

Experimental Development Notes of UAV Formation Maneuvering

(Representation: `***`: [links](#); `***`: linux terminal command; `***`: output)

1. Copyright

This file contains the experimental development notes for the paper:

Title: Angle-Constrained Formation Maneuvering of Unmanned Aerial Vehicles

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Our experimental platform for UAV formation maneuvering are based on the following Steps 2-11, which need to be executed sequentially.

2. Opti track Motion Capture System for global positioning

Two ethernet network cards were installed in the center computer. One is for the Opti track system, and the other is for the local network communication (TPLink router). The broadcast IP address is 192.168.0.102.

We need to turn on the streaming service in Opti Track - Motive with VRPN stream function. Details are shown as following,

[OptiTrack/Motion + ROS](#)

3. Ubuntu OS

Install ubuntu 18.0

4. ROS installation and configuration

Install ROS (Melodic)

<http://wiki.ros.org/melodic/Installation/Ubuntu>

```
pip3 install catkin_pkg
```

5. Optitrack ROS package

Install the vrpn_client_ros

```
sudo apt-get install ros-melodic-vrpn-client-ros
roscd vrpn_client_ros/launch
sudo cp sample.launch drone_swarm.launch
sudo gedit drone_swarm.launch
```

Change the "localhost" to "192.168.0.102" which is the IP address of the computing center.

```
roslaunch vrpn_client_ros drone_swarm.launch server:=192.168.0.102
roslaunch rviz rviz
```

6. Visualization and data recording

Open a new terminal window.

```
roslaunch rviz rviz;
add TF, and global coordinate frame.
Add the topic into the display panel.
```

Data recording:
open rostopic, then echo the topic you want

```
rostopic echo #rostopic
rosbag record -a
```

7. Change the Tello Edu drones' connection mode to station mode (into local network)

Download the software Packet Sender <https://packetsender.com/>

Connect Tello Edu drones with Wi-Fi

Evaluate the connection

Send ap #ssid #pwd to the connected Tello.

Send the corresponding commands (change the connection mode) to tello drones.

Refer to <https://www.youtube.com/watch?v=cIsddY4SKgA>

8. Assign static IP addresses for Tello drones, which will be connected to the router (TPLink)

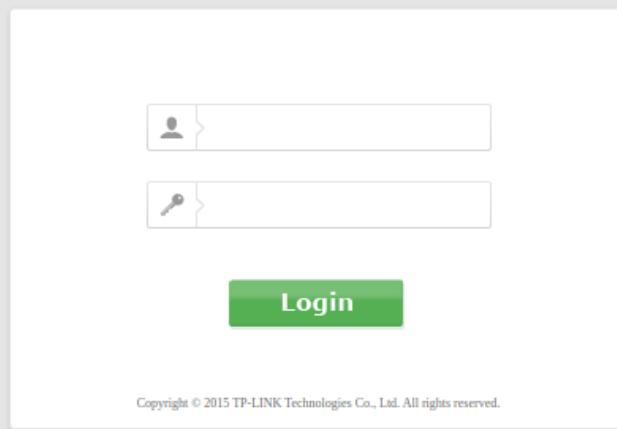
Enter `http://192.168.0.1/` in your browser and then you can login to the router's setting web.

After that you can reserve the IP address for your Tello and your computer with Opti track system. The IP addresses are reserved with specific MAC addresses. In our experiments, Tello 1-Tello 4 are reserved from 192.168.0.120-192.168.0.123

Right now, for example:

Tello1: 192.168.0.120

Tello2: 192.168.0.121



Status

Quick Setup

Network

Dual Band Selection

Wireless 2.4GHz

Wireless 5GHz

Guest Network

DHCP

- DHCP Settings

- DHCP Clients List

- Address Reservation

USB Settings

Address Reservation

ID	MAC Address	Reserved IP Address	Status	Modify
1	60-60-1F-62-7C-FF	192.168.0.120	Enabled	Modify Delete
2	60-60-1F-59-D4-A6	192.168.0.121	Enabled	Modify Delete
3	70-66-55-30-37-75	192.168.0.105	Enabled	Modify Delete
4	E4-54-E8-C4-A4-41	192.168.0.102	Enabled	Modify Delete

Add New...

