

Robotics Lab: Homework 1

Building your robot manipulator

ANDREA MORGHEN P38000230

a.morghen@studenti.unina.it

https://github.com/Andremorgh/RL_HW_01.git

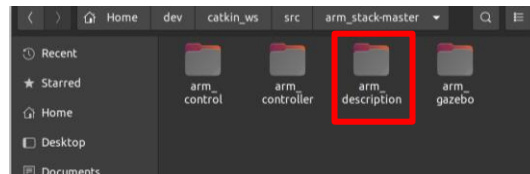
Esteemed Prof.

Mario Selvaggio

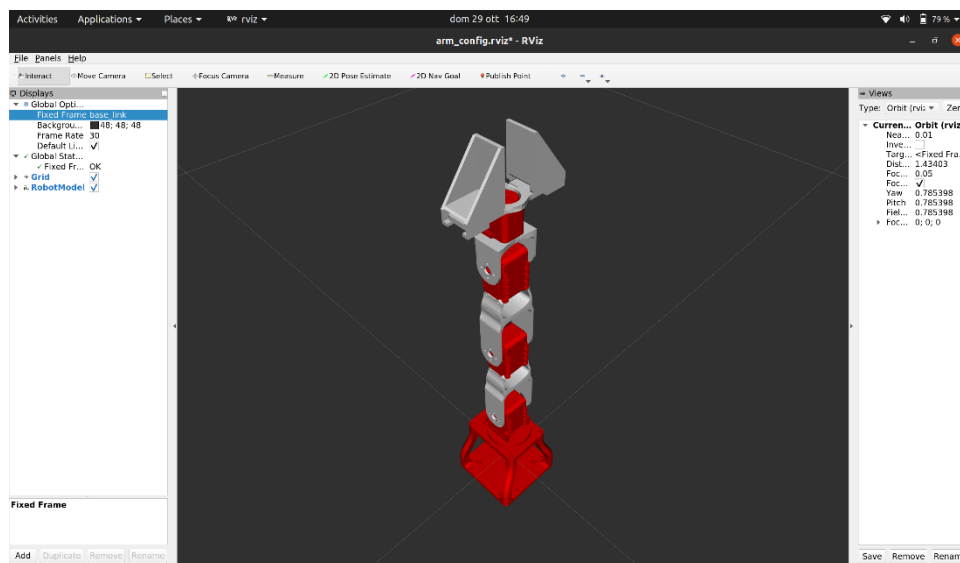
1. Create the description of your robot and visualize it in Rviz

- (a) Download the arm_description package from the repo https://github.com/RoboticsLab2023/arm_description.git into your catkin_ws using git commands

git clone https://github.com/RoboticsLab2023/arm_description.git



- (b) Within the package create a launch folder containing a launch file named display.launch that loads the URDF as a robot_description ROS param and starts the robot_state_publisher node, the joint_state_publisher node, and the rviz node. Launch the file using roslaunch. **Note:** To visualize your robot in rviz you have to change the Fixed Frame in the lateral bar and add the RobotModel plugin interface. **Optional:** save a .rviz configuration file, that automatically loads the RobotModel plugin by default, and give it as an argument to your node in the display.launch file



```

1 <?xml version="1.0"?>
2
3 <launch>
4
5   <!-- Load URDF as robot_description parameter -->
6   <!-- <param name="robot_description" textfile="$(find arm_description)/urdf/arm.urdf.xacro" /> -->
7   <param name="robot_description" command="$(find xacro)/xacro '$(find arm_description)/urdf/arm.urdf.xacro'"/>
8
9
10  <!-- Start robot state publisher -->
11  <node name="robot_state_publisher" pkg="robot_state_publisher" type="robot_state_publisher" />
12
13  <!-- Start joint state publisher -->
14  <node name="joint_state_publisher" pkg="joint_state_publisher" type="joint_state_publisher" />
15
16  <!-- Start RViz with the proper configuration file -->
17  <node name="rviz" pkg="rviz" type="rviz" args="-d $(find arm_description)/arm_config.rviz" />
18
19 </launch>

