RBE550: Motion Planning

Motion Planning Project 0

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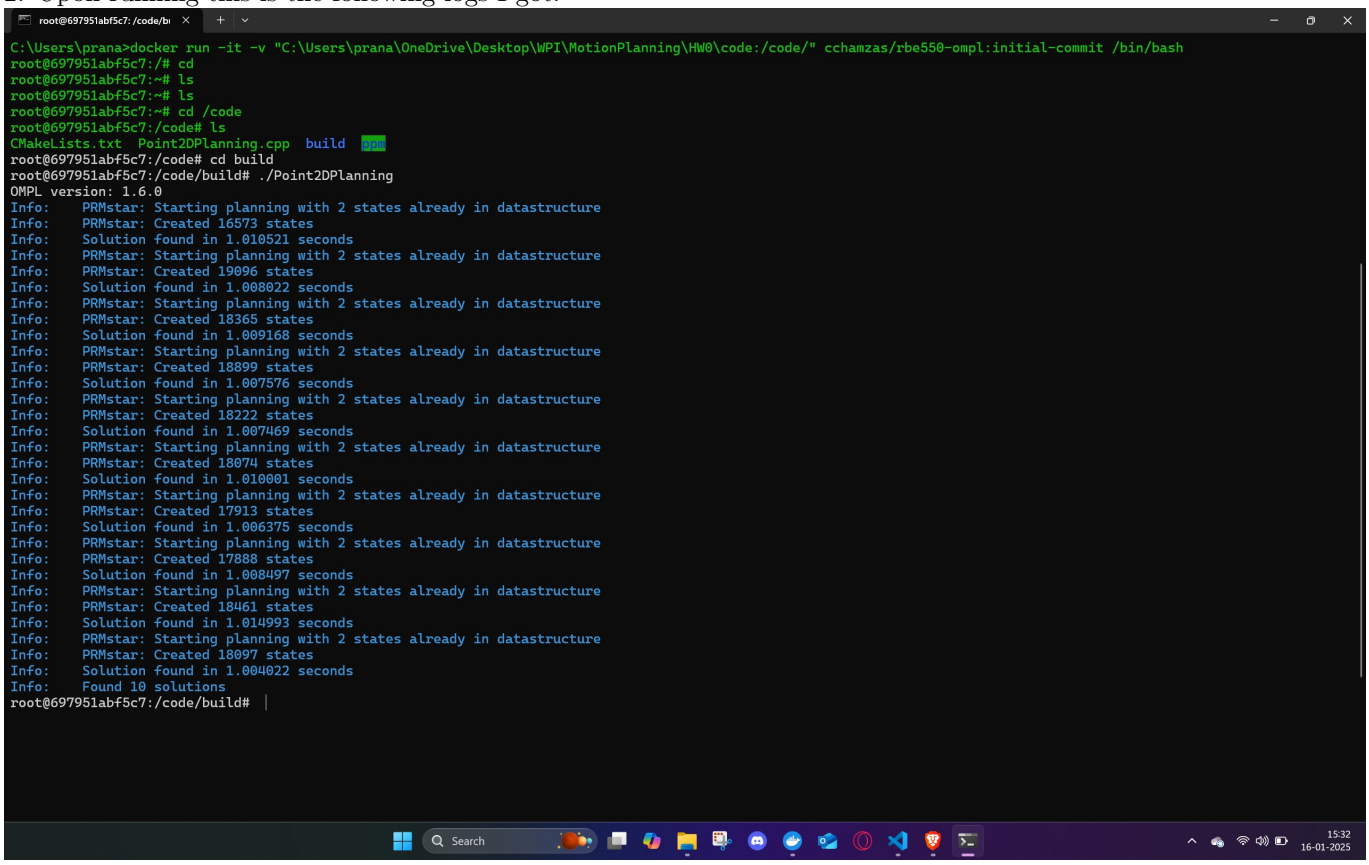
1. I installed the Docker Desktop, as it provided me with GUI and CLI interfaces to work with the docker. the installation process was pretty simple. Then setting up the OMPL, pulling the files from professor's repository and setting the whole folder up took about 45 minutes. Encountered some issues while installation but was able to fix them.

