CHAPTER 1

CONCLUSION AND RECOMMENDATION

In this research, a prototype is developed for compliant usage in industrial setup. The robot is as 6R manipulator, with six-degree-of-freedom. Each joints is actuated with Dynamixel servo and are back-drivable. The end-effector is equipped with an RGB-D sensor. The robot is named as *r_ mini*. Since the Dynamixel motors are not supplemented with a mathematical model, the joints are controlled based on time-parameterized controller where, the set up of each of the motor's velocity profile depends on the angular velocity limits and the angular acceleration limit which was successfully tuned. All of the *r_ mini* controllers parameters and system configuration, including it's driver, are package as a stack of ROS packages.

A benchmark was done to ascertain the best sampling-based planner for the *r_ mini*'s capability to avoid moving obstacles. The simulation for the benchmark considers a static object, placed in the manipulator's workspace. RRT was selected given it's rapid processing time, 0.031 s, at giving a planning solution. Another simulation was done where a moving object with the shape of a cylinder is placed in the robot's workspace.

The simulation based on the moving obstacle is reiterated with the robot hardware. The hardware validates the same result as the simulation, where the robot capability to avoid the moving obstacle, although successful, has not been consistent. The avoidance fails if the RRT is invoke when the obstacle nearly approaching the C_{cycle} The moving obstacle is augmented into the configuration space of the robot manipulator.

This thesis's SLAM implementation, by repurposing RTAB-Map as the SLAM framework as the state estimation pipeline of the RTAB-Map, shows an intermittent and sparse estimation of the C_{ee} which fails to continuously estimate the joint-configuration of the manipulator.

Although the performance of the RRT on a dynamic obstacle imposed under the cyclical space prescribed in algorithm **??**, is not satisfactory, the result shows that the robot is capable at reacting to an obstacles when the obstacle is moving.

1.1 Recommendation for Future Works

This thesis recommends a future work on improved state estimations of the RTAB-Map where the singularities reading during state estimation can be pass to a splining process. The splining would consider the last reading of the RTAB-Map estimation pipeline at, t_{last}, and the output from the *equation 1.1*,

$$\underset{t_{last} \leqslant t, C \in \{C_{cycle}, t\}}{\operatorname{argmax}} \|C - \hat{C}_{last}\|_2 \tag{1.1}$$

where $\hat{C}_{last}$ is the last state estimation of the RTAB-Map before data silence.