

Lab 2 Report

Robotics Integration Group Project I

Yuwei ZHAO (23020036096)
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Abstract

This report documents the setup and experimentation undertaken in Lab 2. The primary objectives are to install and configure the Robot Operating System (*ROS*) environment on Ubuntu, establish a functioning Catkin workspace, and gain practical experience with core ROS communication mechanisms. Through a sequence of hands-on tasks, the lab introduces essential ROS concepts such as node creation, publisher-subscriber communication, topic monitoring, and system visualization using tools like `rqt_graph` and `roscore`. The experiment provides a foundational understanding of how ROS facilitates modular, distributed robotics software development.

See Resources on github.com/RamessesN/Robotics_MIT.

1 Introduction

This laboratory session focuses on the installation, configuration and initial exploration of the Robot Operating System (*ROS*), which serves as the middleware framework for subsequent robotics development. Before implementing perception, planning or control modules, it is essential to understand the *ROS* architecture and its communication mechanisms. The experiment involves setting up the *ROS* environment, creating and managing a catkin workspace, and developing simple publisher and subscriber nodes to exchange data through topics.

2 Procedure

2.1 Part I

2.1.1 Objective

To set up the *ROS* environment on the *Ubuntu 24.04* operating system, including the installation of essential packages and the configuration of a functional Catkin workspace.

2.1.2 Methodology

The initial approach for installing *ROS Noetic* was as follows:

1. Add the *ROS* package sources and install *ROS Noetic*:

```
sudo sh -c 'echo "deb http://packages.ros.org/ros/ubuntu $(lsb_release -sc)
→ main" > /etc/apt/sources.list.d/ros-latest.list'
curl -s https://raw.githubusercontent.com/ros/rosdistro/master/ros.asc | sudo
→ apt-key add -
sudo apt update
sudo apt install ros-noetic-desktop-full
```

2. Configure the *ROS* environment and install additional dependencies:

```
echo "source /opt/ros/noetic/setup.bash" >> ~/.bashrc
source ~/.bashrc
sudo apt install python3-rosdep python3-rosinstall python3-rosinstall-generator
→ \
python3-vcstool build-essential python3-catkin-tools python-is-python3
```

3. Initialize *rosdep* to enable dependency management:

```
sudo rosdep init
rosdep update
```

However, the above method is not fully compatible with *Ubuntu 24.04*. To address this, an alternative installation procedure using the *Shrike* repository was adopted, which provided a successful setup.

1. Clone the *Shrike* repository from GitHub:

```
git clone git@github.com:Minoic-Intelligence/shrike.git
```

2. Follow the instructions provided in the *Shrike* repository to complete the installation. The resulting terminal output is shown in Figure 1.

```
./scripts/install_ubuntu24.sh
./src/catkin/bin/catkin_make_isolated --install -DCMAKE_BUILD_TYPE=Release
source ./install_isolated/setup.bash
```

