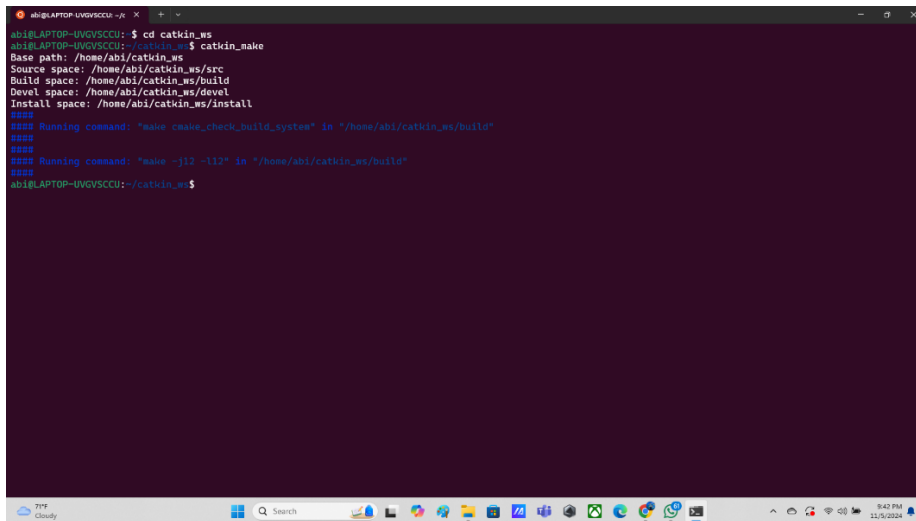


Nama : Ketut Satria Wibisana
NIM : 1103213148
Kelas : TK-45-G09

Implementasi dan Simulasi Probabilistic Roadmap (PRM) dengan Python

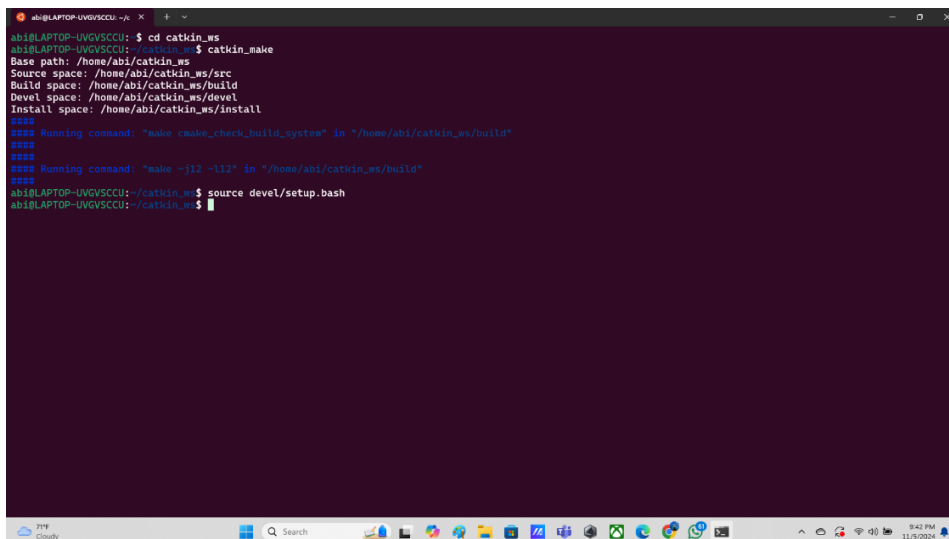
1. Gunakan perintah **cd catkin_ws** untuk masuk ke direktori workspace ROS, lalu jalankan **catkin_make** untuk membangun workspace tersebut. Kedua syntax ini berfungsi memastikan semua file konfigurasi dan dependensi ROS berada dalam kondisi siap digunakan



```
abi@LAPTOP-UNGVSCCU: ~$ cd catkin_ws
abi@LAPTOP-UNGVSCCU: ~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install

#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UNGVSCCU: ~/catkin_ws$
```