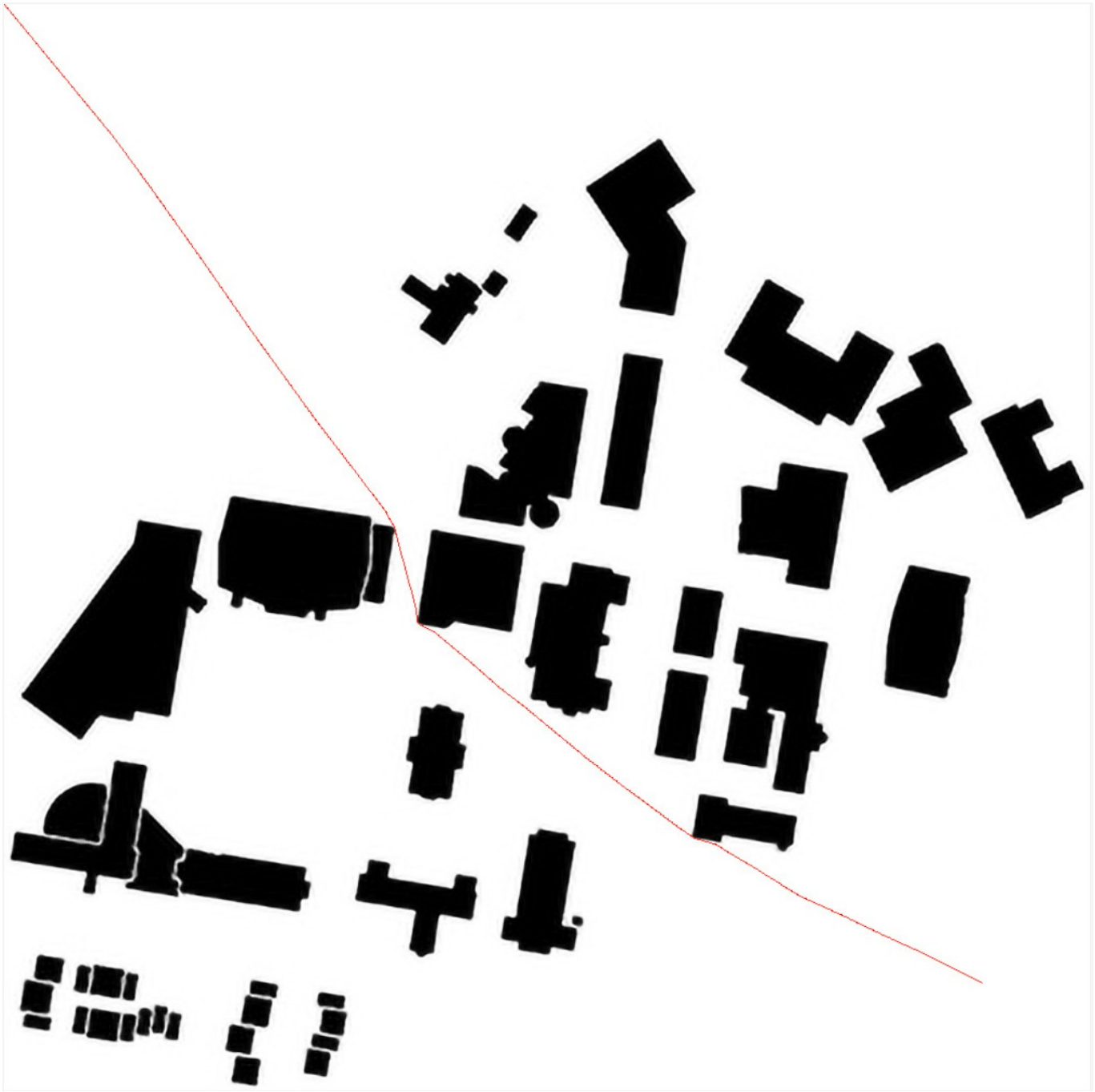
2. Upon running this is the following logs I got:



and the path that was outputted by the PRM* Solver was :

