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## Implementasi dan Simulasi Probabilistic Roadmap (PRM) dengan Python

1. **cd catkin\_ws** untuk masuk ke direktori workspace ROS, dan **catkin\_make** untuk membangun workspace.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd catkin_ws
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
###
###
### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
###
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$
```

2. **source devel/setup.bash** untuk mengaktifkan workspace yang telah dibuat.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd catkin_ws
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
###
###
### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
###
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$
```

3. **echo "source ~/ws\_moveit/devel/setup.bash" >> ~/.bashrc** untuk menambahkan perintah sourcing otomatis setiap kali terminal dibuka.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd catkin_ws
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
####
#### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
####
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$
```

4. Untuk PRM tanpa matplotlib, gunakan perintah **catkin\_create\_pkg prm\_planner rospy std\_msgs** untuk membuat package ROS prm\_planner dengan dependensi rospy dan std\_msgs.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd catkin_ws
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
####
#### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
####
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ cd ~/catkin_ws/src
fadhildz@DESKTOP-IMTGFNL:~/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/fadhildz/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws/src$
```

5. **cd prm\_planner** untuk masu ke direktori package baru.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd catkin_ws
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
####
####
#### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
####
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ cd ~/catkin_ws/src
fadhildz@DESKTOP-IMTGFNL:~/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/fadhildz/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws/src$ cd prm_planner
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws/src/prm_planner$
```

6. **nano ~/catkin\_ws/src/prm\_planner/src/prm.py** untuk membuat file prm.py sebagai tempat menuliskan kode simulasi PRM.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd catkin_ws
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
####
####
#### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
####
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ cd ~/catkin_ws/src
fadhildz@DESKTOP-IMTGFNL:~/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/fadhildz/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws/src$ cd prm_planner
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws/src/prm_planner$
```

7. Tulis kode Python untuk melakukan simulasi PRM di dalam prm.py.

```
GNU nano 4.8 /home/fadhildz/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)
                total += 1

    def computeNeighborGraph(self, obsVec):
        [ Read 95 lines ]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos ^M-A Mark Text ^M-] To Bracket
^X Exit ^R Read File ^\ Replace ^U Paste Text ^T To Spell ^_ Go To Line ^M-E Redo ^M-G Copy Text ^_ Where Was
```

8. `chmod +x ~/catkin_ws/src/prm_planner/src/prm.py` untuk memberikan hak eksekusi pada prm.py.

```
fadhildz@DESKTOP-INTGFNL:~$ cd catkin_ws
fadhildz@DESKTOP-INTGFNL:~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
####
####
#### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
####
fadhildz@DESKTOP-INTGFNL:~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-INTGFNL:~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
fadhildz@DESKTOP-INTGFNL:~/catkin_ws$ cd ~/catkin_ws/src
fadhildz@DESKTOP-INTGFNL:~/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/fadhildz/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src$ cd prm_planner
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner$ chmod +x ~/catkin_ws/src/prm_planner/src/prm.py
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner$
```

9. `nano ~/catkin_ws/src/prm_planner/config/params.yaml` untuk membuat file konfigurasi `params.yaml`.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd catkin_ws
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
#### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
####
#### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
####
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ cd ~/catkin_ws/src
fadhildz@DESKTOP-IMTGFNL: ~/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/fadhildz/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src$ cd prm_planner
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src/prm_planner$ chmod +x ~/catkin_ws/src/prm_planner/src/prm.py
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src/prm_planner$
```

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

```
GNU nano 4.8 /home/fadhildz/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     ^M Cut Text     ^J Justify      ^C Cur Pos      M-U Undo        M-A Mark Text   M-] To Bracket
^X Exit          ^R Read File    ^_ Replace      ^P Paste Text   ^T To Spell     ^_ Go To Line   M-E Redo       M-G Copy Text   ^Q Where Was
```

## 11. nano ~/catkin\_ws/src/prm\_planner/launch/prm.launch untuk membuat file launch prm.launch.

