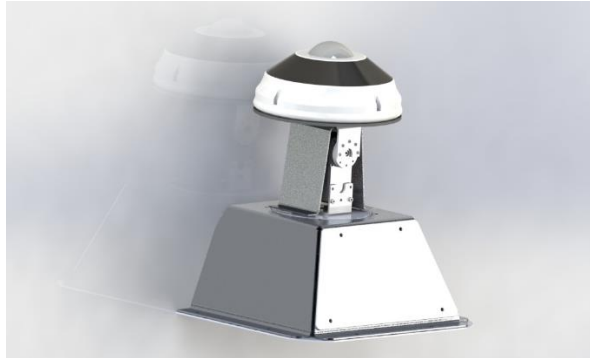


Solar Tracker Guideline

Made by Qiu Liuming, Valen

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Before using it, please download the VNC viewer and Remote. it (or use remote.it online) on your computer and sign up/in an account.

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I. Connect method

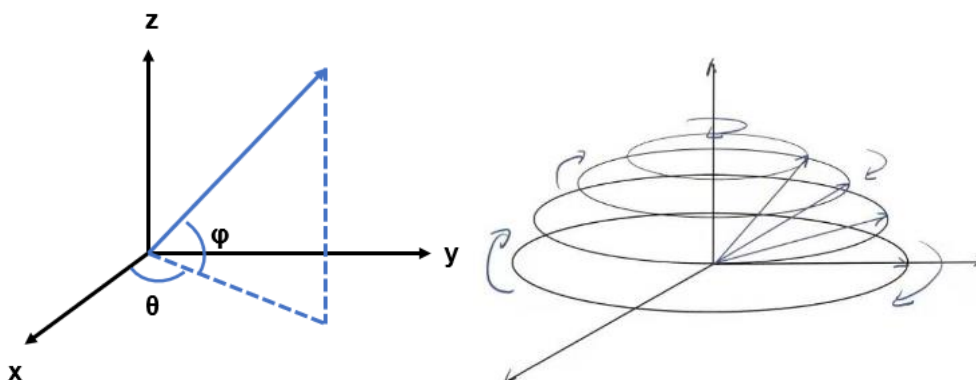
1. Direct connection: Connect the raspberry pi with the monitor, mouse, and keyboard
2. Remote connection via local network: Connect your computer and raspberry pi to the same local network, download & open the VNC viewer and connect it by inputting the IP address of raspberry pi; or connect the computer to the switch in the plastic case (use cable), and do the above step
3. Remote connection via Internet: Find a way to access the raspberry pi first, open the VNC server, sign in with your VNC account, and add it to your Team. After finishing it, you can remote connect the raspberry pi through any internet environment (if and only if the raspberry pi is turned on and connected to the internet, Lol)

II. Solar Tracker Introduction

The solar tracker is developed base on Raspberry Pi 4B, and the operating system is Raspbian OS (Linux). The raspberry pi is powered by a rechargeable lithium battery, allowing the device to work for around 2-3 hours even when the power goes out.

All power and network are provided by the white plastic box connected to the tracker. A switch and router (very old, provided by Mr. Yuen KO, not stable, lol) are placed inside the box for networking, and the IP address is fixed (depends on which port you connect).

There are only two servo motors as actuators; one is a 360-degree rotatable 25kg*cm servo motor for controlling the azimuth angle (θ). The other is a 180-degree rotatable 60kg*cm servo motor (the torque is large because the camera/sensor is heavy) for controlling zenith angle (φ). Both motors have a certain waterproof ability.



The tracker has a certain waterproof ability, but it has not been specifically tested, and it is recommended not to use it in extreme weather or rain. If it must be used in the above weather, it is recommended to take additional waterproof measures.

III. Cables connection

The cables are shown in image 4.1. To use it, please connect the wires following image 4.2, which connect the ethernet cable and power source with the tracker.



- Power Source For tracker
- Ethernet Port For tracker
- Ethernet Cable For the device
- Power Source For tracker
- Power Source 220V AC

Image 4.1

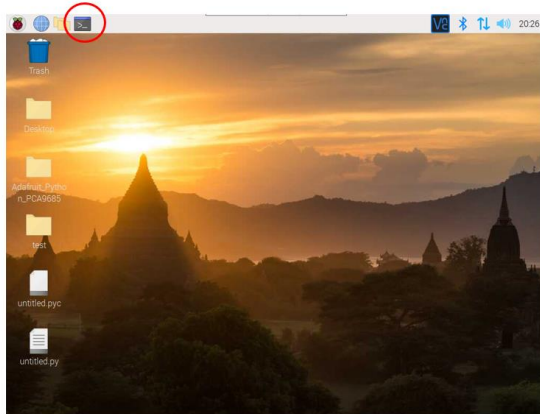


Image 4.2

IV. Connect Solar Tracker

1. Local Network

1.1. Connect a monitor to raspberry pi, and connect it to the internet. You can also connect your computer to the switch inside the box (highly recommended so that you can know whether the router is working normally, if the router is not well, reboot it until your computer can connect to the Internet). Click the terminal icon (or use Ctrl + Alt + T) to open the terminal.

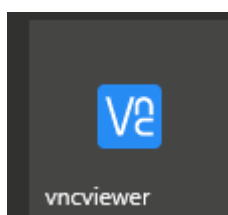


Input: ifconfig

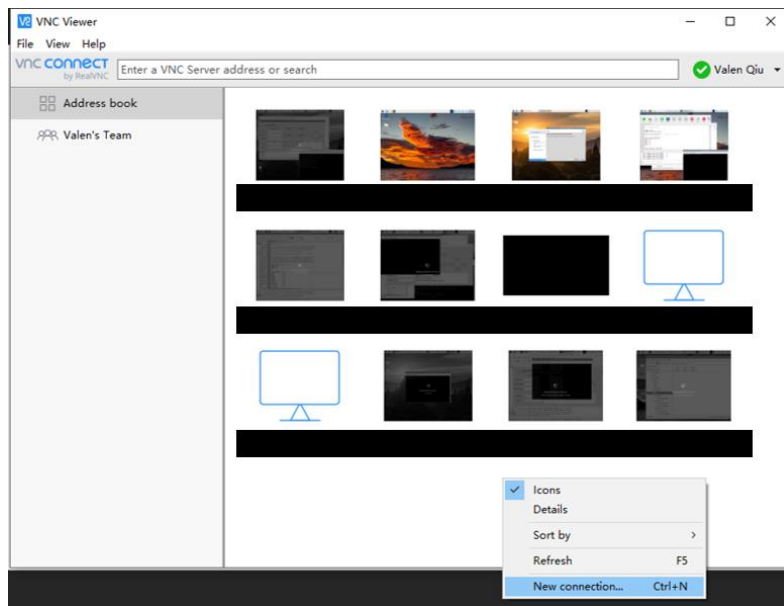
The IP address will appear; in this case, the IP address is 192.168.1.23

```
pi@raspberrypi: ~  
File Edit Tabs Help  
pi@raspberrypi:~ $ ifconfig  
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
    inet 192.168.1.23 netmask 255.255.255.0 broadcast 255.255.255.255  
    inet6 fe80::bfa6:caf3:a00:bc5 prefixlen 64 scopeid 0x20<link>  
    ether dc:a6:32:1b:81:92 txqueuelen 1000 (Ethernet)  
    RX packets 5001 bytes 504759 (492.9 KiB)  
    RX errors 0 dropped 1 overruns 0 frame 0  
    TX packets 1806 bytes 432204 (422.0 KiB)  
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536  
    inet 127.0.0.1 netmask 255.0.0.0  
    inet6 ::1 prefixlen 128 scopeid 0x10<host>  
    loop txqueuelen 1000 (Local Loopback)  
    RX packets 5 bytes 284 (284.0 B)  
    RX errors 0 dropped 0 overruns 0 frame 0  
    TX packets 5 bytes 284 (284.0 B)  
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
pi@raspberrypi:~ $
```