3. within the Main section of the C++ file, I was able to locate the *env.plan*() function that contained the Start and Stop points within the pixel limits of the image. since the PPM file was 1000x1000 I simply had to change the start and stop path to valid coordinates on the map so the new path can be generated.

I changed them to : $0, 0$ and $900, 900$ respectively and got the following path generated for the WPI map.



4. For this part I had to try some demos, I chose PlannerData.cpp and RigidBodyPlanning.py to accommodate for the C++ file I had to modify the CMakeLists.txt file, by adding the

```
add_executable(PlannerData PlannerData.cpp)

target_link_libraries(PlannerData PRIVATE ${OMPL_LIBRARIES})
target_include_directories(PlannerData PRIVATE ${OMPL_INCLUDE_DIRS})
target_link_directories(PlannerData PRIVATE ${OMPL_INCLUDE_DIRS})
```

so that the relevant dependencies could be used while making it. For the python file i didnt require this and simply executed the commands :

```
for the C++ file :
./PlannerData

for the Python File:
python3 RigidBodyPlanning.py
```

The following Log outputs were received respectively :

C++ :

```
    root@167ac7a26dbf:/code/build# ./PlannerData
Info:    No planner specified. Using default.
Info:    LBKPIECE1: Attempting to use default projection.
Debug:   LBKPIECE1: Planner range detected to be 7.242362
Properties of the state space 'SE3CompoundSpace0'
  - signature: 6 5 6 1 3 3 3
  - dimension: 6
  - extent: 36.2118
  - sanity checks for state space passed
  - probability of valid states: 1
  - average length of a valid motion: 15.9585
  - average number of samples drawn per second: sampleUniform()=1.06676e+07 sampleUniformNear()=8.87138e+0
Settings for the state space 'SE3CompoundSpace0'
  - state validity check resolution: 1%
  - valid segment count factor: 1
  - state space:
Compound state space 'SE3CompoundSpace0' of dimension 6 (locked) [
Real vector state space 'RealVectorSpace1' of dimension 3 with bounds:
  - min: -10 -10 -10
  - max: 10 10 10
 of weight 1
SO(3) state space 'SO3Space2' (represented using quaternions)
 of weight 1
]
Registered projections:
  - <default>
Projection of dimension 3
Cell sizes (computed defaults): [1 1 1]

Declared parameters:
longest_valid_segment_fraction = 0.01
projection.cellsize.0 = 1
projection.cellsize.1 = 1
projection.cellsize.2 = 1
projection.cellsize_factor = 0
valid_segment_count_factor = 1
Valid state sampler named uniform with parameters:
nr_attempts = 100
Planner LBKPIECE1 specs:
Multithreaded:                No
Reports approximate solutions: No
Can optimize solutions:       No
Aware of the following parameters: border_fraction min_valid_path_fraction range
Declared parameters for planner LBKPIECE1:
border_fraction = 0.9
min_valid_path_fraction = 0.5
range = 7.24236
Start states:
Compound state [
RealVectorState [-8.1088 -5.16918 3.91752]
SO3State [-0.234488 0.740129 0.629393 0.033008]
]
Goal state, threshold = 2.22045e-16, memory address = 0x558da677a860, state =
Compound state [
RealVectorState [0.0460756 -6.69908 -2.17564]
SO3State [-0.725419 0.297348 0.16137 0.599426]
]
OptimizationObjective = nullptr
```

```
There are 0 solutions
Info:    LBKPIECE1: Starting planning with 1 states already in datastructure
Info:    LBKPIECE1: Created 203 (101 start + 102 goal) states in 197 cells (98 start (98 on boundary) + 99
Info:    Solution found in 0.001509 seconds

Found solution with 132 states and length 581.307
Writing PlannerData to file './myPlannerData'

Reading PlannerData from './myPlannerData'
Found stored solution with 132 states and length 581.307
```