2.1.3 Observations

```
parallels@ubuntu-linux-2404:~/shrike$ chmod 755 ./scripts/install_ubuntu24.sh
parallels@ubuntu-linux-2404:~/shrike$ sudo ./scripts/install_ubuntu24.sh
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
Note, selecting 'libglog-1.9.0t64' instead of 'libglog-1.9.0v5'
build-essential is already the newest version (12.10ubuntu1).
cmake is already the newest version (3.28.3-1build7).
git is already the newest version (1:2.43.0-1ubuntu7.3).
python3 is already the newest version (3.12.3-0ubuntu2).
python3-pip is already the newest version (24.0+dfsg-1ubuntu1.3).
python3.12-venv is already the newest version (3.12.3-1ubuntu0.8).
curl is already the newest version (8.5.0-2ubuntu10.6).
wget is already the newest version (1.21.4-1ubuntu4.1).
pkg-config is already the newest version (1.8.1-2build1).
libboost-all-dev is already the newest version (1.83.0-1ubuntu2).
libconsole-bridge-dev is already the newest version (1.0.1+dfsg2-3build1).
liborocos-kdl1.5 is already the newest version (1.5.1-4build1).
liborocos-kdl-dev is already the newest version (1.5.1-4build1).
libpytide2-dev is already the newest version (5.15.13-1).
pyqt5-dev is already the newest version (5.15.10+dfsg-1build6).
libshiboken2-dev is already the newest version (5.15.13-1).
shiboken2 is already the newest version (5.15.13-1).
libbz2-dev is already the newest version (1.0.8-5.1build0.1).

parallels@ubuntu-linux-2404:~/shrike$ ./src/catkin/bin/catkin_make_isolated --install -DCMAKE_BUILD_TYPE=Release
Base path: /home/parallels/shrike
Build space: /home/parallels/shrike/build_isolated
Devel space: /home/parallels/shrike/devel_isolated
Install space: /home/parallels/shrike/install_isolated
Additional CMake Arguments: -DCMAKE_BUILD_TYPE=Release

-- traversing 228 packages in topological order:
-- catkin
-- genmsg
-- genpy
-- genlisp
-- genodejs
-- genpy
-- bond_core
-- cmake_modules
-- class_loader
-- common_msgs
-- common_tutorials
-- cpp_common
-- desktop
```

Figure 1: Installation of *ROS Noetic* on *Ubuntu 24.04*

2.1.4 Discussion

Installing *ROS Noetic* on *Ubuntu 24.04* presents several challenges due to incompatibilities between the standard Noetic packages and the latest system libraries. By utilizing the *Shrike* repository—which provides customized build scripts tailored for Ubuntu 24.04—the installation process was completed successfully. This outcome highlights the necessity of adapting traditional installation procedures to evolving system environments and demonstrates the value of community-maintained solutions when official support is unavailable.

2.2 Part II

2.2.1 Objective

To deepen the understanding of the *ROS* communication framework by implementing publisher and subscriber nodes, exploring topic-based message exchange, and visualizing the inter-node topology. This experiment establishes the foundation for modular, event-driven robotic behavior through:

1. Implementing *ROS* nodes that publish and subscribe to custom message types.
2. Demonstrating data flow between nodes via topics and verifying correct message delivery.
3. Utilizing diagnostic and visualization tools (such as `rqt_graph`) to examine node-topic connectivity.
4. Ensuring the workspace is properly configured to build, launch, and manage multiple nodes within a *ROS* ecosystem.

2.2.2 Methodology

- ***ROS Master***

Start the *ROS* Master using the following command. The resulting output is shown in Figure 2.

```
roscore
```

- ***ROS Nodes***

1. Launch the *turtlesim* node in a new terminal:

```
rosrun turtlesim turtlesim_node
```

2. List active nodes using:

```
rosnodes list
```

3. Launch the *turtle_teleop_key* node to control the turtle with keyboard input:

```
rosrun turtlesim turtle_teleop_key
```

4. The corresponding runtime output is illustrated in Figure 3.

- ***ROS Topics***

1. Visualize the communication graph of running nodes and topics:

```
rosrun rqt_graph rqt_graph
```

2. Monitor velocity commands sent to the turtle in real time:

```
rostopic echo /turtle1/cmd_vel
```

3. Create a simple C++ example node:

```

1 #include <ros/ros.h>
2
3 int main(int argc, char** argv) {
4     ros::init(argc, argv, "example_node");
5     ros::NodeHandle n;
6
7     ros::Rate loop_rate(50);
8
9     while (ros::ok()) {
10         ros::spinOnce();
11         loop_rate.sleep();
12     }
13     return 0;
14 }
```

To compile and execute this example using *Shrike*, follow these steps:

```
cd ~/shrike/ros_ws/src
catkin_create_pkg ros_sample roscpp std_msgs
```

The resulting workspace structure is:

```
- ros_ws/
  - src/
    - ros_sample/
      - CMakeLists.txt
      - include/
      - package.xml
      - src/
        - ros_sample.cpp
```