```
fadhildz@DESKTOP-INTGFNL: ~$ cd catkin_ws
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
### Running command: "make cmake_check_build_system" in "/home/fadhildz/catkin_ws/build"
####
###
### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
###
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws$ echo "source ~/ws_moveit/devel/setup.bash" >> ~/.bashrc
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws$ cd ~/catkin_ws/src
fadhildz@DESKTOP-INTGFNL: ~/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/fadhildz/catkin_ws/src/prm_planner. Please adjust the values in package.xml.
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws/src$ cd prm_planner
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/src/prm.py
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws/src/prm_planner$ chmod +x ~/catkin_ws/src/prm_planner/src/prm.py
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/config/params.yaml
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws/src/prm_planner$ nano ~/catkin_ws/src/prm_planner/launch/prm.launch
fadhildz@DESKTOP-INTGFNL: ~/catkin_ws/src/prm_planner$
```

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

```
GNU nano 4.8 /home/fadhildz/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>
```

[ Read 4 lines (Converted from DOS format) ]

<b>^G</b> Get Help	<b>^O</b> Write Out	<b>^W</b> Where Is	<b>^R</b> Read File	<b>^M</b> Cut Text	<b>^J</b> Justify	<b>^C</b> Cur Pos	<b>M-U</b> Undo	<b>M-A</b> Mark Text	<b>M-]</b> To Bracket
<b>^X</b> Exit	<b>^R</b> Read File	<b>^W</b> Where Is	<b>^N</b> Replace	<b>^U</b> Paste Text	<b>^T</b> To Spell	<b>^L</b> Go To Line	<b>M-E</b> Redo	<b>M-G</b> Copy Text	<b>^Q</b> Where Was

13. **cd ~/catkin\_ws** untuk kembali ke direktori workspace, dan **catkin\_make** untuk membangun kembali workspace setelah penambahan file.

```
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src/prm_planner$ cd ~/catkin_ws
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ catkin_make
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
#### Running command: "cmake /home/fadhildz/catkin_ws/src -DCATKIN_DEVEL_PREFIX=/home/fadhildz/catkin_ws/devel -DCMAKE_INSTALL_PREFIX=/home/fadhildz/catkin_ws/install -G Unix Makefiles" in "/home/fadhildz/catkin_ws/build"
####
-- Using CATKIN_DEVEL_PREFIX: /home/fadhildz/catkin_ws/devel
-- Using CMAKE_PREFIX_PATH: /home/fadhildz/catkin_ws/devel;/opt/ros/noetic
-- This workspace overlays: /home/fadhildz/catkin_ws/devel;/opt/ros/noetic
-- Found PythonInterp: /usr/bin/python3 (found suitable version "3.8.10", minimum required is "3")
-- Using PYTHON_EXECUTABLE: /usr/bin/python3
-- Using Debian Python package layout
-- Using empy: /usr/lib/python3/dist-packages/em.py
-- Using CATKIN_ENABLE_TESTING: ON
-- Call enable_testing()
-- Using CATKIN_TEST_RESULTS_DIR: /home/fadhildz/catkin_ws/build/test_results
-- Forcing gtest/gmock from source, though one was otherwise available.
-- Found gtest sources under '/usr/src/gtest': gtests will be built
-- Found gmock sources under '/usr/src/gmock': gmock will be built
-- Found PythonInterp: /usr/bin/python3 (found version "3.8.10")
-- Using Python nosetests: /usr/bin/nosetests3
-- catkin 0.8.10
-- BUILD_SHARED_LIBS is on
-- BUILD_SHARED_LIBS is on
-- 
-- traversing 2 packages in topological order:
--   - prm_planner
--   - my_robot_controller
-- 
-- ++ processing catkin package: 'prm_planner'
-- ==> add_subdirectory(prm_planner)
-- ++ processing catkin package: 'my_robot_controller'
-- ==> add_subdirectory(my_robot_controller)
-- Configuring done
-- Generating done
-- Build files have been written to: /home/fadhildz/catkin_ws/build
####
#### Running command: "make -j20 -l20" in "/home/fadhildz/catkin_ws/build"
```

14. **roslaunch prm\_planner prm.launch** untuk menjalankan simulasi PRM dan melihat jalur terpendek di terminal.

