoder:

```
std::string udpstrBehindData = " ! application/x-rtp,media=video,encoding-name=H264 ! rtph264depay ! h264parse ! omxh264dec ! videoconvert ! appsink";
```

- Build

```
cd UnitreecameraSDK
mkdir build
cd build
cmake ..
make
```

- Run

```
cd ..
./bins/examples_getimagetrans
```

Note: Do not cd to bins to run, it will lack dependencies

3.4 Simultaneous acquisition of images from the head front camera and the chin camera

Sometimes we need to get the screen of two cameras on a Nano at the same time, at this time we can create two transmission configuration files trans_rect_config_cam1.yaml and trans_rect_config_cam2.yaml, and then create two transmission programs to run separately to send both cameras out at the same time. Of course, it is also possible to transmit twice, in the same program.
For example:

```
int main(int argc, char *argv[])
{
    UnitreeCamera cam0("trans_rect_config_cam1.yaml"); ///< init camera by device node number
    UnitreeCamera cam1("trans_rect_config_cam2.yaml"); ///< init camera by device node number
    if(!cam0.isOpened())   ///< get camera open state
        exit(EXIT_FAILURE);
    if(!cam1.isOpened())   ///< get camera open state
        exit(EXIT_FAILURE);
    cam0.startCapture(true,false); ///< disable share memory sharing and able image h264 encoding
    cam1.startCapture(true,false); ///< disable share memory sharing and able image h264 encoding

    usleep(500000);
    while(cam0.isOpened()&&cam1.isOpened())
    {
        cv::Mat left0,right0, left1, right1;
        if(!cam0.getRectStereoFrame(left0,right0))
        {
            usleep(500);
            continue;
        }
         if(!cam1.getRectStereoFrame(left1,right1))
        {
            usleep(500);
            continue;
```

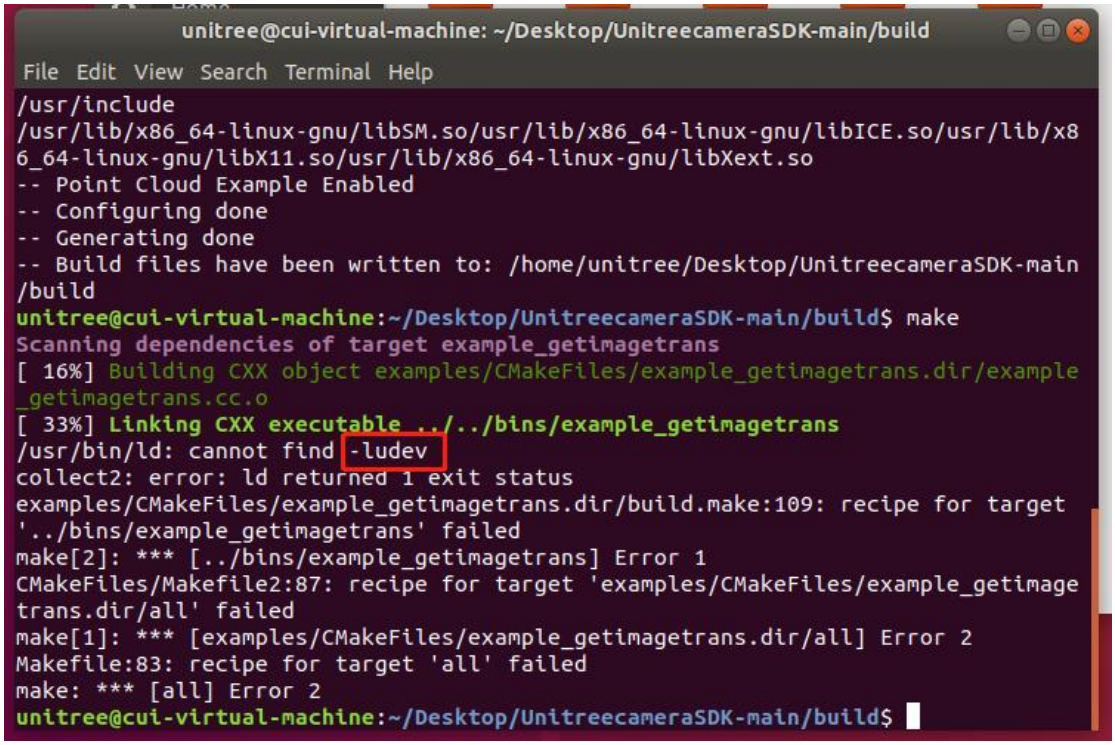
```
        }
        char key = cv::waitKey(10);
        if(key == 27) // press ESC key
            break;
    }

    cam0.stopCapture(); ///< stop camera capturing
    cam1.stopCapture(); ///< stop camera capturing
    return 0;
}
```

3.5 Common errors and solutions when using UnitreecameraSDK

3.5.1 Synchronize the system time first for any error

Reason for error: Compilation error or compilation failure caused by system time.
Solution: https://blog.csdn.net/n_fly/article/details/123270214

3.5.2 Can't find -ludev error when compiling



Reason for error: missing usb and udev related dependencies

Workaround: sudo apt-get install libusb-1.0-0-dev libusb-dev libudev-dev

4. Write image receiving program using python

```
# -*- coding: utf-8 -*-
'''copyright Copyright (c) 2020-2021, Hangzhou Yushu Technology Stock CO.LTD. All Rights Reserved
writen by Zhentao Xie
supporter: Zhentao Xie xiezhentao_1998@163.com
'''

import cv2

class camera:
    def __init__(self, cam_id = None, width = 640, height = 480):
        self.width = 640
        self.cam_id = cam_id
        self.width = width
        self.height = height
    def get_img(self):
        IpLastSegment = "123"
        cam = self.cam_id
        udpstrPrevData = "udpsrc address=192.168.123."+ IpLastSegment + " port="
```

```
        udpPORT = [9201,9202,9203,9204,9205]
        udpstrBehindData = " ! application/x-rtp,media=video,encoding-name=H264 !
rtph264depay ! h264parse ! avdec_h264 ! videoconvert ! appsink"
        udpSendIntegratedPipe_0 = udpstrPrevData +  str(udpPORT[cam-1]) +
udpstrBehindData
        print(udpSendIntegratedPipe_0)

        self.cap = cv2.VideoCapture(udpSendIntegratedPipe_0)

    def demo(self):
        self.get_img()
        while(True):
            self.ret, self.frame = self.cap.read()
            self.frame = cv2.resize(self.frame, (self.width, self.height))
            if self.cam_id == 1:
                self.frame = cv2.flip(self.frame, -1)
            if self.frame is not None:
                cv2.imshow("video0", self.frame)
            if cv2.waitKey(2) & 0xFF == ord('q'):
                break
        self.cap.release()
        cv2.destroyAllWindows()
```

Note: Using pip3 to install opencv-python and opencv-contrib-python will be missing dependencies, be sure to source install opencv