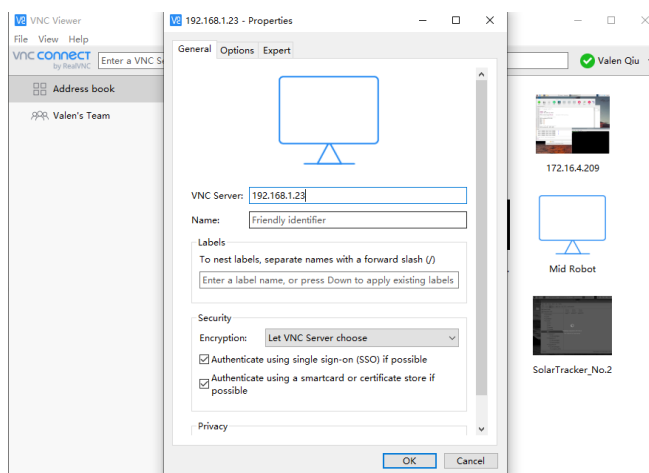
1.2. Open the VNC viewer



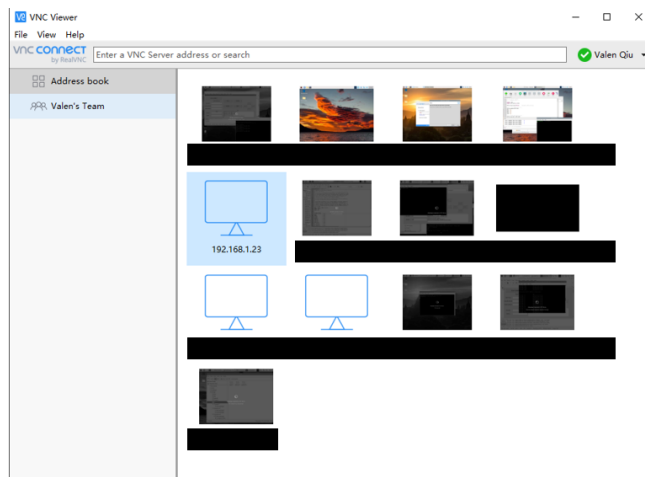
1.3. Right-click and choose “New Connection.”



1.4. Input the IP address you get (192.168.1.23 in this case) to the VNC Server, and then click OK. If you want to specify the connection, you can input the name you wish to in the Name.



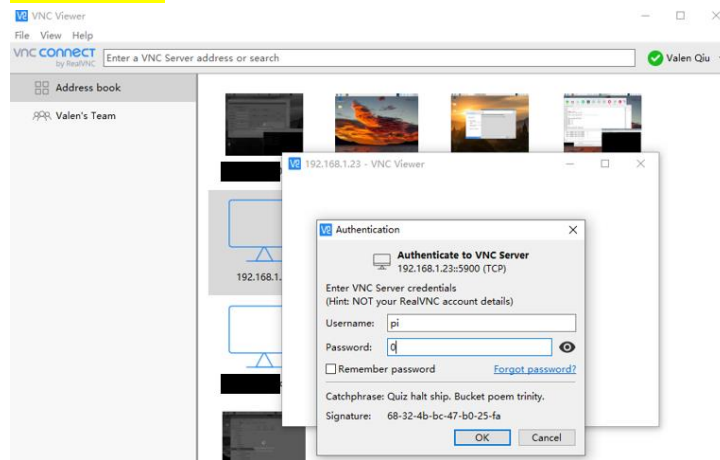
As shown in the image below, a new connection has been successfully created.



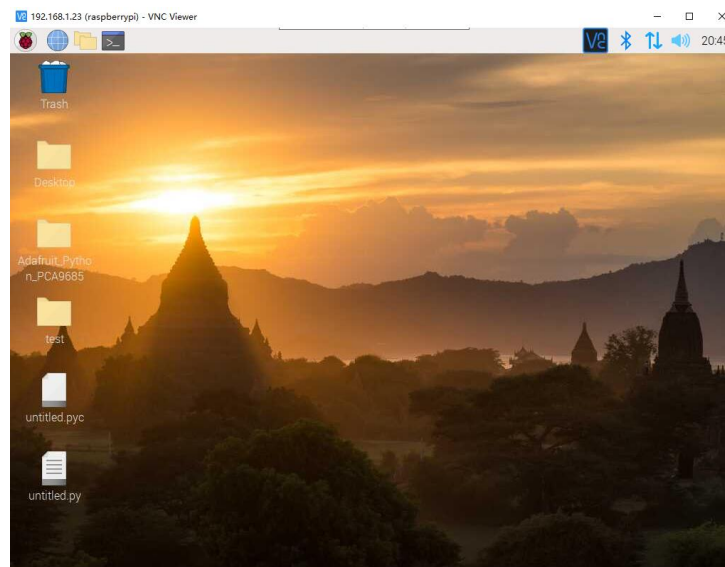
1.5. Double-click the connection icon you just created, input the user name and password into the window, and click OK.