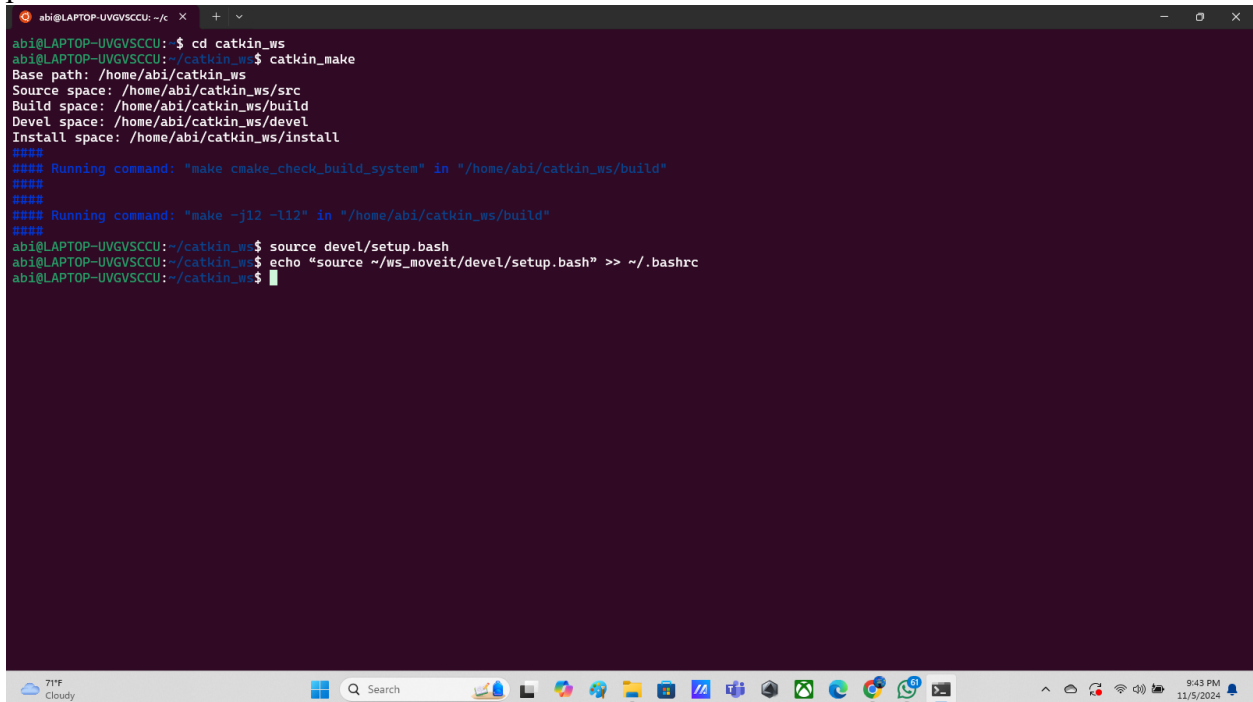
2. Gunakan perintah **source devel/setup.bash** untuk mengaktifkan workspace yang baru saja dibuat. Perintah ini memastikan bahwa semua konfigurasi dan lingkungan ROS siap digunakan dalam terminal saat ini.



```
abi@LAPTOP-UNGVSCCU: ~$ cd catkin_ws
abi@LAPTOP-UNGVSCCU: ~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install

#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UNGVSCCU: ~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UNGVSCCU: ~/catkin_ws$
```

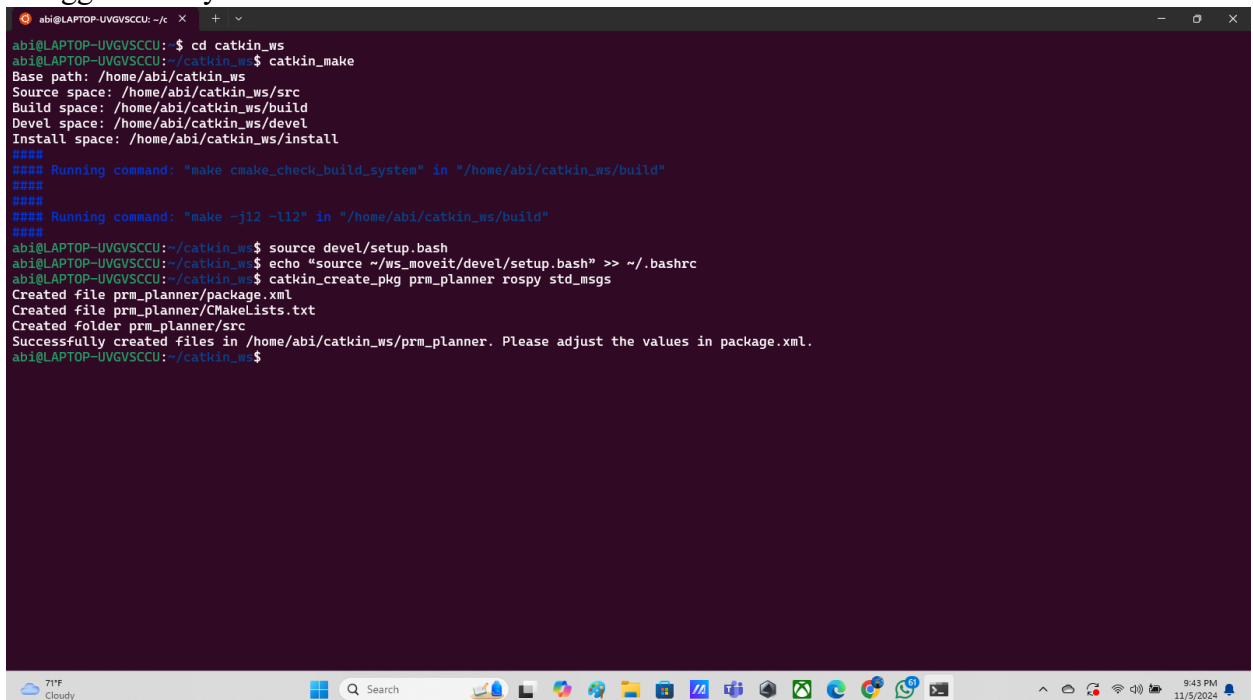
3. Gunakan perintah `echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc` untuk menambahkan perintah sourcing secara otomatis ke dalam file konfigurasi `.bashrc`. Dengan cara ini, setiap kali terminal dibuka, workspace ROS akan aktif tanpa perlu mengetik ulang perintah tersebut.



```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install

####
#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
abi@LAPTOP-UVGVSCCU:~/catkin_ws$
```