Replace *example_node.cpp* with *ros_sample.cpp* and update the *CMakeLists.txt* file as follows:

```

cmake_minimum_required(VERSION 3.0.2)
project(ros_sample)

find_package(catkin REQUIRED COMPONENTS
  roscpp
  std_msgs
)

catkin_package()

include_directories(
  ${catkin_INCLUDE_DIRS}
)

add_executable(ros_sample_node src/ros_sample.cpp)
target_link_libraries(ros_sample_node ${catkin_LIBRARIES})
```

Build and source the workspace:

```
cd ~/shrike/ros_ws
```

```
catkin_make_isolated --install -DCMAKE_BUILD_TYPE=Release
source ~/shrike/ros_ws/devel_isolated/setup.bash
rosrun ros_sample ros_sample_node
```

Verify that the node is active using `rosnode list`. The corresponding results are shown in Figure 4.

4. **TF Tools**

- Launch the Turtle TF demo:

```
roslaunch turtle_tf turtle_tf_demo.launch
```

Note: On Ubuntu 24.04 with *Shrike*, older Noetic packages may depend on Python 2, while only Python 3 is installed. To resolve this compatibility issue, create a symbolic link:

```
sudo ln -s /usr/bin/python3 /usr/bin/python
```

- Visualize the TF tree using:

```
rosrun rqt_tf_tree rqt_tf_tree
```

The visualization shows three coordinate frames: *world* (parent), *turtle1*, and *turtle2*.

- Inspect transformations in real time:

```
rosrun tf tf_echo /turtle1 /turtle2
```

- The resulting output is illustrated in Figure 5.

5. Using *RViz*

Run the following command to launch *RViz*:

```
LIBGL_ALWAYS_SOFTWARE=1 rviz
```

Software rendering is required because *RViz* relies on OpenGL, which may not be fully supported in virtualized environments. The visualization result is shown in Figure 6.

Notice: Modify the `view_frames` script for Python 3.x compatibility:

```
try:
    vstr = subprocess.Popen(args, stdout=subprocess.PIPE,
                           stderr=subprocess.STDOUT).communicate()[0]
    vstr = vstr.decode('utf-8')
except OSError as ex:
    print("Warning: Could not execute `dot -V`. Is graphviz installed?")
    sys.exit(-1)

v = distutils.version.StrictVersion('2.16')
r = re.compile(r".*version (\d+\.\?\d*)")
print(vstr)
m = r.search(vstr)
```

2.2.3 Observations

- *ROS* Master

```

parallels@ubuntu-linux-2404:~$ roscore
... logging to /home/parallels/.ros/log/81a8cb0a-bf87-11f0-94ca-001c42d84326/roslaunch-ubuntu-linux-2404-16591.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started rosrun server http://ubuntu-linux-2404:45307/
ros_comm version 1.17.0

SUMMARY
=====

PARAMETERS
* /rosdistro: noetic
* /rosversion: 1.17.0

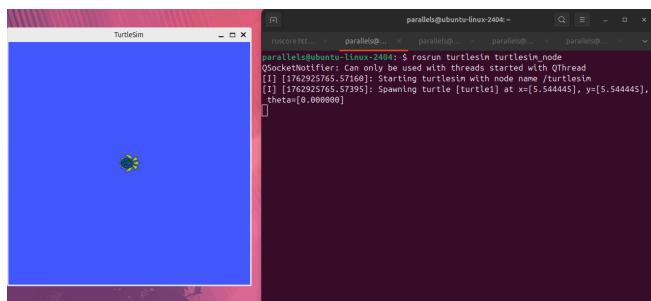
NODES

auto-starting new master
process[master]: started with pid [16602]
ROS_MASTER_URI=http://ubuntu-linux-2404:11311/

