



Multicopter Design and Control Practice Experiments

RflySim Advanced Courses Lesson 01: Introduction

Dr. Xunhua Dai, Associate Professor,
School of Computer Science and Engineering,
Central South University, China;

Email: dai.xh@csu.edu.cn ;

<https://faculty.csu.edu.cn/daixunhua>



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1. Installation Instructions

1.1 Check the computer configuration. The following minimum configuration or performance are recommended:

- **System:** Windows 10 x64 system (OS version 1809 and above)
- **CPU:** Intel i7 6th-gen processor and above, or AMD processor with equivalent performance
- **Graphics card:** discrete graphics card NVIDIA GTX1060 and above, or AMD graphics card with equivalent performance
- **Memory:** Capacity of 8G and above, DDR3 with frequency of 1600MHz and above
- **Hard disk:** remaining capacity of 40G and above (solid state hard disk is recommended)
- **Display:** resolution of 1080P (1920*1080) and above (dual screen is recommended)
- **Interface:** at least one USB Type A interface (or use extension cable)
- **MATLAB:** 2017B or above (2017b is recommended)

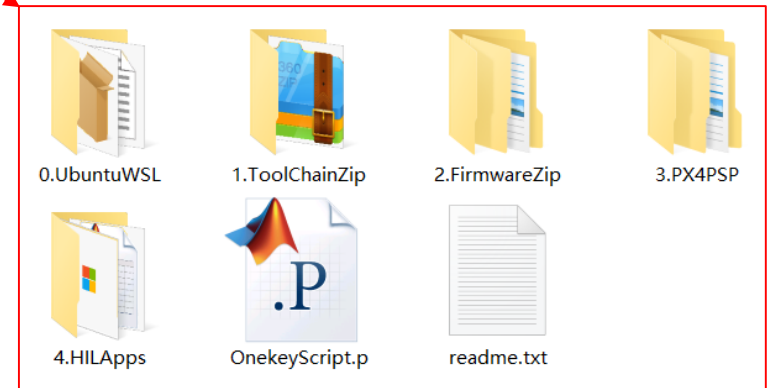
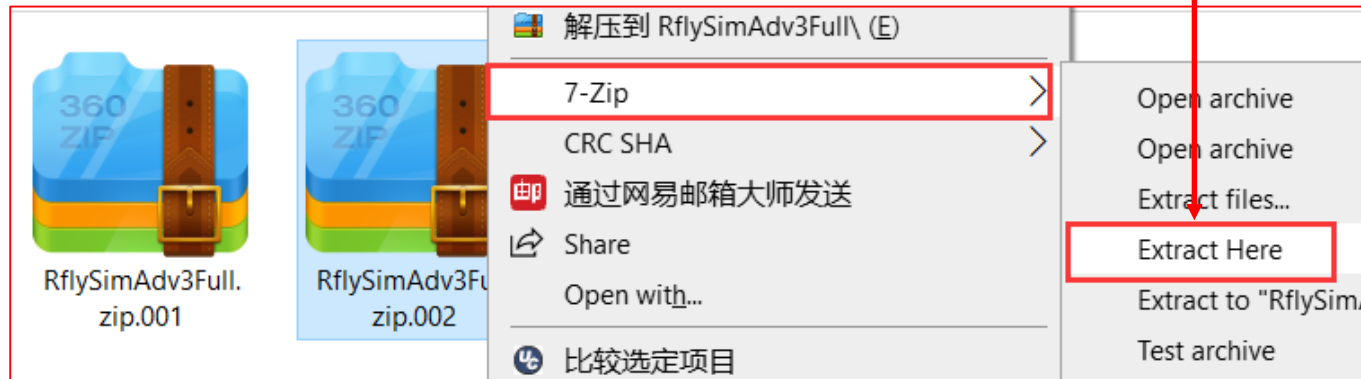
Note1: The computer performance should be as high as possible. Low-configuration computers can also run the platform Demos, but problems such as unstable control and poor experimental results may occur. **Note2:** Please install MATLAB in advance.



1. Installation Instructions

1.2 Download installation package

- If you have obtained the installation mirror with suffix .iso, you can load the mirroring with right click – “**Open With**” – “**Windows Explorer**” (or unzip it with decompression software, or load it with a virtual CD-ROM drive) to obtain the installation package folder shown on the right.
- If you get a sub compressed package like “*****.zip.001**” ~ “*****.zip.004**”, click any file with the mouse, and right-click “**Extract Here**” to get the bottom right, the installation package folder is shown in the figure.



Note: You can buy RflySim advanced version by email rflysim@163.com to acquire download link and actuation code



1. Installation Instructions

1.3 Install Win10WSL compiler.

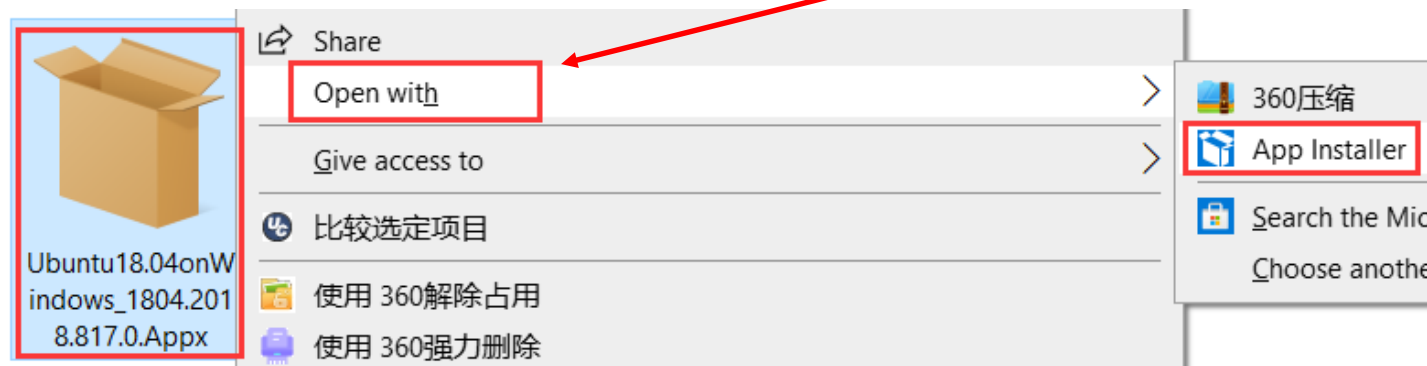
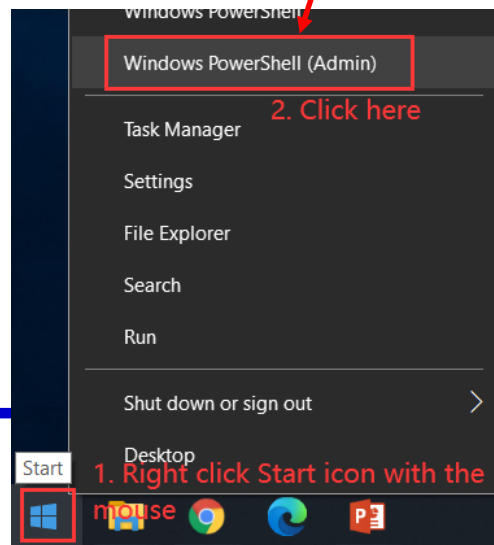
- Place the mouse on the Windows menu and right click to pop up the menu as shown in the figure below. Click the **"Windows PowerShell (Administrator) (A)"** button to enter the PowerShell command line window.
- Input **"Enable-WindowsOptionalFeature -Online -FeatureName Microsoft-Windows-Subsystem-Linux"** as shown in the upper right picture, press Enter to execute the command; according to the prompt, enter "Y" and press Enter to restart the computer.
- On the file **"0.UbuntuWSL\Ubuntu18.04onWindows_1804.2018.817.0.Appx"** in the installation package, as shown in the right lower right figure, in the right-click menu, **"Open With" - "Application Installer"**, the WSL installation page will pop up.

```
Administrator: Windows PowerShell
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Try the new cross-platform PowerShell https://aka.ms/pscore6

PS C:\WINDOWS\system32> Enable-WindowsOptionalFeature -Online -FeatureName Microsoft-Windows-Subsystem-Linux
```

Note: Note that the system is required to be Window 10 x64 1809 and above, otherwise compilation problems will occur.

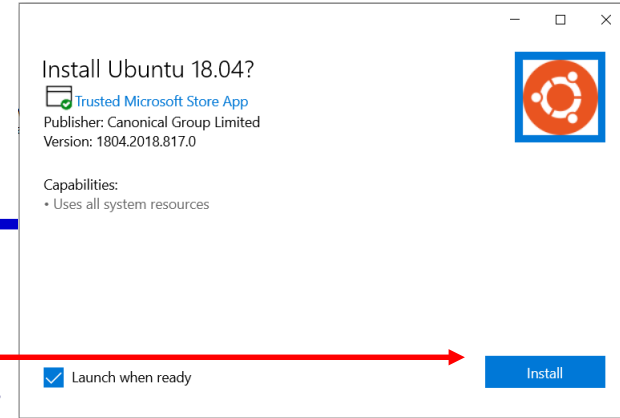




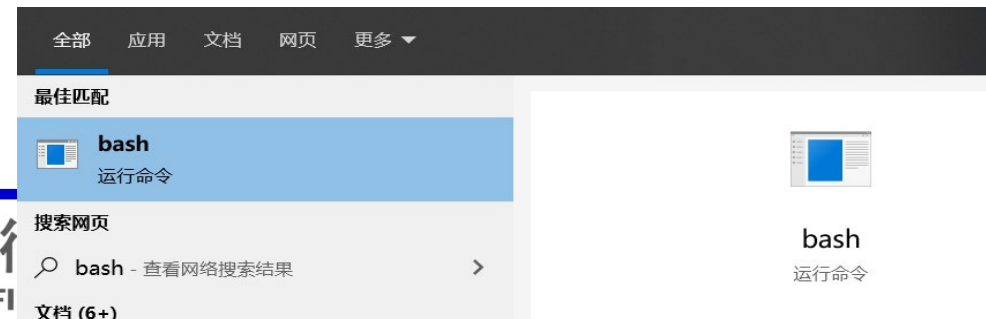
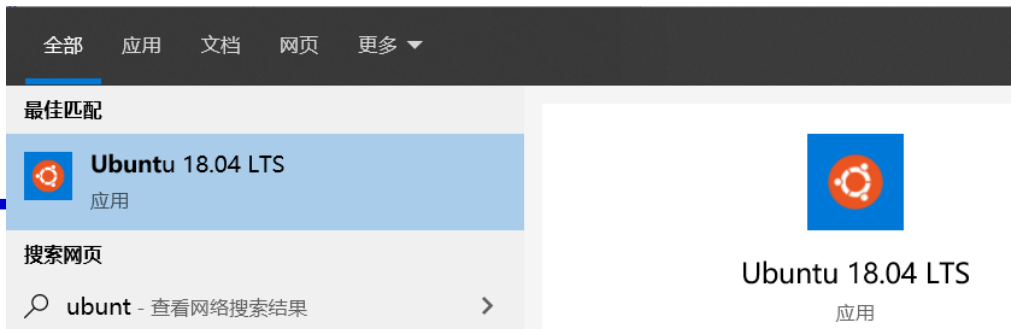
1. Installation Instructions

1.3 Install Win10WSL compiler.

- Click the **"Install"** button on the interface to install the Ubuntu system.
- After the installation is complete, a black box will pop up to show it's installing (if it doesn't pop up, please manually open Ubuntu from the start menu). After a few minutes, the initialization will be completed and a page for entering **"UNIX username"** will display as shown in the figure below. **Note! Do not enter the account password here**, close the window directly. Then, you can get a root account without password.
- At this point, search for **"Ubuntu"** or **"bash"** in Windows Start menu, and you can see the program to open the Ubuntu subsystem.



```
dai@dai: ~
Installing, this may take a few minutes...
Installation successful!
Please create a default UNIX user account. The username does not need to match your Windows username.
For more information visit: https://aka.ms/wslusers
Enter new UNIX username:
```

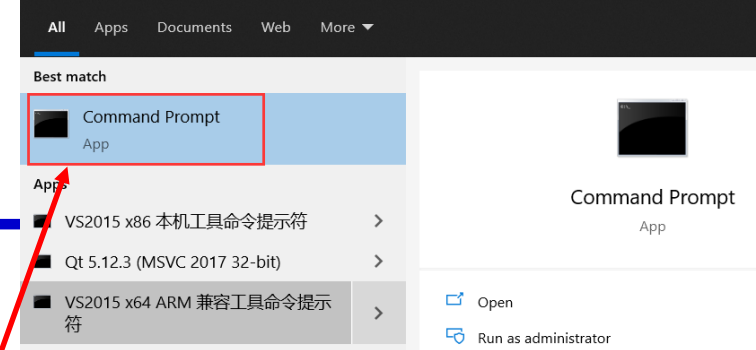




1. Installation Instructions

1.3 Install Win10WSL compiler.

- After the installation completed, as shown in the figure below, enter three commands in the command prompt window (search “**CMD**” in the start menu) to check whether the Ubuntu subsystem has been installed and configured correctly.
- “**Wslconfig /I**”: You should see “**Ubuntu-18.04 (default)**”.



Note: The current platform does not support WSL2, if it has been installed before, please switch to the WSL1 version of the subsystem

```
C:\> root@DESKTOP-NQLAGE1: /mnt/c/Users/dream
Microsoft Windows [Version 10.0.19041.508]
(c) 2020 Microsoft Corporation. All rights reserved.

C:\Users\dream>Wslconfig /I
Windows Subsystem for Linux Distributions:
Ubuntu-18.04 (Default)

C:\Users\dream>Wsl lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description: Ubuntu 18.04.1 LTS
Release: 18.04
Codename: bionic

C:\Users\dream>Bash
root@DESKTOP-NQLAGE1:/mnt/c/Users/dream#
```



1. Installation Instructions

- "**Wsl lsb_release -a**": You should be able to see that the installed Ubuntu version is **18.04 LTS**.
- "**Bash**": You should be able to enter the Ubuntu terminal and display an account named "**root@*****".
- Note: If the above conditions are not met, it means that the Ubuntu subsystem has not been installed correctly. Please uninstall and reinstall it on the "**Applications and Features**" page. If you cannot uninstall, please enter "**wslconfig /u Ubuntu-18.04**" in the command prompt window to uninstall

Note: The current platform does not support WSL2, if it has been installed before, please switch to the WSL1 version of the subsystem

```
root@DESKTOP-NQLAGE1: /mnt/c/Users/dream
Microsoft Windows [Version 10.0.19041.508]
(c) 2020 Microsoft Corporation. All rights reserved.

C:\Users\dream>Wslconfig /1
Windows Subsystem for Linux Distributions:
Ubuntu-18.04 (Default)

C:\Users\dream>Wsl lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description: Ubuntu 18.04.1 LTS
Release: 18.04
Codename: bionic

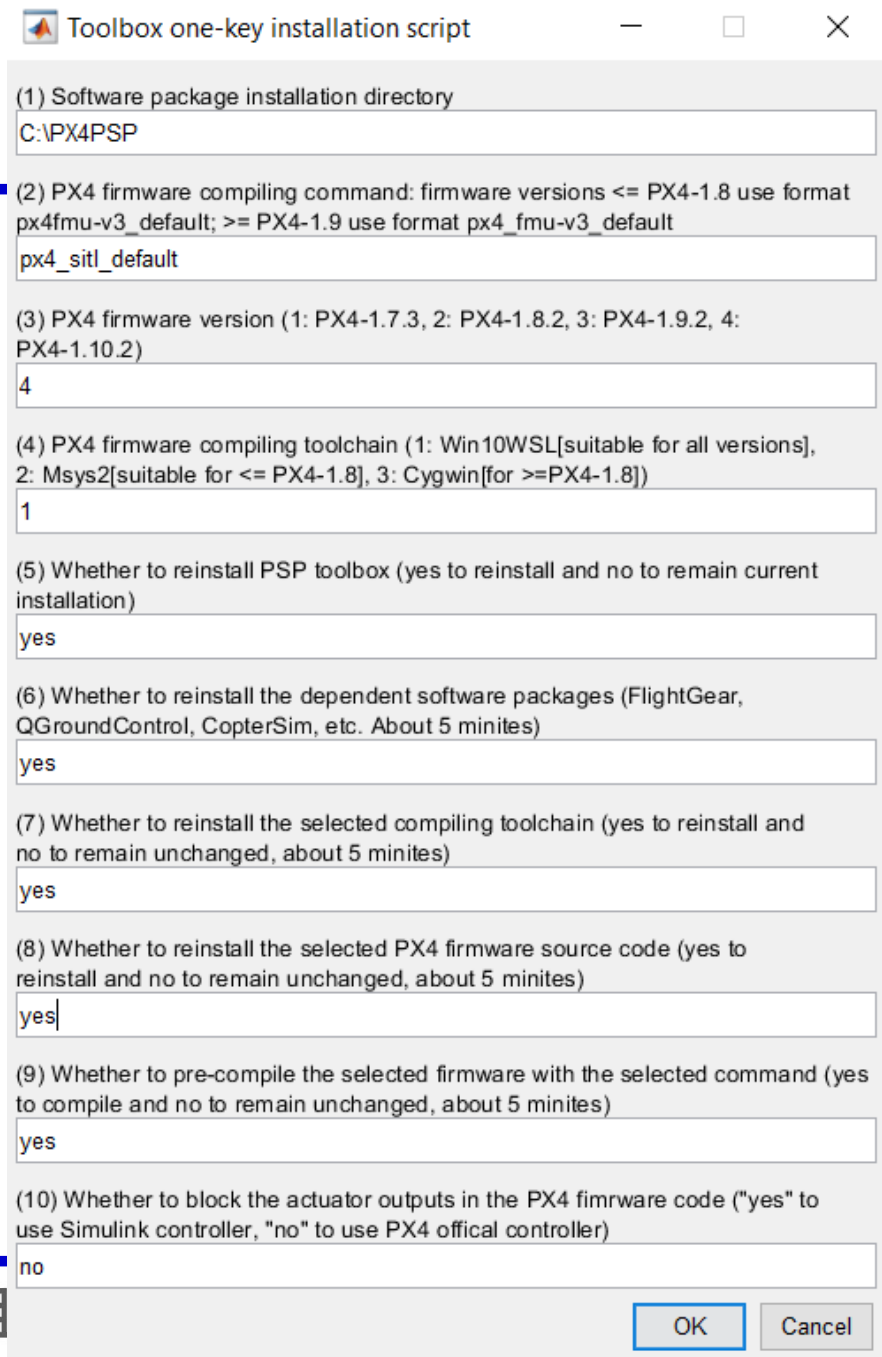
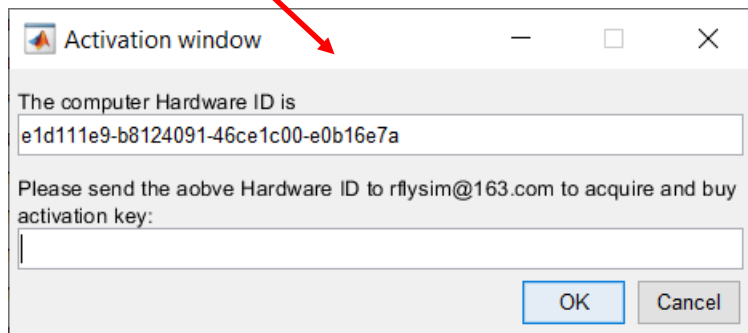
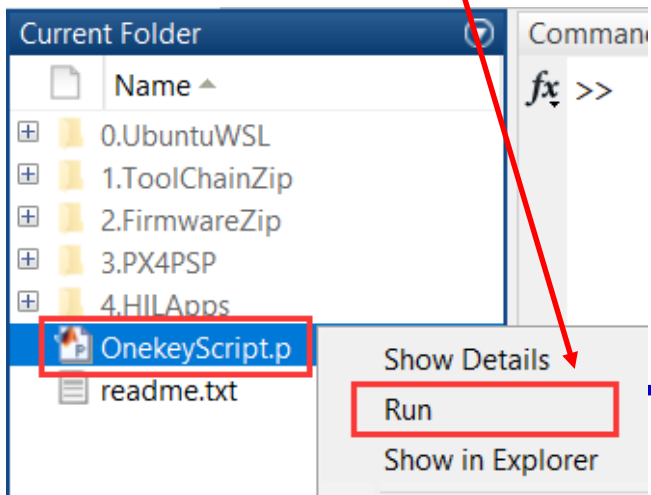
C:\Users\dream>Bash
root@DESKTOP-NQLAGE1: /mnt/c/Users/dream#
```