Enable All

Disable All

Delete All

9. Scan the IP addresses of Tello drones

(1) (Download Advanced IP Scanner to know the IP address of each Tello AP access. (Windows)

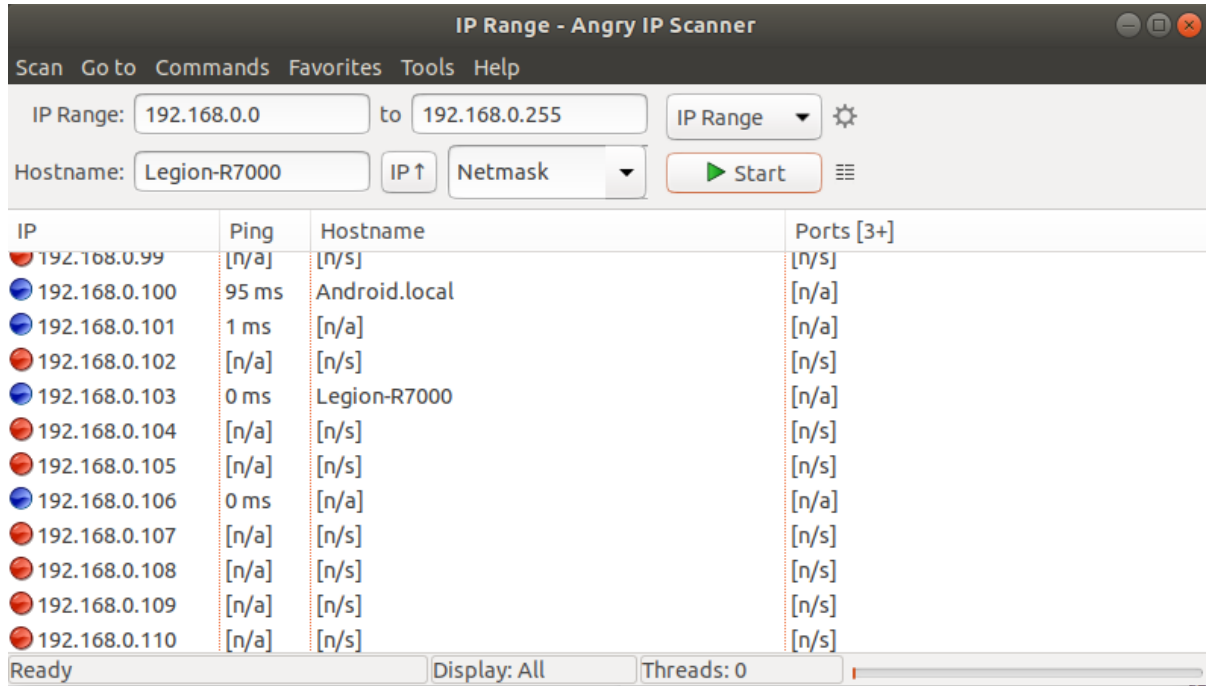
<https://www.advanced-ip-scanner.com/>

Or

(2) Download the Angry IP Scanner (Linux)

<https://angryip.org/download/#linux>

Just download the click the deb package (ipscan_3.7.6_amd64.deb) and the installation will auto start. After the installation of the IP scanner, click Start, you will obtain the IP address of the Tellos.



The blue dot means the active IP host. Here, 192.168.0.101 is the right IP address. However, it is not easy to know which one is the corresponding tello's IP address.

Also, we can install arp-scan

```
sudo apt-get install arp-scan
```

```
sudo arp-scan -l
```

```
jiaping@Legion-R7000:~/Downloads$ sudo arp-scan -l
Interface: wlp4s0, datalink type: EN10MB (Ethernet)
Starting arp-scan 1.9 with 256 hosts (http://www.nta-monitor.com/tools/arp-scan/)
192.168.0.1      d4:6e:0e:35:f0:1f      (Unknown)
192.168.0.101   60:60:1f:62:7c:ff     SZ DJI TECHNOLOGY CO.,LTD
192.168.0.102   e4:54:e8:c4:a4:41     (Unknown)
192.168.0.106   34:e1:2d:dd:24:0d     (Unknown)

4 packets received by filter, 0 packets dropped by kernel
Ending arp-scan 1.9: 256 hosts scanned in 2.626 seconds (97.49 hosts/sec). 4 res
ponded
```

With arp-scan, we can know the IP address (192.168.0.101) of the tello.