4. Gunakan perintah `catkin_create_pkg prm_planner rospy std_msgs` untuk membuat package ROS bernama `prm_planner` tanpa dependensi `matplotlib`. Syntax ini menghasilkan package baru dengan dependensi `rospy` dan `std_msgs`, yang diperlukan untuk komunikasi dalam ROS menggunakan Python.



```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install

####
#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_create_pkg prm_planner rospy std_msgs
Created file prm_planner/package.xml
Created file prm_planner/CMakeLists.txt
Created folder prm_planner/src
Successfully created files in /home/abi/catkin_ws/prm_planner. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws$
```

5. Jalankan perintah **cd prm_planner** untuk masuk ke direktori package baru dan mulai mengelola atau mengedit file yang terkait dengan package **prm_planner** tersebut.

```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_create_pkg prm_planner rospy std_msgs
Created file prm_planner/package.xml
Created file prm_planner/CMakeLists.txt
Created folder prm_planner/src
Successfully created files in /home/abi/catkin_ws/prm_planner. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd prm_planner
abi@LAPTOP-UVGVSCCU:~/catkin_ws/prm_planner$
```

6. Jalankan perintah **nano ~/catkin_ws/src/prm_planner/src/prm.py** untuk membuat file **prm.py**, yang akan digunakan sebagai tempat menulis kode simulasi untuk PRM. Dengan perintah ini, editor nano akan terbuka dan siap untuk penulisan kode PRM langsung di file tersebut.

```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner rospy std_msgs
Created file prm_planner/package.xml
Created file prm_planner/CMakeLists.txt
Created folder prm_planner/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py

abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$
```

7. Tulis kode python untuk melakukan simulasi PRM didalam prm.py

```
GNU nano 4.8 /home/abi/catkin_ws/src/prm_planner/src/prm.py
#!/usr/bin/env python3

import rospy
import numpy as np
import math

class Point:
    def __init__(self, x, y):
        self.x = x
        self.y = y

class Node:
    def __init__(self, x, y, node_id):
        self.point = Point(x, y)
        self.node_id = node_id
        self.neighbors = []

class PRM:
    def __init__(self, x_max, x_min, y_max, y_min, numNodes):
        self.x_max = x_max
        self.y_max = y_max
        self.x_min = x_min
        self.y_min = y_min
        self.numNodes = numNodes
        self.nodes = []
        self.nodes.append(Node(0, 0, 0)) # Start node
        self.nodes.append(Node(18, 18, 1)) # Goal node

    def generateRandomPoints(self, obsVec):
        total = 0
        while total < self.numNodes:
            p = Node(np.random.uniform(self.x_min, self.x_max),
                    np.random.uniform(self.y_min, self.y_max),
                    total + 2)
            if not self.intersectsObs(p.point, p.point, obsVec) and self.isWithinWorld(p.point):
                self.nodes.append(p)
```

- Jalankan syntax **chmod +x ~/catkin_ws/src/prm_planner/src/prm.py** untuk memberikan hak agar dapat mengeksekusi pada prm.py.

```
abi@LAPTOP-UVGVSCCU: ~$ cd catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install

####
#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner rospy std_msgs
Created file prm_planner/package.xml
Created file prm_planner/CMakeLists.txt
Created folder prm_planner/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py

abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ chmod +x ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$
```

9. Jalankan syntax **nano ~/catkin_ws/src/prm_planner/config /params.yaml** untuk membuat file konfigurasi params.yaml.

```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner rospy std_msgs
Created file prm_planner/package.xml
Created file prm_planner/CMakeLists.txt
Created folder prm_planner/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py

abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ chmod +x ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config /params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config /params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$
```

10. Tulis pengaturan yang dibutuhkan untuk PRM di dalam params.yaml.

```
GNU nano 4.8 /home/abi/catkin_ws/src/prm_planner/config/params.yaml
numNodes: 50
x_max: 20
x_min: 0
y_max: 20
y_min: 0

[ Read 5 lines (Converted from DOS format) ]
^G Get Help      ^O Write Out    ^W Where Is     ^K Cut Text     ^J Justify      ^C Cur Pos     ^U Undo         ^A Mark Text    ^I To Bracket
^X Exit          ^R Read File    ^_ Replace      ^U Paste Text   ^T To Spell    ^_ Go To Line  ^E Redo        ^M Copy Text   ^_ Where Was
```

11. Jalankan syntax **nano ~/catkin_ws/src/prm_planner/launch/prm.launch** untuk membuat file launch prm.launch.

```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner rospy std_msgs
Created file prm_planner/package.xml
Created file prm_planner/CMakeLists.txt
Created folder prm_planner/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py

abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ chmod +x ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/launch/prm.launch
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$
```

