

# ECS653U/ECS7004P Advanced Robotic Systems (Robotics III)

## WEEK 5 (ASSESSED LAB - 10%) [Mid-term Test]

The objective of this Mid-term Test (10% of your final exam mark) is to **create a ROS package that will automatically generate point-to-point cubic trajectories connecting pairs of randomly generated points**.

A user should be able to install the package (i.e. download the .zip folder of the package, unzip it on their computer within their catkin workspace and compile it), and after running a single launch file they should see different random trajectories appearing on the `rqt_plot` GUI (i.e. a different set of trajectories every 20 seconds).

Add brief comments in all the code files (nodes, messages, services, launch) to explain what each part of the code does (this will affect your mark!)

Detailed instructions follow, in 4 parts **[Total mark is 100 points]**.

### Part I --- Configuration --- [25 points]

#### PACKAGE

- **One ROS Package** named **`ar_week5_test`** should be created, within the `src` folder of your catkin workspace (note: make sure you later modify your Manifest and CMakeLists files depending on the specific requirements of your package...).
- The `ar_week5_test` package should depend on the following ROS packages: **`rospy`**; **`std_msgs`**.
- Four additional folders must be created under the `ar_week5_test` folder: `scripts`; `msg`; `srv`; `launch`.

#### MESSAGES

- **Two ROS messages** should be created in the `msg` folder.
- **1) `cubic_traj_params`**, which contains 6 real values (float): `p0`, `pf`, `v0`, `vf`, `t0`, `tf`; i.e. initial and final position, initial and final velocity, initial and final time.
- **2) `cubic_traj_coeffs`**, which contains 6 real values (float): `a0`, `a1`, `a2`, `a3`, `t0`, `tf`; i.e. the four coefficients of a cubic polynomial trajectory, plus the initial and final time.

#### SERVICE

- **One ROS Service** called **`compute_cubic_traj`** should be created in the `srv` folder, which takes as input one full set of cubic trajectory parameters (initial and final position, initial and final velocity, initial and final time), and returns the four coefficients of the cubic polynomial trajectory (`a0`, `a1`, `a2`, `a3`).

#### LAUNCH FILE

- **One ROS Launch file** named **`cubic_traj_gen.launch`** should be created in the `launch` folder, that will start the four Nodes and the `rqt_plot` GUI automatically.

#### README FILE

- A text file named **`README.txt`** should be created in the package folder, that briefly explains the main steps needed to compile and use the package. The first line must include your name and student ID.

## **Part II --- The Nodes --- [25 points]**

- **Four ROS nodes** will need to be created in the scripts folder:
- **1) `points_generator.py`** This node should generate different random values (e.g. you can use the Python `random.uniform()` function for that) for initial and final position,  $p_0$ ,  $p_f$ , initial and final velocity,  $v_0$ ,  $v_f$ , initial and final time,  $t_0$ ,  $t_f$ , every 20 seconds, and publish them on a ROS Topic using the `cubic_traj_params` message. Positions should not exceed a maximum/minimum value  $P\_MAX = \pm 10$ ; velocities should not exceed a maximum/minimum value  $V\_MAX = \pm 10$ . For the time,  $t_0$  should always be 0, and  $t_f$  should be  $t_f = t_0 + dt$ , with  $dt$  a random real number (i.e. float) between 5 and 10.
- **2) `cubic_traj_planner.py`** This node should subscribe to the ROS Topic created by Node 1, read the desired  $p_0$ ,  $p_f$ ,  $v_0$ ,  $v_f$ ,  $t_0$ ,  $t_f$  published every 20 seconds, and should compute the  $a_0, a_1, a_2, a_3$  coefficients of the cubic polynomial trajectory of the form  $p(t) = a_0 + a_1*t + a_2*t^2 + a_3*t^3$  that best fit those requirements. To compute the coefficients, the Node should call a "compute\_cubic\_traj" Service made available by Node 3. Then, the Node should publish the  $a_0, a_1, a_2, a_3$  coefficients and  $t_0, t_f$  time parameters on a ROS Topic, using the `cubic_traj_coeffs` message.
- **3) `compute_cubic_coeffs.py`** This Node should make the "compute\_cubic\_traj" Service available to any external node requesting it.
- **4) `plot_cubic_traj.py`** This Node should subscribe to the ROS Topic created by Node 2, read the  $a_0, a_1, a_2, a_3$  coefficients and  $t_0, t_f$  time parameters published every 20 seconds, and publish three separate ROS topics: position trajectory, velocity trajectory and acceleration trajectory. These trajectories should be then visualized with the `rqt_plot` GUI, on the same plot, with different colors. The three trajectories should appear on the GUI at the same time, and last for  $t_f$  seconds.

## **Part III --- The Video --- [50 points]**

- **Take a 120 seconds screenshot video of your screen while you run the launch file**, visualizing the ROS graph and the real-time plotting of the pos/vel/acc trajectories **(see example on QM+)**.
- The screen should include:
  - **the terminal** from which you are running the Launch file;
  - **the ros\_graph** showing the nodes, topics and their connections;
  - **the rqt\_plot GUI** showing the trajectories;
  - a window showing your **readme.txt file**, with your name well visible.

## **Part IV --- QM+ submission --- [fundamental: no QM+ submission, no mark]**

- You should submit a single `.rar` (or `.zip`) folder named `YourStudentID_ar_week5_test`, which includes:
  - the `ar_week5_test` package folder (Part I and Part II);
  - the video (Part III).