10. Tello-ros

Install the tello-ros package:

<https://github.com/xjp99v5/tello-driver-ros>

Rostopic:

```
rostopic list -v
```

Published topics:

```
* /tello/image_raw/h264 [sensor_msgs/CompressedImage] 1 publisher
* /tello/tello_driver_node/parameter_updates [dynamic_reconfigure/Config] 1 publisher
* /tello/image_raw/compressed/parameter_updates [dynamic_reconfigure/Config] 1 publisher
* /tello/odom [nav_msgs/Odometry] 1 publisher
* /rosout [roscpp_msgs/Log] 4 publishers
*   /tello/tello_driver_node/parameter_descriptions [dynamic_reconfigure/ConfigDescription] 1
publisher
* /rosout_agg [roscpp_msgs/Log] 1 publisher
* /tello/imu [sensor_msgs/Imu] 1 publisher
* /tello/cmd_vel [geometry_msgs/Twist] 1 publisher
* /tello/status [tello_driver/TelloStatus] 1 publisher
* /tello/image_raw/compressed/parameter_descriptions [dynamic_reconfigure/ConfigDescription] 1
publisher
* /tello/camera/camera_info [sensor_msgs/CameraInfo] 1 publisher
* /tello/image_raw/compressed [sensor_msgs/CompressedImage] 1 publisher
```

Subscribed topics:

```
* /tello/fast_mode [std_msgs/Empty] 1 subscriber
* /tello/throw_takeoff [std_msgs/Empty] 1 subscriber
* /tello/flip [std_msgs/UInt8] 1 subscriber
* /tello/palm_land [std_msgs/Empty] 1 subscriber
* /rosout [roscpp_msgs/Log] 1 subscriber
* /tello/flattrim [std_msgs/Empty] 1 subscriber
* /tello/takeoff [std_msgs/Empty] 1 subscriber
* /tello/emergency [std_msgs/Empty] 1 subscriber
* /tello/image_raw [sensor_msgs/Image] 1 subscriber
* /tello/manual_takeoff [std_msgs/Empty] 1 subscriber
* /tello/video_mode [std_msgs/Empty] 1 subscriber
* /tello/cmd_vel [geometry_msgs/Twist] 1 subscriber
* /tello/land [std_msgs/Empty] 1 subscriber
* /statistics [roscpp_msgs/TopicStatistics] 1 subscriber
```

`rosservice list`

```
/rosout/get_loggers
/rosout/set_logger_level
/rqt_gui_py_node_20626/get_loggers
/rqt_gui_py_node_20626/set_logger_level
/teleop_twist_keyboard/get_loggers
/teleop_twist_keyboard/set_logger_level
/tello/image_compressed/get_loggers
/tello/image_compressed/set_logger_level
/tello/image_raw/compressed/set_parameters
/tello/tello_driver_node/get_loggers
/tello/tello_driver_node/set_logger_level
/tello/tello_driver_node/set_parameters
```