1. Installation Instructions

1.4 One-key install script

- Use MATLAB to locate the folder where “**OnekeyScript.p**” is located, right-click and click the “**Run**” Option
- The activation page will pop up, enter the activation key (from rflysim@163.com) with the Hardware ID.
- Then the installation page shown on the right will pop up (before installation, please close the antivirus software according to the “**readme.txt**” in the installation package)



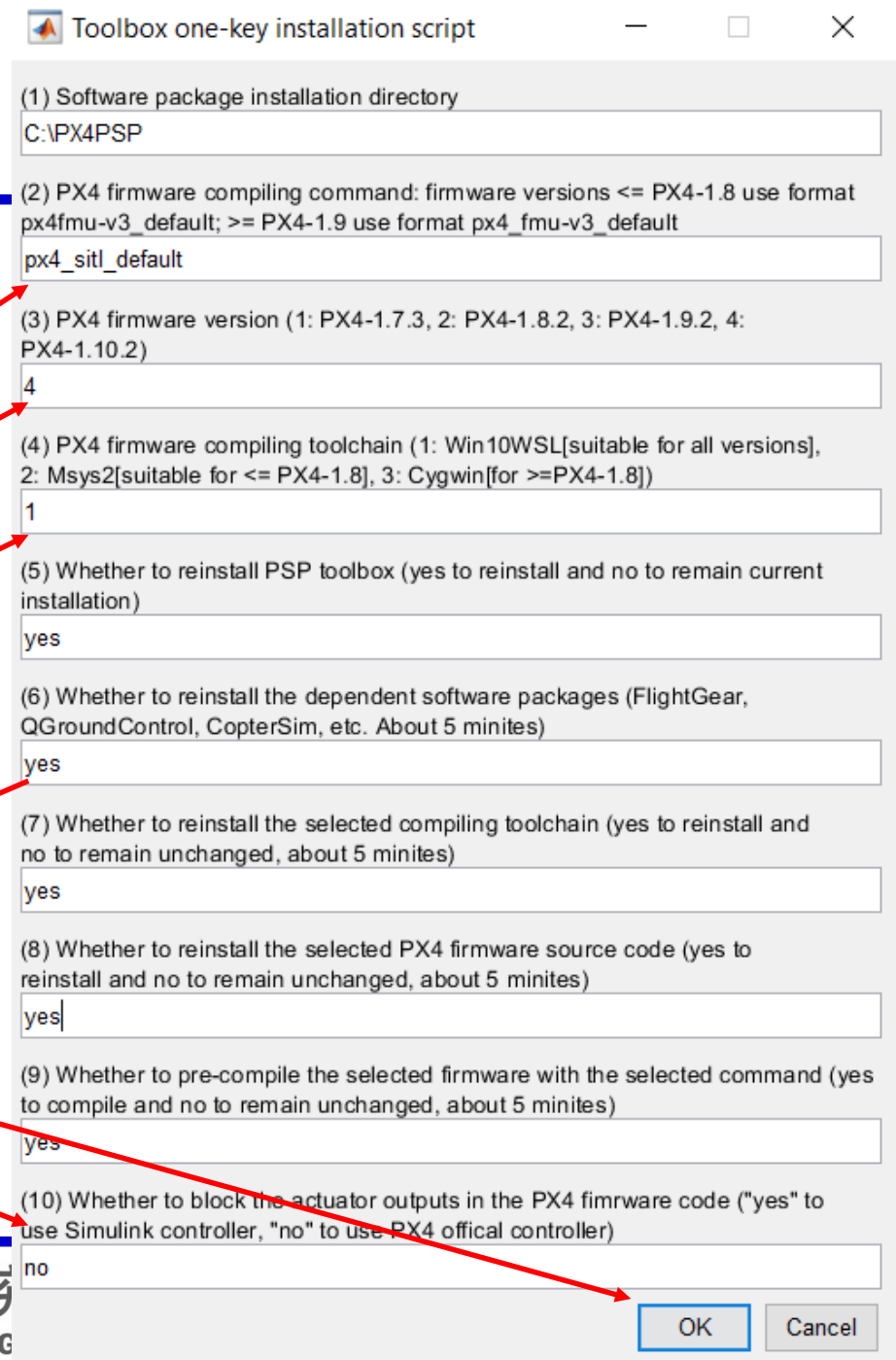


1. Installation Instructions

1.5 Visual swarm development configuration

- When this platform is used for vision and swarm development, it is recommended to use the following default configurations:
 - Use the PX4 SITL software to compile the firmware in the loop and enter "**px4_sitl_default**"
 - Use the latest PX4 firmware **PX4-1.10.2**, select "**4**" for the firmware version
 - Use **Win10WSL** compiler, so select "**1**" for the compiler
 - Use PX4 official code as the bottom controller (you don't need to design with Simulink yourself), whether to shield PX4 output item, select "**no**"
 - Click the "**OK**" button to start the installation.

Note: You can also input the app names in (6) separating by comma to specify desired apps. The options include:
3DDisplay, CopterSim, drivers, eclipse, FlightGear, QGround Control, RflySim3D, RflySimAPIs, UE3DDisplay



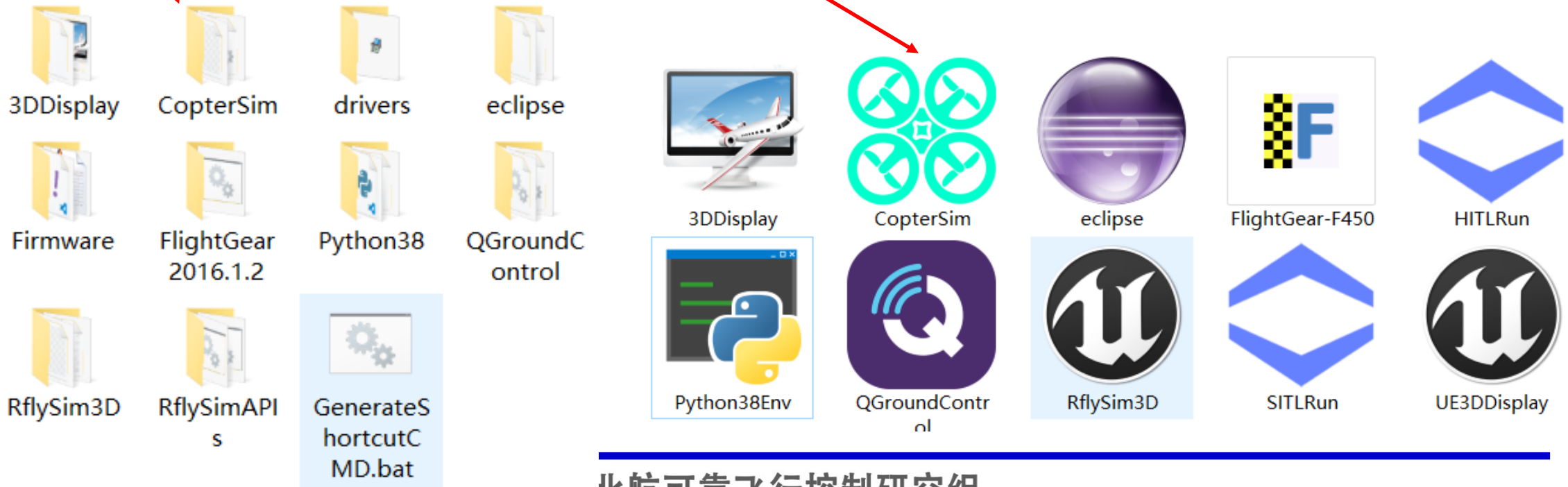
控制研究



1. Installation Instructions

1.6 After installation

- As shown in the figure below, you can get a series of folders under the installation directory (C: \PX4PSP by default), the "**RflySimAPIs**" folder is the most important interface tutorial folder for advanced functions,.
- As shown on the right, a series of shortcuts are available on "**RflyTools**" of Desktop.



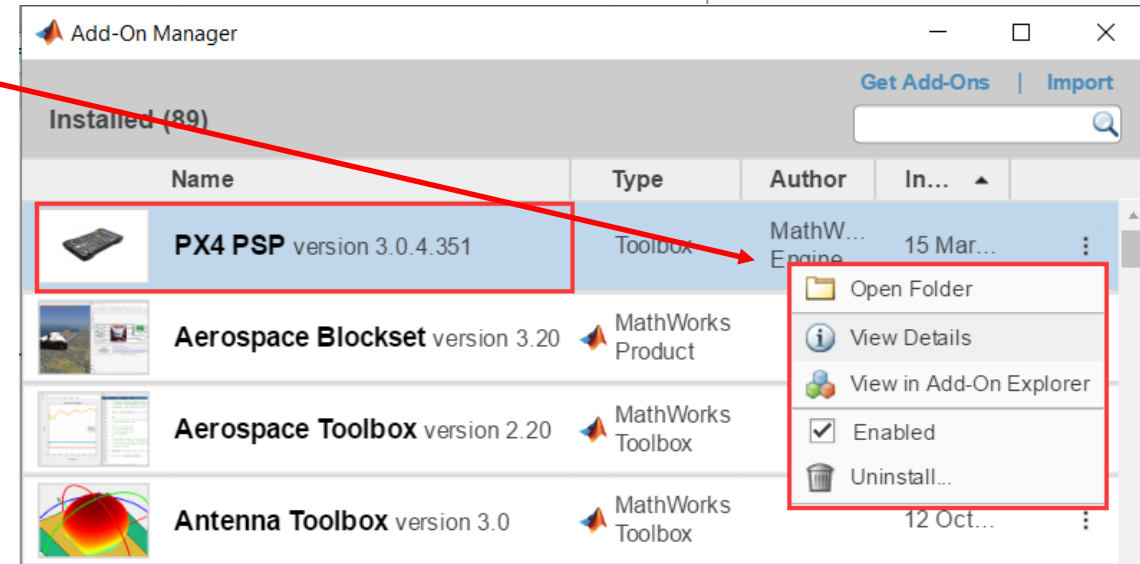
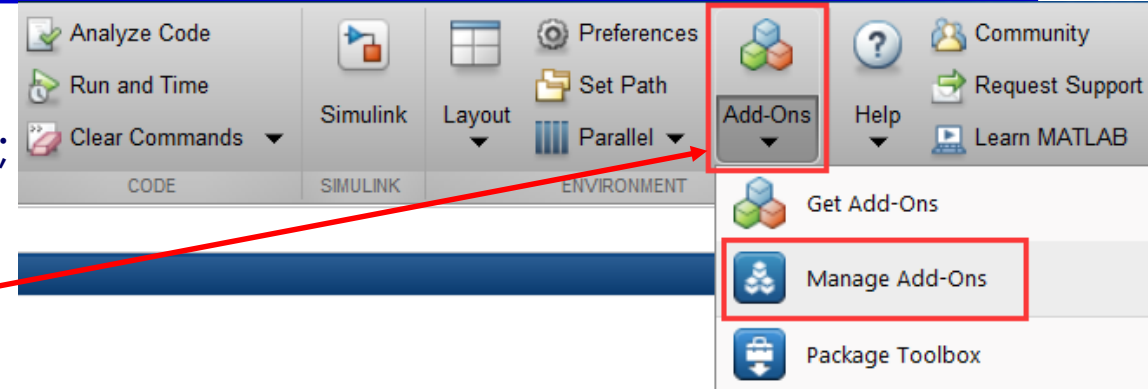


1. Installation Instructions

Note: Do not follow the operations in this page, only when you want to uninstall the platform

1.7 Platform software uninstall method

- Delete the shortcut shown in RflyTools on the desktop;
- Delete all files and subfolders in the installation directory (default "C: \PX4PSP") folder;
- In the "**Manage Add-Ons**" Page of MATLAB, click the "**Uninstall**" button to uninstall the PSP toolbox. (If the uninstallation fails here, you can also close MATLAB and delete the **[Document]\MATLAB\Add-Ons\Toolboxes\PX4PSP**, the folder in your computer to uninstall)
- Restart MATLAB and enter "**edit pathdef.m**" in the command window to find and delete the remaining PX4PSP path entries;
- Note: The serial number and other files are stored in the **[Document]\Ogre** directory, and it is recommended to keep.



```
matlabroot, '\toolbox\audio\audio\compiled;', ...
matlabroot, '\toolbox\audio\audiodemos;', ...
matlabroot, '\toolbox\audio\templates;', ...
'C:\Users\dream\Documents\MATLAB\Add-Ons\Toolboxes\PX4PSP\code;', ...
'C:\Users\dream\Documents\MATLAB\Add-Ons\Toolboxes\PX4PSP\code\Work;', ...
```



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Note: The Pixhawk hardware is not necessary for the experiments in RflySim platform, you can skip the hardware-in-the-loop (HIL) simulation steps and just do software-in-the-loop (SIL) simulation



2. Platform Composition

Note: HIL and HITL are the same in this lesson representing hardware-in-the-loop; the same for SIL and SITL

2.1 Software and hardware relationship

- **CopterSim**: The core simulation software of this platform, which runs the dynamic model of multi-rotor motion, and forms software-in-the-loop(SIL)/hardware-in-the-loop(HIL) simulation with other software
- **RflySim3D**: The core 3D display software of this platform, developed based on **Unreal Engine 4 (UE4)** 3D engine, has highly-realistic **virtual reality (VR)** display effects.
- **HILRun/SILRun** one-key quick start scripts, you can quickly open all vision/swarm related software, and complete the required configuration
- **Python38Env**: A Python environment containing Modules such as OpenCV



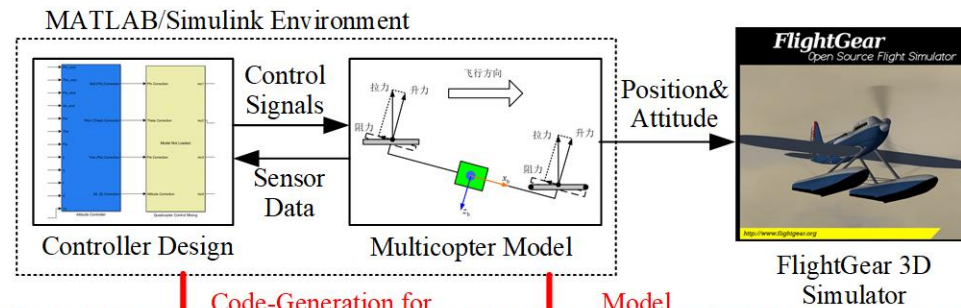


2. Platform Composition

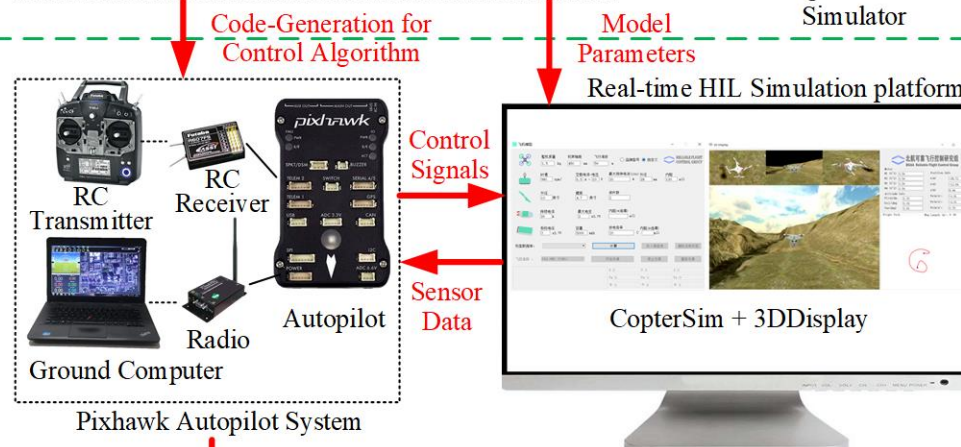
2.2 The overall experiment process

- Controller design and simulation
- Simulink code generation/Python programming
- Software/hardware-in-the-loop simulation
- Outdoor experiment