```
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ dos2unix ~/catkin_ws/src/prm_planner/src/prm.py
dos2unix: converting file /home/fadhildz/catkin_ws/src/prm_planner/src/prm.py to Unix format...
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ roslaunch prm_planner prm.launch
... logging to /home/fadhildz/.ros/log/4e04a0ae-9596-11ef-8b47-51ac70082bef/roslaunch-DESKTOP-IMTGFNL-2405.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://DESKTOP-IMTGFNL:40977/

SUMMARY
=====

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 [2413]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 4e04a0ae-9596-11ef-8b47-51ac70082bef
process[rosout-1]: started with pid [2423]
started core service [/rosout]
process[prm_node-2]: started with pid [2430]
[INFO] [1730165827.151674]: Shortest path found: [1, 25, 26, 23, 21, 43, 0]
[prm_node-2] process has finished cleanly
log file: /home/fadhildz/.ros/log/4e04a0ae-9596-11ef-8b47-51ac70082bef/prm_node-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$
```

15. **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**.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd ~/catkin_ws/src
fadhildz@DESKTOP-IMTGFNL: ~/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/fadhildz/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src$
```

16. **cd prm\_planner\_matplotlib** untuk masuk ke package baru ini.

```
fadhildz@DESKTOP-IMTGFNL: ~$ cd ~/catkin_ws/src
fadhildz@DESKTOP-IMTGFNL: ~/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/fadhildz/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src$ cd prm_planner_matplotlib
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws/src/prm_planner_matplotlib$
```



17. nano ~/catkin\_ws/src/prm\_planner\_matplotlib/src/prm\_matplotlib.py untuk membuat file prm\_matplotlib.py.

```
fadhildz@DESKTOP-IMTGFNL:~$ cd ~/catkin_ws/src
fadhildz@DESKTOP-IMTGFNL:~/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/fadhildz/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
fadhildz@DESKTOP-IMTGFNL:~/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/fadhildz/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 + 2)
            if not self.intersectsObs(p.point, p.point, obsVec) and self.isWithinWorld(p.point):
                self.nodes.append(p)
                total += 1

    def computeNeighborGraph(self, obsVec):
        Read 118 lines (Converted from DOS format)
        ^G Get Help      ^O Write Out      ^W Where Is      ^M Cut Text      ^J Justify      ^C Cur Pos      ^U Undo      ^A Mark Text      ^] To Bracket
        ^X Exit          ^R Read File      ^\ Replace      ^U Paste Text    ^I To Spell     ^_ Go To Line    ^E Redo      ^G Copy Text      ^Q Where Was
```