for Python :

```
    root@167ac7a26dbf:/code# python3 RigidBodyPlanning.py

A module that was compiled using NumPy 1.x cannot be run in
NumPy 2.1.0 as it may crash. To support both 1.x and 2.x
versions of NumPy, modules must be compiled with NumPy 2.0.
Some module may need to rebuild instead e.g. with 'pybind11>=2.12'.

If you are a user of the module, the easiest solution will be to
downgrade to 'numpy<2' or try to upgrade the affected module.
We expect that some modules will need time to support NumPy 2.

Traceback (most recent call last):  File "/code/RigidBodyPlanning.py", line 40, in <module>
    from ompl import base as ob
  File "/usr/lib/python3/dist-packages/ompl/base/__init__.py", line 2, in <module>
    from ompl.base._base import *
AttributeError: _ARRAY_API not found
ImportError: numpy.core._multiarray_umath failed to import
Info:    No planner specified. Using default.
Info:    LBKPIECE1: Attempting to use default projection.
Debug:   LBKPIECE1: Planner range detected to be 0.879845
Info:    LBKPIECE1: Starting planning with 1 states already in datastructure
Info:    LBKPIECE1: Created 36 (9 start + 27 goal) states in 34 cells (9 start (9 on boundary) + 25 goal (
Info:    Solution found in 0.001501 seconds
Info:    SimpleSetup: Path simplification took 0.001375 seconds and changed from 21 to 2 states
Geometric path with 2 states
Compound state [
RealVectorState [0.5 0.529462]
SO2State [2.67537]
]
Compound state [
RealVectorState [-0.5 -0.701876]
SO2State [0.545349]
]



Info:    RRTConnect: Space information setup was not yet called. Calling now.
Debug:   RRTConnect: Planner range detected to be 0.879845
Settings for the state space 'SE2CompoundSpace3'
  - state validity check resolution: 1%
  - valid segment count factor: 1
  - state space:
Compound state space 'SE2CompoundSpace3' of dimension 3 (locked) [
Real vector state space 'RealVectorSpace4' of dimension 2 with bounds:
  - min: -1 -1
  - max: 1 1
 of weight 1
SO2 state space 'SO2Space5'
 of weight 0.5
```