User name: pi

Password: 0

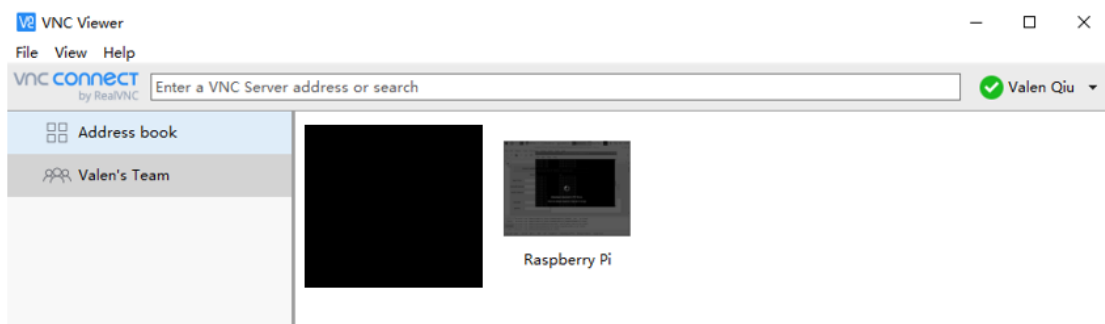


1.6. Connect successfully!



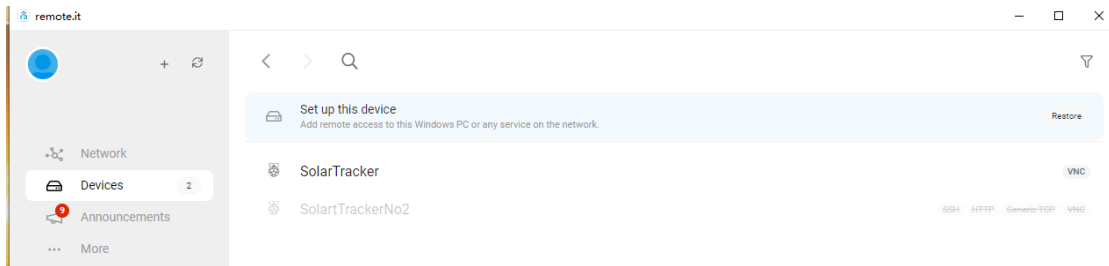
2. Internet

To connect the raspberry conveniently, you can sign up for a VNC account by email and add the raspberry pi to your Team. After doing this, you can directly connect to your raspberry pi, you do not need to be on the same network. As shown in the image. The detail method can be searched online.

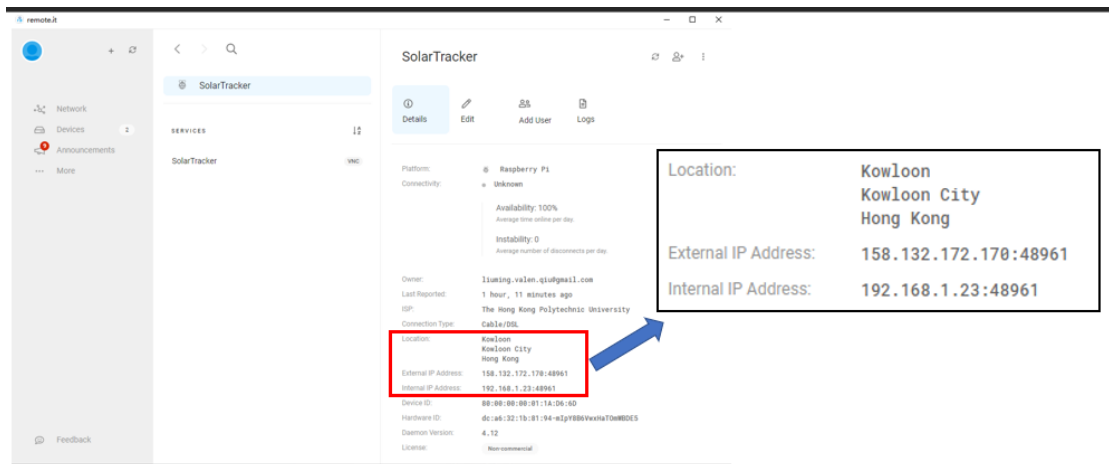


3. Remote.it

Besides, it is highly recommended to use Remote.it to detect the internet connection. Besides, it can also get the ethernet IP address.



With the ethernet IP address, you can repeat step 1.4, but input this ethernet IP address, you can also remotely connect the raspberry pi, and no need to connect to the same local network.

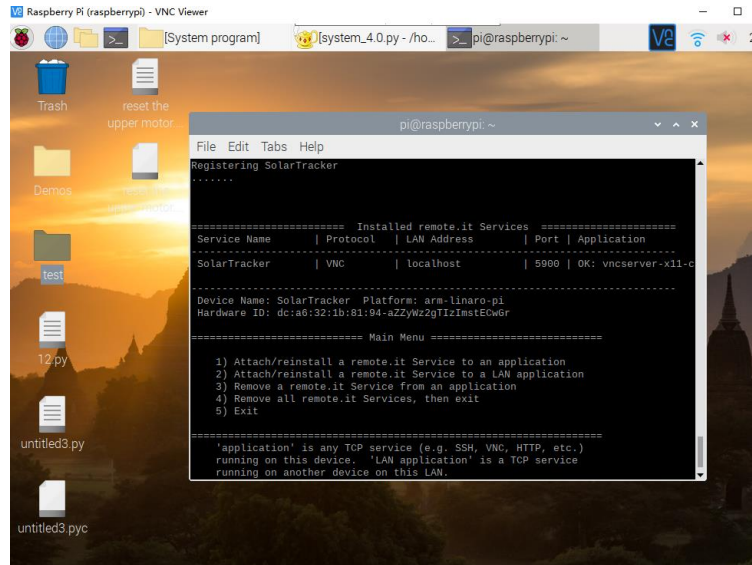


Link for the video tutorial on applying Remote.it:

<https://www.youtube.com/watch?v=B8E1dE5kW4&t=167s>

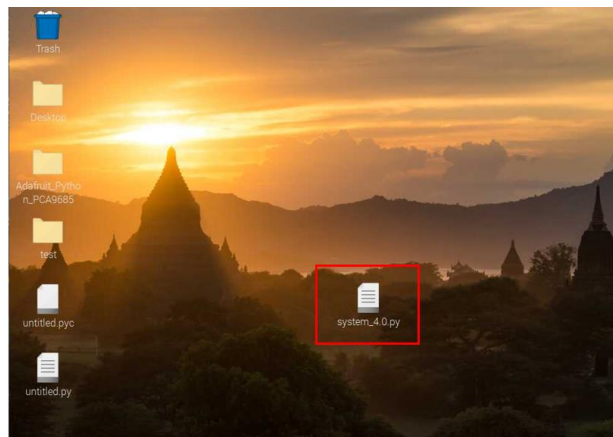
Some steps for setting up Remote.it are shown below:

```
pi@raspberrypi: ~  
File Edit Tabs Help  
pi@raspberrypi:~ $ sudo raspi-config  
pi@raspberrypi:~ $ sudo netstat -ltn | grep tcp  
tcp        0      0 0.0.0.0:22        0.0.0.0:*        LISTEN  
507/sshd  
tcp        0      0 0.0.0.0:5900     0.0.0.0:*        LISTEN  
492/vncserver-x11-c  
tcp6       0      0 :::22            :::*             LISTEN  
507/sshd  
tcp6       0      0 :::5900         :::*             LISTEN  
492/vncserver-x11-c  
pi@raspberrypi:~ $
```