12. Tulis pengaturan untuk menjalankan PRM di dalam prm.launch.

```
GNU nano 4.8 /home/abi/catkin_ws/src/prm_planner/launch/prm.launch
<launch>
<rosparam file="$(find prm_planner)/config/params.yaml" command="load"/>
<node name="prm_node" pkg="prm_planner" type="prm.py" output="screen"/>
</launch>
```

13. Jalankan syntax `cd ~/catkin_ws` untuk kembali ke direktori workspace, dan `catkin_make` untuk membangun kembali workspace setelah penambahan file.

```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ catkin_make
Base path: /home/abi/catkin_ws
Source space: /home/abi/catkin_ws/src
Build space: /home/abi/catkin_ws/build
Devel space: /home/abi/catkin_ws/devel
Install space: /home/abi/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/abi/catkin_ws/build"
####
#### Running command: "make -j12 -l12" in "/home/abi/catkin_ws/build"
####
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ source devel/setup.bash
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner rospy std_msgs
Created file prm_planner/package.xml
Created file prm_planner/CMakeLists.txt
Created folder prm_planner/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py

abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ chmod +x ~/catkin_ws/src/prm_planner/src/prm.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/launch/prm.launch
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ cd ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$
```

14. Jalankan syntax `roslaunch prm_planner prm.launch` untuk menjalankan simulasi PRM dan melihat jalur terpendek di terminal.

```
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/launch/prm.launch
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner$ cd ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ roslaunch prm_planner prm.launch
... logging to /home/abi/.ros/log/0c93afdc-9b88-11ef-a1e9-d78db18dae75/roslaunch-LAPTOP-UVGVSCCU-2198.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 roslaunch server http://LAPTOP-UVGVSCCU:41487/

SUMMARY
=====

PARAMETERS
* /numNodes: 50
* /roscdistro: noetic
* /rosversion: 1.17.0
* /x_max: 20
* /x_min: 0
* /y_max: 20
* /y_min: 0

NODES
/
  prm_node (prm_planner/prm.py)

auto-starting new master
process[master]: started with pid [2208]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 0c93afdc-9b88-11ef-a1e9-d78db18dae75
process[rosout-1]: started with pid [2218]
started core service [/rosout]
process[prm_node-2]: started with pid [2221]
[INFO] [1738819411.211412]: Shortest path found: [1, 43, 10, 45, 12, 3, 0]
[prm_node-2] process has finished cleanly
log file: /home/abi/.ros/log/0c93afdc-9b88-11ef-a1e9-d78db18dae75/prm_node-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
```

15. Jalankan syntax `cd ~/catkin_ws/src` untuk masuk ke direktori src, dan untuk PRM dengan matplotlib, gunakan perintah `catkin_create_pkg prm_planner_matplotlib rospy std_msgs`.

```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src
SUMMARY
=====
PARAMETERS
* /numNodes: 50
* /roscdistro: noetic
* /rosversion: 1.17.0
* /x_max: 20
* /x_min: 0
* /y_max: 20
* /y_min: 0

NODES
/
  prm_node (prm_planner/prm.py)

auto-starting new master
process[master]: started with pid [2208]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 0c93afdc-9b88-11ef-ale9-d78db18dae75
process[rosout-1]: started with pid [2218]
started core service [/rosout]
process[prm_node-2]: started with pid [2221]
[INFO] [1730819411.211412]: Shortest path found: [1, 43, 10, 45, 12, 3, 0]
[prm_node-2] process has finished cleanly
log file: /home/abi/.ros/log/0c93afdc-9b88-11ef-ale9-d78db18dae75/prm_node-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner_matplotlib rospy std_msgs
Created file prm_planner_matplotlib/package.xml
Created file prm_planner_matplotlib/CMakeLists.txt
Created folder prm_planner_matplotlib/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$
```

16. Jalankan syntax `cd prm_planner_matplotlib` untuk masuk ke package baru ini

```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src
SUMMARY
=====
PARAMETERS
* /numNodes: 50
* /roscdistro: noetic
* /rosversion: 1.17.0
* /x_max: 20
* /x_min: 0
* /y_max: 20
* /y_min: 0

NODES
/
  prm_node (prm_planner/prm.py)

auto-starting new master
process[master]: started with pid [2208]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 0c93afdc-9b88-11ef-ale9-d78db18dae75
process[rosout-1]: started with pid [2218]
started core service [/rosout]
process[prm_node-2]: started with pid [2221]
[INFO] [1730819411.211412]: Shortest path found: [1, 43, 10, 45, 12, 3, 0]
[prm_node-2] process has finished cleanly
log file: /home/abi/.ros/log/0c93afdc-9b88-11ef-ale9-d78db18dae75/prm_node-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner_matplotlib rospy std_msgs
Created file prm_planner_matplotlib/package.xml
Created file prm_planner_matplotlib/CMakeLists.txt
Created folder prm_planner_matplotlib/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner_matplotlib
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$
```