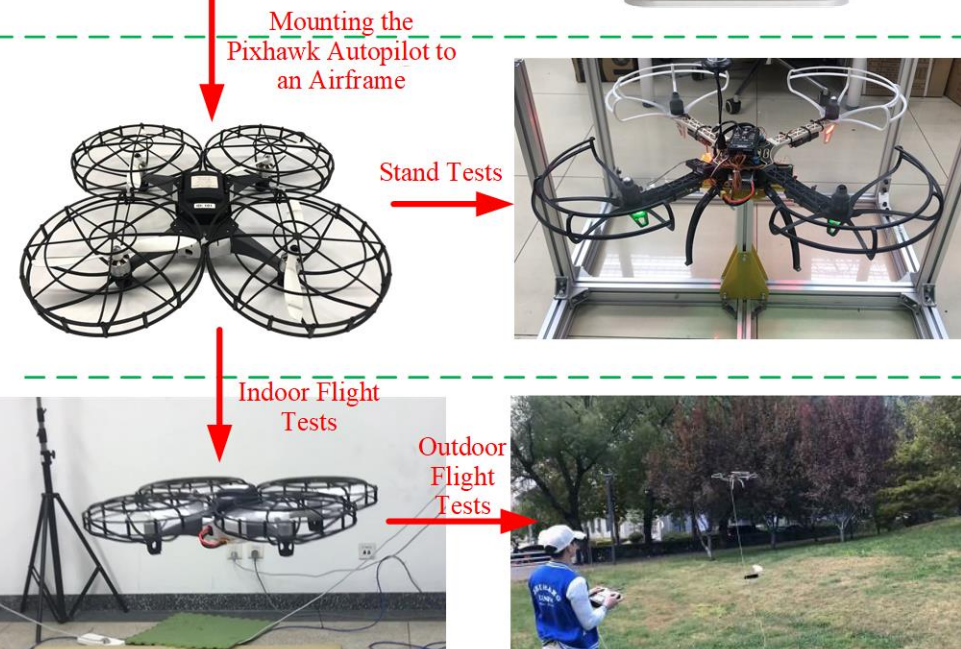
Software-in-the-Loop Simulation



Hardware-in-the-Loop Simulation



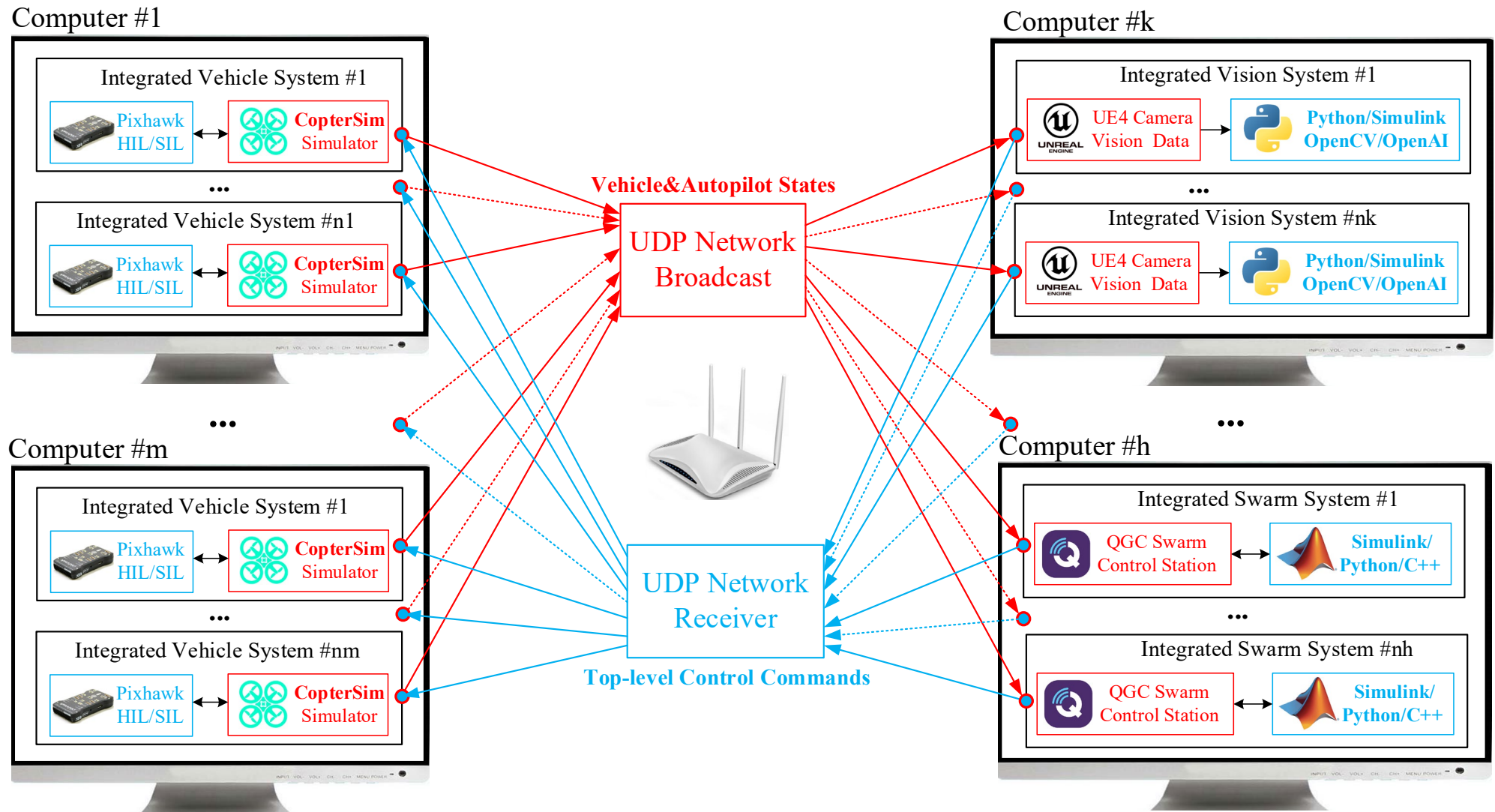
Flight Tests





2. Platform Composition

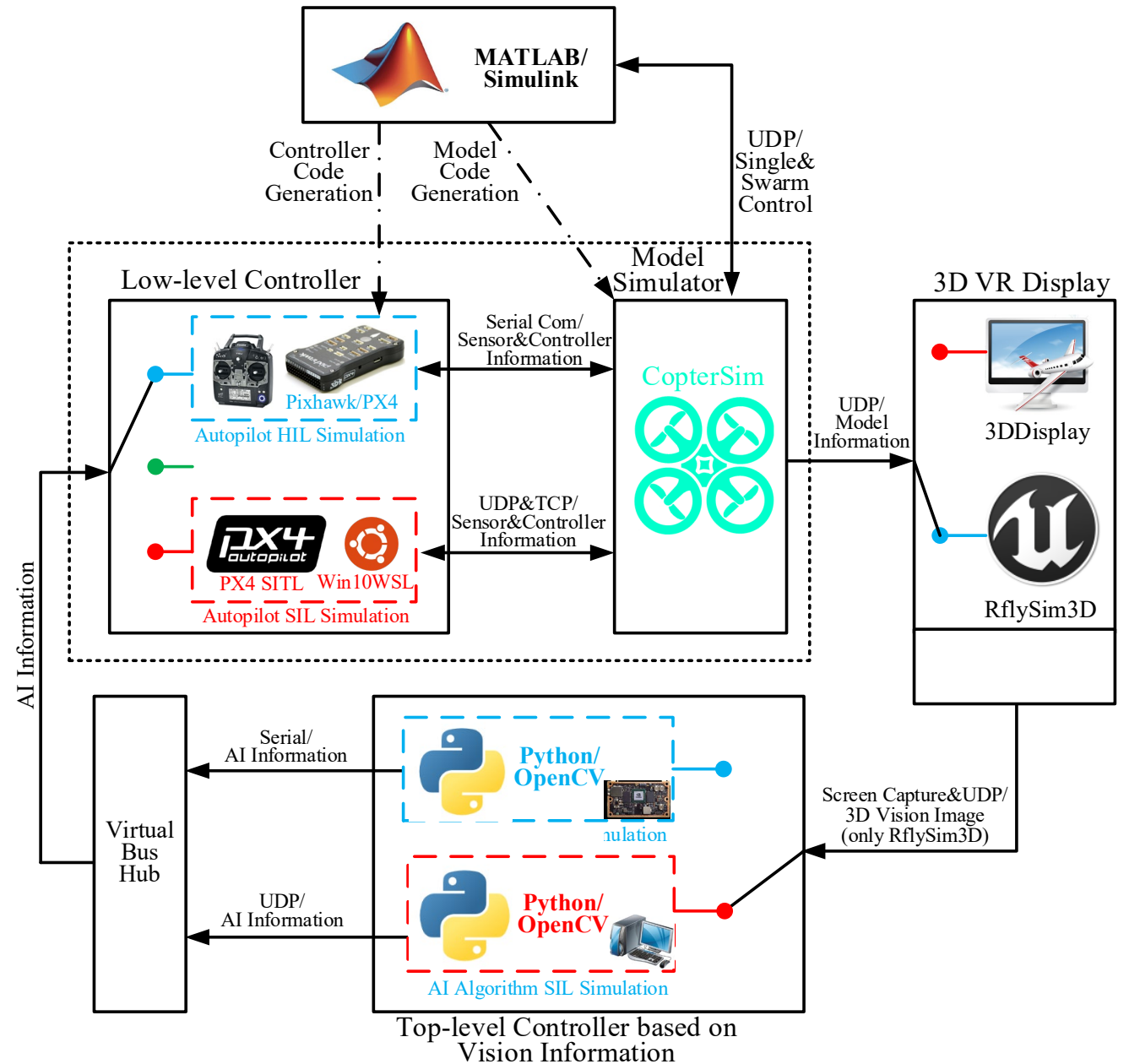
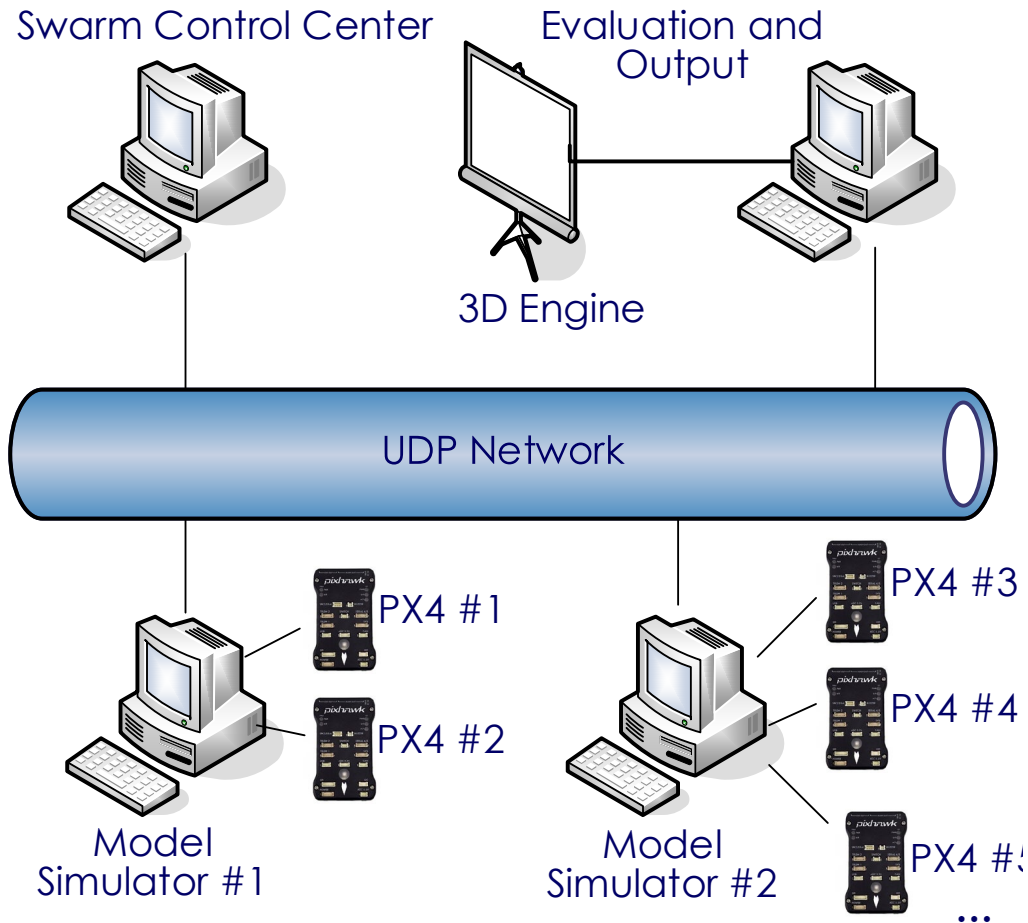
2.3 Distributed Framework for UAV Swarm





2. Platform Compoc

2.3 Discrete structure (CopterSim communication center)





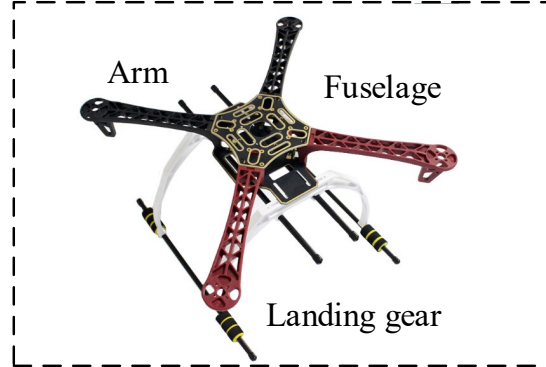
2. Platform Composition

2.4 Hardware system composition

- **Ground computer**/Onboard computer
- Airframe system(Arm, body, Landing gear and etc.)
- **Propulsion system**(motor, ESC, battery, propeller and etc.)
- **Radio Control system**(remoter launcher, receiver, charger, lithium battery and etc.)
- **Autopilot system**(Autopilot/Flight control, GPS module, battery module, USB cable, data transmission module)



Airframe system



Propulsion system



Radio control (RC) system



Autopilot hardware system





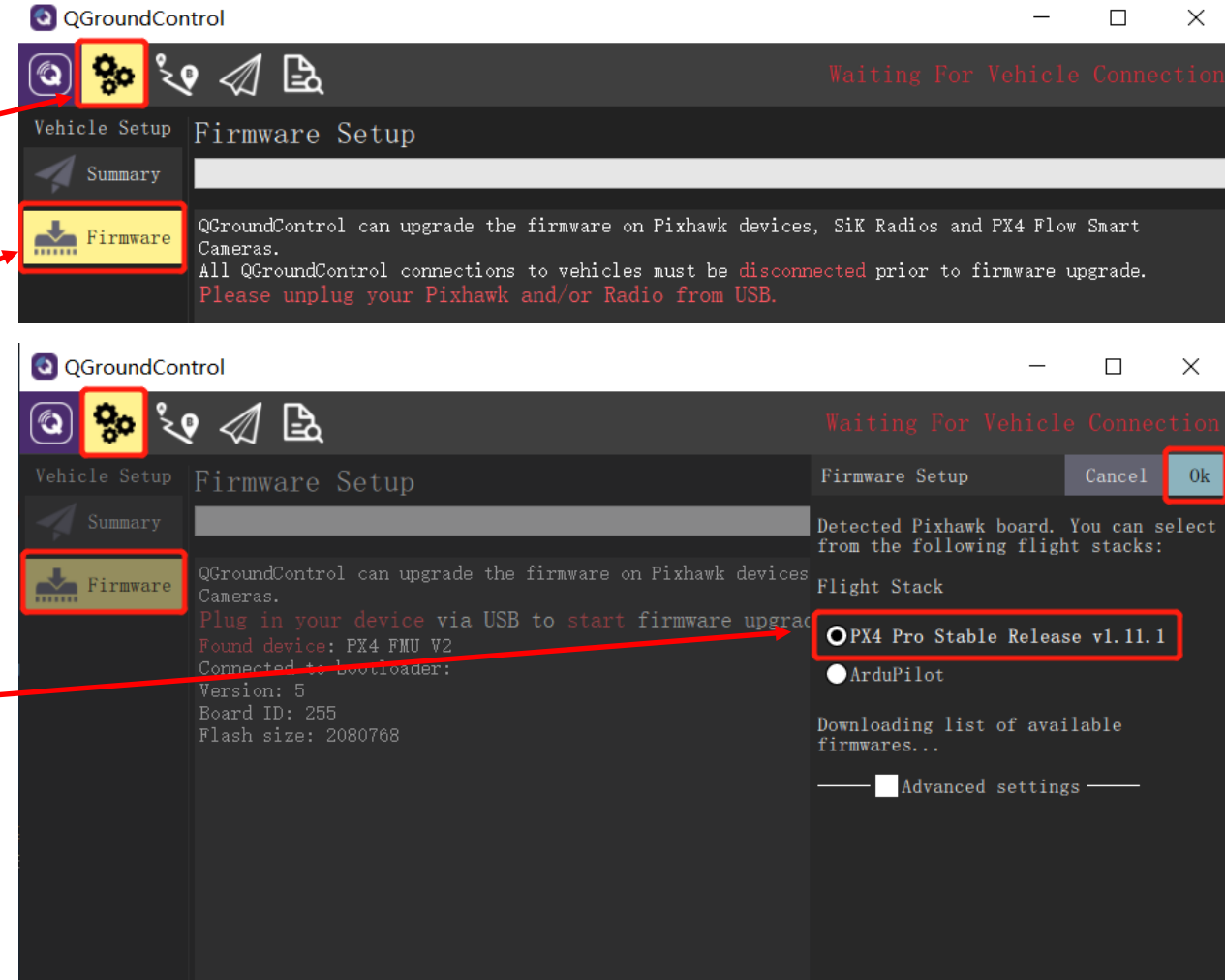
2. Platform Composition

Note: The examples in this section need the official firmware of PX4, any version is acceptable, the latest firmware is selected here

2.5 Pixhawk hardware configuration(1): Online firmware download

Methods:

- 1) Open the QGC ground station software;
- 2) As shown in the figure on the right, click the gear icon in the toolbar to enter the settings page, and then click the "Firmware" label to enter the firmware burning page;
- 3) Connect the Pixhawk autopilot to the computer with a USB cable. At this time, the software will automatically recognize the Pixhawk hardware, as shown in the figure below, the firmware configuration window will pop up on the right side of the interface, check "PX4 ***", and then click "Ok", QGC starts to download automatically (Internet connection is required, please refer to the next lecture to use local firmware) and install the latest PX4 firmware into Pixhawk;



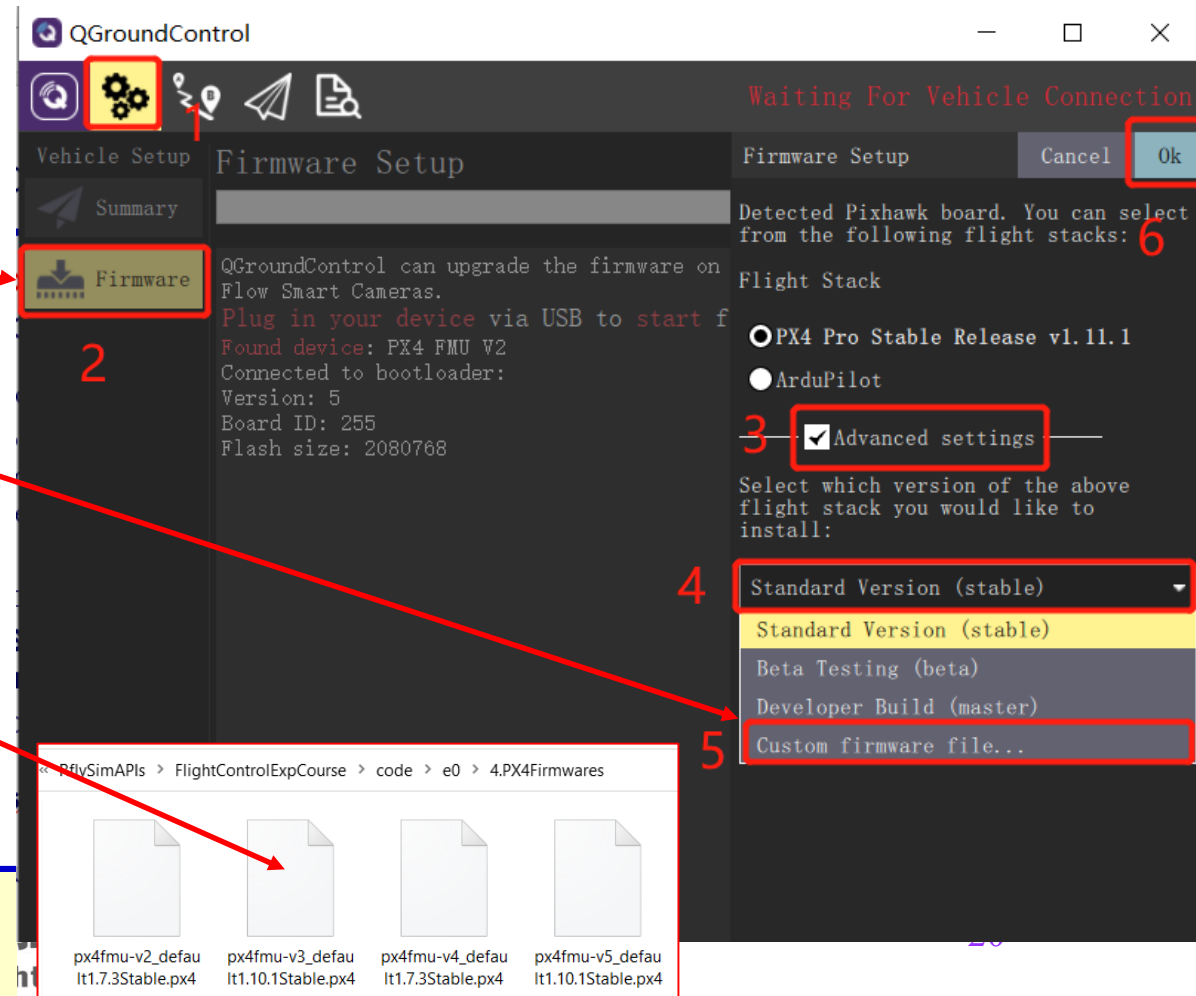


2. Platform Composition

2.5 Pixhawk hardware configuration (2) : offline firmware download (used when the firmware cannot be downloaded online due to the network)

Methods:

- 1) Open the QGC ground station software;
- 2) Click the **"Firmware"** tab, and connect the Pixhawk autopilot with the USB cable, then Pixhawk will automatically connect with QGC.
- 3) Check the **"advanced settings"** checkbox;
- 4) Click the **"Standard Version (stable)"** tab → **"Custom firmware file"** option;
- 5) In the file selection page that pops up, if you use Pixhawk1 flight control, select "C: PX4PSP(Installation Directory)\RflySimAPIs\FlightControlExpCourse\code\e0\4.PX4Firmwares**px4fmu-v3_default1.10.1Stable.px4**", if you use Pixhawk 4, select **fmu-v5** firmware.