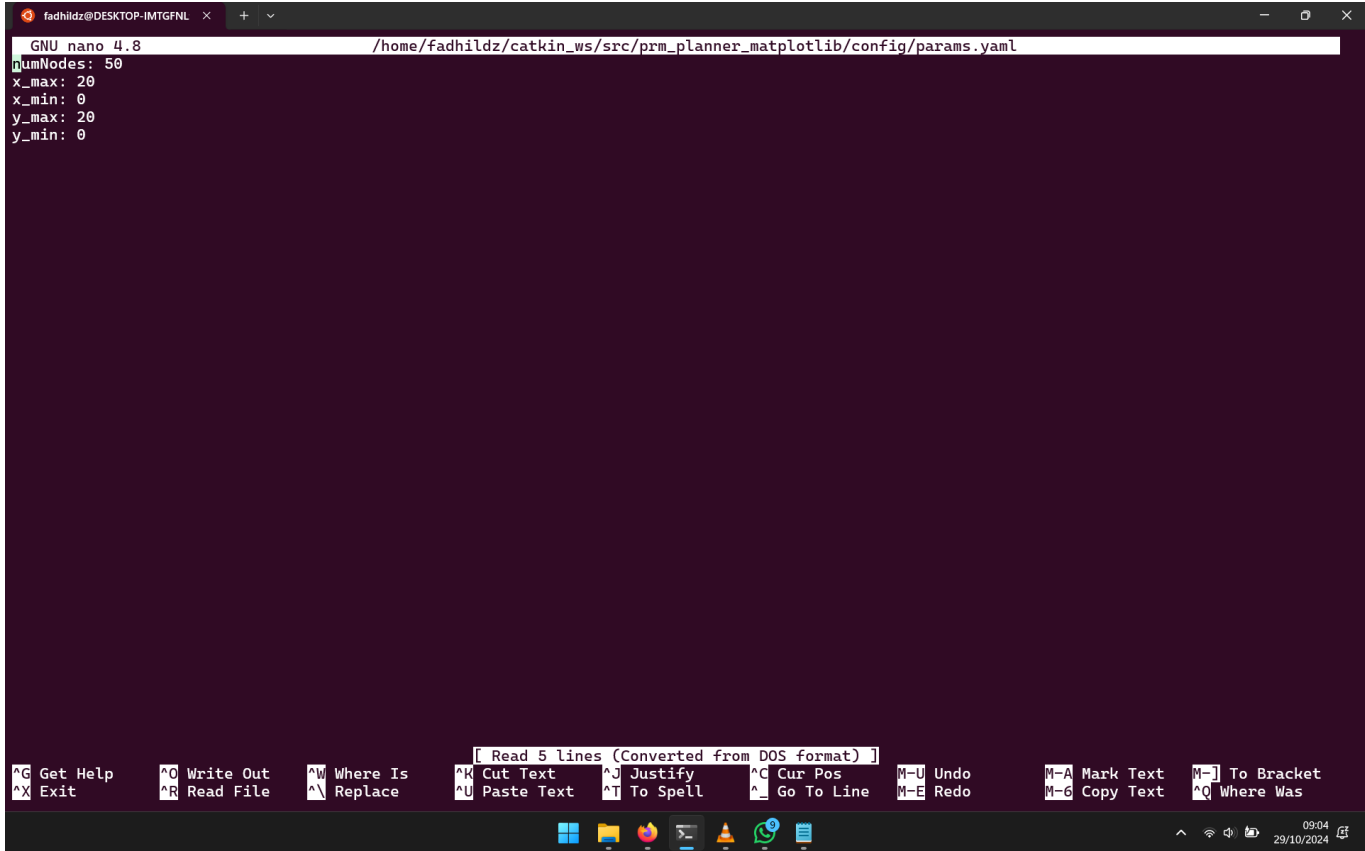
19. `chmod +x ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py` untuk memberikan hak eksekusi pada `prm_matplotlib.py`.

```
fadhildz@DESKTOP-INTGFNL: ~$ cd ~/catkin_ws/src
fadhildz@DESKTOP-INTGFNL:~/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/fadhildz/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ chmod +x ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$
```