17. Jalankan syntax `nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py` untuk membuat file `prm_matplotlib.py`.

```
=====
PARAMETERS
* /numNodes: 50
* /rostdistro: noetic
* /rosversion: 1.17.0
* /x_max: 20
* /x_min: 0
* /y_max: 20
* /y_min: 0

NODES
/
  prm_node (prm_planner/prm.py)

auto-starting new master
process[master]: started with pid [2208]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 0c93afdc-9b88-11ef-ale9-d78db18dae75
process[rosout-1]: started with pid [2218]
started core service [/rosout]
process[prm_node-2]: started with pid [2221]
[INFO] [1738819411.211412]: Shortest path Found: [1, 43, 10, 45, 12, 3, 0]
[prm_node-2] process has finished cleanly
log file: /home/abi/.ros/log/0c93afdc-9b88-11ef-ale9-d78db18dae75/prm_node-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner_matplotlib rospy std_msgs
Created file prm_planner_matplotlib/package.xml
Created file prm_planner_matplotlib/CMakeLists.txt
Created folder prm_planner_matplotlib/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner_matplotlib
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$
```

18. Tulis kode Python untuk simulasi PRM dengan visualisasi matplotlib di dalam `prm_matplotlib.py`.

```
GNU nano 4.8 /home/abi/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
#!/usr/bin/env python3
import rospy
import numpy as np
import math
import matplotlib.pyplot as plt

class Point:
    def __init__(self, x, y):
        self.x = x
        self.y = y

class Node:
    def __init__(self, x, y, node_id):
        self.point = Point(x, y)
        self.node_id = node_id
        self.neighbors = []

class PRM:
    def __init__(self, x_max, x_min, y_max, y_min, numNodes):
        self.x_max = x_max
        self.y_max = y_max
        self.x_min = x_min
        self.y_min = y_min
        self.numNodes = numNodes
        self.nodes = []
        self.nodes.append(Node(0, 0, 0)) # Start node
        self.nodes.append(Node(18, 18, 1)) # Goal node

    def generateRandomPoints(self, obsVec):
        total = 0
        while total < self.numNodes:
            p = Node(np.random.uniform(self.x_min, self.x_max),
                    np.random.uniform(self.y_min, self.y_max),
                    total + 1)
            if not self.intersectsObs(p.point, obsVec) and self.isWithinWorld(p.point):
                self.nodes.append(p)
                total += 1

    def intersectsObs(self, p, obsVec):
        for obs in obsVec:
            if obs.x == p.x and obs.y == p.y:
                return True
        return False

    def isWithinWorld(self, p):
        return p.x >= self.x_min and p.x <= self.x_max and p.y >= self.y_min and p.y <= self.y_max
```

19. Jalankan syntax `chmod +x ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py` untuk memberikan hak eksekusi pada `prm_matplotlib.py`.

```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src
PARAMETERS
* /numNodes: 50
* /roscdistro: noetic
* /rosversion: 1.17.0
* /x_max: 20
* /x_min: 0
* /y_max: 20
* /y_min: 0

NODES
/
  prm_node (prm_planner/prm.py)

auto-starting new master
process[master]: started with pid [2208]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 0c93afdc-9b88-11ef-a1e9-d78db18dae75
process[rosout-1]: started with pid [2218]
started core service [/rosout]
process[prm_node-2]: started with pid [2221]
[INFO] [1738819411.211412]: Shortest path found: [1, 43, 10, 45, 12, 3, 0]
[prm_node-2] process has finished cleanly
log file: /home/abi/.ros/log/0c93afdc-9b88-11ef-a1e9-d78db18dae75/prm_node-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner_matplotlib rospy std_msgs
Created file prm_planner_matplotlib/package.xml
Created file prm_planner_matplotlib/CMakeLists.txt
Created folder prm_planner_matplotlib/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner_matplotlib
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$ chmod +x ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$
```

20. Jalankan syntax `nano ~/catkin_ws/src/prm_planner_matplotlib/config/params.yaml` untuk membuat file konfigurasi `params.yaml`.