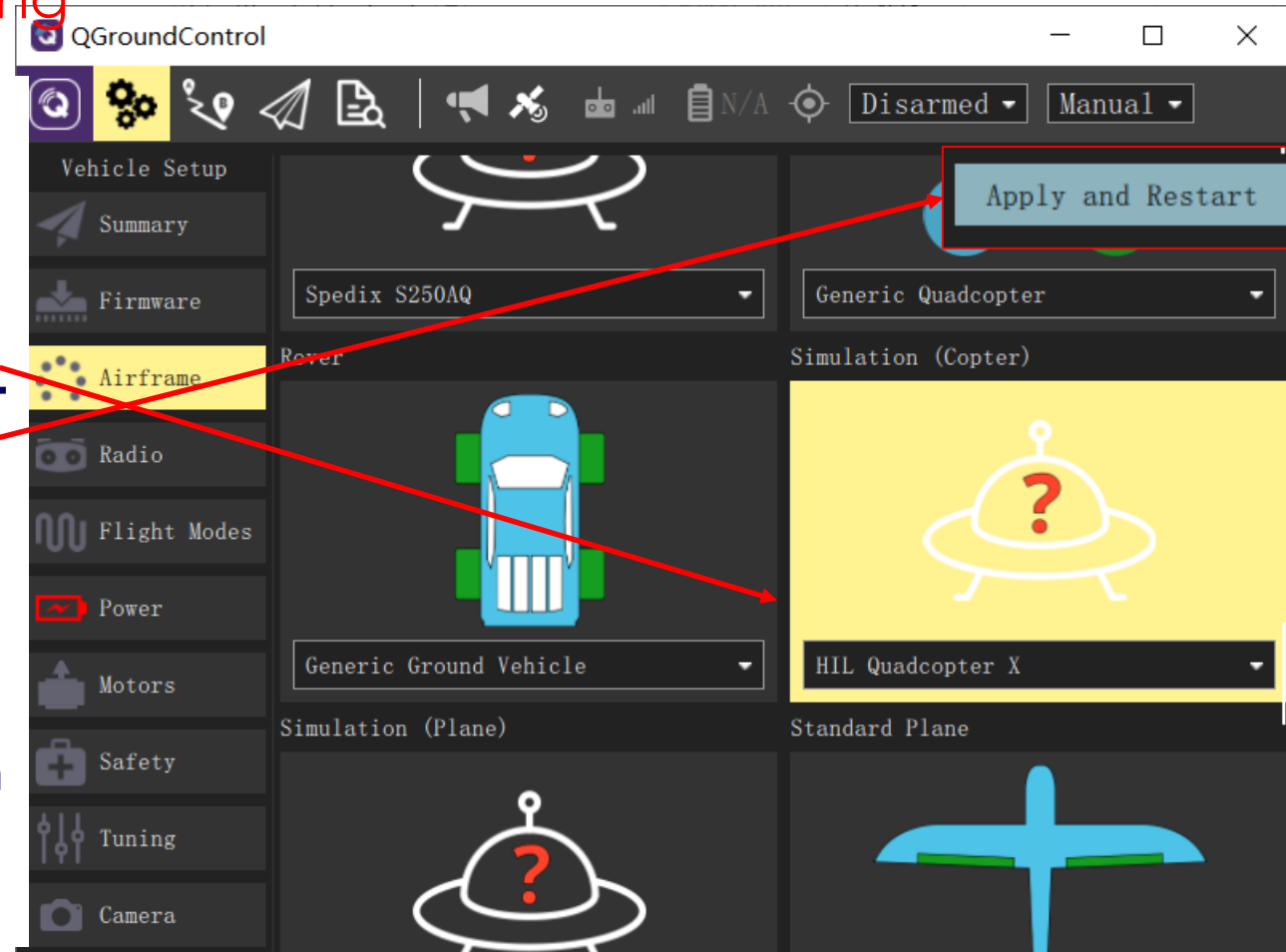
Note: If there is no required firmware version, please visit <https://github.com/PX4/Firmware/releases> to download



2. Platform Composition

2.6 Pixhawk HIL simulation mode setting

- After completing the firmware burning, the autopilot will automatically restart and connect to the QGC; at the same time, as shown on the right, enter the "Airframe" tab, select the rack type as "HIL Quadcopter X", and click the upper right corner "Apply and Restart" button, the autopilot will restart automatically;
- After restarting, QGC will automatically find the port and connect to Pixhawk. At the same time, check each configuration page to ensure that Pixhawk enters hardware-in-the-loop simulation mode.



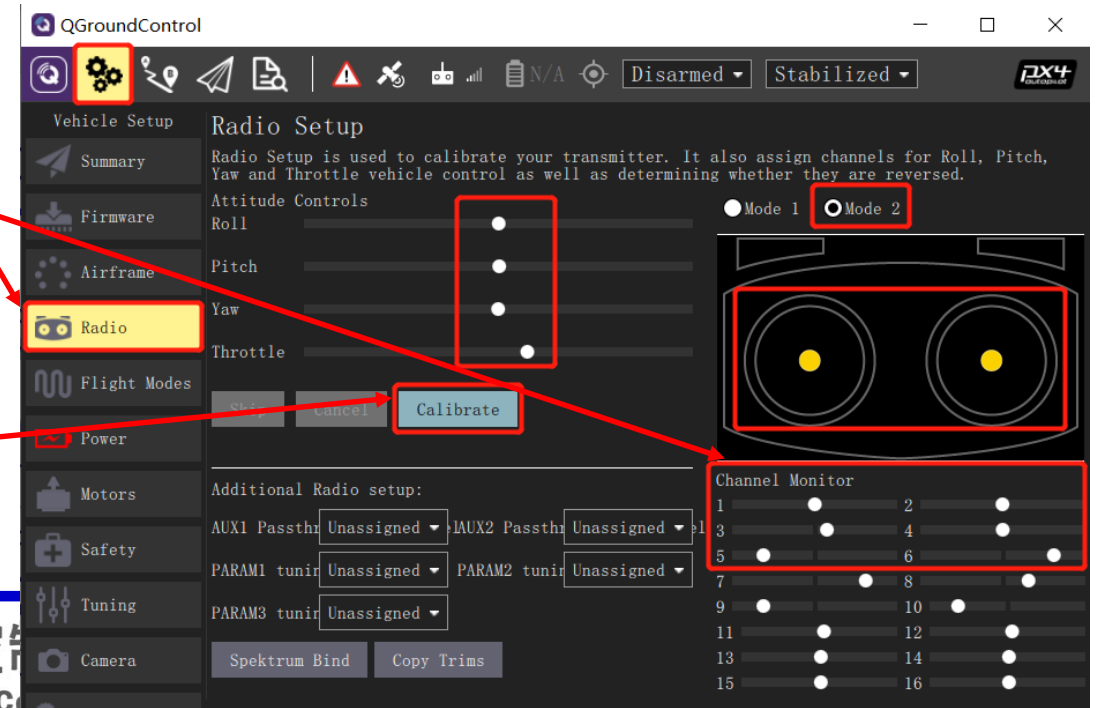
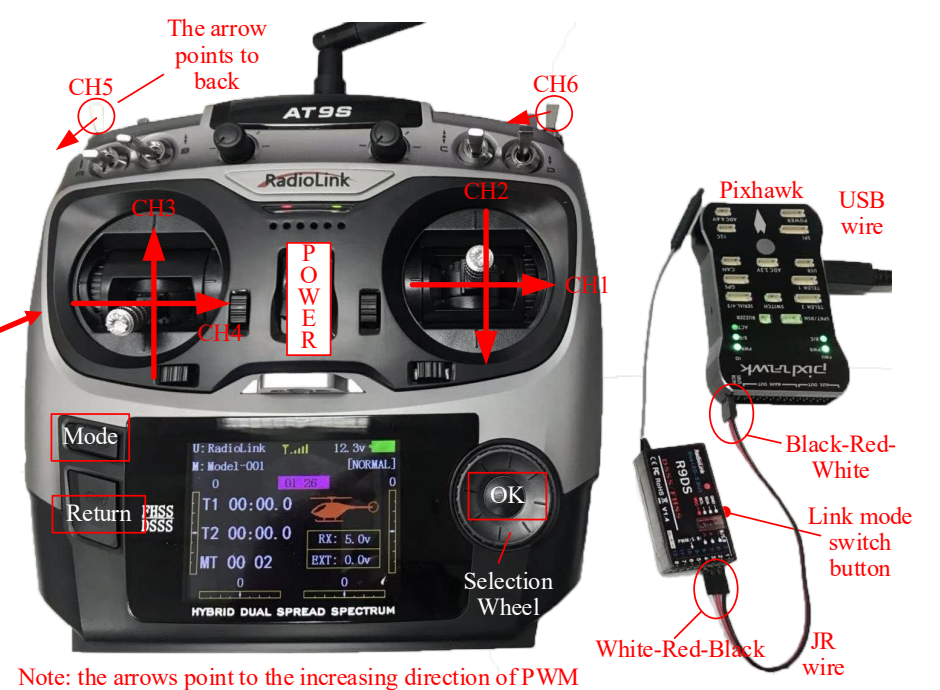
- *Note: please ignore other warning message (battery missing parameters, etc.) on QGC. These Warning will not affect the simulation results.*



2. Platform Compositio

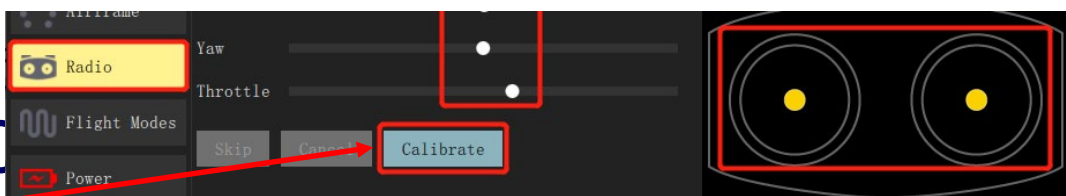
2.7 RC configuration and calibration

1. Connect the Pixhawk and the RC receiver correctly, connect the Pixhawk and the computer with a USB cable, power on the RC transmitter, open the QGC ground station software, and click the "Radio" tab as shown in the lower right figure.
2. Turn the CH1 to CH5 sticks of the RC transmitter from left to right (or from top to bottom) (see the upper right picture), and observe the white points of each channel in the red frame area on the right side of the ground station in the lower right picture. If you observe: the small point 1, 2, 4, 5, and 6 move from left to right (PWM from about 1100 to 1900); the point 3 moves from right to left, indicating that the RC system is set correctly. Otherwise, you need to reconfigure the RC transmitter.
3. Click the "Calibrate" button in the lower right picture and follow the prompts to calibrate the RC transmitter.

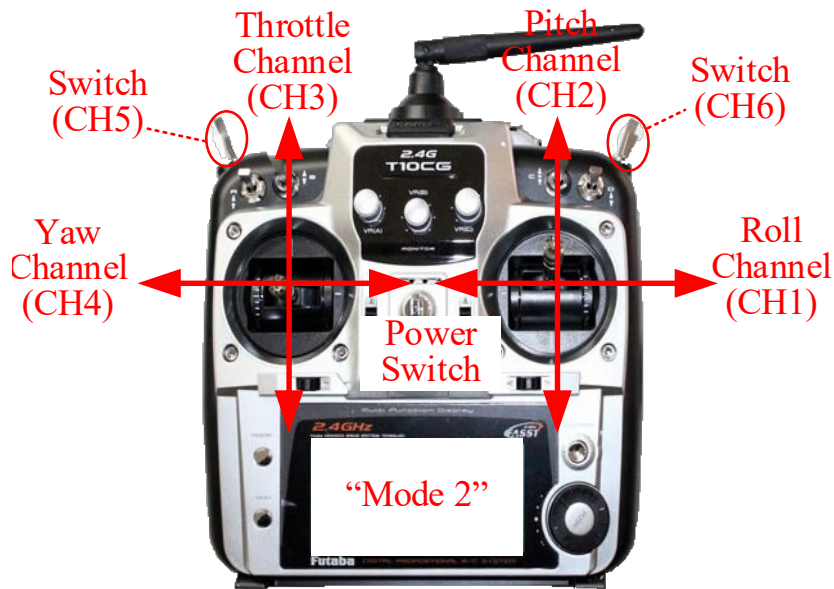




2. Platform Comp



4. Click the "**Calibrate**"-"**Next**" button on the QGC ground station, and then place the RC sticks in the position shown on the right (according to the real-time prompt on the QGC page) to complete the RC transmitter calibration.



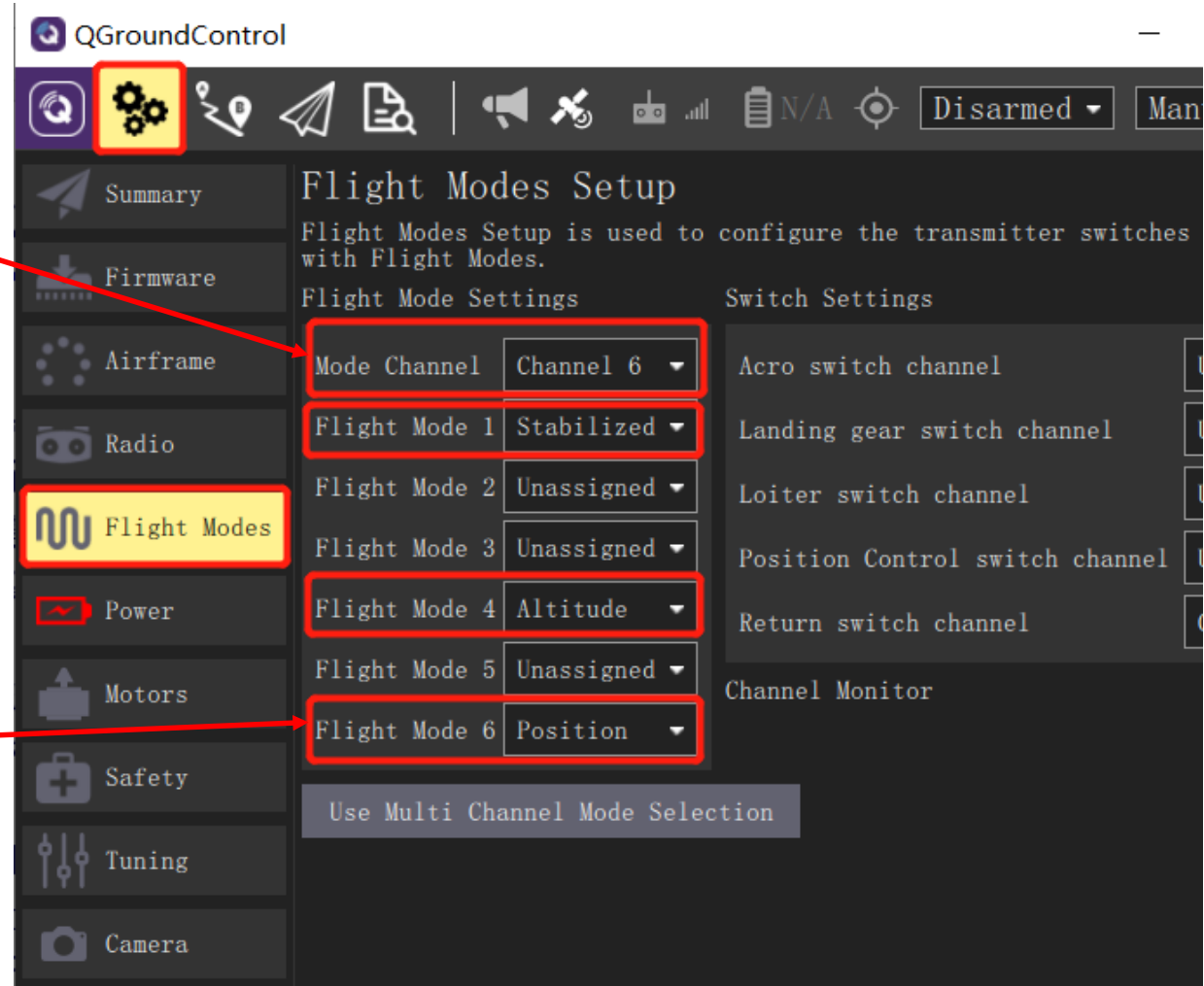
- Throttle : control up-down movement
- Pitch : control forward-backward
- Yaw : control vehicle head direction
- Roll : control left-right movement



2. Platform Composition

2.8 Flight mode settings

1. After the above RC transmitter calibration steps, click on the QGC ground station to enter the "**Flight Modes**" setting page, and select "**Mode Channel**" as the previously tested CH6 channel. Since the CH6 channel is a three-stage switch, the top, middle, and lower positions of the switch correspond to the three labels "**Flight Mode 1, 4, and 6**" respectively.
2. As shown in the figure on the right, set these three labels to "**Stabilized**" (self-stabilization mode, only attitude control), "**Altitude**" (fixed height mode, with attitude and height control) and "**Position**" (fixed-point mode, with attitude, fixed height and horizontal position control). In the subsequent HIL simulation, you can experience different control effects by switching different modes.