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

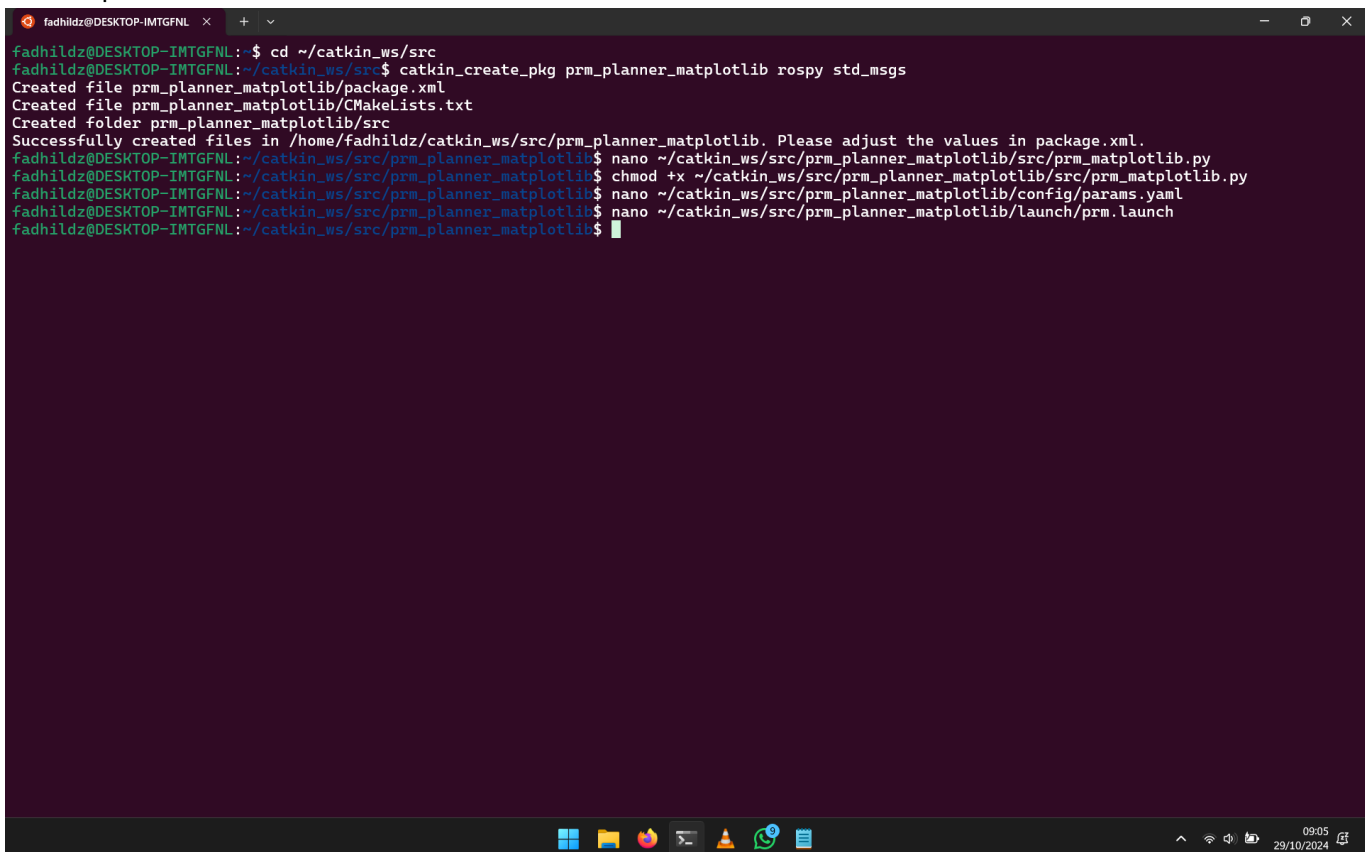
```
fadhildz@DESKTOP-INTGFNL: ~$ cd ~/catkin_ws/src
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src$ catkin_create_pkg prm_planner_matplotlib rospy std_msgs
Created file prm_planner_matplotlib/package.xml
Created file prm_planner_matplotlib/CMakeLists.txt
Created folder prm_planner_matplotlib/src
Successfully created files in /home/fadhildz/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ chmod +x ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/config/params.yaml
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$
```