```

Figure 2: ROS Master

- *ROS Nodes*



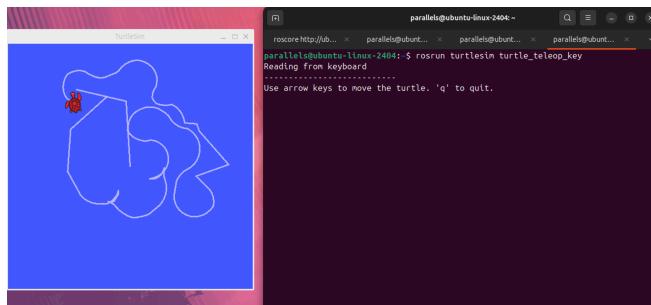
(a) Turtlesim node running

```

parallels@ubuntu-linux-2404:~$ rosnode list
/turtlesim
parallels@ubuntu-linux-2404:~$

```

(b) rosnode list output



(c) Turtle teleop node running

```

parallels@ubuntu-linux-2404:~$ rosnode list
/teleop_turtle
/turtlesim
parallels@ubuntu-linux-2404:~$

```

(d) rosnode list output

Figure 3: ROS nodes

- *ROS Topics*

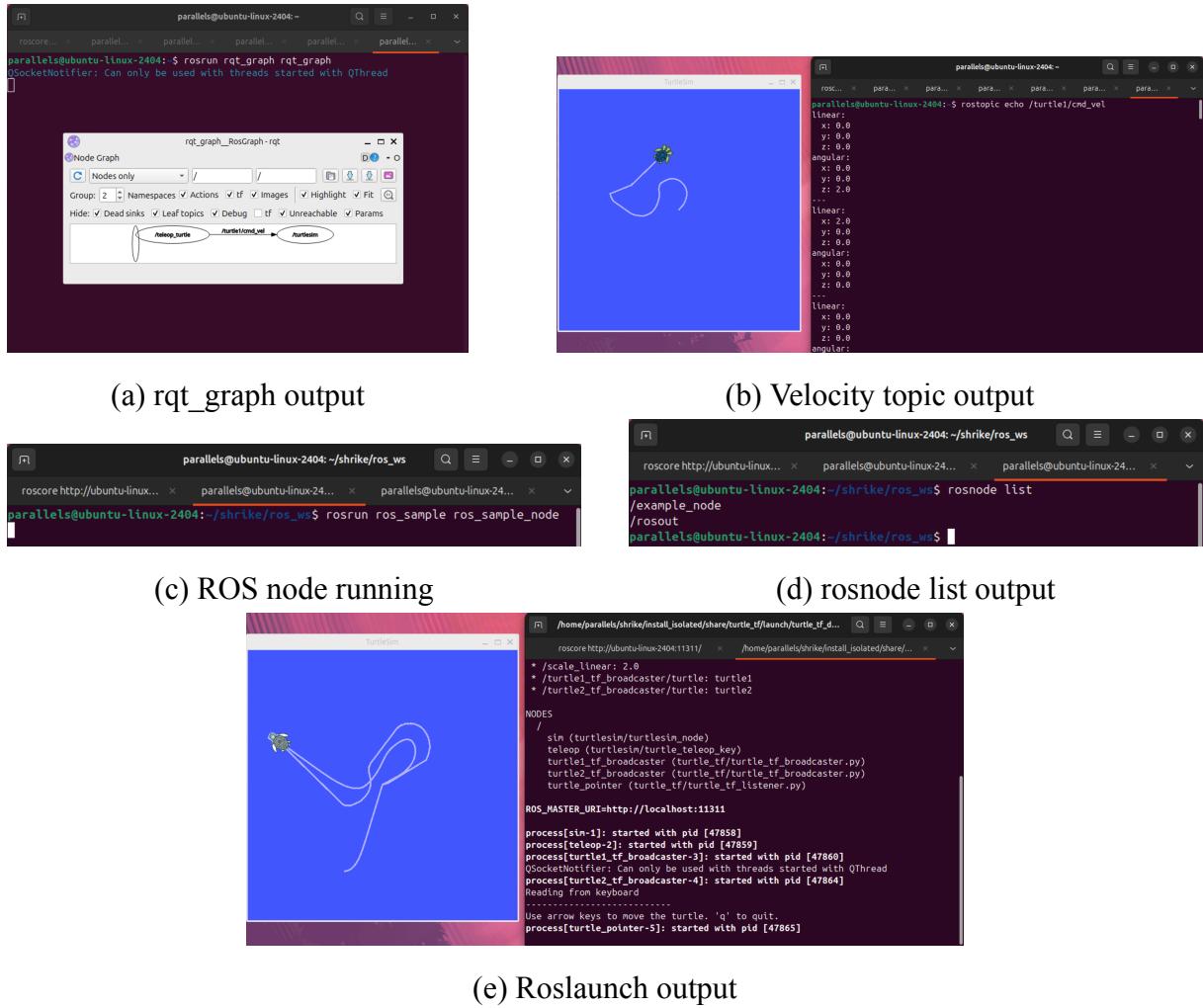


Figure 4: ROS topics

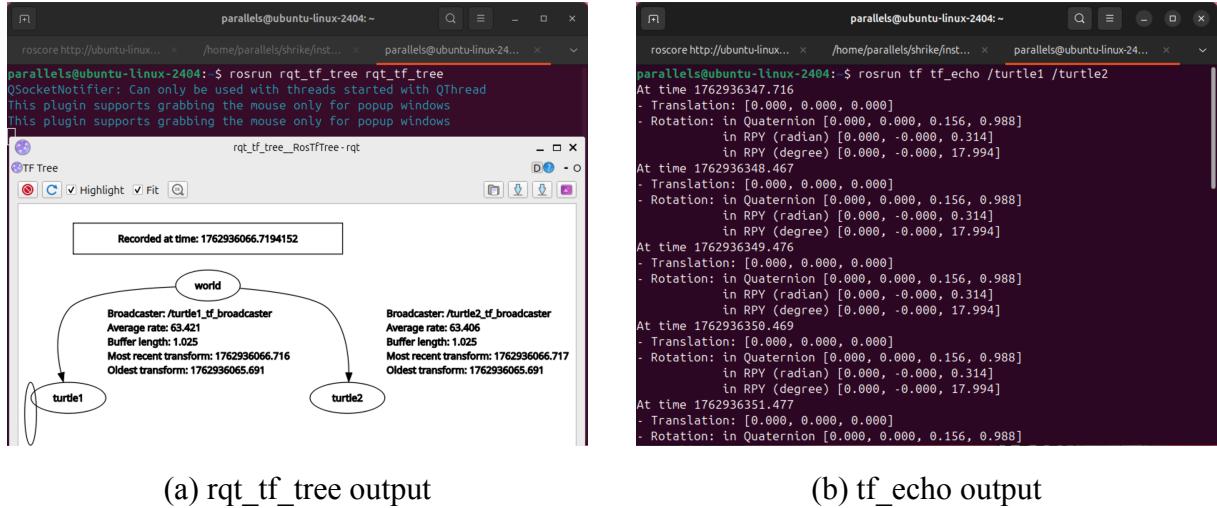


Figure 5: TF tools

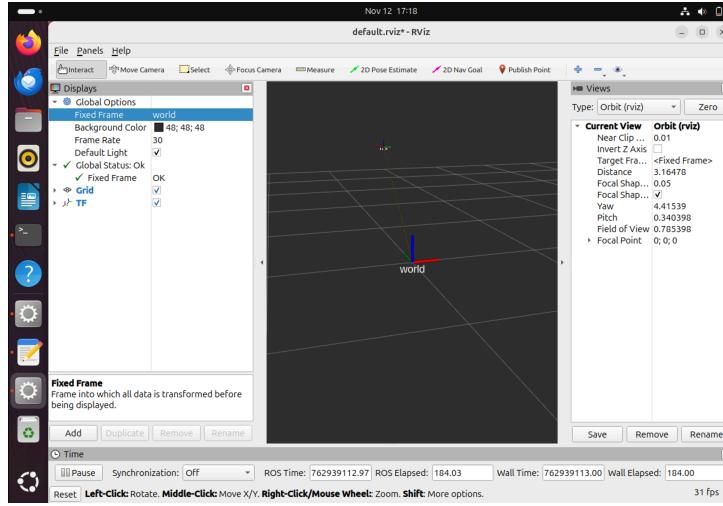


Figure 6: RViz

2.2.4 Discussion

This section demonstrates the core principles of inter-node communication and system visualization within the *ROS* framework. By implementing publisher and subscriber nodes and observing message flow using *rqt_graph* and *rostopic echo*, it becomes clear how