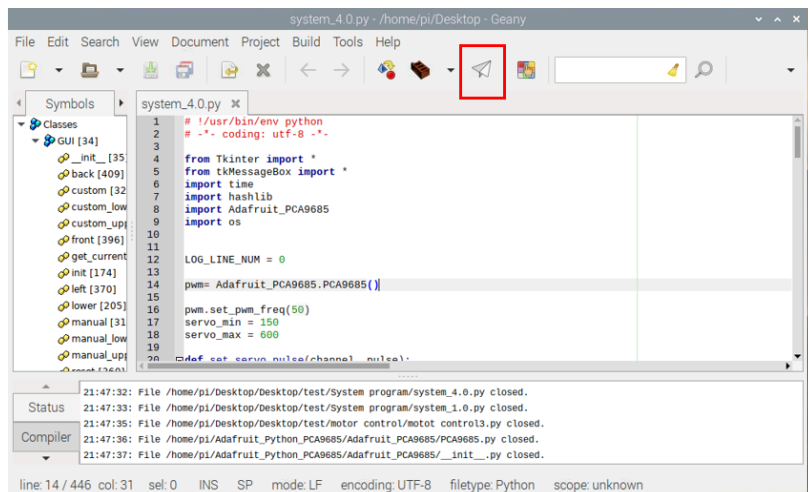


V. Functions: Scanning, Angle Control, Camera...

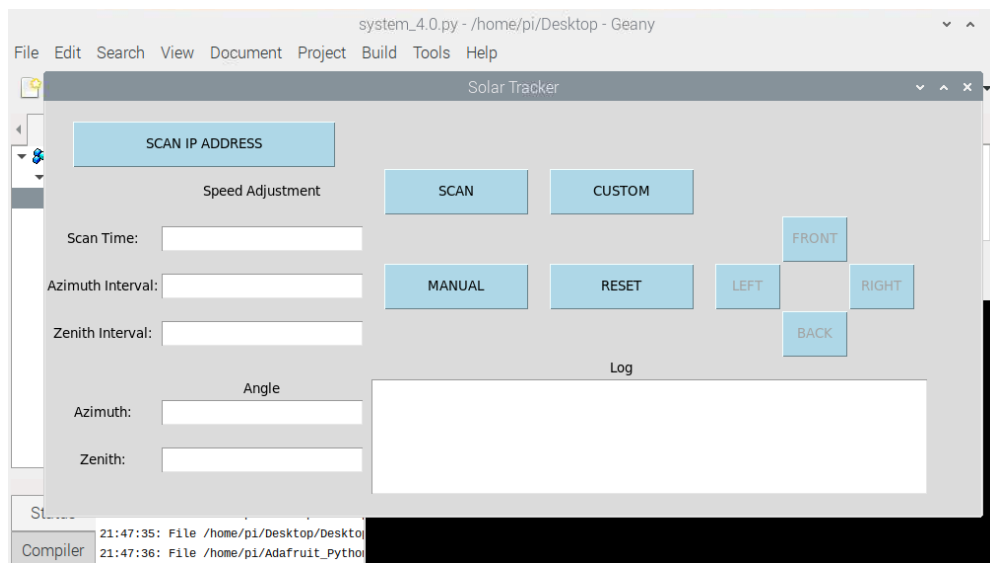
After accessing the raspberry pi, click the system_4.0.py on the desktop, and run it. Remarks: please use Geany to run the code. The system is developed under the Geany, and cannot guarantee that other programmers will not report errors.



Since the tracker may need further improvement, the code is not encapsulated into an exe.

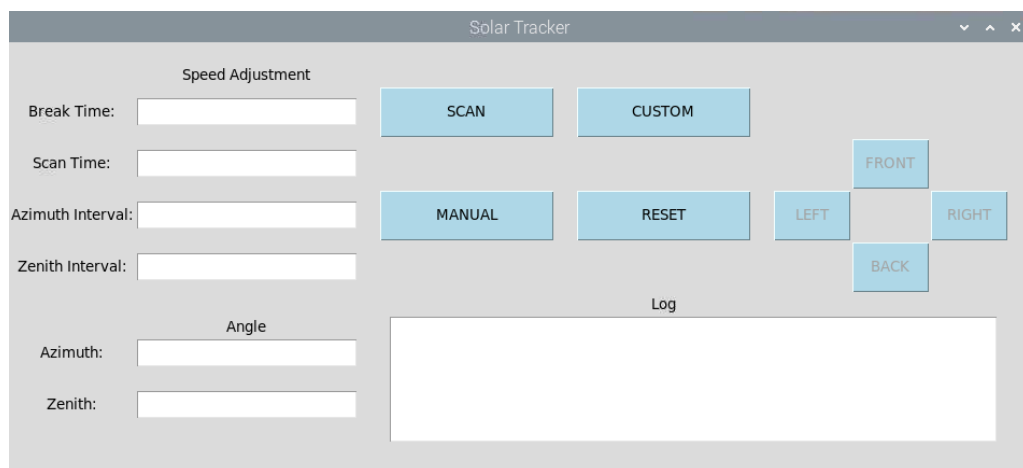


After run the program, GUI will come out.

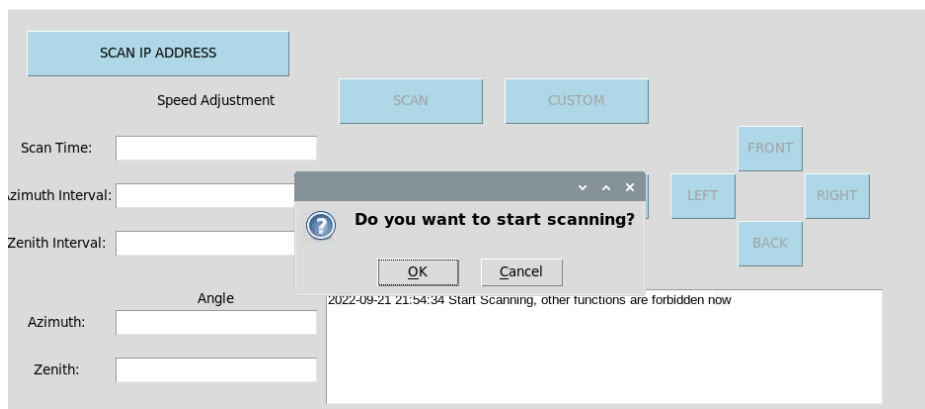


1. User manual of the GUI

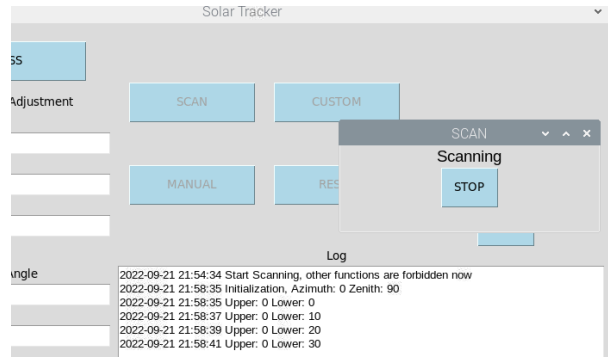
(Written in 2021 summer, lol)



1. SCAN



Click the "SCAN" button, a window will come out. Click OK for starting, and click Cancel to stop it. The Solar Tracker will start with default settings (10 degrees of Zenith and 6 degrees of Azimuth for each step, scan time is 60s (for testing, only 2s).



Click the “STOP” button can quit the scanning mode after the initialization. When it is in the scanning mode, other functions will be forbidden.