```

**OPTIONAL
PART**

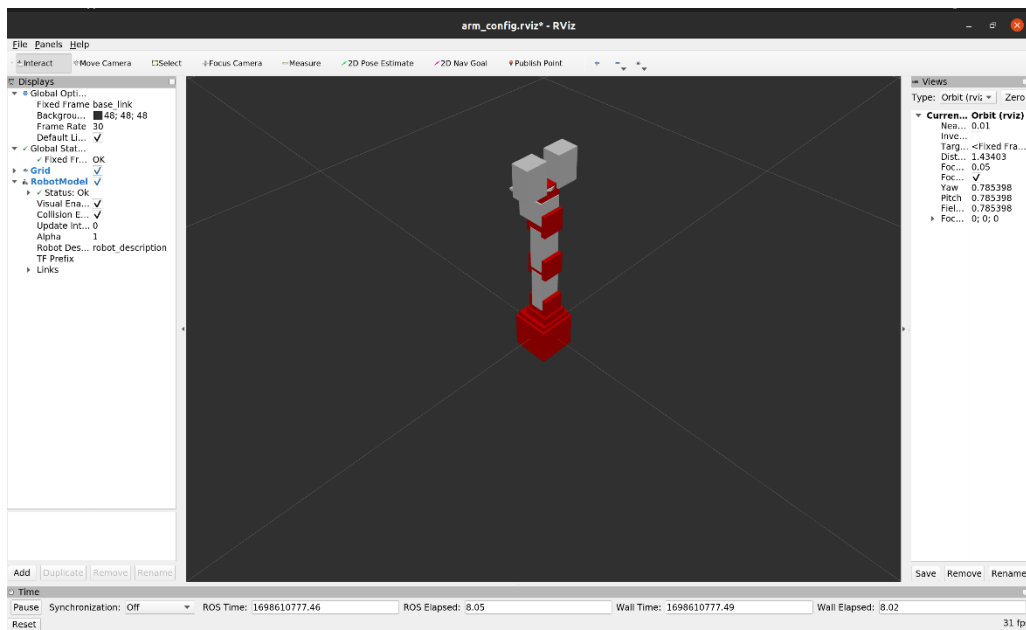
- (c) Substitute the collision meshes of your URDF with primitive shapes. Use `<box>` geometries of Reasonable size approximating the links. **Hint:** Enable collision visualization in rviz (go to the lateral bar > Robot model > Collision Enabled) to adjust the collision meshes size

```

arm.urdf.xacro X
arm_stack-master > arm_description > urdf > arm.urdf.xacro
6 <xacro:include filename="$(find arm_description)/urdf/
7 <!-- Import Transmissions -->
8 <xacro:include filename="$(find arm_description)/urdf/
9 <!-- Import Camera plugin -->
10 <xacro:include filename="$(find arm_description)/urdf/
11
12 <link name="base_link">
13 <visual>
14 <geometry>
15 | <mesh filename="package://arm_description/mesh/
16 </geometry>
17 <origin rpy="0 0 0" xyz="0 0 0"/>
18 </visual>
19 <collision>
20 <geometry>
21 | <box size="0.09 0.09 0.09"/>
22 </geometry>
23 <origin rpy="0 0 0" xyz="0 0 0"/>
24 </collision>
25 <inertial>
26 <mass value="0.1"/>
27 <inertia ixx="1.06682889e+08" ixy="0.0" ixz="0.0"
28 </inertial>
29 </link>
30

```

This was done for all the links, calibrating the size of the boxes according to the size of the link.



- (d) Create a file named `arm.gazebo.xacro` within your package, define a `xacro:macro` inside your file containing all the `<gazebo>` tags you find within your `arm.urdf` and import it in your URDF using `xacro:include`. Remember to rename your URDF file to `arm.urdf.xacro`, add the string `xmlns:xacro="http://www.ros.org/wiki/xacro"` within the `<robot>` tag, and load the URDF in your launch file using the `xacro` routine

```

arm_stack-master > arm_description > urdf > arm.gazebo.xacro
1  <?xml version="1.0"?>
2
3  <robot xmlns:xacro="http://www.ros.org/wiki/xacro">
4
5      <xacro:macro name="arm_gazebo">
6
7          <!-- Load Gazebo lib and set the robot namespace -->
8          <gazebo>
9              <plugin name="gazebo_ros_control" filename="libgazebo_ros_control.so">
10                 <robotNamespace>/arm</robotNamespace>
11             </plugin>
12         </gazebo>
13
14         <gazebo reference="f4">
15             <material>Gazebo/Red</material>
16         </gazebo>
17
18         <gazebo reference="f5">
19             <material>Gazebo/Red</material>
20         </gazebo>
21
22         <gazebo reference="wrist">
23             <material>Gazebo/Red</material>
24         </gazebo>
25
26         <gazebo reference="crawler_base">

```

```

arm_stack-master > arm_description > urdf > arm.urdf.xacro
1  <?xml version="1.0"?>
2
3  <robot name="arm" xmlns:xacro="http://www.ros.org/wiki/xacro">
4
5      <!-- Include the Gazebo-specific tags and collision properties -->
6      <xacro:include filename="$(find arm_description)/urdf/arm.gazebo.xacro" />
7      <!-- Import transmissions -->
8      <xacro:include filename="$(find arm_description)/urdf/arm.transmission.xacro" />
9      <!-- Import Camera plugin -->
10     <xacro:include filename="$(find arm_description)/urdf/camera.urdf.xacro" />
11
12     <link name="base_link">
13         <visual>
14             <geometry>
15                 <mesh filename="package://arm_description/meshes/base_link.stl" scale="0.001 0.001 0.001"/>
16             </geometry>
17             <origin rpy="0 0 0" xyz="0 0 0"/>
18         </visual>
19         <collision>
20             <geometry>
21                 <box size="0.09 0.09 0.09"/>
22             </geometry>
23             <origin rpy="0 0 0" xyz="0 0 0"/>
24         </collision>
25         <inertial>

```

```

arm_stack-master > arm_description > launch > display.launch
1  <?xml version="1.0"?>
2
3  <launch>
4
5      <!-- Load URDF as robot description parameter -->
6      <!-- <param name="robot_description" testfile="$(find arm_description)/urdf/arm.urdf.xacro" /> -->
7      <param name="robot_description" command="$(find xacro)/xacro '$(find arm_description)/urdf/arm.urdf.xacro'"/>
8
9
10     <!-- Start robot state publisher -->
11     <node name="robot_state_publisher" pkg="robot_state_publisher" type="robot_state_publisher" />
12
13     <!-- Start joint state publisher -->
14     <node name="joint_state_publisher" pkg="joint_state_publisher" type="joint_state_publisher" />
15
16     <!-- Start RViz with the proper configuration file -->
17     <node name="rviz" pkg="rviz" type="rviz" args="-d $(find arm_description)/arm_config.rviz" />
18
19 </launch>

```

```

435 <xacro:arm_gazebo/>
436
437 <xacro:arm_transmission robot_name="arm"/>
438
439 <xacro:camera_sensor xyz="0 0 1" rpy="0 1.57 1.57" parent="base_link"/>
440
441 </robot>

```

2. Add transmission and controllers to your robot and spawn it in Gazebo

- (a) Create a package named `arm_gazebo`

```
catkin_create_pkg arm_gazebo
```

- (b) Within this package create a launch folder containing a `arm_world.launch` file

```
mkdir launch
```

```
touch arm_world.launch
```