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



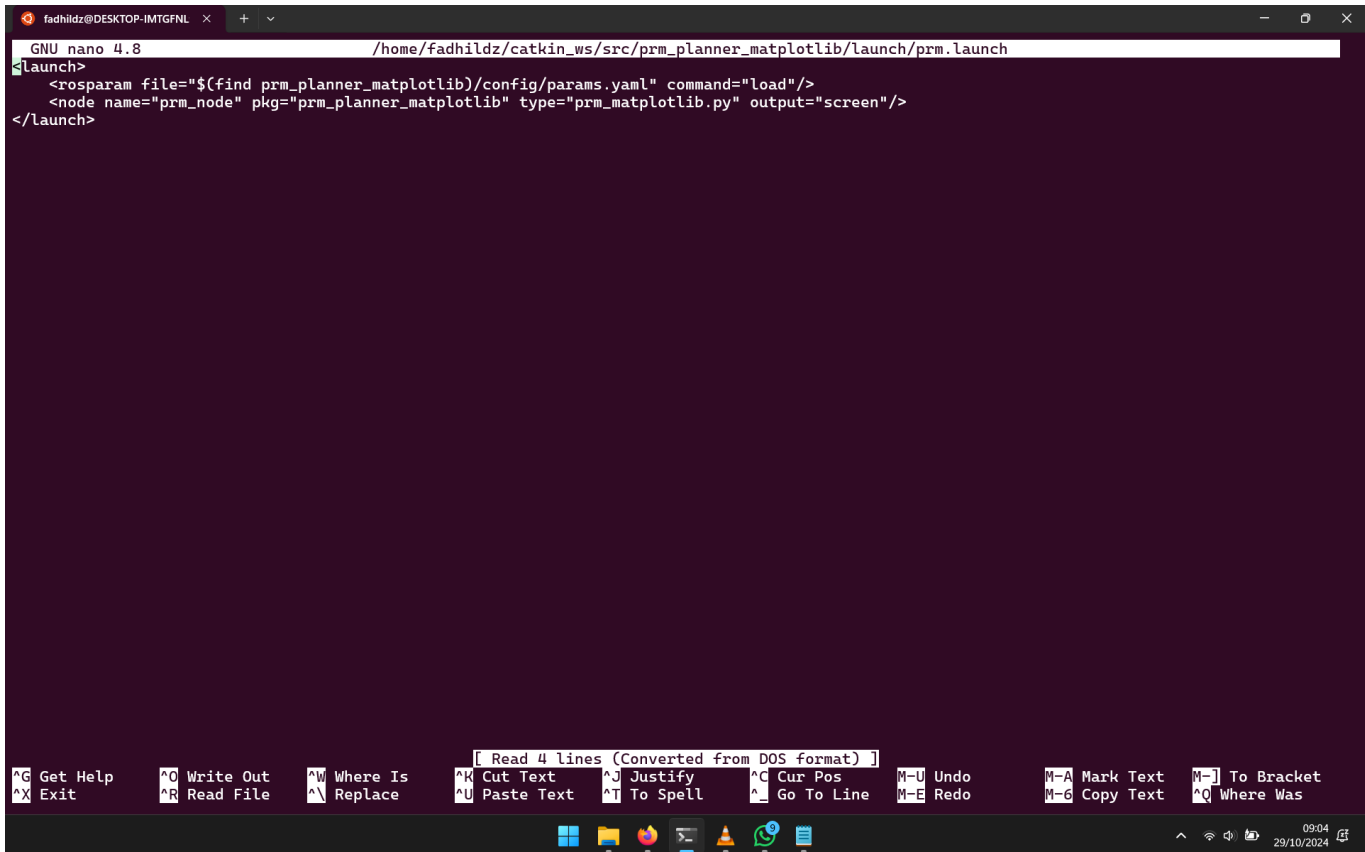
```
GNU nano 4.8 /home/fadhildz/catkin_ws/src/prm_planner_matplotlib/config/params.yaml
numNodes: 50
x_max: 20
x_min: 0
y_max: 20
y_min: 0
```

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



```
fadhildz@DESKTOP-INTGFNL:~$ cd ~/catkin_ws/src
fadhildz@DESKTOP-INTGFNL:~/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/fadhildz/catkin_ws/src/prm_planner_matplotlib. Please adjust the values in package.xml.
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ chmod +x ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/config/params.yaml
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ nano ~/catkin_ws/src/prm_planner_matplotlib/launch/prm.launch
fadhildz@DESKTOP-INTGFNL:~/catkin_ws/src/prm_planner_matplotlib$
```