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Note: The Pixhawk hardware is not necessary for the experiments in RflySim platform, you can skip the hardware-in-the-loop (HIL) simulation steps and just do software-in-the-loop (SIL) simulation



3. Basic Usage

Note: You can open multiple CopterSims (for RflySimSwarm and Full version) and one RflySim3D at the same time, and then try the following shortcuts

3.1 RflySim3D's basic keyboard shortcuts

- **F1**: pop-up help menu notice;
- **ESC**: clear all vehicles
- **S**: show/hide vehicle ID;
- **M**: switch among maps (All CopterSim should be closed to observe effect);
- **M+number***: switch to the *th map;
- **B**: switch among different vehicles;
- **B+number***: switch to the *th vehicle;
- **C**: switch current vehicle 3D model;
- **C+number***: switch to the *th 3D model;
- **CTRL + C**: switch all vehicle's 3D Model
- **V**: switch among viewpoints on vehicle body, **0**: chasing view, **1**: front camera, **2**: right camera, ...;
- **V+number***: switch to *th viewpoint

RflySim3D (64-bit Development PCD3D_SM5)

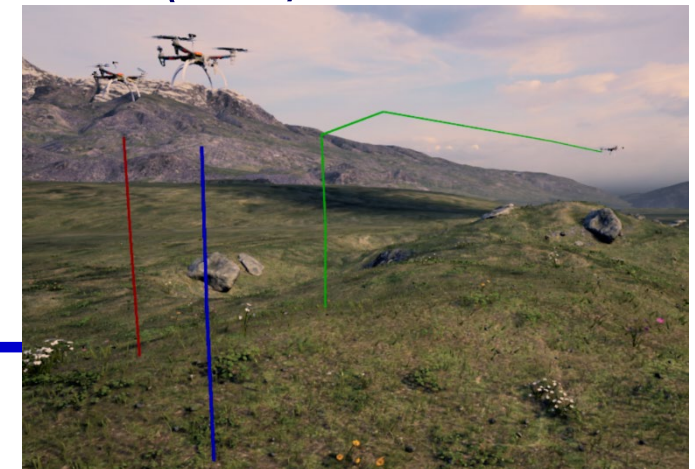




3. Basic Usage

Note: You can open CopterSim and RflySim3D at the same time, and then try the following shortcuts

- **N:** switch to vehicle god's viewpoint, **0:** follow vehicle perspective (not changing perspective angle with posture changing), **1:** fixed ground perspective and keep looking at current vehicle, **2:** fixed ground northern perspective, **3:** fixed ground southern perspective...
- **N+number*:** switch to *th god's perspective,
- **Mouse left key press to move:** switch perspective angle; **Mouse right key press to move:** switch vertical yz location of the perspective
- **Mouse middle wheel:** switch horizontal x location of the perspective
- **CRTL + Mouse middle wheel:** zoom in/out all the vehicles' size (easy to observe multi vehicles' move);
- **ALT + Mouse middle wheel:** zoom in/out current vehicle.
- **T:** show or hide vehicles' trajectories
- **T+ number*:** change the width of trajectories.







3. Basic Usage

Note 1: If using HIL simulation, you need to wait for about 10 seconds after the flight controller is connected to the computer, then using CopterSim to start the HIL simulation after Pixhawk is started.

Open CopterSim program

- **Vehicle ID:** the unique ID of each vehicle
- **UDP Port:** Interface to receive data from external programs such as Simulink/Python, and broadcast state&info data to Udp port +1
- **Simulation Mode:** HIL simulation or SIL simulation mode
- **Select Pixhawk Com:** the COM port of the Pixhawk hardware
- **3D Scene Selection:** Control the map displayed by RflySim3D
- **Link:** Whether to communicate with other computers in the LAN
- **UDP Mode:** Data mode for external program communication, Mavlink or custom structure can be selected

The screenshot shows the CopterSim application window with the following sections:

- Mode configuration UI:** A section with a red border containing dropdown menus for Frame Type (Quadcopter), Motor Brand (DJI), Propeller Brand (APC), ESC Brand (Hobbywing), and Battery Brand (ACE). It also includes input fields for Total Weight (1.5 kg), Diagonal Size (450 mm), and Altitude (50 m). On the right, there are radio buttons for Brand Model (selected) and Custom Design, along with a logo for FEISILAB. Below these are dropdown menus for Model selection for Motor, Propeller, ESC, and Battery.
- Simulation function UI:** A section with a red border containing fields for Vehicle ID (1), UDP Port (20100), Use DLL Model (unchecked), Simulation Mode (PX4_HIL), 3D Scene Selection (Grasslands), Link (unchecked), and Vehicle Initial Pos (x: 0, y: 0, yaw: 0). It also includes a dropdown for Select Pixhawk Com (UDP_Full) and buttons for Start Simulation, Stop Simulation, and Restart Simulation.
- State display UI:** A section with a red border containing input fields for X, Y, Z, phi, theta, and psi, all currently set to 0.

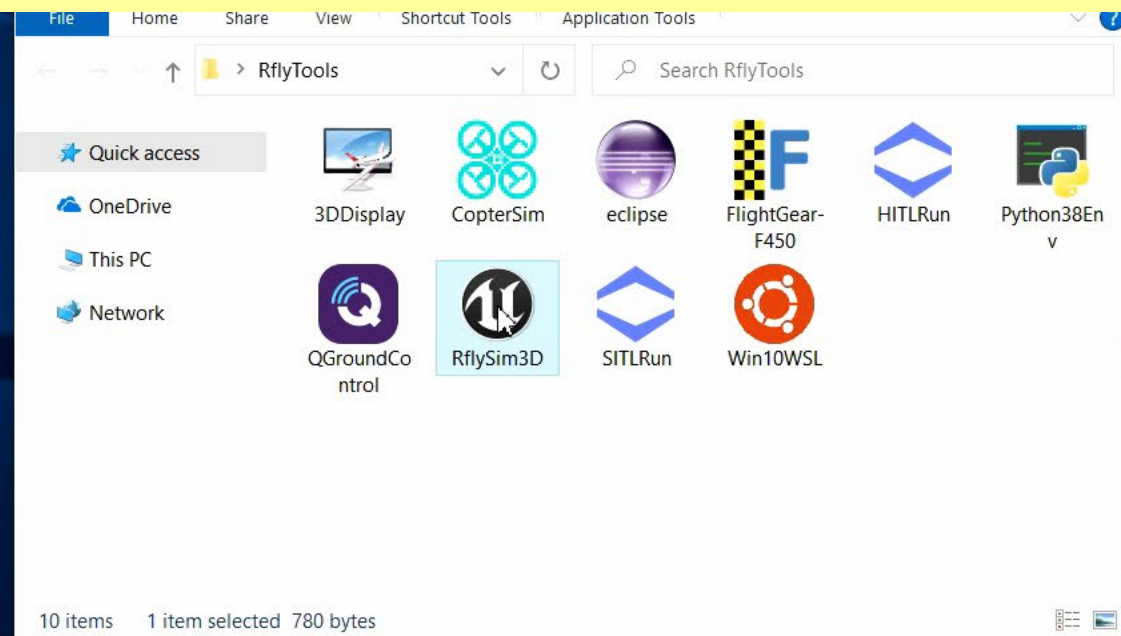
Note 2: Regardless of SIL or HIL simulation, both need to wait for the CopterSim message bar to display "GPS 3D Fixed" before using QGC/Simulink/Python to control the vehicle

RflySim: Platform introduction & How to use hardware-in-the-loop simulation for one vehicle

Watch this video by clicking the following links:

YouTube: <https://youtu.be/3ytbk63Og5k>

Youku: https://v.youku.com/v_show/id_XNDcwNjA4MjEwNA==.html



Click Desktop shortcut to Open RflySim3D

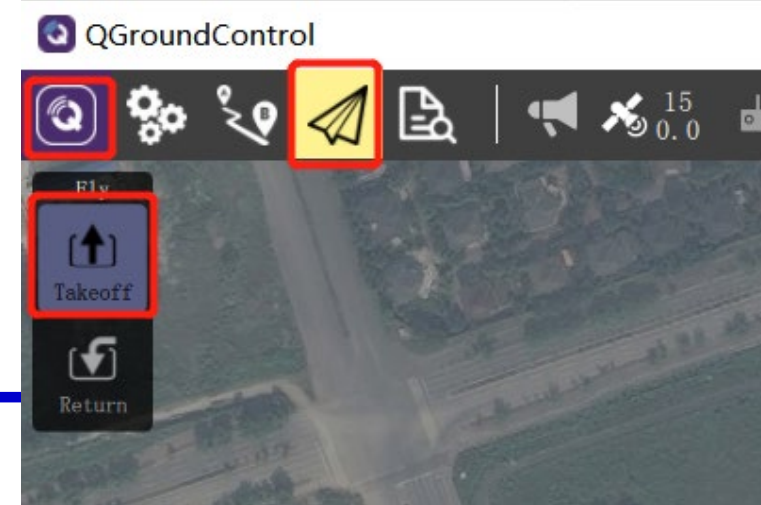
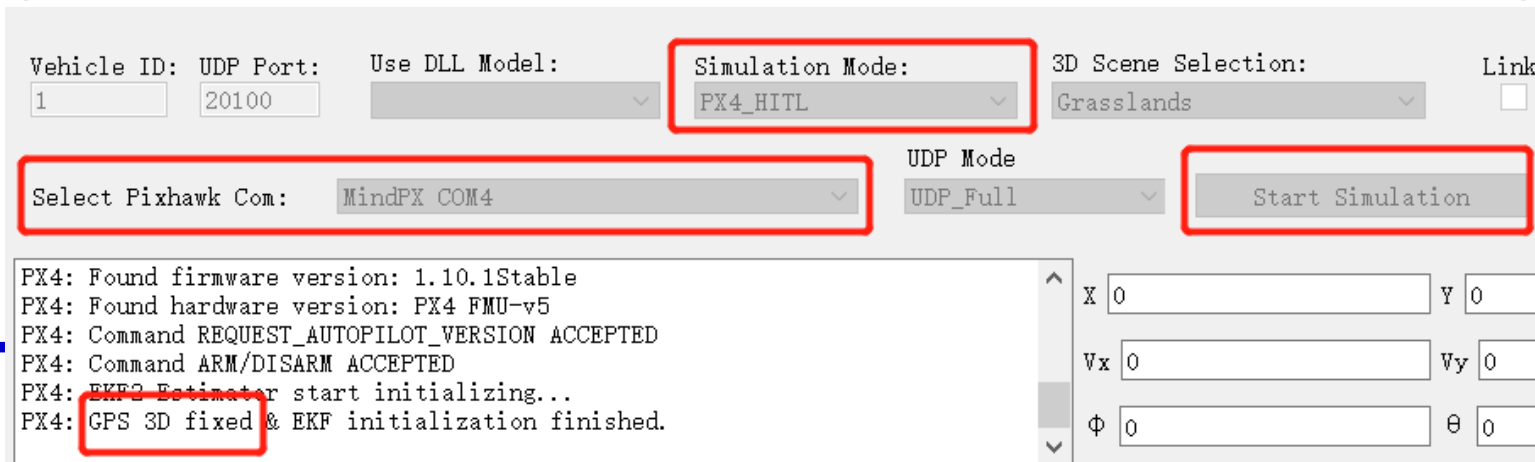


3. Basic Usage

Note: If you do not have Pixhawk hardware, skip to the next page to test SIL simulation

Manually start Hardware-In-the-Loop (HIL) simulation:

- Connect the Pixhawk (configured as the previous section, and connected with RC system) to the computer with a USB cable
- Open CopterSim and select “PX4_HITL” option in “Simulation Mode”, check other configurations (3D Map, initial position, etc.), and Open RlfySim3D.
- Choose Pixhawk COM port in CopterSim and click “Start Simulation” button to start HIL simulation, then wait for message “GPS 3D Fixed” on CopterSim
- Start QGroundControl (QGC) ground control program or RC transmitter, then you can arm and control the drone to take off and fly.

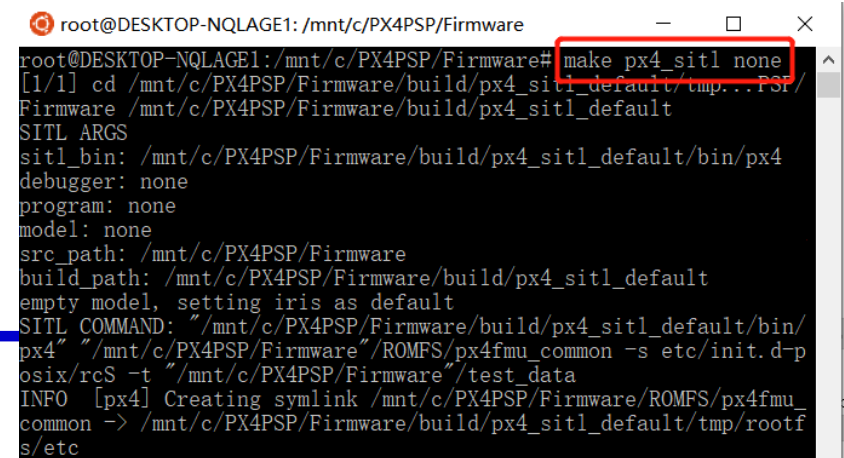
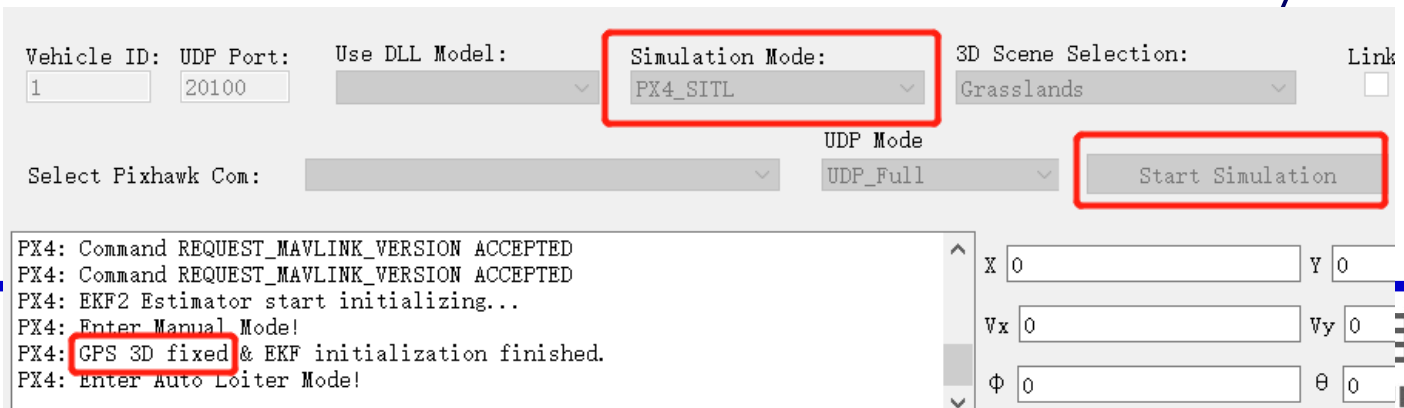




3. Basic Usage

Manually start Software-In-the-Loop (SIL) simulation:

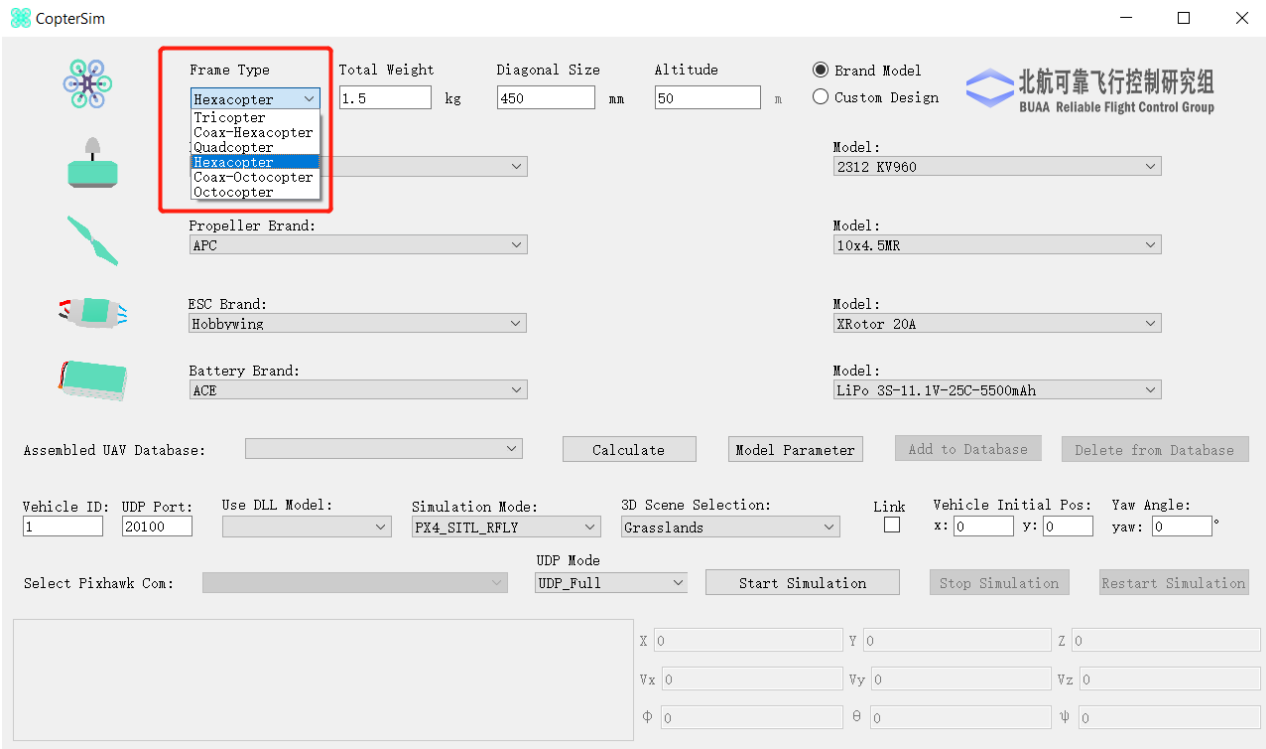
- Open CopterSim and select “PX4_SITL” option in “Simulation Mode”, check other configurations (3D Map, initial position, etc.), and Open RflySim3D.
- click “Start Simulation” button on CopterSim UI to start SIL simulation which will wait PX4_SITL data from the network
- Click the compiler shortcut on Desktop/RflyTools folder (e.g., Win10WSL), and enter command “make px4_sitl none” to connect to CopterSim to form a SIL simulation loop, then wait for message “GPS 3D Fixed” on CopterSim
- Start QGroundControl (QGC) ground control or RC transmitter, then you can arm and control the drone to take off and fly.