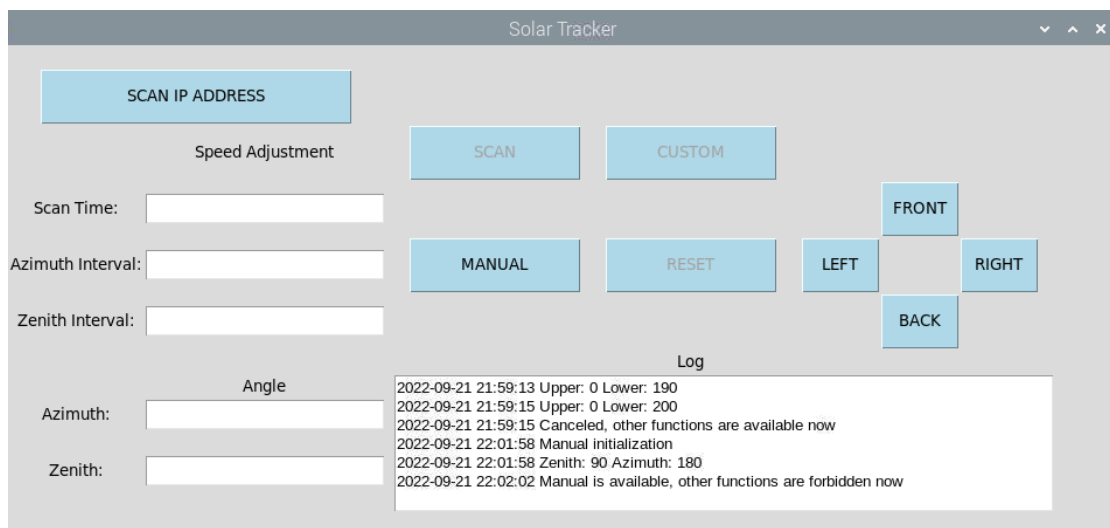
“Break Time” is not available now. Input the scan time to adjust the time for scanning (input number should be integer and larger than 0), input the azimuth/zenith interval to adjust the angel interval of each step (azimuth: integer in range 0-360, which preferably 360 can be divisible by the integer; zenith: integer in range 0-90, which preferably 90 can be divisible by the integer).

After inputting the numbers for adjustment, click “SCAN” again, the Solar Tracker will start with the new settings. You can input a specific one/two, and others will keep in the default setting.

The initialization angle is Zenith: 90°, Azimuth: 0°, see the definition of zenith and azimuth in part II.

2. MANUAI

Click the “MANUAL” button, wand it for the initialization, those four buttons on he right side of the GUI will be available, and the Solar Tracker can be controlled by those buttons. Each click of the button will let the Solar Tracker move 2° in the corresponding direction.



When the Solar Tracker is in the manual control mode, other functions will be forbidden, you can click the “MANUAL” button again to quit the mode, and other functions will become available.

The initialization angle is Zenith: 90°, Azimuth: 180°.

3. CUSTOM

Type the angle you want in the “Angle” input panel, and click the “CUSTOM” button, the Solar Tracker will turn to the angle. However, the user must enter both azimuth and zenith to set the custom angle, otherwise, it will ask you to input an angle and end this function.

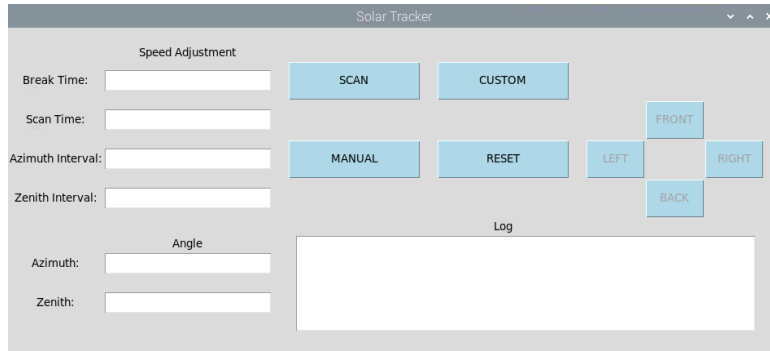
4. RESET

Click the “RESET” button will clean all the input and the setting will become back to the default mode.

Remark: After testing, please go to the code, and change the scan time to 60s for each step (now is 2s).

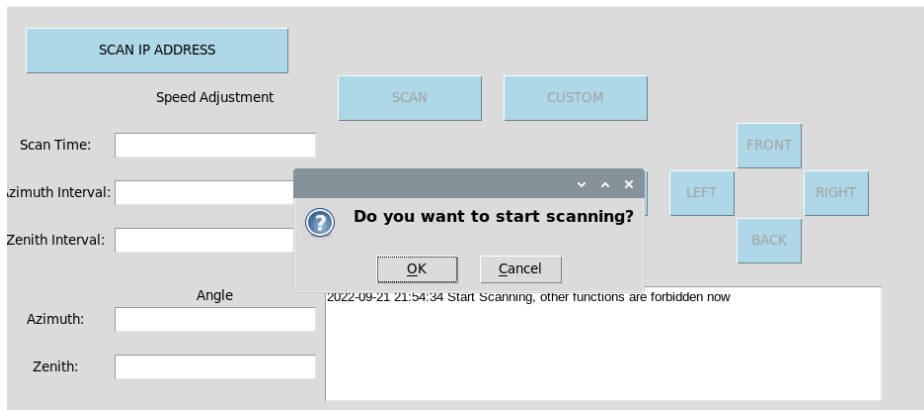
因为一年前的英文写的太烂，为了避免产生误解，特意准备了中文版的 GUI 使用说明
(备注：该中文版的使用说明也是一年前写的 lol)

用户手册

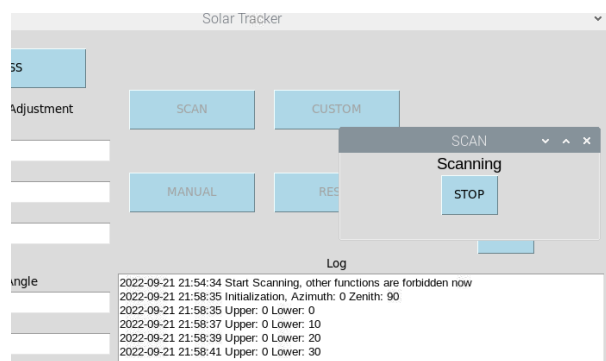


1. SCAN

点击“SCAN”按钮，Solar Tracker 将会以默认设定开始运行（广角每次十度以及仰角每次六度，扫描时间为 60 秒（测试需要，现在是 2 秒）。



开始扫描后，点击初始化后弹出窗口的“STOP”按钮可以退出扫描模式。但当 Solar Tracker 在扫描模式时，其他功能将被禁用。



“Break Time”按钮暂时不能使用。在调整面板输入期望的扫描时间（不为零的整数）来调节扫描的时间，广角间隔（0-360 范围内的 360 的整数因数）和仰角间隔（0-90 范围内的 90 的整数因数）代表每次扫描后的角度间隔。