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

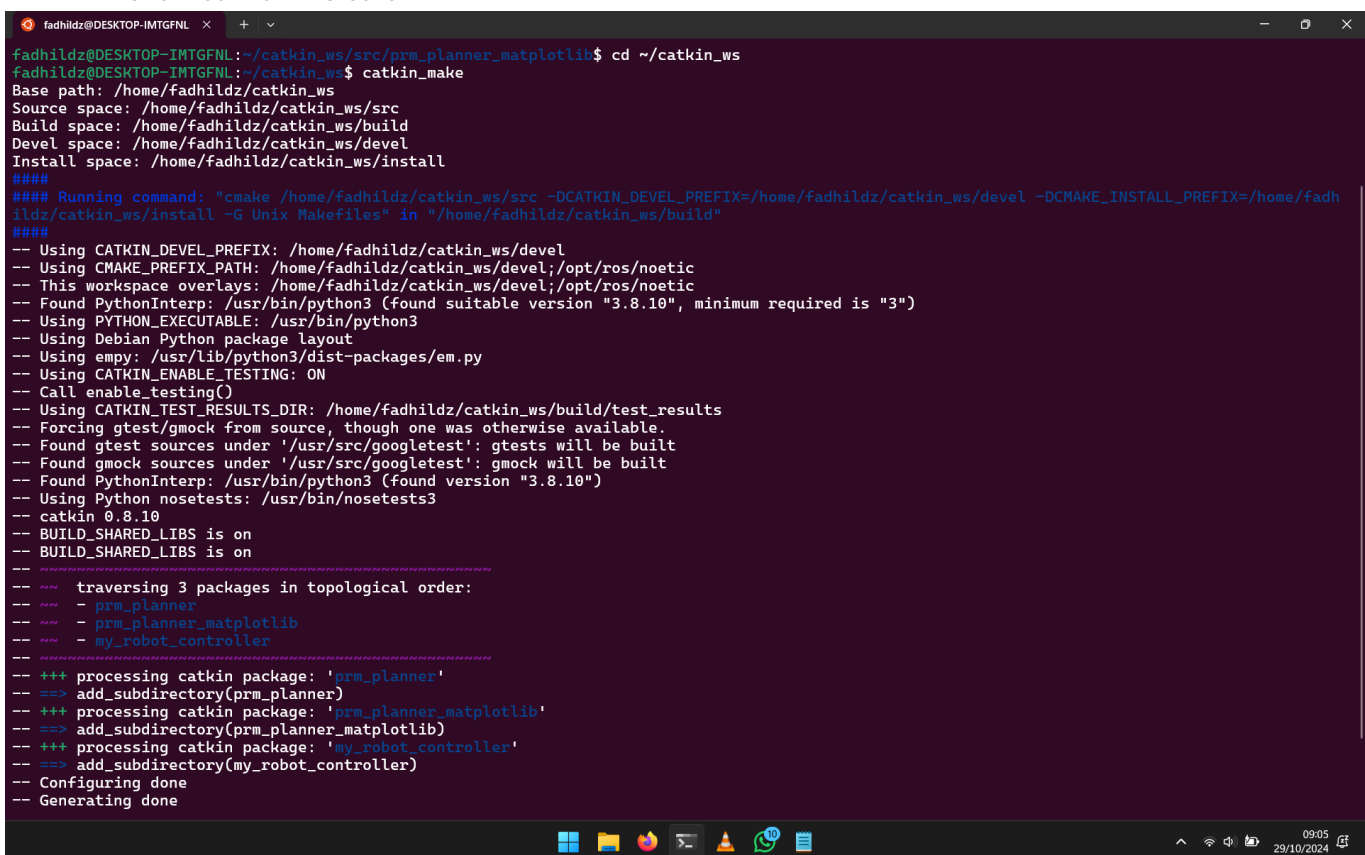


The screenshot shows a terminal window with the nano text editor open. The file being edited is `/home/fadhildz/catkin_ws/src/prm_planner_matplotlib/launch/prm.launch`. The content of the file is as follows:

```
GNU nano 4.8 /home/fadhildz/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>
```

The terminal window has a status bar at the bottom showing various keyboard shortcuts and the current time as 09:04 on 29/10/2024.