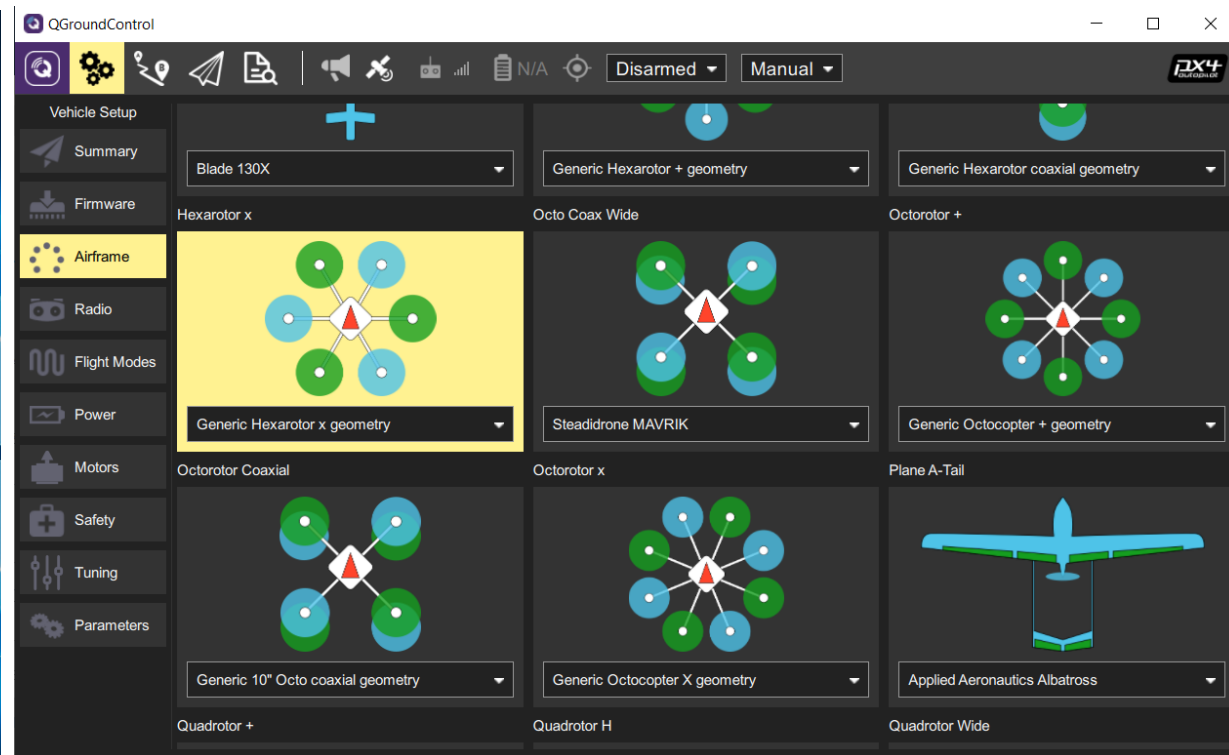


3. Basic Usage

3.2 How to simulate other types of multicopters



Change and apply model to hexacopter in CopterSim



Select a hexacopter airframe and enable HITL mode in QGroundControl

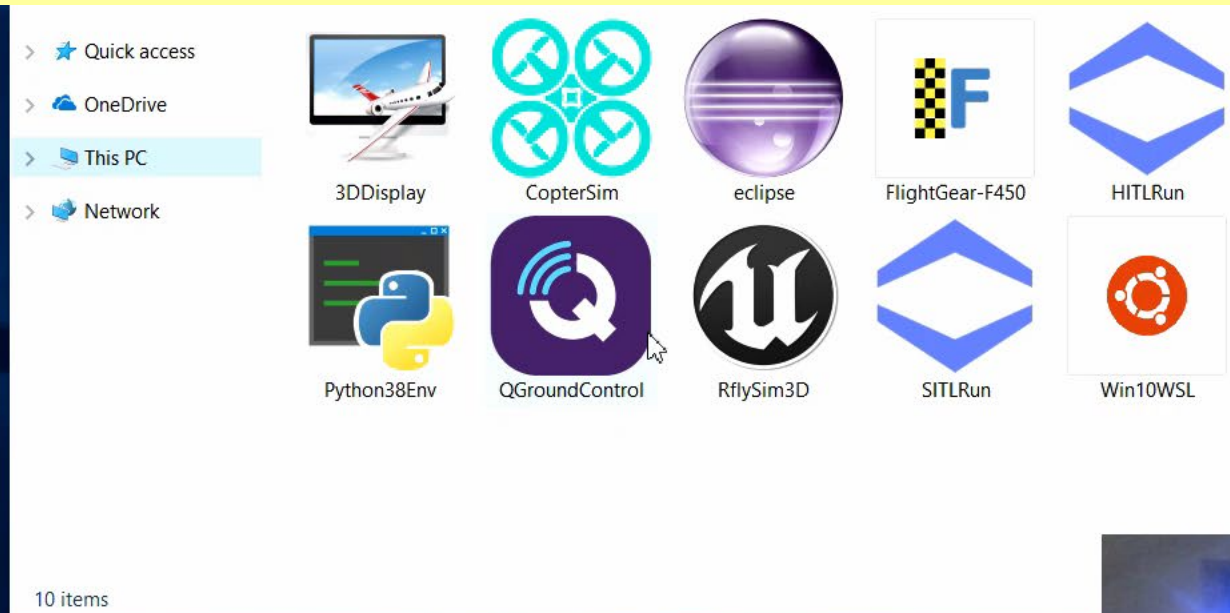
RflySim: How to simulate other types of multicopters

Watch this video by clicking the following links:

YouTube: <https://youtu.be/bryZXxaJE5M>

Youku: https://v.youku.com/v_show/id_XNDcwNjA4MDY2MA==.html

https://v.youku.com/v_show/id_XNDcwNjA4MDY2MA==.html



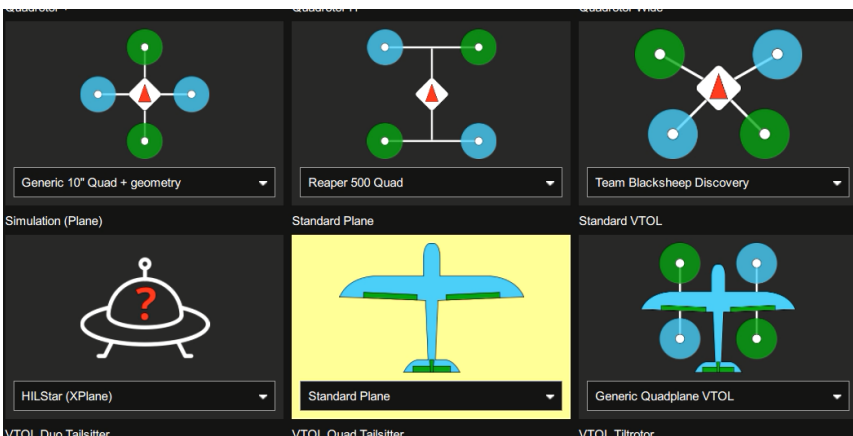
Connect Pixhawk and open QGC



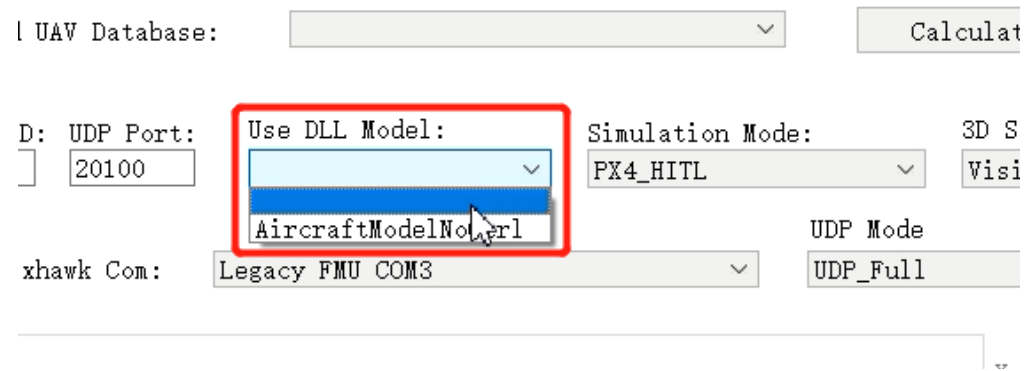


3. Basic Usage

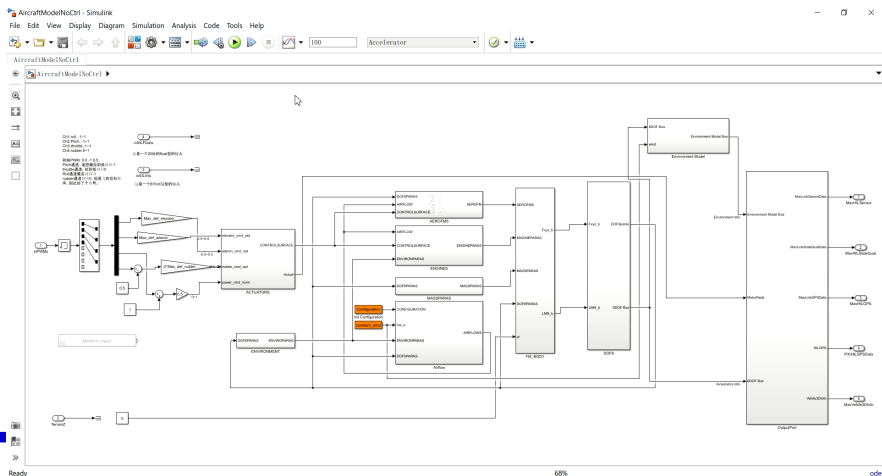
3.3 How to simulate other types of vehicles



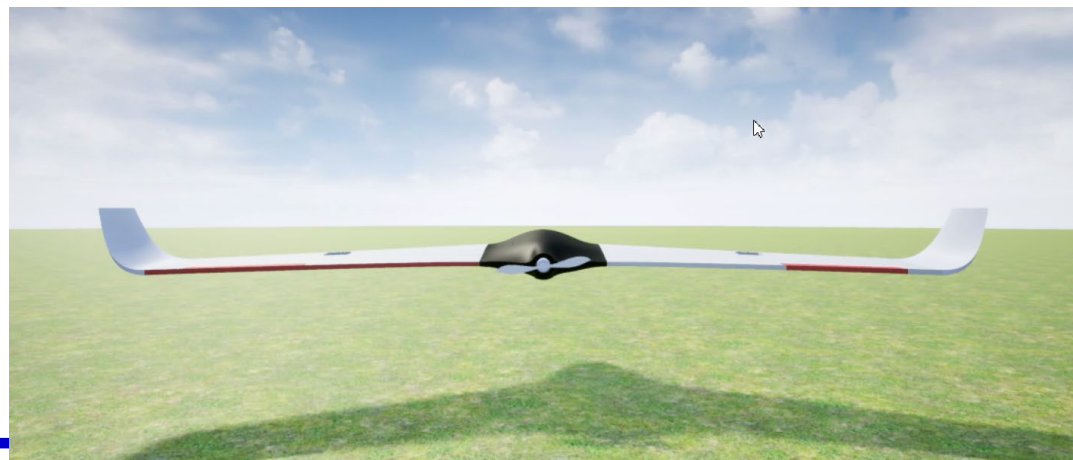
1. QGC change to fixed-wing aircraft mode



3. CopterSim select the aircraft DLL model



2. Simulink build aircraft model to DLL file

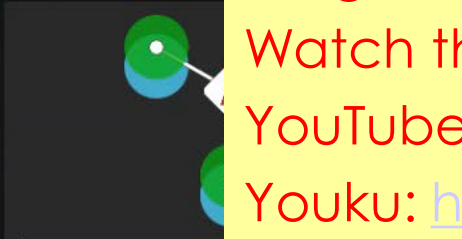


4. RflySim3D auto select aircraft's 3D model

RflySim: How to simulate other types of vehicles, for example fixed-wing aircraft
 Watch this video by clicking the following links:
 YouTube: <https://youtu.be/gt7IIUx7JRC>
 Youku: https://v.youku.com/v_show/id_XNDcwNjA4MTQxMg==.html

- Vehicle Setup
- Summary
- Firmware
- Airframe**
- Radio
- Flight Modes
- Power
- Motors
- Safety
- Tuning
- Camera
- Parameters

Hexarotor Coaxial



Generic Hexarotor coaxial geometry

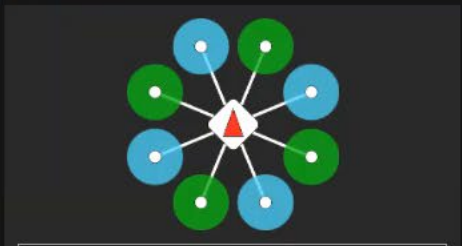
Generic Hexarotor x geometry

Steadidrone MAVRIK

Generic Octocopter + geometry

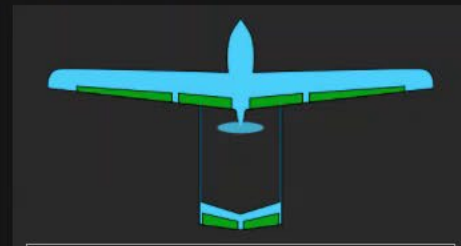
Generic 10" Octo coaxial geometry

Octorotor x



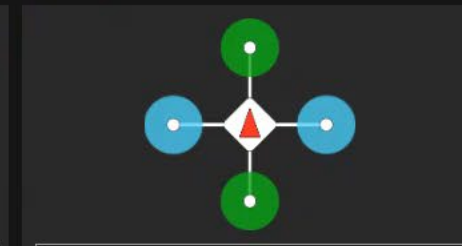
Generic Octocopter X geometry

Plane A-Tail



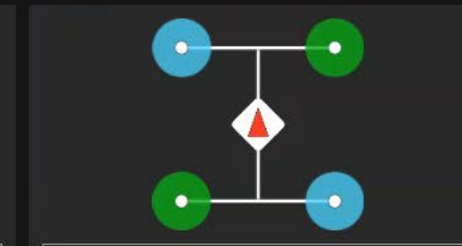
Applied Aeronautics Albatross

Quadrotor +



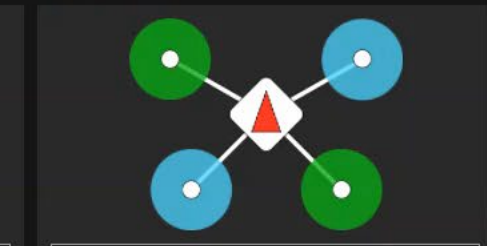
Generic 10" Quad + geometry

Quadrotor H



Reaper 500 Quad

Quadrotor Wide



Team Blacksheep Discovery

Quadrotor x



Simulation (Copter)



Copter X

Simulation (Plane)



HILStar (XPlane)

Standard Plane



Standard Plane

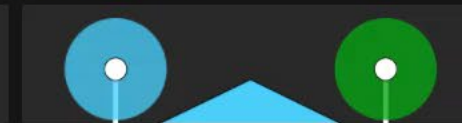
Standard VTOL



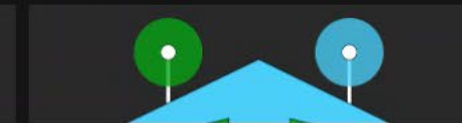
Generic Quadplane VTOL



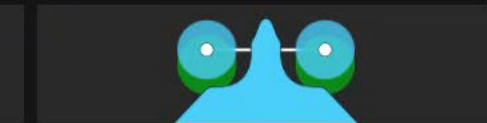
VTOL Duo Tailsitter



VTOL Quad Tailsitter



VTOL Tiltrotor



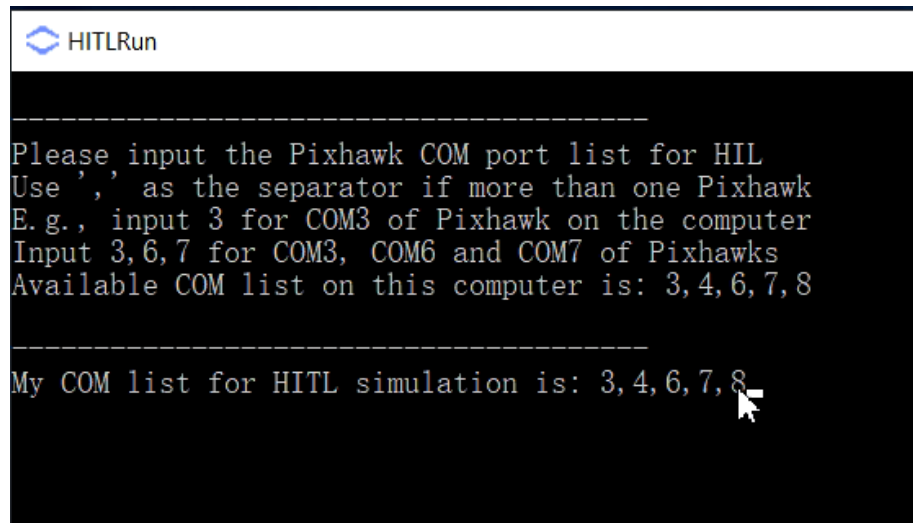


3. Basic Usage

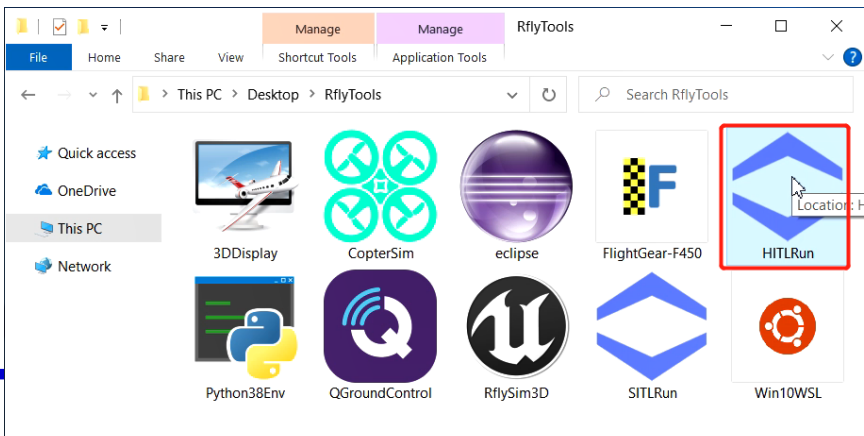
3.4 How to connect multiple Pixhawks for swarm simulation