topic-based communication enables modular and decoupled node interaction. The ability to monitor live message streams allows developers to validate correct behavior and quickly identify configuration or runtime issues.

The use of *TF* frames further illustrates the importance of coordinate transformation management in robotic systems. The hierarchical relationship among the *world*, *turtle1*, and *turtle2* frames highlights how spatial relationships are maintained and broadcast across the *ROS* network. Tools such as *rqt_tf_tree* and *tf_echo* provide intuitive means of visualizing and debugging frame hierarchies, reinforcing understanding of kinematic relationships and transformation propagation.

Running *RViz* in a virtualized environment emphasizes practical considerations for deploying visualization tools. The need to enforce software rendering with `LIBGL_ALWAYS_SOFTWARE=1` underscores how hardware acceleration and OpenGL support directly affect performance and usability.

2.3 Part III

2.3.1 Objective

To utilize *TF* to control the movement of drones.

2.3.2 Methodology

1. Setting up the workspace

First, create a Catkin workspace named `vnav_ws` under the home directory:

```
mkdir -p ~/vnav_ws/src  
cd ~/vnav_ws/  
catkin init
```

The output should appear as shown in Figure 7. Next, copy the `two_drones_pkg` package into the `src` folder:

```
cp -a /source_path/two_drones_pkg ~/vnav_ws/src
```

Then, build the workspace using:

```
catkin build
```

The build output is shown in Figure 7. After the build completes, source the setup file to refresh the environment:

```
source devel/setup.bash
```

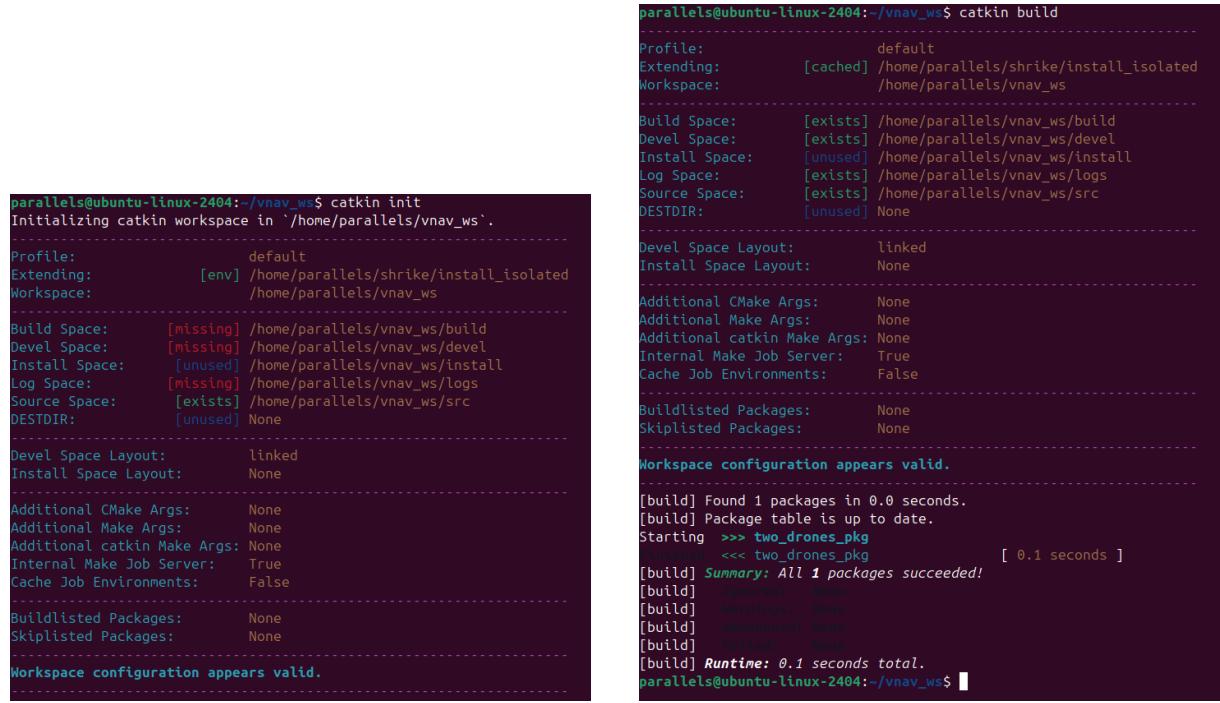
Finally, launch *ROS* to visualize the static drone scene in *RViz*:

```
roslaunch two_drones_pkg two_drones.launch static:=True
```