- (c) Fill this launch file with commands that load the URDF into the ROS Parameter Server and spawn your robot using the `spawn_model` node. **Hint:** follow the `iiwa_world.launch` example from the package `iiwa_stack`: https://github.com/IFL-CAMP/iiwa_stack/tree/master. Launch the `arm_world.launch` file to visualize the robot in Gazebo

```

1  <?xml version="1.0"?>
2  <launch>
3
4      <!-- Loads the arm.world environment in Gazebo. -->
5
6      <!-- These are the arguments you can pass this launch file, for example paused:=true -->
7      <arg name="paused" default="false"/>
8      <arg name="use_sim_time" default="true"/>
9      <arg name="gui" default="true"/>
10     <arg name="headless" default="false"/>
11     <arg name="debug" default="false"/>
12     <arg name="hardware_interface" default="PositionJointInterface"/>
13     <arg name="robot_name" default="arm" />
14
15     <!-- We resume the logic in empty_world.launch, changing only the name of the world to be launched -->
16     <include file="$(find gazebo_ros)/launch/empty_world.launch"
17       <arg name="world_name" value="$(find arm_gazebo)/world/arm.world" />
18       <arg name="debug" value="$(arg debug)" />
19       <arg name="gui" value="$(arg gui)" />
20       <arg name="paused" value="$(arg paused)" />
21       <arg name="use_sim_time" value="$(arg use_sim_time)" />
22       <arg name="headless" value="$(arg headless)" />
23     </include>
24
25     <!-- Load the URDF with the given hardware interface into the ROS Parameter Server -->
26     <include file="$(find arm_gazebo)/launch/arm.launch"
27       <!-- <arg name="hardware_interface" value="$(arg hardware_interface)" --> -->
28     </include>
29
30     <!-- Run a python script to send a service call to spawn a URDF robot -->
31     <node name="urdf_spawner" pkg="gazebo_ros" type="spawn_model" respawn="false" output="screen"
32       args="-urdf -model arm -param robot_description" />
33
34 </launch>

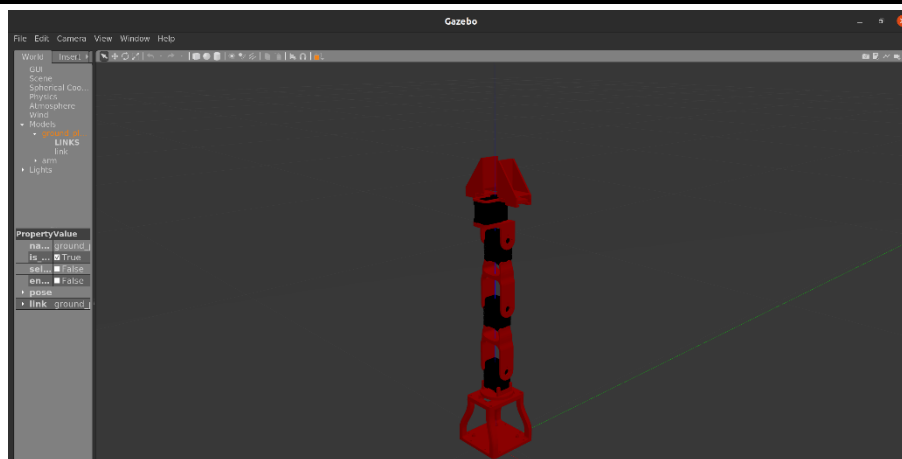
```

```

1  <?xml version="1.0" ?>
2  <sdf version="1.4">
3
4      <world name="default">
5
6          <include>
7            <uri model="//ground_plane/uri">
8          </include>
9
10         <!-- Global Light source -->
11         <include>
12           <uri model="//sun/uri">
13         </include>
14
15         <physics name="default physics" default="0" type="ode">
16           <max_step_size>0.01</max_step_size>
17           <real_time_factor>1</real_time_factor>
18           <real_time_update_rate>100</real_time_update_rate>
19           <ode>
20             <solver>
21               <type>quick</type>
22               <iters>50</iters>
23               <scr>1.0</scr> <!-- Important, see issue #2209 -->
24               <use_dynamic_moi_rescaling>false</use_dynamic_moi_rescaling>
25             </solver>
26           </ode>
27         </physics>
28
29         <!-- Focus camera -->
30         <gui fullscreen="0">
31           <camera name="user camera">
32             <pose>4.927360 -4.376610 3.740080 0.000000 0.275643 2.356100</pose>
33             <view_controller>orbit</view_controller>
34           </camera>
35         </gui>
36       </world>
37
38 </sdf>

```

```
root@andrea-Surface-Pro-8:/home/dev/catkin_ws# roslaunch arm_gazebo arm_world.launch
```