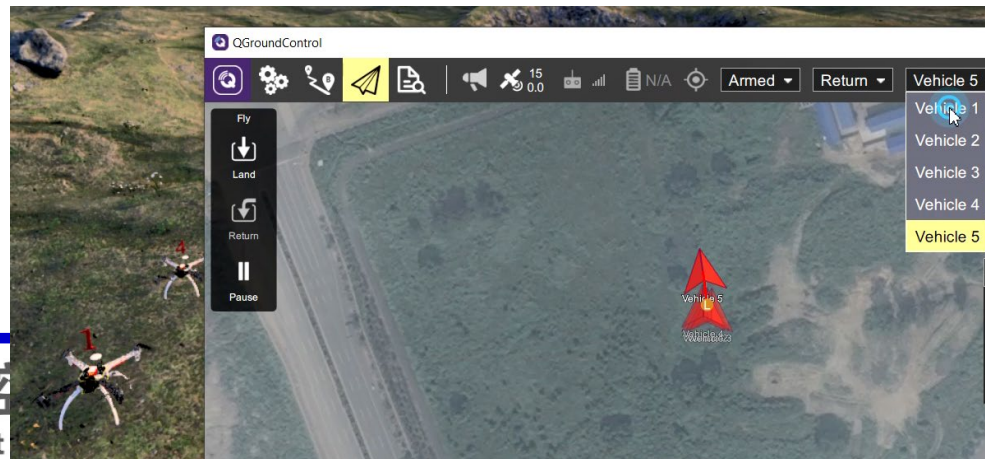
1. Connect several Pixhawks on computer



3. Input the list of all Pixhawk coms



2. Click the HITLRun script



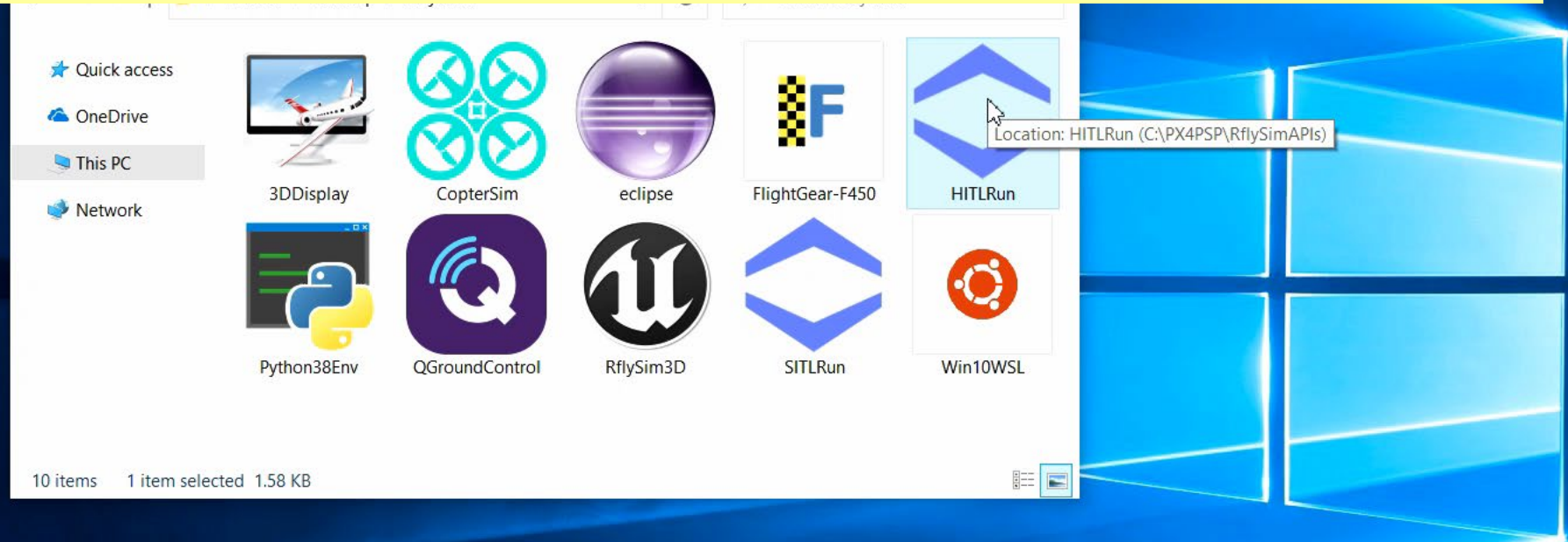
RflySim: How to use hardware-in-the-loop simulation for UAV swarm

Watch this video by clicking the following links:

YouTube: https://youtu.be/oZ_yhEgebA

Youku: https://v.youku.com/v_show/id_XNDcwNjA3OTQ0MA==.html

https://v.youku.com/v_show/id_XNDcwNjA3OTQ0MA==.html



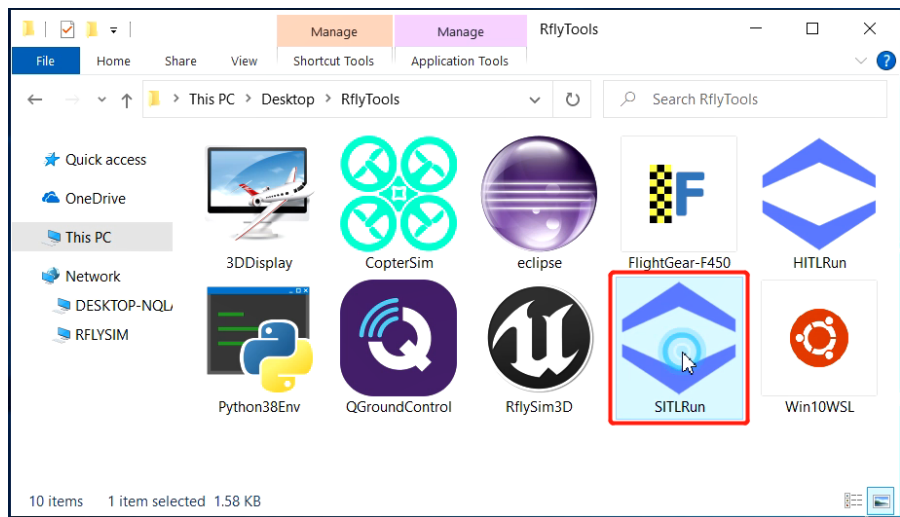
Connect all Pixhawks to computer with USB





3. Basic Usage

3.5 How to perform simulation without Pixhawk hardware



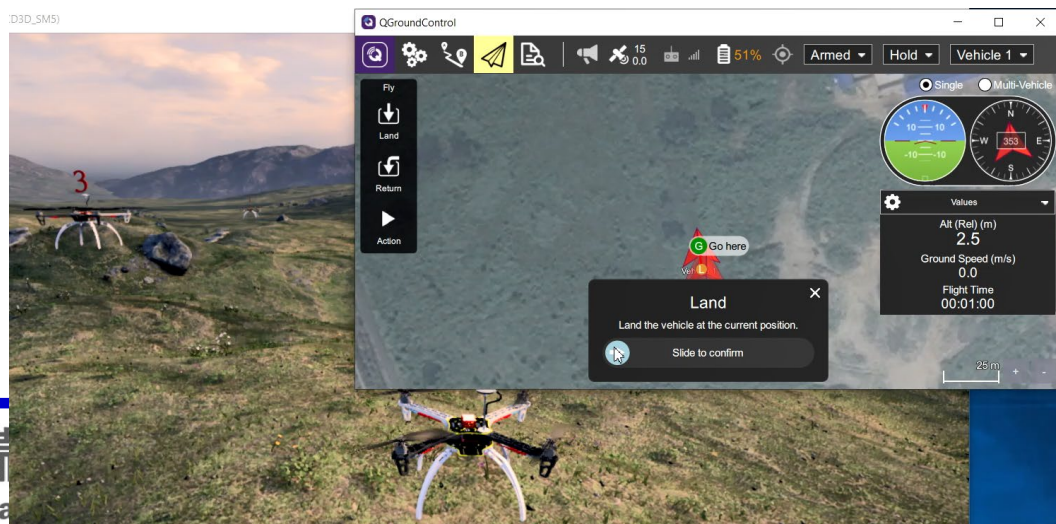
1. Click the SITLRun script

```
SITLRun
-----
Please input UAV swarm number:4
Start QGroundControl
Kill all CopterSims
Starting PX4 Build
[1/1] Generating ../../logs
killing running instances
starting instance 1 in /mnt/c/PX4PSP/Firmware/build/px4_sitl_default/instance_1
starting instance 2 in /mnt/c/PX4PSP/Firmware/build/px4_sitl_default/instance_2
starting instance 3 in /mnt/c/PX4PSP/Firmware/build/px4_sitl_default/instance_3
starting instance 4 in /mnt/c/PX4PSP/Firmware/build/px4_sitl_default/instance_4
PX4 instances start finished
Press any key to exit
```

3. Auto start n PX4 SITL controllers on computer

```
SITLRun
-----
Please input UAV swarm number:4
4
```

2. Input the vehicle number

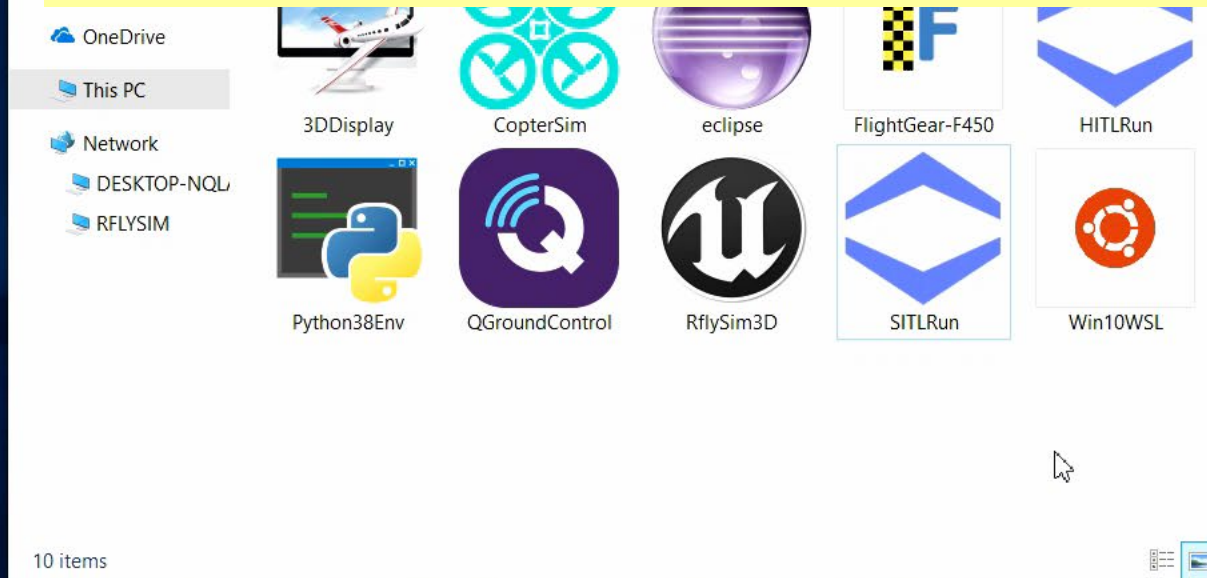


RflySim: How to quickly perform software-in-the-loop simulation for one multicopter UAV

Watch this video by clicking the following links:

YouTube: <https://youtu.be/QxNGOwANY-o>

Youku: https://v.youku.com/v_show/id_XNDcwNjA4MzUxNg==.html



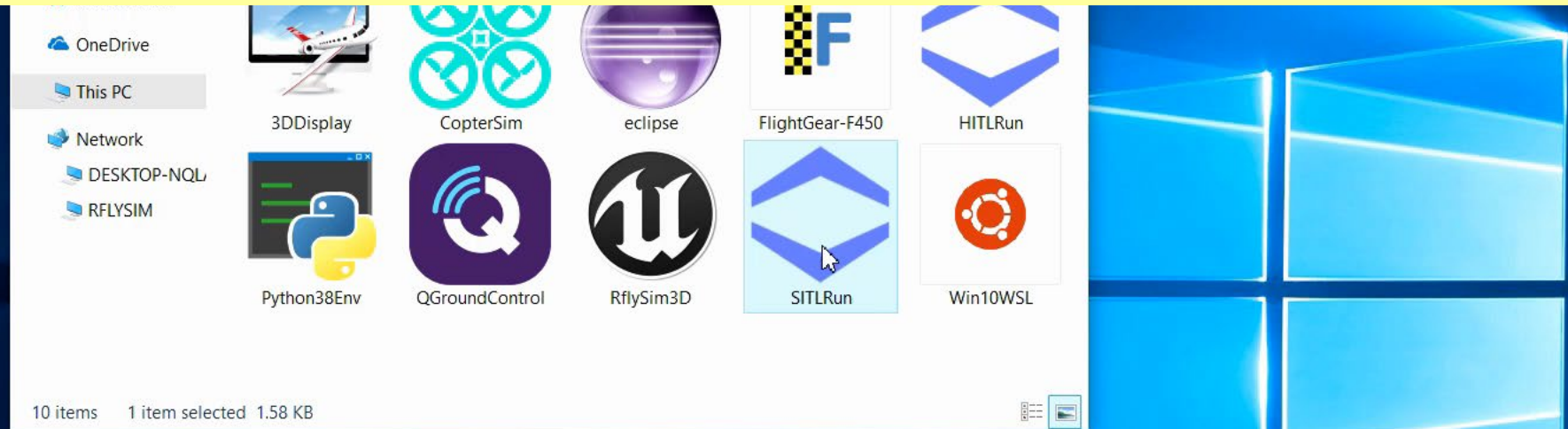
Click one-key script and input vehicle number 1

RflySim: How to quickly perform software-in-the-loop (SIL) simulation for UAV swarm

Watch this video by clicking the following links:

YouTube: <https://youtu.be/88dGpErXPJ8>

Youku: https://v.youku.com/v_show/id_XNDcwNjA4MzA0NA==.html



Start one-key script and input vehicle number 4



Content

1. Installation Instructions

2. Platform Composition

3. Basic Usage

4. Functions List

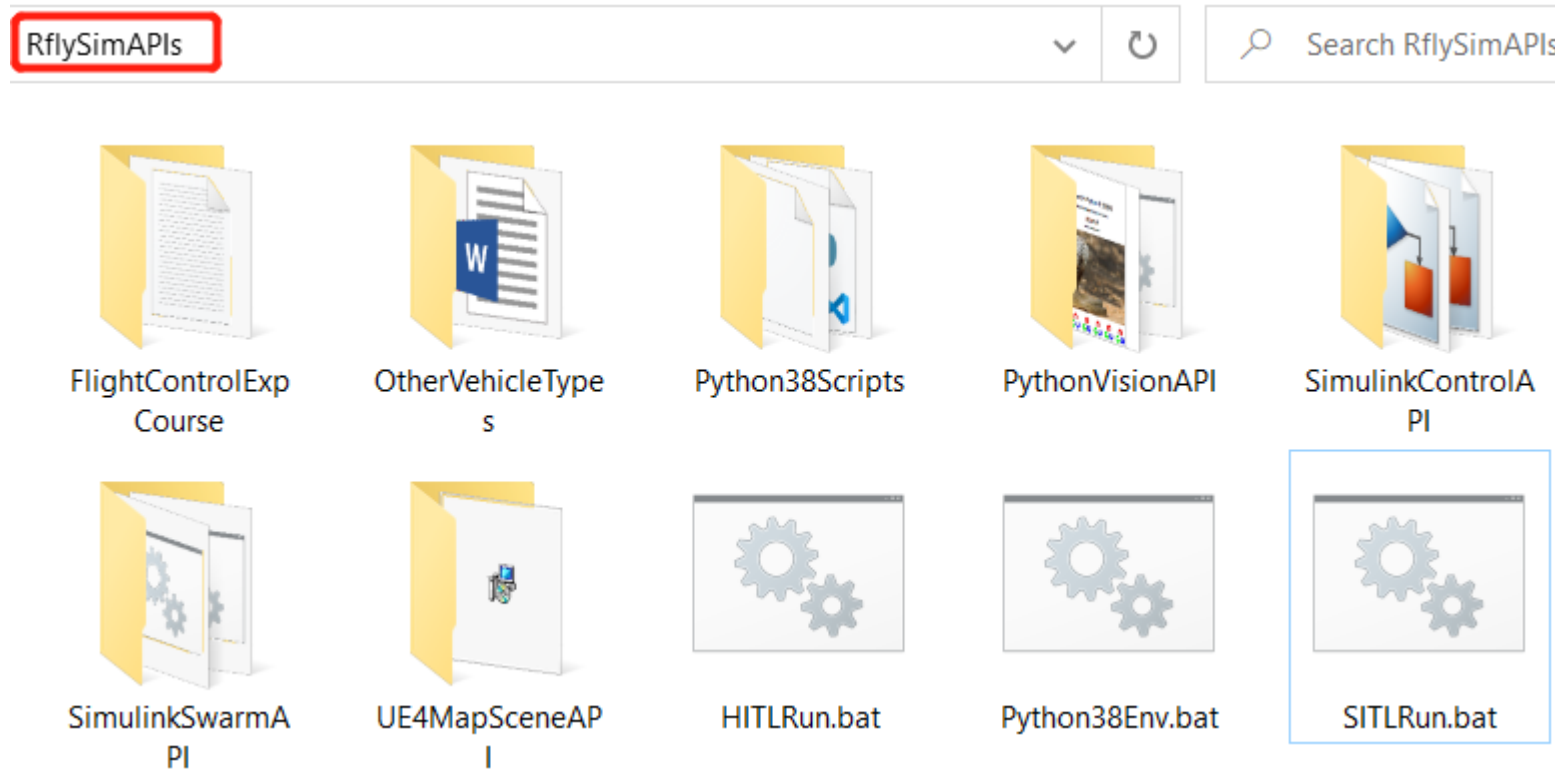
5. Summary



4. Functions list

4.1 API Folder list

The following picture shows “**RflySimAPIs**” folder under the installation directory (**C: \PX4PSP** by default), including demos and files for all APIs of this platform





4. Functions list

4.2 Use of SIL one-click startup script

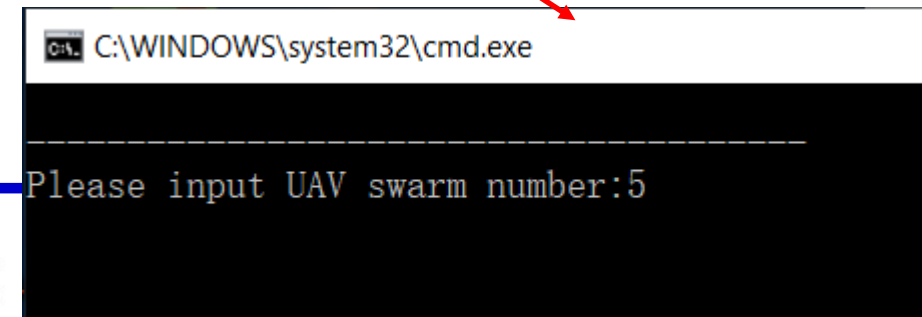
- “**SITLRun.bat**” is a batch file to start multi-machine SIL simulation (note: using SIL simulation needs to ensure that the following three conditions are met in accordance with the installation configuration shown in the figure above, and Win10WSL compiler + PX4 version 1.10 firmware + final A shield PX4 controller is set to “no”), double-click it, enter the number of vehicles you want to generate, you can generate a UAV swarm software-in-the-loop simulation, and then you can control the vehicle to take off through QGC. After running, press any key in the CMD black command window to automatically close all programs.
- **Note:** This batch file essentially configures the CopterSim software options through a script. You can open the file with an editor, view and modify the startup parameters according to your needs.
- **Note 1:** The *RflySim Vision* version cannot create multiple vehicles, so there is no need to enter the number of vehicles, it will directly open the SITL simulation environment of one vehicle.