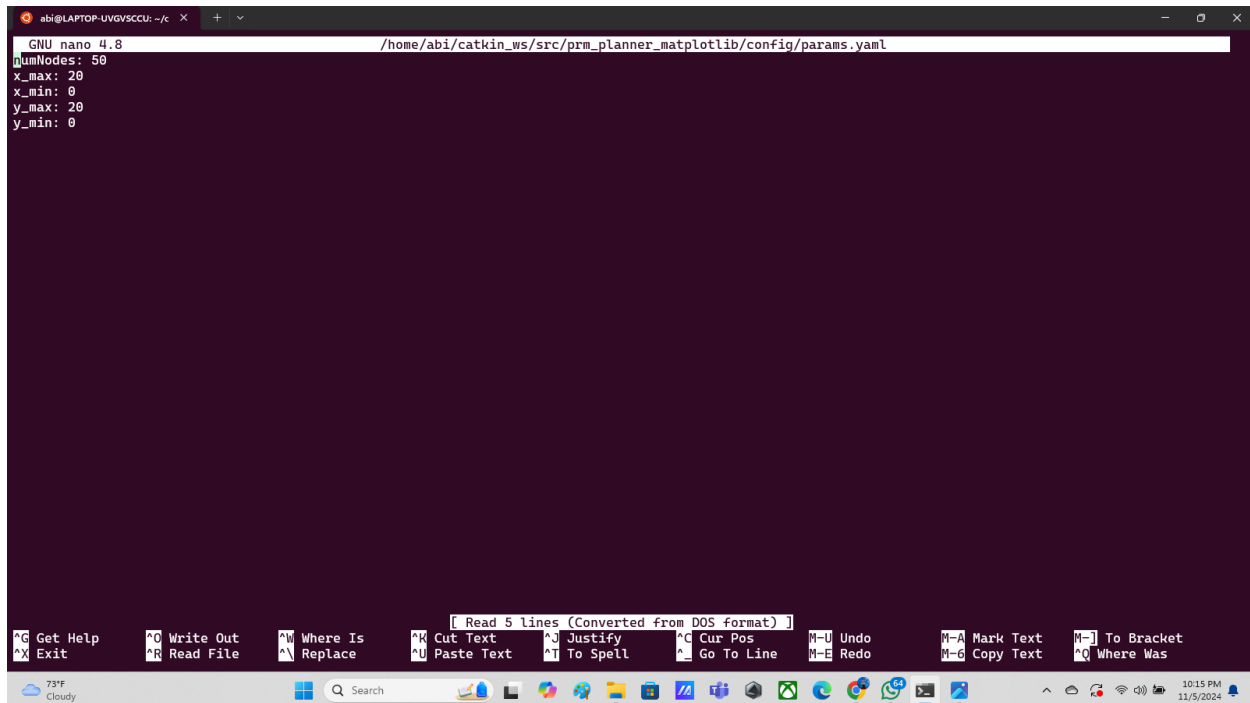
```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src
PARAMETERS
* /numNodes: 50
* /roscdistro: noetic
* /rosversion: 1.17.0
* /x_max: 20
* /x_min: 0
* /y_max: 20
* /y_min: 0

NODES
/
  prm_node (prm_planner/prm.py)

auto-starting new master
process[master]: started with pid [2208]
ROS_MASTER_URI=http://localhost:11311

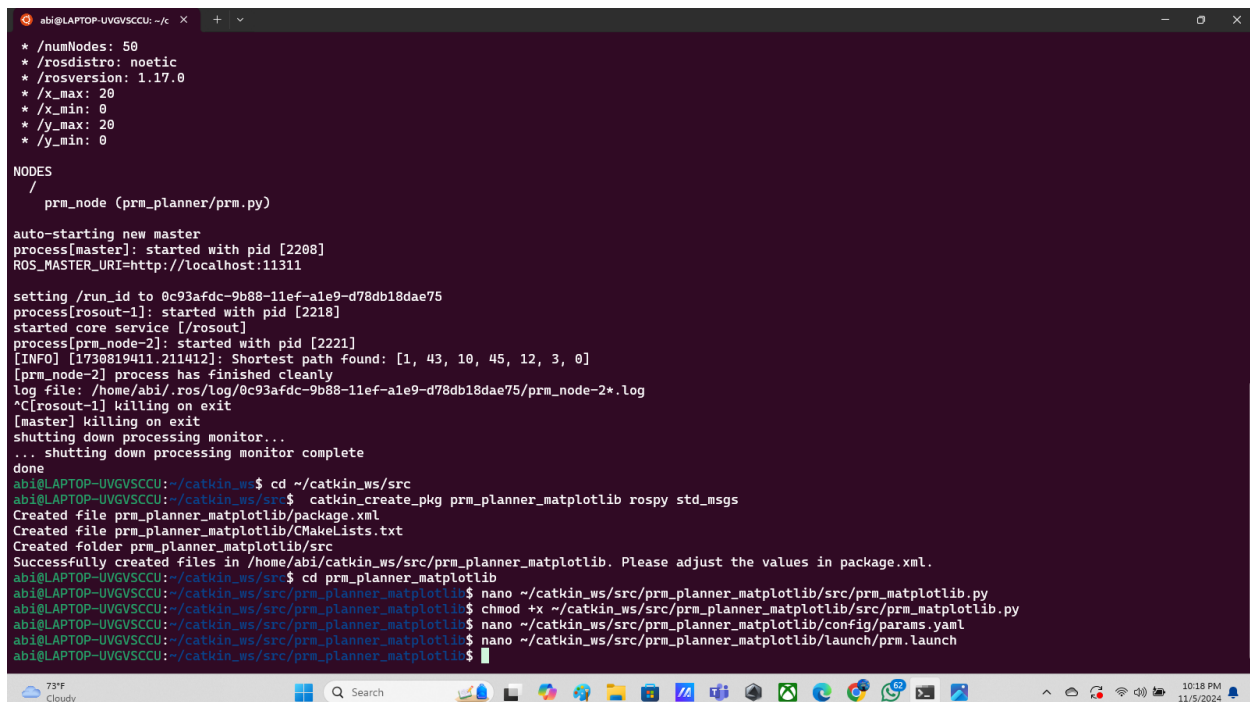
setting /run_id to 0c93afdc-9b88-11ef-a1e9-d78db18dae75
process[rosout-1]: started with pid [2218]
started core service [/rosout]
process[prm_node-2]: started with pid [2221]
[INFO] [1738819411.211412]: Shortest path found: [1, 43, 10, 45, 12, 3, 0]
[prm_node-2] process has finished cleanly
log file: /home/abi/.ros/log/0c93afdc-9b88-11ef-a1e9-d78db18dae75/prm_node-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ catkin_create_pkg prm_planner_matplotlib rospy std_msgs
Created file prm_planner_matplotlib/package.xml
Created file prm_planner_matplotlib/CMakeLists.txt
Created folder prm_planner_matplotlib/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src$ cd prm_planner_matplotlib
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$ chmod +x ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/config/params.yaml
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm_planner_matplotlib$
```