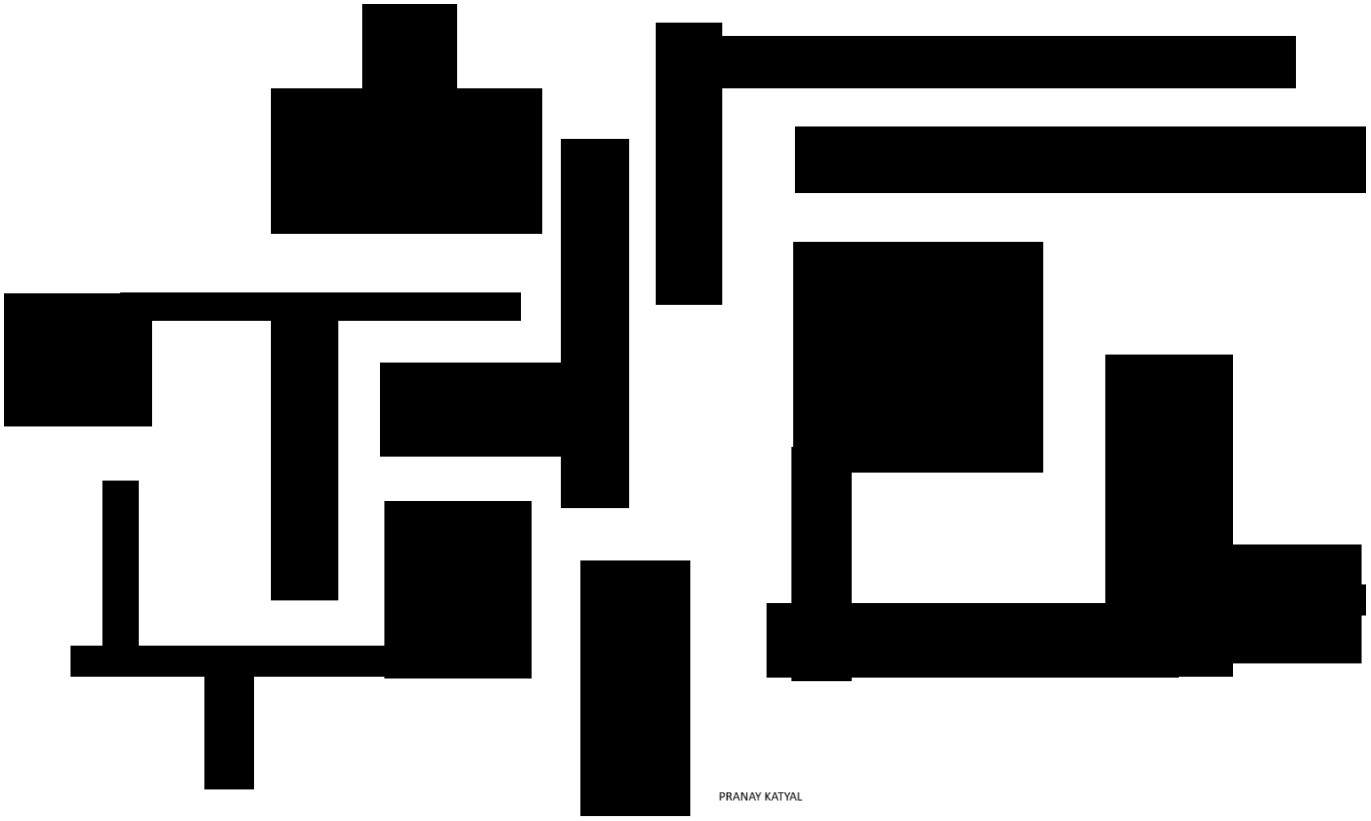
```
]
Registered projections:
  - <default>
Projection of dimension 2
Cell sizes (computed defaults): [0.1 0.1]

Declared parameters:
longest_valid_segment_fraction = 0.01
projection.cellsize.0 = 0.1
projection.cellsize.1 = 0.1
projection.cellsize_factor = 0
valid_segment_count_factor = 1
Valid state sampler named uniform with parameters:
nr_attempts = 100

Start states:
Compound state [
RealVectorState [-0.102325 0.701084]
SO2State [2.2529]
]
Goal state, threshold = 2.22045e-16, memory address = 0x563500497050, state =
Compound state [
RealVectorState [-0.94624 0.0725845]
SO2State [0.228551]
]
OptimizationObjective = nullptr
There are 0 solutions

Info:    RRTConnect: Starting planning with 1 states already in datastructure
Info:    RRTConnect: Created 5 states (2 start + 3 goal)
Found solution:
Geometric path with 4 states
Compound state [
RealVectorState [-0.102325 0.701084]
SO2State [2.2529]
]
Compound state [
RealVectorState [-0.281284 0.391039]
SO2State [1.20918]
]
Compound state [
RealVectorState [-0.469651 0.300828]
SO2State [0.931391]
]
Compound state [
RealVectorState [-0.94624 0.0725845]
SO2State [0.228551]
]
```

Bonus : SO using Paint and an online converter https://convertio.co/jpg-ppm/ I made this MAP for the PRM* to execute the path planning in.



and upon running the Path planning algorithm on it, this is the path that has been generated :