输入需要调整的数字后，再次点击“SCAN”，Solar Tracker 将会以新的设定开始运行。可以仅输入需要调整的设置，其他无输入的设置将会以默认设定运行。

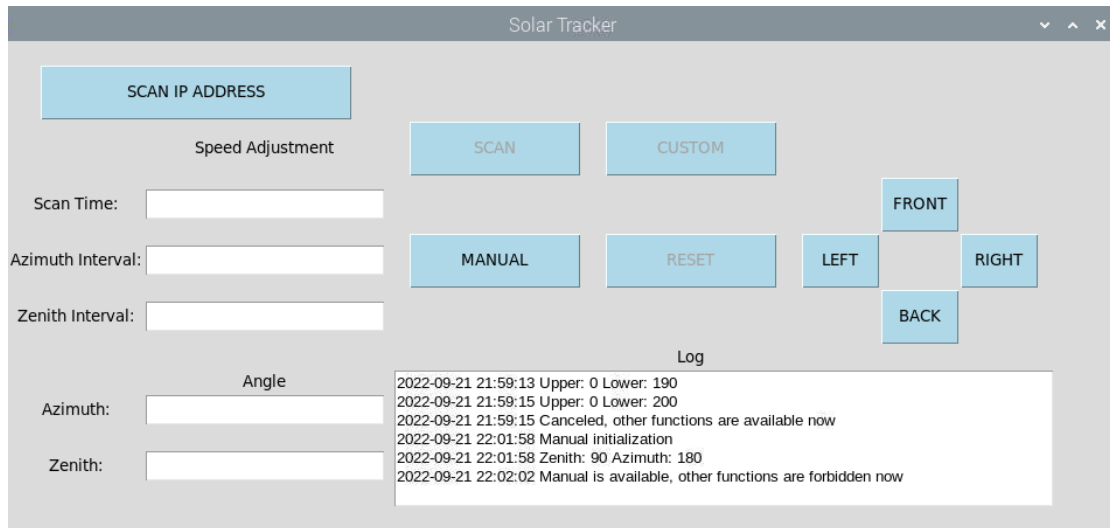
初始化的角度为广角 0 度，仰角 90 度。

2. MANUAL

点击“MANUAL”按钮，等待设备初始化，GUI 界面右侧的四个按钮将可以使用，其余按钮将被禁用。接着，用户可以通过这四个按钮控制 Solar Tracker 的角度，每点击一次按钮，装置将朝着对应方向运动两度。

当 Solar Tracker 在手动控制模式时，其他功能将会被禁用，用户可以再次点击“MANUAL”按钮来退出手动控制模式，其余功能也将被再次激活。

初始化角度为广角 180 度，仰角 90 度。



3. CUSTOM

输入想要到达的特殊角度，点击“CUSTOM”按钮，Solar Tracker 将会转到该特定角度。但是，用户必须输入广角和仰角才能控制自定义角度，否则系统将会提示你输入角度并退出自定义模式。

4. RESET

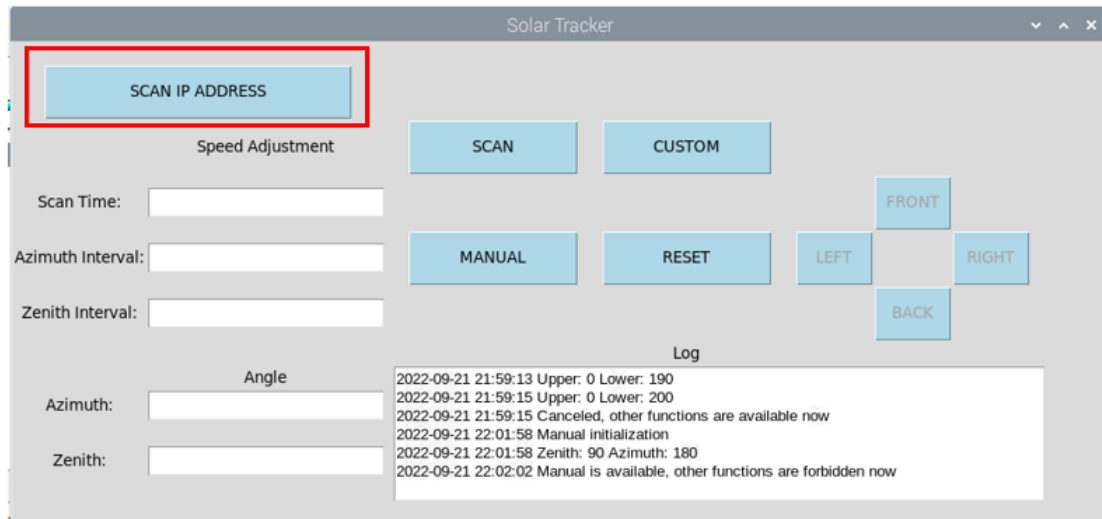
点击“RESET”按钮将会清空 GUI 面板左侧的全部输入，并且使 Solar Tracker 恢复默认设定。

备注：测试阶段的扫描时间设定为 2 秒，再确认装置符合要求后，请在程序中将扫描时间 (scan time) 改为 60s

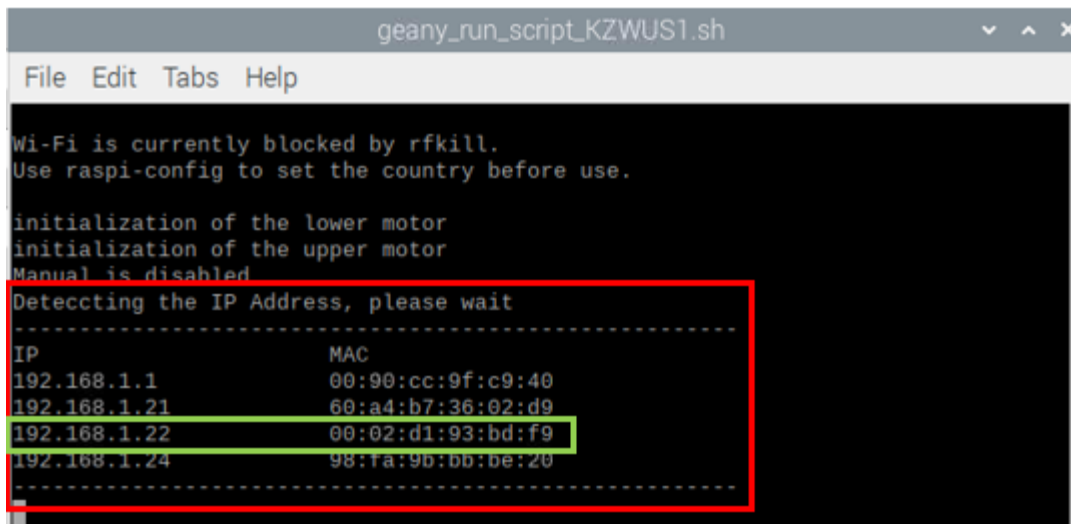
2. Camera

The fisheye camera used here is for simulating the sensor, in case you want to access the image of the camera, here is the way to do it.

In the GUI, click the **SCAN IP ADDRESS**, and wait for a while. It will scan the IP address and MAC address of devices which connected to the local network.