- (d) Now add a PositionJointInterface as hardware interface to your robot: create a arm.transmission.xacro file into your arm_description/urdf folder containing a xacro:macro with the hardware interface and load it into your arm.urdf.xacro file using xacro:include.launch the file

```

arm_stack-master X
arm_stack-master > arm_description > urdf > arm.transmission.xacro
1 <?xml version="1.0"?>
2 <robot xmlns:xacro="http://www.ros.org/wiki/xacro">
3   <xacro:macro name="arm_transmission" param="robot_name">
4
5     <transmission name="${robot_name}_tran_1">
6       <robotNamespace/${robot_name}/robotNamespace>
7       <type>transmission_interface/SimpleTransmission</type>
8       <joint name="j0">
9         <hardwareInterface>hardware_interface/PositionJointInterface</hardwareInterface>
10      </joint>
11     <actuator name="${robot_name}_motor_1">
12       <hardwareInterface>hardware_interface/PositionJointInterface</hardwareInterface>
13       <mechanicalReduction>1</mechanicalReduction>
14     </actuator>
15   </transmission>
16
17   <transmission name="${robot_name}_tran_2">
18     <robotNamespace/${robot_name}/robotNamespace>
19     <type>transmission_interface/SimpleTransmission</type>
20     <joint name="j1">
21       <hardwareInterface>hardware_interface/PositionJointInterface</hardwareInterface>
22     </joint>
23     <actuator name="${robot_name}_motor_2">
24       <hardwareInterface>hardware_interface/PositionJointInterface</hardwareInterface>
25       <mechanicalReduction>1</mechanicalReduction>
26     </actuator>
27   </transmission>
28
29   <transmission name="${robot_name}_tran_3">
30     <robotNamespace/${robot_name}/robotNamespace>
31     <type>transmission_interface/SimpleTransmission</type>
32     <joint name="j2">
33       <hardwareInterface>hardware_interface/PositionJointInterface</hardwareInterface>
34     </joint>
35     <actuator name="${robot_name}_motor_3">
36       <hardwareInterface>hardware_interface/PositionJointInterface</hardwareInterface>
37       <mechanicalReduction>1</mechanicalReduction>
38     </actuator>
39   </transmission>

```

The parameter "robot_name" is not strictly necessary but has been inserted anyway.

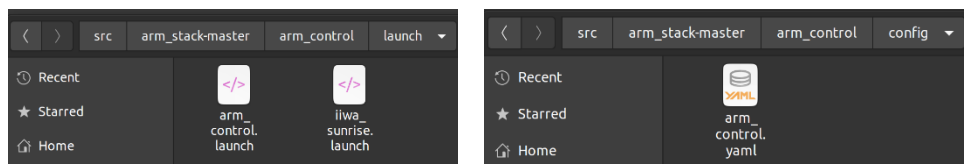
```

arm_stack-master > arm_description > urdf > arm.urdf.xacro
1 <?xml version="1.0"?>
2 <robot name="arm" xmlns:xacro="http://www.ros.org/wiki/xacro">
3   <!-- Include the Gazebo-specific tags and collision properties -->
4   <xacro:include filename="$(find arm_description)/urdf/arm.gazebo.xacro" />
5   <!-- Import Transmissions -->
6   <xacro:include filename="$(find arm_description)/urdf/arm.transmission.xacro" />
7   <!-- Import camera properties -->
8   <xacro:include filename="$(find arm_description)/urdf/camera.urdf.xacro" />
9
10  <link name="base link">
11    <visual>
12      <xacro:arm_gazebo/>
13    </visual>
14    <xacro:arm_transmission robot_name="arm"/>
15  </link>
16  <xacro:camera_sensor xyz="0 0 1" rpy="0 1.57 1.57" parent="base link"/>
17</robot>

```

- (e) Add joint position controllers to your robot: create a arm_control package with a arm_control.launch file inside its launch folder and a arm_control.yaml file within its config folder

catkin_create_pkg arm_control



- (f) Fill the `arm_control.launch` file with commands that load the joint controller configurations from the `.yaml` file to the parameter server and spawn the controllers using the `controller_manager` package. **Hint:** follow the `iiwa_control.launch` example from corresponding package

```

1 arm_control.launch X
2 arm_stack-master > arm_control > launch > arm_control.launch
3
4 <!-- Loads joint controller configurations from YAML file to parameter server -->
5 <rosparam file="$(find arm_control)/config/arm_control.yaml" command="load" />
6
7 <!-- Loads the controllers -->
8 <node name="controller_spawner" pkg="controller_manager" type="spawner" respawn="false"
9   output="screen" ns="arm" args="joint0_position_controller joint1_position_controller joint2_position_controller joint3_position_controller" />
10
11 <node name="robot_state_publisher" pkg="robot_state_publisher" type="robot_state_publisher"
12   respawn="false" output="screen"
13   <remap from="/joint_states" to="/arm/joint_states" />
14 />
15
16 </launch>

```

this step is critical because a subspace was used in the `arm_control.yaml` file

- (g) Fill the `arm_control.yaml` adding a `joint_state_controller` and a `JointPositionController` to all the joints

```

1 arm_control.launch ! arm_control.yaml X
2 arm_stack-master > arm_control > config > ! arm_control.yaml
3
4 arm:
5   # Publish all joint states -----
6   joint_state_controller:
7     type: joint_state_controller/JointStateController
8     publish_rate: 50
9
10  # Effort Position Controllers -----
11
12  joint0_position_controller:
13    type: position_controllers/JointPositionController
14    joint: j0
15    pid: {p: 100.0, i: 0.01, d: 10.0}
16
17  joint1_position_controller:
18    type: position_controllers/JointPositionController
19    joint: j1
20    pid: {p: 100.0, i: 0.01, d: 10.0}
21
22  joint2_position_controller:
23    type: position_controllers/JointPositionController
24    joint: j2
25    pid: {p: 100.0, i: 0.01, d: 10.0}
26
27  joint3_position_controller:
28    type: position_controllers/JointPositionController
29    joint: j3
30    pid: {p: 100.0, i: 0.01, d: 10.0}
31
32

```

- (h) Create an `arm_gazebo.launch` file into the launch folder of the `arm_gazebo` package loading the Gazebo world with `arm_world.launch` and spawning the controllers within `arm_control.launch`. Go to the `arm_description` package and add the `gazebo_ros_control` plugin to your main URDF into the `arm.gazebo.xacro` file. Launch the simulation and check if your controllers are correctly loaded

```

1 arm_control.launch arm_gazebo.launch X
2 arm_stack-master > arm_gazebo > launch > arm_gazebo.launch
3
4 <?xml version="1.0"?>
5 <launch>
6
7   <!-- Loads the Gazebo world. -->
8   <include file="$(find arm_gazebo)/launch/arm_world.launch"/>
9
10  <include file="$(find arm_control)/launch/arm_control.launch"/>
11
12 </launch>