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



The screenshot shows a terminal window with the following commands and output:

```
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws/src/prm_planner_matplotlib$ cd ~/catkin_ws
fadhildz@DESKTOP-IMTGFNL:~/catkin_ws$ catkin_make
```

The output of `catkin_make` is as follows:

```
Base path: /home/fadhildz/catkin_ws
Source space: /home/fadhildz/catkin_ws/src
Build space: /home/fadhildz/catkin_ws/build
Devel space: /home/fadhildz/catkin_ws/devel
Install space: /home/fadhildz/catkin_ws/install
####
### Running command: "cmake /home/fadhildz/catkin_ws/src -DCATKIN_DEVEL_PREFIX=/home/fadhildz/catkin_ws/devel -DCMAKE_INSTALL_PREFIX=/home/fadhildz/catkin_ws/install -G Unix Makefiles" in "/home/fadhildz/catkin_ws/build"
####
-- Using CATKIN_DEVEL_PREFIX: /home/fadhildz/catkin_ws/devel
-- Using CMAKE_PREFIX_PATH: /home/fadhildz/catkin_ws/devel;/opt/ros/noetic
-- This workspace overlays: /home/fadhildz/catkin_ws/devel;/opt/ros/noetic
-- Found PythonInterp: /usr/bin/python3 (found suitable version "3.8.10", minimum required is "3")
-- Using PYTHON_EXECUTABLE: /usr/bin/python3
-- Using Debian Python package layout
-- Using empy: /usr/lib/python3/dist-packages/em.py
-- Using CATKIN_ENABLE_TESTING: ON
-- Call enable_testing()
-- Using CATKIN_TEST_RESULTS_DIR: /home/fadhildz/catkin_ws/build/test_results
-- Forcing gtest/gmock from source, though one was otherwise available.
-- Found gtest sources under '/usr/src/gtest': gtests will be built
-- Found gmock sources under '/usr/src/gmock': gmock will be built
-- Found PythonInterp: /usr/bin/python3 (found version "3.8.10")
-- Using Python nosetests: /usr/bin/nosetests3
-- catkin 0.8.10
-- BUILD_SHARED_LIBS is on
-- BUILD_SHARED_LIBS is on
-- traversing 3 packages in topological order:
--   - prm_planner
--   - prm_planner_matplotlib
--   - my_robot_controller
-- ++ processing catkin package: 'prm_planner'
-- ==> add_subdirectory(prm_planner)
-- ++ processing catkin package: 'prm_planner_matplotlib'
-- ==> add_subdirectory(prm_planner_matplotlib)
-- ++ processing catkin package: 'my_robot_controller'
-- ==> add_subdirectory(my_robot_controller)
-- Configuring done
-- Generating done
```

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

```
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ dos2unix ~/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py
dos2unix: converting file /home/fadhildz/catkin_ws/src/prm_planner_matplotlib/src/prm_matplotlib.py to Unix format...
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ source devel/setup.bash
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$ roslaunch prm_planner_matplotlib prm.launch
... logging to /home/fadhildz/.ros/log/6c64f81a-959a-11ef-8b47-51ac70082bef/roslaunch-DESKTOP-IMTGFNL-2715.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://DESKTOP-IMTGFNL:37467/

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 [2723]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 6c64f81a-959a-11ef-8b47-51ac70082bef
process[rosout-1]: started with pid [2733]
started core service [/rosout]
process[prm_node-2]: started with pid [2740]
[INFO] [1730167597.970216]: Shortest path found: [1, 15, 12, 31, 19, 13, 0]
^C[prm_node-2] killing on exit
[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
fadhildz@DESKTOP-IMTGFNL: ~/catkin_ws$
```

26. Akan terbuka Figure 1 yang berisi visualisasi PRM dengan jalur terpendek menggunakan matplotlib.