After adding the *TF* display, three colored axes will appear for each coordinate frame, as illustrated in Figure 8. Remember to save the *RViz* configuration once the setup is complete.

2.

2.3.3 Observations



```

parallels@ubuntu-linux-2404:~/vnav_ws$ catkin init
Initializing catkin workspace in '/home/parallels/vnav_ws'.
...
Profile:           default
Extending:        [env] /home/parallels/shrike/install_isolated
Workspace:        /home/parallels/vnav_ws
...
Build Space:      [missing] /home/parallels/vnav_ws/build
Devel Space:      [missing] /home/parallels/vnav_ws/devel
Install Space:   [unused] /home/parallels/vnav_ws/install
Log Space:        [missing] /home/parallels/vnav_ws/logs
Source Space:    [exists] /home/parallels/vnav_ws/src
DESTDIR:          [unused] None
...
Devel Space Layout: linked
Install Space Layout: None
...
Additional CMake Args: None
Additional Make Args: None
Additional catkin Make Args: None
Internal Make Job Server: True
Cache Job Environments: False
...
Buildlisted Packages: None
Skiplisted Packages: None
...
Workspace configuration appears valid.
...
[build] Found 1 packages in 0.0 seconds.
[build] Package table is up to date.
Starting >>> two_drones_pkg
[build] <<< two_drones_pkg [ 0.1 seconds ]
[build] Summary: All 1 packages succeeded!
[build]   Ignored: 0 warnings.
[build]   Warnings: 0.
[build]   Abandoned: 0.
[build]   Failed: 0.
[build] Runtime: 0.1 seconds total.
parallels@ubuntu-linux-2404:~/vnav_ws$ 

```

(a) catkin init

(b) catkin build

Figure 7: catkin init & build

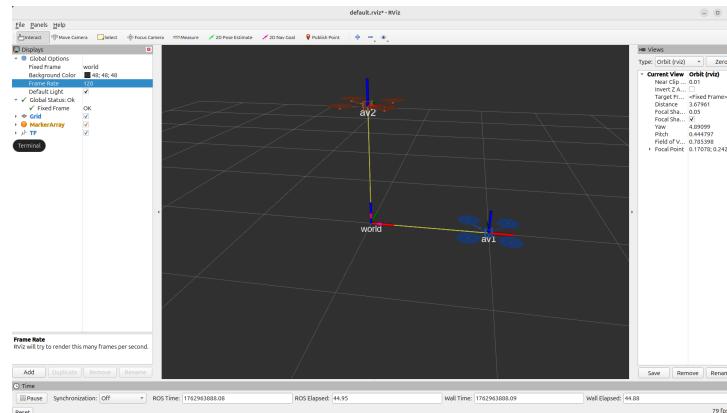


Figure 8: Two drones

2.3.4 Discussion

2.4 Part IV

2.4.1 Objective

2.4.2 Methodology

2.4.3 Observations

2.4.4 Discussion

3 Reflection and Analysis

4 Conclusion

5 Source Code