```

```

1 arm.gazebo.xacro X
2 arm_stack-master > arm_description > urdf > arm.gazebo.xacro
3
4 <?xml version="1.0"?>
5 <robot xmlns:xacro="http://www.ros.org/wiki/xacro">
6
7   <xacro:macro name="arm_gazebo">
8
9     <!-- Load Gazebo lib and set the robot namespace -->
10    <gazebo>
11      <plugin name="gazebo_ros_control" filename="libgazebo_ros_control.so">
12        <robotNamespace>arm</robotNamespace>
13      </plugin>
14    </gazebo>
15
16    <gazebo reference="f4">
17      <material>Gazebo/Red</material>
18    </gazebo>
19
20  </xacro:macro>
21 </robot>

```

PLUGIN

3. Add a camera sensor to your robot

- (a) Go into your arm.urdf.xacro file and add a camera_link and a fixed camera_joint with base_link as a parent link. Size and position the camera link opportunely

```

arm.urdf.xacro
urdf > arm.urdf.xacro
406 | <inertia ixx="0.00015881e+01" ixy="0.0" i
407 | </inertia>
408 | </link>
409
410 | <!-- Add camera link and joint -->
411 | <!-- <link name="camera_link">
412 | <!-- <visual>
413 | <!-- <geometry>
414 | <!-- <box size="0.1 0.1 0.1"/>
415 | </geometry>
416 | <!-- <origin rpy="0 0 0" xyz="0 0 0"/>
417 | <!-- <material name="green">
418 | <!-- <color rgba="1 1 1 1"/>
419 | </material>
420 | </visual>
421 | <!-- <collision>
422 | <!-- <geometry>
423 | <!-- <box size="0.1 0.1 0.1"/>
424 | </geometry>
425 | <!-- <origin rpy="0 0 0" xyz="0.1 0 0.2"/>
426 | </collision>
427 | </link>
428
429 | <!-- <joint name="camera_joint" type="fixed">
430 | <!-- <parent link="base_link"/>
431 | <!-- <child link="camera_link"/>
432 | <!-- <origin xyz="0 0 1" rpy="0 0 0"/>
433 | </joint> -->
434

```

the code is commented out since in the final file I used camera.xacro as suggested in point (d)

- (b) In the arm.gazebo.xacro add the gazebo sensor reference tags and the libgazebo_ros_camera plugin to your xacro (slide 74-75)

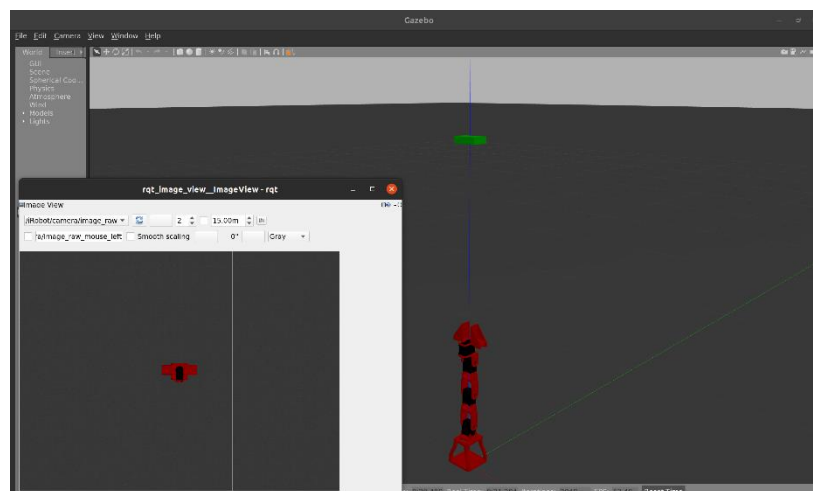
```

arm.gazebo.xacro
urdf > arm.gazebo.xacro
43 | <material>Gazebo/Black</material>
44 | </gazebo>
45
46 | <gazebo reference="dyn3">
47 | <material>Gazebo/Black</material>
48 | </gazebo>
49
50 | <gazebo reference="dyn4">
51 | <material>Gazebo/Black</material>
52 | </gazebo>
53
54 | <gazebo reference="dyn5">
55 | <material>Gazebo/Black</material>
56 | </gazebo>
57
58 | <gazebo reference="crazer_left">
59 | <material>Gazebo/Red</material>
60 | </gazebo>
61
62 | <gazebo reference="crazer_right">
63 | <material>Gazebo/Red</material>
64 | </gazebo>
65
66 | <!-- <gazebo reference="camera_link">
67 | <!-- <material>Gazebo/Green</material>
68 | <!-- </gazebo> -->
69
70 | </xacro:macro>
71
72 | </robot>
73

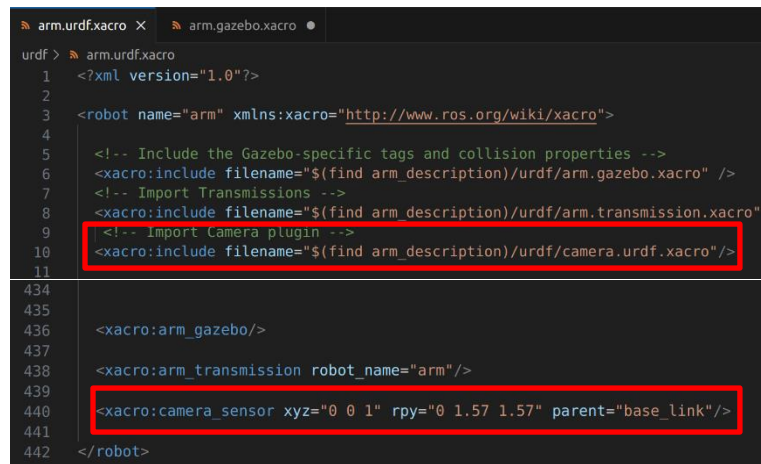
```

the code is commented out since in the final file I used camera.xacro as suggested in point (d)