21. Tulis pengaturan yang dibutuhkan untuk PRM dengan matplotlib di dalam params.yaml.



```
GNU nano 4.8 /home/abi/catkin_ws/src/prm_planner_matplotlib/config/params.yaml
numNodes: 50
x_max: 20
x_min: 0
y_max: 20
y_min: 0
```

22. Jalankan syntax `nano ~/catkin_ws/src/prm_planner_matplotlib/launch/prm.launch` untuk membuat file launch prm.launch.



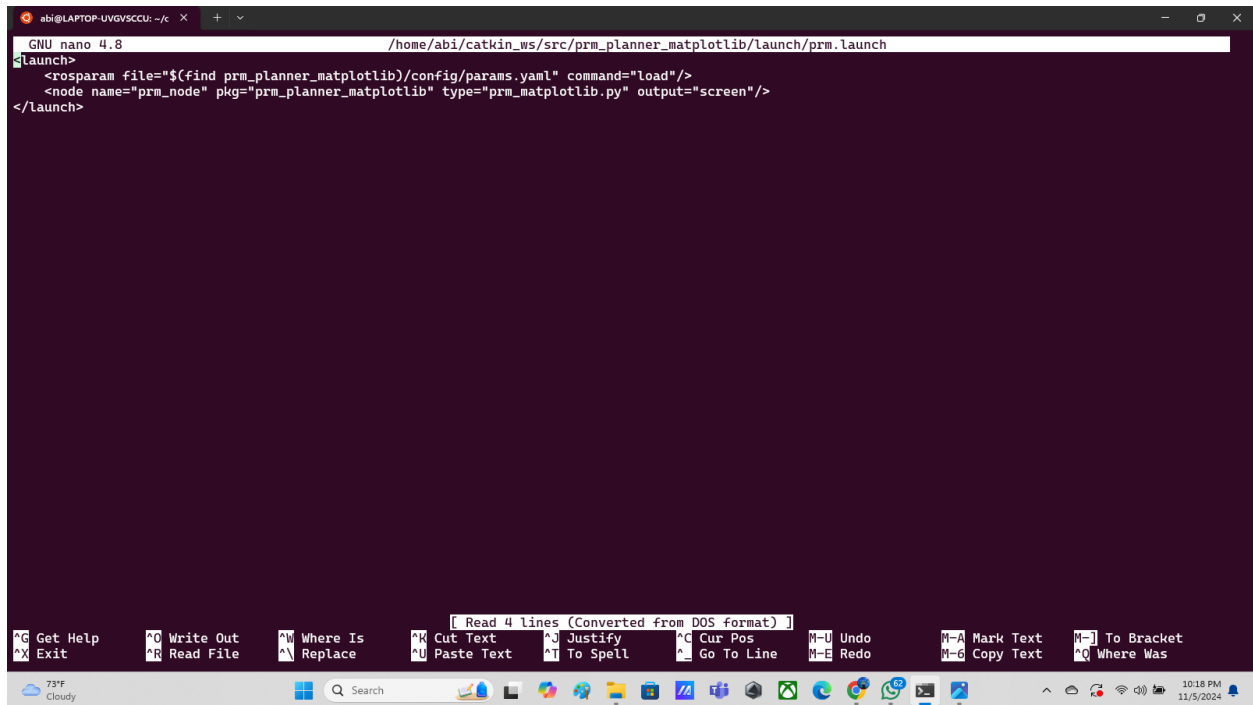
```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src/prm_planner_matplotlib/launch/prm.launch
* /numNodes: 50
* /rosdistro: noetic
* /rosversion: 1.17.0
* /x_max: 20
* /x_min: 0
* /y_max: 20
* /y_min: 0

NODES
/
  prm_node (prm_planner/prm.py)

auto-starting new master
process[master]: started with pid [2208]
ROS_MASTER_URI=http://localhost:11311

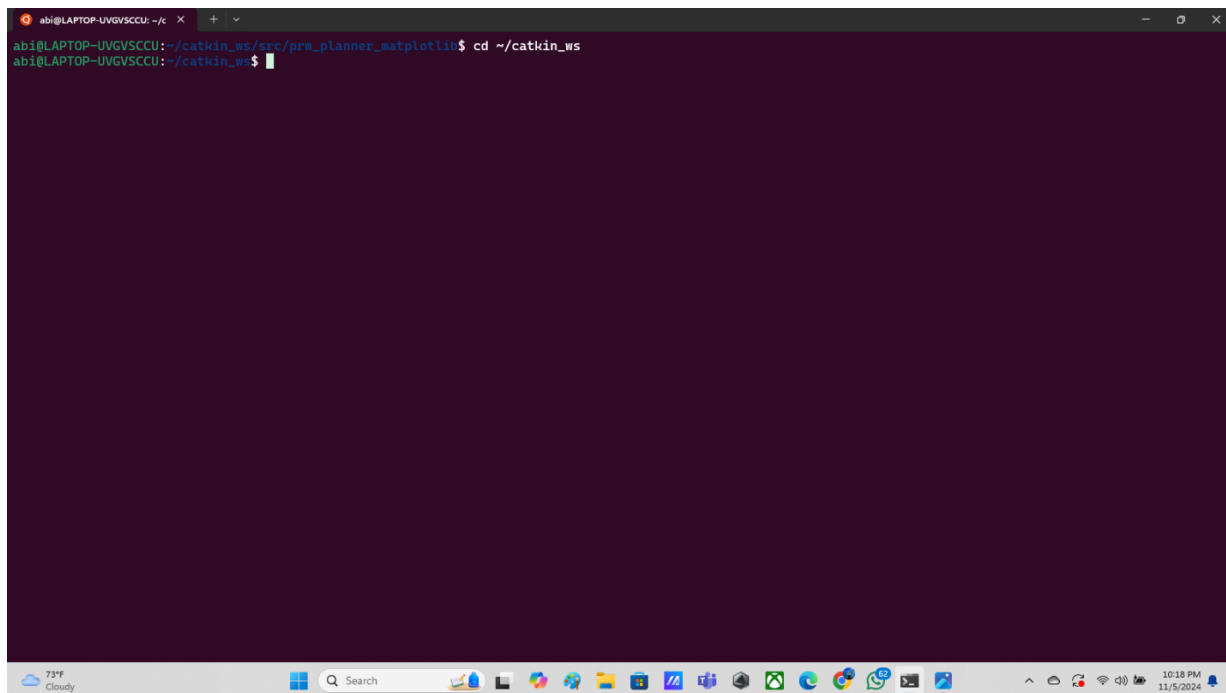
setting /run_id to 0c93afdc-9b88-11ef-a1e9-d78db18dae75
process[rosout-1]: started with pid [2218]
started core service [/rosout]
process[prm_node-2]: started with pid [2221]
[INFO] [1730819411.211412]: Shortest path found: [1, 43, 10, 45, 12, 3, 0]
[prm_node-2] process has finished cleanly
log file: /home/abi/.ros/log/0c93afdc-9b88-11ef-a1e9-d78db18dae75/prm_node-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
abi@LAPTOP-UVGVSCCU: ~/catkin_ws$ cd ~/catkin_ws/src
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src$ catkin_create_pkg prm_planner_matplotlib rospy std_msgs
Created file prm_planner_matplotlib/package.xml
Created file prm_planner_matplotlib/CMakeLists.txt
Created folder prm_planner_matplotlib/src
Successfully created files in /home/abi/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src$ cd prm_planner_matplotlib
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src/prm_planner_matplotlib$ chmod +x ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/config/params.yaml
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/launch/prm.launch
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src/prm_planner_matplotlib$
```