(2) PX4 firmware compiling command: firmware versions <= PX4-1.8 use format px4fmu-v3_default; >= PX4-1.9 use format px4_fmu-v3_default
px4_sitl_default

(3) PX4 firmware version (1: PX4-1.7.3, 2: PX4-1.8.2, 3: PX4-1.9.2, 4: PX4-1.10.2)
4

(4) PX4 firmware compiling toolchain (1: Win10WSL[suitable for all versions], 2: Msys2[suitable for <= PX4-1.8], 3: Cygwin[for >=PX4-1.8])
1

(10) Whether to block the a use Simulink controller, "no"
no





4. Functions list

- Note 2:** You can open the script with an editor (such as VS Code) with the right mouse button to modify the startup parameters. The most important one is the startup command of CopterSim. The interface of CopterSim are as follows:

```
start CopterSim.exe 1 %cntr% %portNum% %DLLModel% %SimMode% %UE4_MAP% %IS_BROADCAST% %PosXX% %PosYY% %ORIGIN_YAW% 1 %UDPSIMMODE%
```

- start CopterSim.exe param0, param1, param2, ..., param12**

Vehicle ID: 1 Param1	UDP Port: 20100 Param2	Use DLL Model: Param3	Simulation Mode: PX4_HITL Param4	3D Scene Selection: Grasslands Param5	Link <input type="checkbox"/> Param6	Vehicle Initial Pos: x: 0 y: 0 Param7 Param8	Yaw Angle: yaw: 0° Param9
Select Pixhawk Com: Param10	UDP Mode: UDP_Full Param11	Start Simulation Param0		Stop Simulation	Restart Simulation		

- Note 3:** Param0 indicates whether auto start Simulation. For the input of the drop-down box in the above parameters, it can be an option number or a string name. For example, parameter 5 corresponds to a three-dimensional scene and can be set to "1" or set to "**Grasslands**" to select a grass map. The following figure shows two demos.

```
start CopterSim.exe 1 1 20100 0 2 1 0 0 0 0 1 0  
start CopterSim.exe 1 2 20102 MulticopterNoCtrl PX4_HITL Grasslands 127.0.0.1 0.5 0.5 90 3 Mavlink_Full
```

46



4. Functions list

```
start CopterSim.exe 1 %cntr% %portNum% %DLLModel% %SimMode% %UE4_MAP% %IS_BROADCAST% %PosXX% %PosYY% %ORIGIN_YAW% 1 %UDPSIMMODE%
```

Use a text editor to open “RflySimAPIs\SITLRun.bat” (corresponds to the “SITLRun” Desktop shortcut)

- **SET /a START_INDEX=1** # corresponds to “**Param1**”, the vehicle initial ID of swarm
- **SET /a UDP_START_PORT=20100** # corresponds to “**Param2**”, UDP start port for receiving data
- **SET DLLModel=0** # corresponds to “**Param3**”, whether use DLL model and the index
- **SET SimMode=2** # corresponds to “**Param4**”, simulation mode, “2” for SITL, “0” for HITL
- **SET UE4_MAP=Grasslands** # corresponds to “**Param5**”, 3D scene map, here is name Grasslands
- **SET IS_BROADCAST=0** # corresponds to “**Param6**”, whether broadcast to LAN
- **SET /a ORIGIN_POS_X=0** # corresponds to “**Param7**”, initial X Position, integer number, unit: m
- **SET /a ORIGIN_POS_Y=0** # corresponds to “**Param8**”, initial Y Position, integer number, unit: m
- **SET /a ORIGIN_YAW=0** # corresponds to “**Param9**”, initial yaw angle, integer number, unit: °
- **SET /a VEHICLE_INTERVAL=2** # the interval between two vehicle, integer number, unit: m
- **SET UDPSIMMODE=0** #UDP mode for “**Param11**”, use simple or full data? Use Mavlink?
- **SET PX4SiflFrame=iris** #Set vehicle airframe in PX4 SIL simulation, and here is iris quadcopter

Vehicle ID: <input type="text" value="1"/> Param1	UDP Port: <input type="text" value="20100"/> Param2	Use DLL Model: <input type="text" value="0"/> Param3	Simulation Mode: <input type="text" value="PX4_HITL"/> Param4	3D Scene Selection: <input type="text" value="Grasslands"/> Param5	Link <input type="checkbox"/> Param6	Vehicle Initial Pos: x: <input type="text" value="0"/> y: <input type="text" value="0"/>	Yaw Angle: yaw: <input type="text" value="0"/> ° Param7 Param8 Param9
Select Pixhawk Com: <input type="text" value=""/>	Param10	UDP Mode <input type="text" value="UDP_Full"/> Param11	<input type="button" value="Start Simulation"/> Param0	<input type="button" value="Stop Simulation"/>	<input type="button" value="Restart Simulation"/>		



4. Functions list

4.3 Use of HIL one key startup script

- “**HITLRun.bat**” is a batch file to start UAV swarm HIL simulation. Insert multiple Pixhawks to computer, then double-click the batch file, and enter the Pixhawk's serial port number list (comma separated) that you want to participate in the simulation according to the prompts to start the UAV swarm HIL simulation.

```
C:\WINDOWS\system32\cmd.exe

-----
Please input the Pixhawk COM port list for HIL
Use ',' as the separator if more than one Pixhawk
E.g., input 3 for COM3 of Pixhawk on the computer
Input 3,6,7 for COM3, COM6 and COM7 of Pixhawks
Available COM list on this computer is: 3,4,9
-----

My COM list for HITL simulation is 3,4,9_
```

- **Note:** The *RflySim Vision* version can only simulate one vehicle, so just enter the serial number of the serial port that you want to do HIL simulation.



4. Function list

4.4 Use of Python38 Environment

- “**Python38Env.bat**” corresponds to the quick configuration and startup method of the Python environment in the python38 folder. By running this script, you can enable the python environment we provide without interfering with other Python environments on the computer. Among them, the “**RflySimAPIs\Python38Scripts**” directory is the working directory of our Python environment. Copy the .py file to this directory and execute “**python *.py**” to run it directly. **Note:** This Python environment already contains a series of tools such as OpenCV, Mavlink, pip, etc., which can run all our demos directly.

```
C:\WINDOWS\system32\cmd.exe
```

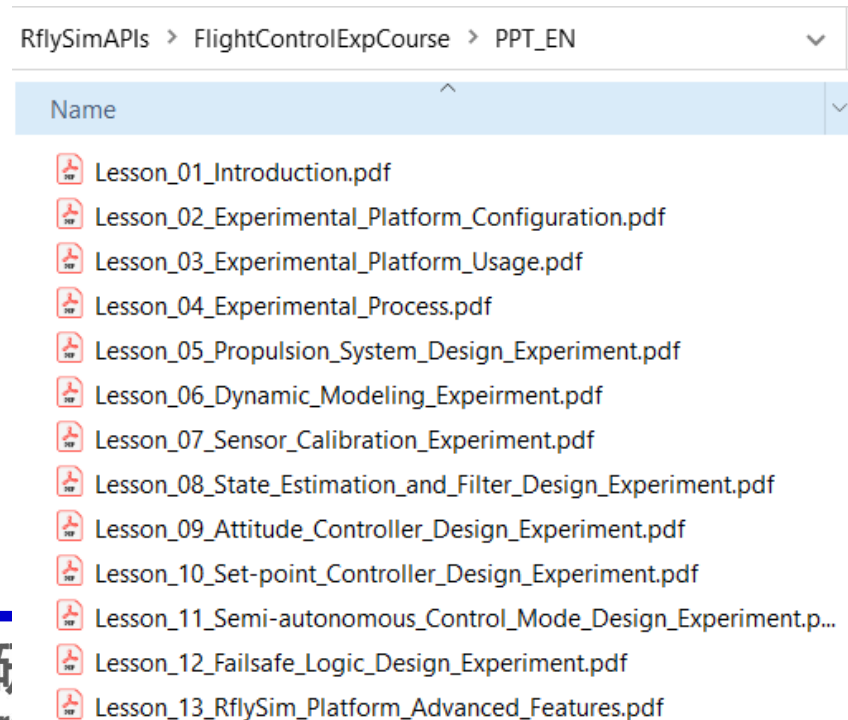
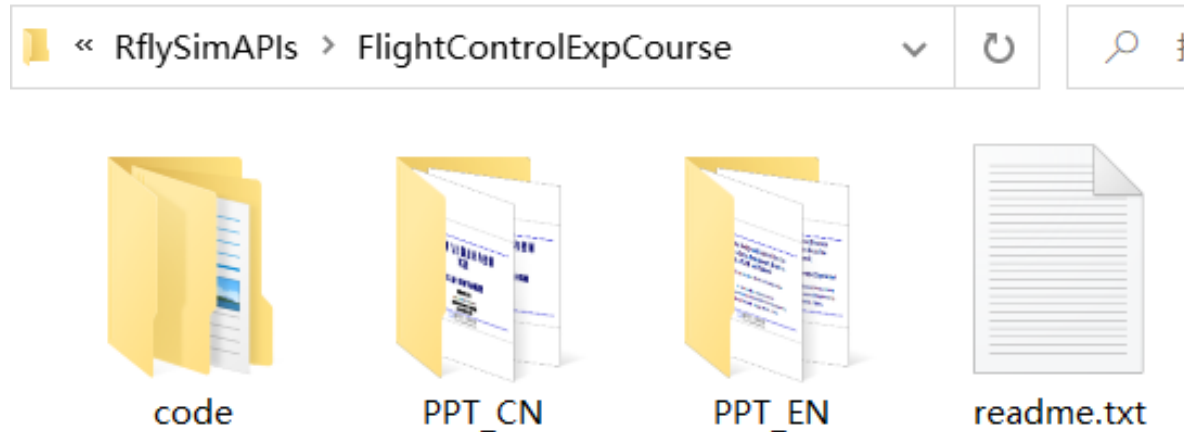
```
Python3.8 environment has been set with openCV+pymavlink+numpy+pyulog etc.  
You can use pip or pip3 command to install other libraries  
Put your python scripts 'XXX.py' into the folder 'D:\PX4PSP\RflySimAPIs\Python38Scripts'  
Use the command: 'python XXX.py' to run the script with Python  
For example, try entering 'python ImgCVShow.py' below to use OpenCV to read and show a image  
You can also use pyulog (see https://github.com/PX4/pyulog) to convert PX4 log file  
For example, try entering 'ulog2csv log.ulg' to convert ulg file to excel files for MATLAB  
D:\PX4PSP\RflySimAPIs\Python38Scripts>python ImgCVShow.py_
```




4. Functions list

4.5 Experimental Courses for Flight Control Algorithm Development

- “**RflySimAPIs \ FlightControlExpCourse**” folder contains a serials of experimental courses for our latest book *Multicopter Design and Control Practice*, where you can enjoy the rapid flight control algorithm development with MBD process of Simulink controller design, SIL simulation, auto code generation, HIL simulation, flight test. You can learn how to use it by reading “**RflySim_Lesson_02_Flight_Control_Experiments.pdf**”.





4. Functions list

4.6 External Control Interface(offboard and etc.) for Single Multicopter

- “**RflySimAPIs\SimulinkControlAPI**” folder contains an API demos by using Simulink to control one HIL multicopter with CopterSim and Pixhawk. ssYou can learn how to use by reading “**RflySim_Lesson_03_External_Control_Interface.pdf**”.

RflySimAPIs > SimulinkControlAPI >



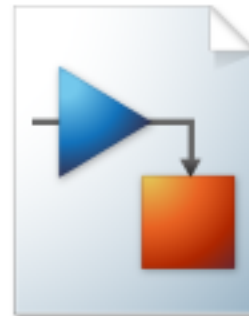
MavlinkDemo



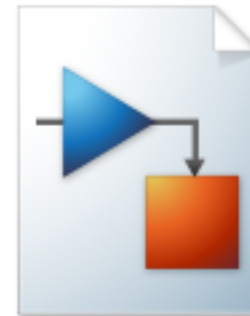
Rfly_API_CTRL



VS2017Installer



ManulControlAPI.
slx



OffboardAPI.slx



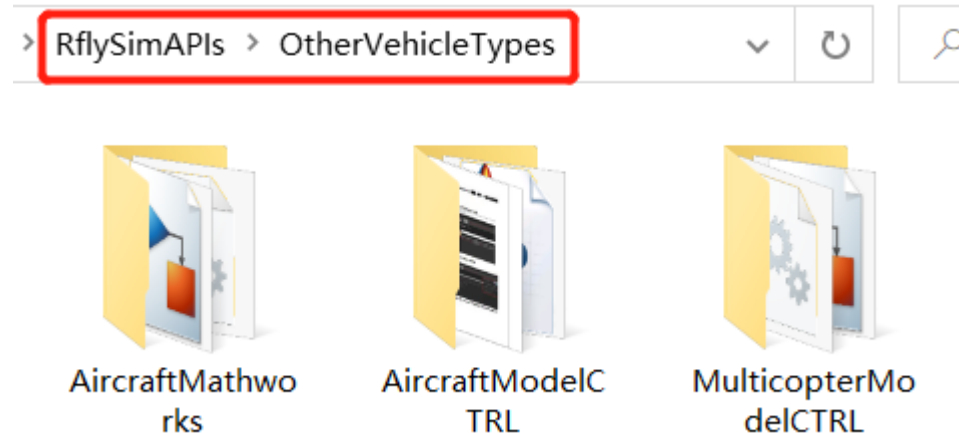
RadioControlAPI.
slx



4. Functions list

4.7 Extension to Other Types of Vehicles (copters, fixed-wing, VTOL, cars, etc.)

- “**RflySimAPIs\OtherVehicleTypes**” folder (only for the **RflySim Full** version) is to make it possible to apply your Simulink model into CopterSim to achieve the simulation of other models such as fixed wing and unmanned vehicles. Currently, the folder contains two examples, one is a multicopter model and the other is a fixed-wing model. You can read “**RflySim_Lesson_04_Other_Types_of_Vehicles.pdf**” to learn how to use it.





4. Functions list

4.8 Build your own 3D scenes and vehicle models for RflySim3D with UE4

- “**RflySimAPIs\UE4MapSceneAPI**” folder contains file and routine of UE4 highly realistic scene and vehicle 3D models to be designed and imported. You can learn how to use by reading “**RflySim_Lesson_05_UE4_3D_Scene_Development.pdf**”.

RflySimAPIs > UE4MapSceneAPI >



GetTerrainAPI



MapCreate



MapImport



VehicleModel



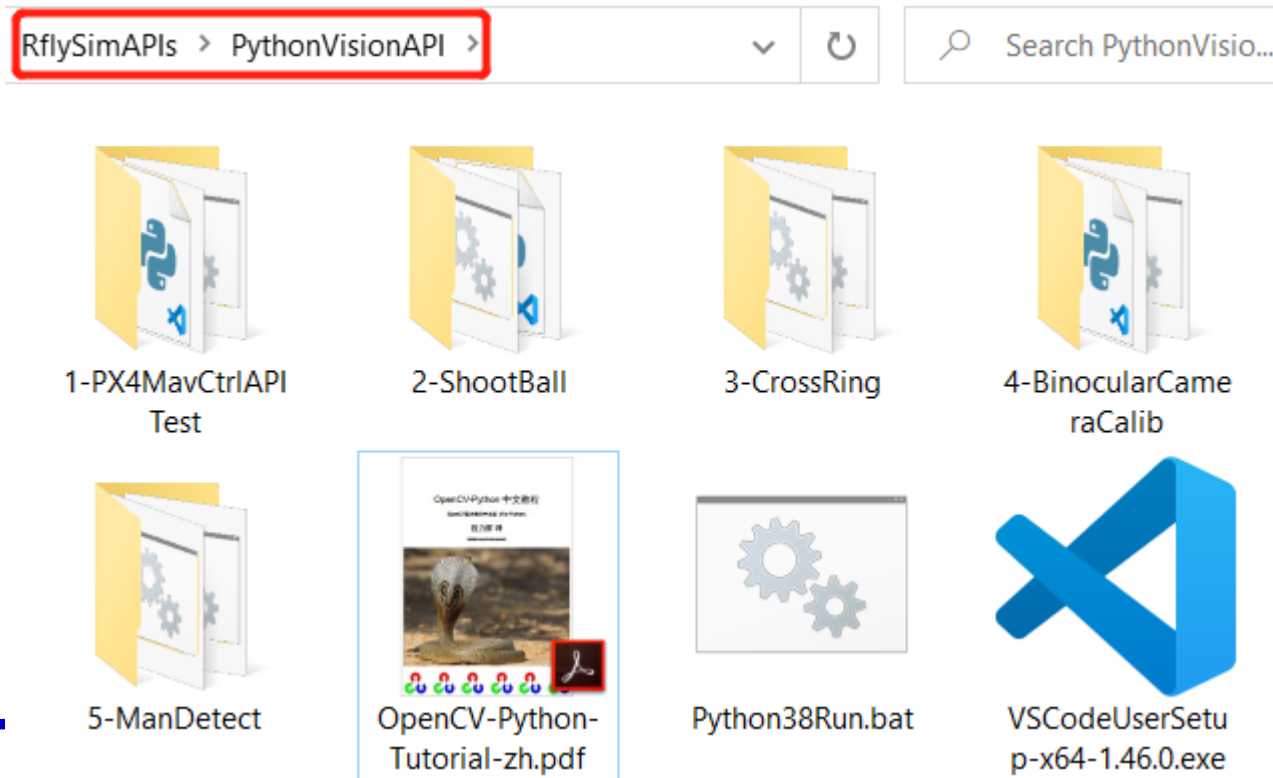
EpicInstaller-10.1
7.0.msi



4. Functions list

4.9 Vision-based Control Interface

- “**RflySimAPIs \ PythonVisionAPI**” folder contains interface demo files used to achieve vision-based close-loop control by Python(only for the **RflySim Vision** version). You can learn it by reading “**RflySim_Lesson_06_Vision_Based_Control.pdf**”.





4. Functions list

4.10 Control Interface for UAV Swarm

- “**RflySimAPIs \ SimulinkSwarmAPI**” folder contains interface routine of Simulink controlling UAV swarm. You can learn how to use by reading “**RflySim_Lesson_07_UAV_Swarm_Control.pdf**”.

RflySimAPIs > SimulinkSwarmAPI >



Se



PythonDemo



SimulinkDemo



SwarmForm



HITLRunUdpFull.
bat



HITLRunUdpSim
ple.bat



SITLRunUdpFull.b
at



SITLRunUdpSimp
le.bat



Thanks