- (c) Launch the Gazebo simulation with using arm_gazebo.launch and check if the image topic is correctly published using rqt_image_view



- (d) **Optionally:** You can create a camera.xacro file (or download one from <https://github.com/CentroEPiaggio/irobotcreate2ros/blob/master/model/camera.urdf.xacro>) and add it to your robot URDF using `<xacro:include>`



```
arm.urdf.xacro x arm.gazebo.xacro
urdf > arm.urdf.xacro
1  <?xml version="1.0"?>
2
3  <robot name="arm" xmlns:xacro="http://www.ros.org/wiki/xacro">
4
5      <!-- Include the Gazebo-specific tags and collision properties -->
6      <xacro:include filename="$(find arm_description)/urdf/arm.gazebo.xacro" />
7      <!-- Import Transmissions -->
8      <xacro:include filename="$(find arm_description)/urdf/arm.transmission.xacro" />
9      <!-- Import Camera plugin -->
10     <xacro:include filename="$(find arm_description)/urdf/camera.urdf.xacro"/>
11
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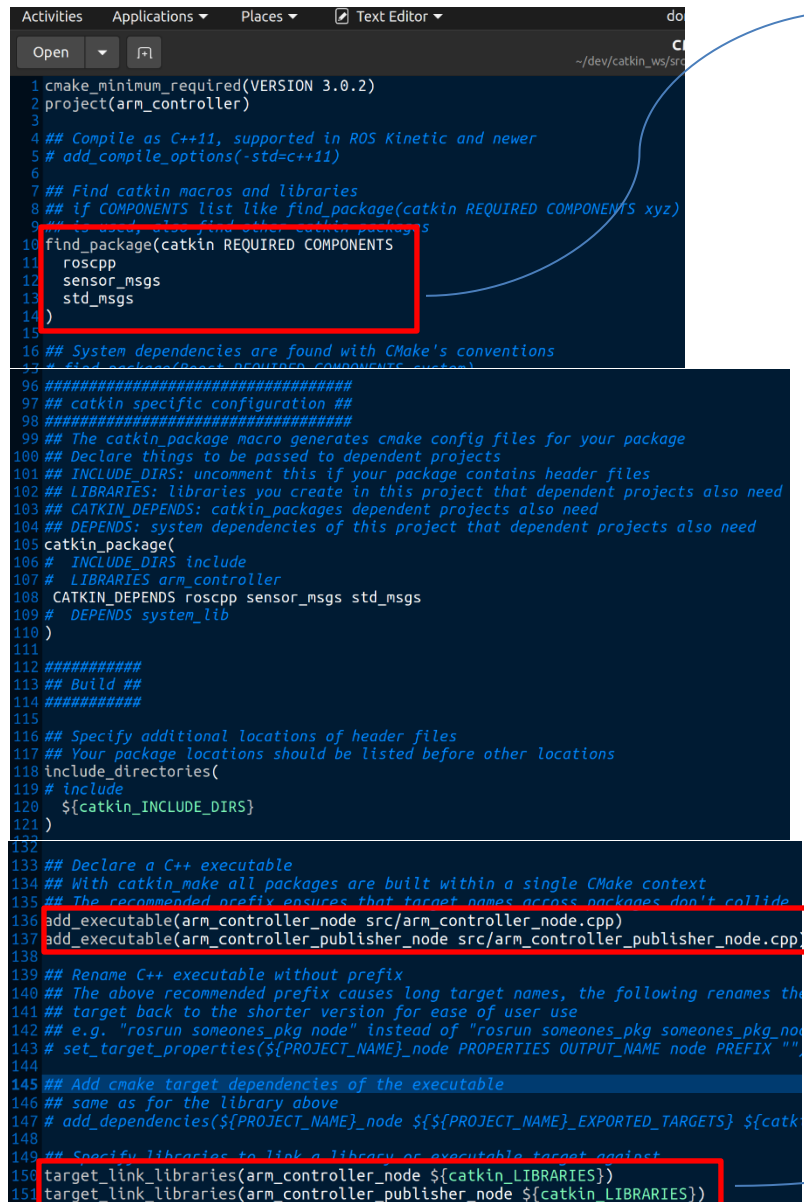
```

4. Create a ROS publisher node that reads the joint state and sends joint position commands to your robot

- (a) Create an arm_controller package with a ROS C++ node named arm_controller_node. The dependencies are roscpp, sensor_msgs and std_msgs. Opportunely modify the CMakeLists.txt file to compile your node. **Hint:** uncomment add_executable and target_link_libraries lines