`rosparam list`

```
/roscdistro
/roslaunch/uris/host_legion_r7000__42137
/rosversion
/run_id
```

```
/tello/image_raw/compressed/format
/tello/image_raw/compressed/jpeg_quality
/tello/image_raw/compressed/png_level
/tello/tello_driver_node/altitude_limit
/tello/tello_driver_node/attitude_limit
/tello/tello_driver_node/camera_calibration
/tello/tello_driver_node/connect_timeout_sec
/tello/tello_driver_node/fixed_video_rate
/tello/tello_driver_node/local_cmd_client_port
/tello/tello_driver_node/local_vid_server_port
/tello/tello_driver_node/low_bat_threshold
/tello/tello_driver_node/stream_h264_video
/tello/tello_driver_node/tello_cmd_server_port
/tello/tello_driver_node/tello_ip
/tello/tello_driver_node/vel_cmd_scale
/tello/tello_driver_node/video_req_sps_hz
```

```
rosparam get /
```

```
rostdistro: 'melodic'
```

```
,
```

```
roslaunch:
```

```
  uris: {host_legion_r7000__42137: 'http://Legion-R7000:42137/'}
```

```
rosversion: '1.14.10'
```

```
,
```

```
run_id: 1cd4149c-b200-11eb-be3a-002b67e4746f
```

```
tello:
```

```
  image_raw:
```

```
    compressed: {format: jpeg, jpeg_quality: 80, png_level: 9}
```

```
  tello_driver_node: {altitude_limit: 10, attitude_limit: 15, camera_calibration:
/home/jiaping/catkin_ws/src/tello-driver-ros/cfg/960x720.yaml,
```

```
    connect_timeout_sec: 10.0, fixed_video_rate: 0, local_cmd_client_port: 8890,
local_vid_server_port: 6038,
```

```
    low_bat_threshold: 7, stream_h264_video: true, tello_cmd_server_port: 8889, tello_ip:
192.168.10.1,
```

```
    vel_cmd_scale: 0.5, video_req_sps_hz: 0.5}
```

```
roslaunch          tello_driver          tello_node.launch          namespace:=tello0
tello_ip:=192.168.0.107
```

Takeoff command:

```
rostopic pub -1 /tello0/takeoff std_msgs/Empty "{}"
```

Land command:

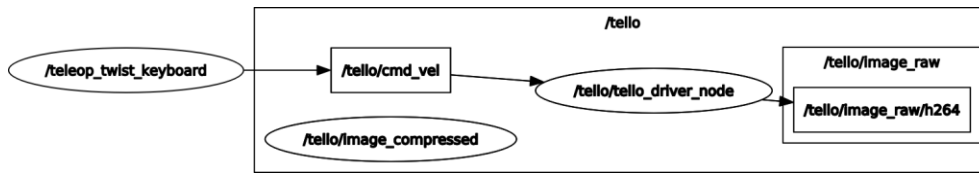
```
rostopic pub -1 /tello/land std_msgs/Empty "{}"
```

View images:

```
roslaunch rqt_image_view rqt_image_view /tello/image_raw/h264
```

View the publish-subscriber relationship:

```
roslaunch rqt_graph rqt_graph
```



11. Create `optitrack_tello_swarm` package according to the proposed formation control algorithm

See <http://wiki.ros.org/ROS/Tutorials/CreatingPackage>

```
cd ~/catkin_ws/src
catkin_create_pkg optitrack_tello_swarm std_msgs roscpp
```

Edit your package by using VS-code:

Open your VS-code and open the folder where you create your package, i.e., `~/catkin_ws/src/optitrack_tello_swarm`.

Refer to <https://github.com/TIERS/uwb-tello-swarm>

After the VS-code is edited well according to the designed formation control algorithm, make sure that it can be compiled successfully. After it is compiled well, run the following commands to finally execute the formation task given in VS-code.

Launch one Tello drone:

```
roslaunch tello_driver tello_node.launch namespace:=tello0
tello_ip:=192.168.0.107
```

Launch multi Tello drone:

```
roslaunch tello_driver tello_node_multi.launch namespace:=tello0
tello_ip:=192.168.0.107 local_cmd_client_port:=8890
local_vid_server_port:=6038 tello_cmd_server_port:=8889
```

```
roslaunch tello_driver tello_node_multi.launch namespace:=tello1
tello_ip:=192.168.0.108 local_cmd_client_port:=8891
local_vid_server_port:=6039 tello_cmd_server_port:=8889
```

Or

```
Python3 mul_drones_launch.py
```

The Opti track publish Pose Stamped.

See http://docs.ros.org/en/melodic/api/geometry_msgs/html/msg/PoseStamped.html

So, we need to subscribe the msg and get the data by `msg.pose.position`

Run the *main python file* and the formation task given in VS-code will continue working until being terminated.

Reference project:

1. <https://github.com/tiers>
2. <http://wiki.ros.org/melodic/Installation/Ubuntu>
3. <https://github.com/xjp99v5/tello-driver-ros>