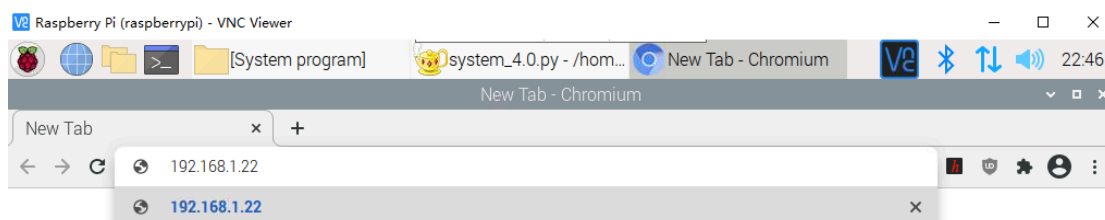


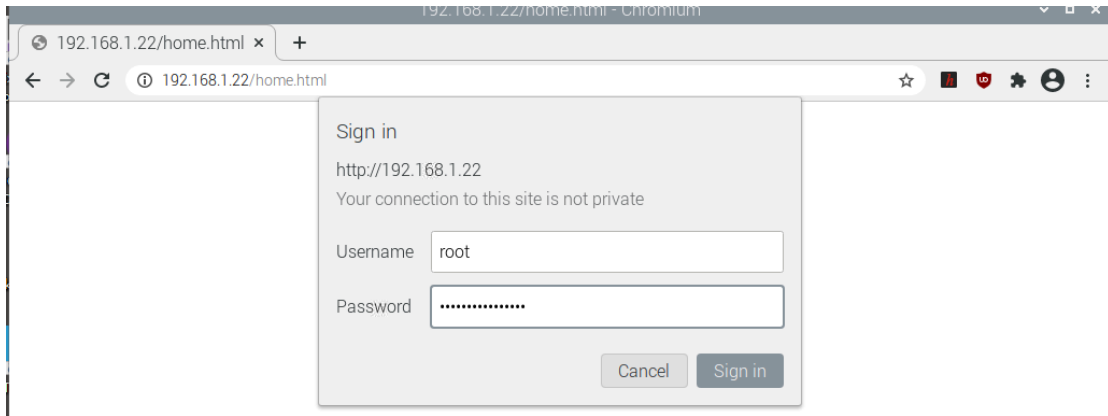
After clicking it, go to the command window, and wait for the result (because of the system permission restrictions, can only read the result in command window)



The MAC address of the fisheye camera is 00:02:d1:93:bd:f9, therefore, the IP address of it is 192.168.1.22

Go to the browser, and then input the IP address, go to the web server of fisheye camera.

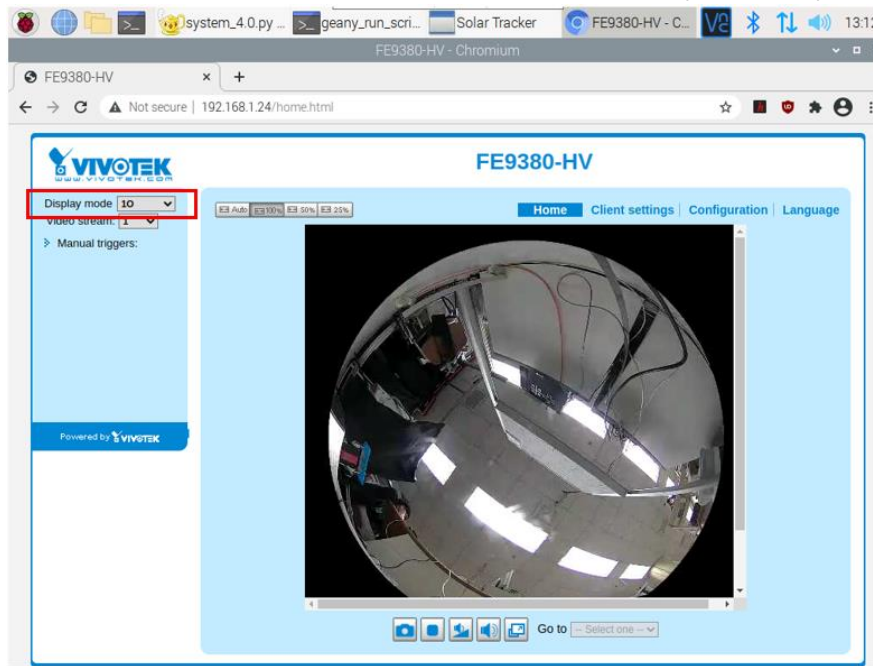




Username: root

Password: SolarTracker2021

And you can access the camera, and there are different modes (see below).



10 mode:



1R mode:



1P mode:



VI. Device Information

1. Fisheye camera

Vivotek FE9380-HV, (see the attached user manual)



<https://webapi.vivotek.com/api/DownloadCenter/Download/global?p1=%2B9U3MHUKXPMhaaUnmBD60g==&p2=j199RdC0wOvZ8pPmTck8Tg==>

The fisheye camera can be powered and connect to internet through PoE (power over Ethernet) by an ethernet cable. Therefore, in order to used it, a switch with PoE is required (see part 2), and obey the IEEE 802.3af. Besides, it also needs to use software called Shepherd (Shepherd 2.4.0.201) or a web browser to assess the video.

19. Please visit VIVOTEK's website to Install the "Shepherd" software utility. The program will search for VIVOTEK Video Receivers, Video Servers or Network Cameras on the same LAN.

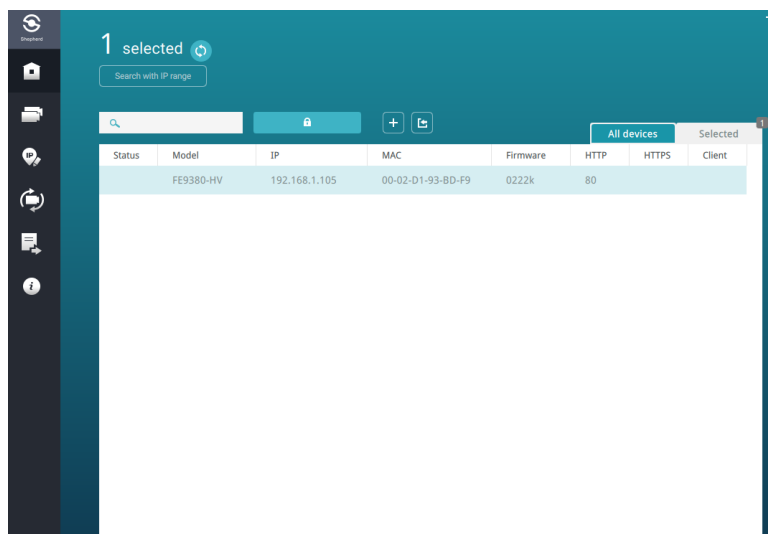
Double-click on the camera's MAC address to open a web console with the camera.