catkin_create_pkg arm_controller roscpp sensor_msgs std_msgs

touch src/arm_controller_node.cpp



```

1 cmake_minimum_required(VERSION 3.0.2)
2 project(arm_controller)
3
4 ## Compile as C++11, supported in ROS Kinetic and newer
5 # add_compile_options(-std=c++11)
6
7 ## Find catkin macros and libraries
8 ## if COMPONENTS list like find_package(catkin REQUIRED COMPONENTS xyz)
9 ## is used, then find_package(catkin REQUIRED COMPONENTS xyz) is also
10 ## required before uncommenting the following.
11 find_package(catkin REQUIRED COMPONENTS
12   roscpp
13   sensor_msgs
14   std_msgs
15 )
16 ## System dependencies are found with CMake's conventions
17 # find_package(Boost REQUIRED COMPONENTS system)
18
19 #####
20 ## catkin specific configuration ##
21 #####
22 ## The catkin_package macro generates cmake config files for your package
23 ## Declare things to be passed to dependent projects
24 INCLUDE_DIRS: uncomment this if your package contains header files
25 LIBRARIES: libraries you create in this project that dependent projects also need
26 CATKIN_DEPENDS: catkin_packages dependent projects also need
27 DEPENDS: system dependencies of this project that dependent projects also need
28 catkin_package(
29   # INCLUDE_DIRS include
30   # LIBRARIES arm_controller
31   CATKIN_DEPENDS roscpp sensor_msgs std_msgs
32   # DEPENDS system_lib
33 )
34
35 #####
36 ## Build ##
37 #####
38
39 ## Specify additional locations of header files
40 ## Your package locations should be listed before other locations
41 include_directories(
42   ${catkin_INCLUDE_DIRS}
43 )
44
45 ## Declare a C++ executable
46 ## With catkin_make all packages are built within a single CMake context
47 ## The recommended prefix ensures that target names across packages don't collide
48 # add_executable(arm_controller_node src/arm_controller_node.cpp)
49 # add_executable(arm_controller_publisher_node src/arm_controller_publisher_node.cpp)
50
51 ## Rename C++ executable without prefix
52 ## The above recommended prefix causes long target names, the following renames them
53 ## target back to the shorter version for ease of user use
54 ## e.g. "roslaunch someones_pkg node" instead of "roslaunch someones_pkg_node"
55 # set_target_properties(${PROJECT_NAME}_node PROPERTIES OUTPUT_NAME node PREFIX "")
56
57 ## Add cmake target dependencies of the executable
58 ## same as for the library above
59 add_dependencies(${PROJECT_NAME}_node ${${PROJECT_NAME}_EXPORTED_TARGETS} ${catkin_EXPORTED_TARGETS})
60
61 ## Specify libraries to link a library or executable target against
62 target_link_libraries(arm_controller_node ${catkin_LIBRARIES})
63 target_link_libraries(arm_controller_publisher_node ${catkin_LIBRARIES})

```

dependencies

I preferred to create two distinct nodes, the first one showing the current values of the controllers and the second one publishing the values on the controllers

- (b) Create a subscriber to the topic `joint_states` and a callback function that prints the current joint positions (see Slide 45). **Note:** the topic contains a `sensor_msgs/JointState`

```

arm_controller_node.cpp X
arm_controller > src > arm_controller_node.cpp
1 #include <ros/ros.h>
2 #include <sensor_msgs/JointState.h>
3
4 void jointStateCallback(const sensor_msgs::JointState::ConstPtr& jointState) {
5     // Stampa le posizioni dei giunti
6     for (size_t i = 0; i < jointState->position.size(); ++i) {
7         ROS_INFO("Joint %zu: %f", i, jointState->position[i]);
8     }
9 }
10
11 int main(int argc, char** argv) {
12     ros::init(argc, argv, "arm_controller_node");
13     ros::NodeHandle nh;
14
15     // Crea un subscriber per il topic "joint_states"
16     ros::Subscriber jointStateSub = nh.subscribe("/arm/joint_states", 100, jointStateCallback);
17
18     ros::spin(); // Mantieni il nodo attivo
19
20     return 0;
21 }