23. Tulis pengaturan untuk menjalankan PRM dengan visualisasi matplotlib di dalam prm.launch.



```
GNU nano 4.8 /home/abi/catkin_ws/src/prm_planner_matplotlib/launch/prm.launch
<launch>
<rosparam file="$(find prm_planner_matplotlib)/config/params.yaml" command="load"/>
<node name="prm_node" pkg="prm_planner_matplotlib" type="prm_matplotlib.py" output="screen"/>
</launch>
```

24. Jalankan syntax **cd ~/catkin_ws** untuk kembali ke workspace, dan **catkin_make** untuk membangun ulang setelah menambahkan file baru.



```
abi@LAPTOP-UVGVSCCU: ~/catkin_ws/src/prm_planner_matplotlib$ cd ~/catkin_ws
abi@LAPTOP-UVGVSCCU: ~/catkin_ws$
```

25. Jalankan syntax **roslaunch prm_planner_matplotlib prm.launch** untuk menjalankan simulasi PRM dengan matplotlib dan melihat jalur terpendek di terminal.

```
abi@LAPTOP-UVGVSCCU:~/catkin_ws/src/prm$ cd ~/catkin_ws
abi@LAPTOP-UVGVSCCU:~/catkin_ws$ roslaunch prm_planner_matplotlib prm.launch
... logging to /home/abi/.ros/log/4af47d78-9b89-11ef-afe9-d78db18dae75/roslaunch-LAPTOP-UVGVSCCU-2325.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 roslaunch server http://LAPTOP-UVGVSCCU:39205/

SUMMARY
=====

PARAMETERS
* /numNodes: 50
* /rosdistro: noetic
* /rosversion: 1.17.0
* /x_max: 20
* /x_min: 0
* /y_max: 20
* /y_min: 0

NODES
/
  prm_node (prm_planner_matplotlib/prm_matplotlib.py)

auto-starting new master
process[master]: started with pid [2333]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 4af47d78-9b89-11ef-afe9-d78db18dae75
process[rosout-1]: started with pid [2343]
started core service [/rosout]
process[prm_node-2]: started with pid [2347]
[INFO] [1738819945.596272]: Shortest path found: [1, 43, 17, 30, 48, 49, 0]
```