The software is in the attached folder, or use this link to download it:

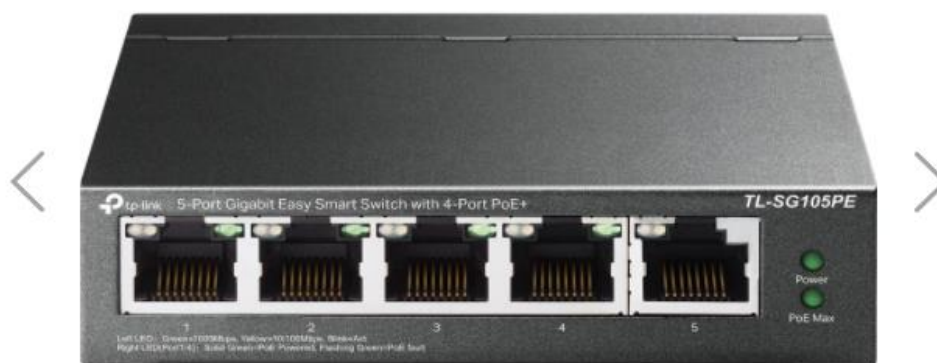
<https://www.vivotek.com/downloads/product>

remarks: Version 2.4.2.201



2. PoE Switch

TL-SG105PE



This is the PoE connection format:

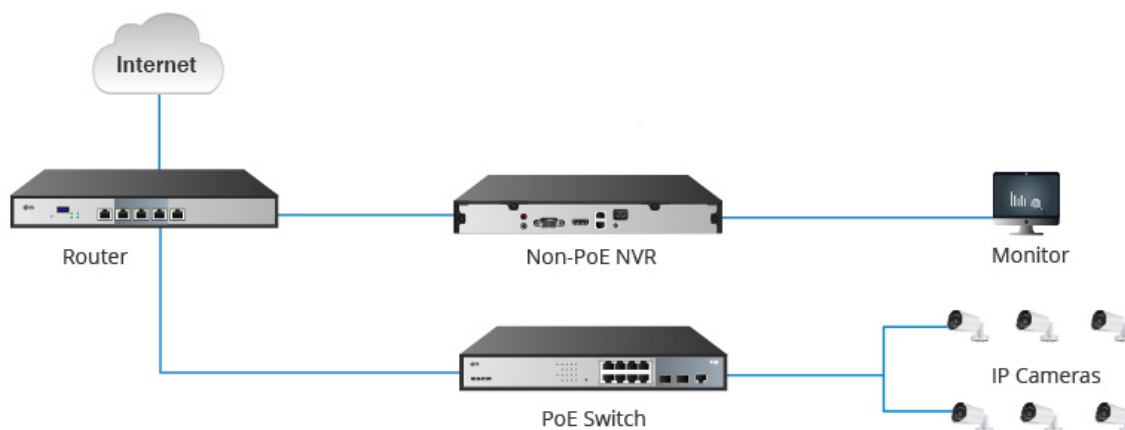
非PoE NVR与IP摄像机连接——需使用PoE交换机

非PoE NVR不具备PoE功能，背板未配置以太网接口，因此该NVR录像机不可与IP摄像机通过网线直接连接。此时，必须使用PoE交换机为IP摄像机供电。具体的连接步骤如下：

使用以太网线将PoE交换机上的LAN端口连接至路由器，同时用以太网线连接非PoE NVR和路由器，确保PoE交换机和NVR录像机在同一个网络中。

使用以太网线将IP摄像机连接在PoE交换机的RJ45端口上，交换机可通过以太网线为IP摄像机供电，并接收来自IP摄像机的数据。使用VGA或HDMI线连接NVR和监控设备（如电脑、电视等），连接时，请注意使用监控设备对应的接口（如VGA接口需使用VGA线连接，HDMI接口需使用HDMI高清线连接）。

使用非PoE NVR监控系统时，用户需在网络中将IP摄像机配置到NVR录像机上，这一步骤，请按照购买的NVR附带的操作手册操作。图2是非PoE NVR监控系统连接示意图。



It also has a software to do some setting, the software is attached in folder as well.

System Info

Device Description	TL-SG105PE
MAC Address	60:A4:B7:36:02:D9
IP Address	192.168.1.21
Subnet Mask	255.255.255.0
Default Gateway	192.168.1.1
Firmware Version	1.0.0 Build 20200415 Rel.55282
Hardware Version	TL-SG105PE 1.0

Device Description:

Note:
The length of device description should not be more than 32 characters.

Username: admin

Password: admin1

3. Router

Provided by Mr. Yuen KO, a very old router, sometimes it fails, but usually it can work well.

Username: (None)

Password: 0000

The screenshot shows the configuration page for a Digi router. The page is in Chinese and has a blue background. At the top, there are navigation tabs: 外部網路 (External Network), 內部網路 (Internal Network), 進階設定 (Advanced Settings), 系統狀況 (System Status), and 其他 (Other). The current page is titled "外部網路 - 固定IP設定" (External Network - Fixed IP Settings). Below the title, there is a dropdown menu set to "固定IP設定 (連接網路使用者)". The main content area is divided into several sections:

- 基本設定 (Basic Settings):** Includes fields for MAC address (00-90-CC-9F-C9-3F), a "修改" (Modify) button, and a field for the device name (BRL-04AX).
- IP 位址設定 (IP Address Settings):** Includes fields for IP address (158.132.172.170), subnet mask (255.255.254.0), and gateway (158.132.172.28).
- DNS 伺服器設定 (DNS Server Settings):** Includes fields for primary DNS (158.132.18.1) and secondary DNS (158.132.14.1).

At the bottom of the page, there are two buttons: "重新設定" (Reset) and "儲存" (Save).

4. MAC address

To identify all devices connect in the local network, all MAC address are listed here:

Router: 00:90:cc:9f:c9:40

PoE Switch: 60:a4:b7:36:02:d9

Fisheye Camera: 00:02:d1:93:bd:f9

5. Raspberry Pi GPIO

树莓派 40Pin 引脚对照表

树莓派 40Pin 引脚对照表

wiringPi 编码	BCM 编码	功能名	物理引脚 BOARD编码		功能名	BCM 编码	wiringPi 编码
		3.3V	1	2	5V		
8	2	SDA.1	3	4	5V		
9	3	SCL.1	5	6	GND		
7	4	GPIO.7	7	8	TXD	14	15
		GND	9	10	RXD	15	16
0	17	GPIO.0	11	12	GPIO.1	18	1
2	27	GPIO.2	13	14	GND		
3	22	GPIO.3	15	16	GPIO.4	23	4
		3.3V	17	18	GPIO.5	24	5
12	10	MOSI	19	20	GND		
13	9	MISO	21	22	GPIO.6	25	6
14	11	SCLK	23	24	CE0	8	10
		GND	25	26	CE1	7	11
30	0	SDA.0	27	28	SCL.0	1	31
21	5	GPIO.21	29	30	GND		
22	6	GPIO.22	31	32	GPIO.26	12	26
23	13	GPIO.23	33	34	GND		
24	19	GPIO.24	35	36	GPIO.27	16	27
25	26	GPIO.25	37	38	GPIO.28	20	28
		GND	39	40	GPIO.29	21	29

表格由树莓派实验室绘制 <http://shumeipai.nxez.com>

VII. Attachments

Link of the OneDrive: [Solar Tracker](#)

1. CAD

Sheet metal.rar:

.DXF files for sheet metal manufacturing

Tracker_Assembly.zip:

SolidWorks files of the tracker, made by sw2021

SolarTracker_eDrawing.easm:

eDrawing of the tracker

2. Code

SolarTracker.py

Python code for the GUI & control

Using python 2.7.16

Need to install libraries:

Tkinter

hashlib

Adafruit_PCA9685

3. Fish Eye Cam

Documents for the fisheye camera, includes user manual, datasheet, engineering drawing and shepherd user manual

4. PoE switch

Installation package of the software for setting up the PoE switch

5. Shepherd_2.4.0.201

Installation package of the Shepherd_2.4.0.201