```

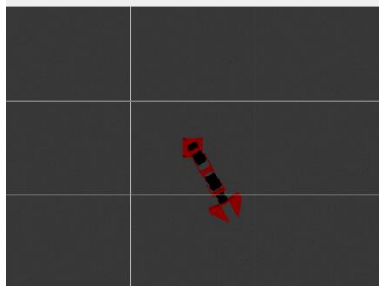
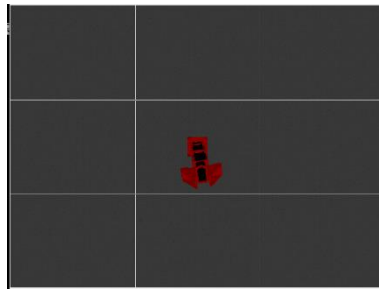
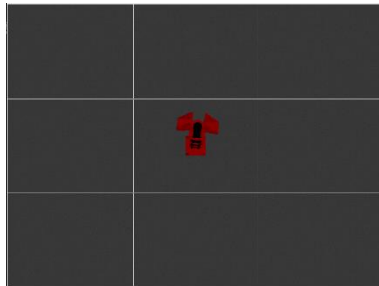
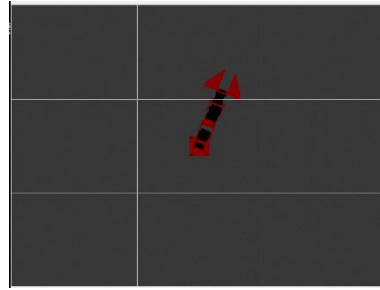
- (c) Create publishers that write commands onto the controllers' /command topics (see Slide 46). **Note:** the command is a `std_msgs/Float64`

```

arm_controller_publisher_node.cpp X
arm_controller_publisher > src > arm_controller_publisher_node.cpp
1 #include <ros/ros.h>
2 #include <std_msgs/Float64.h>
3
4 int main(int argc, char* argv[]) {
5     ros::init(argc, argv, "arm_controller_publisher_node");
6     ros::NodeHandle nh;
7
8     // Crea publisher per inviare comandi ai controller
9     ros::Publisher joint0CommandPub = nh.advertise<std_msgs::Float64>("/arm/joint0_position_controller/command", 100);
10    ros::Publisher joint1CommandPub = nh.advertise<std_msgs::Float64>("/arm/joint1_position_controller/command", 100);
11    ros::Publisher joint2CommandPub = nh.advertise<std_msgs::Float64>("/arm/joint2_position_controller/command", 100);
12    ros::Publisher joint3CommandPub = nh.advertise<std_msgs::Float64>("/arm/joint3_position_controller/command", 100);
13
14    // Imposta la frequenza di aggiornamento (Hz) per la tua traiettoria
15    double frequency = 10.0; // Esempio: 1 Hz
16
17    // Durata di un periodo della traiettoria (secondi)
18    double period = 100.0 / frequency;
19
20    // Valori di ampiezza massima e minima della traiettoria
21    double max_amplitude = 10.0;
22    double min_amplitude = -10.0;
23
24    // Inizia dalla posizione minima
25    double current_position = min_amplitude;
26    bool increasing = true;
27
28    ros::Rate loop_rate(frequency);
29    while (ros::ok())
30    {
31        // Genera comandi di posizione a forma di onda triangolare
32        std_msgs::Float64 position_command_j0;
33        position_command_j0.data = current_position;
34        // Pubblica il comando sul topic del controller del giunto
35        joint0CommandPub.publish(position_command_j0);
36
37        // Invio messaggi distinti anche se il contenuto è il medesimo per avere generalità
38        std_msgs::Float64 position_command_j1;
39        position_command_j1.data = current_position;
40        joint1CommandPub.publish(position_command_j1);
41
42        std_msgs::Float64 position_command_j2;
43        position_command_j2.data = current_position;
44        joint2CommandPub.publish(position_command_j2);
45
46        std_msgs::Float64 position_command_j3;
47        position_command_j3.data = current_position;
48        joint3CommandPub.publish(position_command_j3);
49
50        // Calcolo onda quadra
51        if (increasing)
52        {
53            current_position += (2.0 * max_amplitude / period) * (1.0 / frequency);
54            if (current_position >= max_amplitude)
55            {
56                current_position = max_amplitude;
57                increasing = false;
58            }
59        }
60        else
61        {
62            current_position -= (2.0 * max_amplitude / period) * (1.0 / frequency);
63            if (current_position <= min_amplitude)
64            {
65                current_position = min_amplitude;
66                increasing = true;
67            }
68        }
69
70        ros::spinOnce();
71        loop_rate.sleep();
72    }
73
74    return 0;
75 }

```

I chose an equal triangular wave trajectory for all joints, the result is shown below



```

[INFO] [1698609018.744288193, 83.0600000000]: Joint 3: -0.217000
[INFO] [1698609018.764475164, 83.0800000000]: Joint 0: -0.229000
[INFO] [1698609018.764497869, 83.0800000000]: Joint 1: -0.229000
[INFO] [1698609018.764505745, 83.0800000000]: Joint 2: -0.229000
[INFO] [1698609018.764515998, 83.0800000000]: Joint 3: -0.219000
[INFO] [1698609018.7842171624, 83.1000000000]: Joint 0: -0.231000
[INFO] [1698609018.784211179, 83.1000000000]: Joint 1: -0.231000
[INFO] [1698609018.784217394, 83.1000000000]: Joint 2: -0.231000
[INFO] [1698609018.784224302, 83.1000000000]: Joint 3: -0.221000
[INFO] [1698609018.804395286, 83.1200000000]: Joint 0: -0.233000
[INFO] [1698609018.804424139, 83.1200000000]: Joint 1: -0.233000
[INFO] [1698609018.804431804, 83.1200000000]: Joint 2: -0.233000
[INFO] [1698609018.804442010, 83.1200000000]: Joint 3: -0.223000
[INFO] [1698609018.824117969, 83.1400000000]: Joint 0: -0.235000
[INFO] [1698609018.824146279, 83.1400000000]: Joint 1: -0.235000
[INFO] [1698609018.824154577, 83.1400000000]: Joint 2: -0.235000
[INFO] [1698609018.824164386, 83.1400000000]: Joint 3: -0.225000
[INFO] [1698609018.844420466, 83.1600000000]: Joint 0: -0.237000
[INFO] [1698609018.844446801, 83.1600000000]: Joint 1: -0.237000
[INFO] [1698609018.844452717, 83.1600000000]: Joint 2: -0.237000
[INFO] [1698609018.844459299, 83.1600000000]: Joint 3: -0.227000

generate(dot_graph)
File "/opt/ros/noetic/lib/tf/view_frames", line 89, in generate
  n = r.search(vstr)
TypeError: cannot use a string pattern on a bytes-like object
root@andrea-Surface-Pro-8:/home/dev/catkin_ws# rospack find tf
/opt/ros/noetic/share/tf
root@andrea-Surface-Pro-8:/home/dev/catkin_ws# roslaunch tf tf_relay
[roslaunch] Couldn't find executable named tf_relay below /opt/ros/noetic/share/tf
root@andrea-Surface-Pro-8:/home/dev/catkin_ws# rqt_image_view
QStandardPaths: XDG_RUNTIME_DIR not set, defaulting to '/tmp/runtime-root'
^Croot@andrea-Surface-Pro-8:/home/dev/catkin_ws# roslaunch arm_
arm_control arm_controller arm_description arm_gazebo
root@andrea-Surface-Pro-8:/home/dev/catkin_ws# roslaunch arm_controller arm_contr
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arm_controller_node arm_controller_publisher_node
root@andrea-Surface-Pro-8:/home/dev/catkin_ws# roslaunch arm_controller arm_contr
oller_
arm_controller_node arm_controller_publisher_node
root@andrea-Surface-Pro-8:/home/dev/catkin_ws# roslaunch arm_controller arm_contr
oller_publisher_node

```

arm_controller_node

arm_controller_publisher_node