RO Project Proposals

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1 Rule of Projects

To pass the exam, is mandatory to complete one of these projects. You can choose between these two types of projects:

1. **Group Projects**: In this type of project, you will work on a large project, with **high-level robotic applications**. In each project, can be enrolled until 16 students, divided in 4 sub-groups. Each sub-group will work on a specific task (control, planning, etc.) and collaborates with the other groups.
   If you want to become a Roboticist, we recommend you this type of projects.
2. **Individual Projects**: In this type of project, you will work on a small project, with standard robotic applications.

1.1 Evaluation

In both types of project, you can obtain the full vote. However, the Group Projects guarantees an higher starting vote, due to the work load.

1.2 Tools

Whatever type of project you choose, you have to implement it in ROS and Gazebo. For presenting your data (plot, scheme, etc.), you can also use MATLAB or any software that you prefer.

2 Group Projects

2.1 Pick and Place with Object Detection

In this project you will work on a *Pick and Place* application on a **6 DoFs Robot Arm**, with as end-effector a grip. This manipulator has some sensors: 6 encoders for each joint, 1 IMU and 1 camera. You can choose the pose of your camera or to add 1 camera for stereo vision. The robot arm lives in a simulated

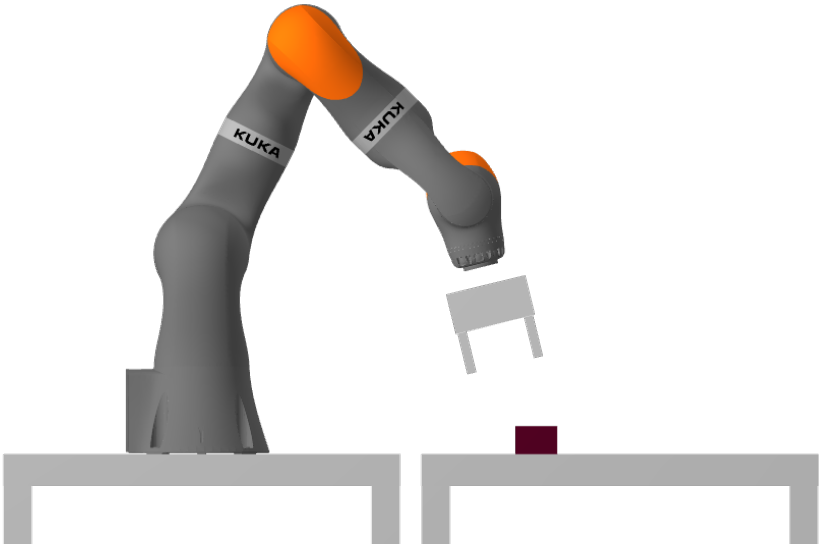

Figure 1: Pick and Place application.

environment in Gazebo (with gravity, friction, etc.). In this environment there are some objects with different shapes. The robot arm has to be able to *pick* an object, move to the target position and *place* the object. This application can be divided in 4 tasks:

1. **Simulation Task**: In this subgroup, you have to simulate the entire environment (robot arm, sensors, objects, etc.).
2. **Control Task**: In this subgroup, you have to control your manipulator, in order to satisfy the desired position/orientation that the planning node send to you. You can choose whatever type of controller (if it works).
3. **Planning Task**: In this subgroup, you have to plan the motion of the manipulator, during all the phases of pick and place. If there are some objects in your path, you must avoid it.
4. **Estimation Task**: In this subgroup, you have to estimate the pose of your manipulator, thanks to the sensors built in the robot. From the camera, you have to be able to detect the objects in your field of view and their geometrical information.

2.2 Quadruped Robot

In this project, you will work on a quadruped robot, that lives in a simulated environment in Gazebo. The legged robot is sensorized by encoders in each

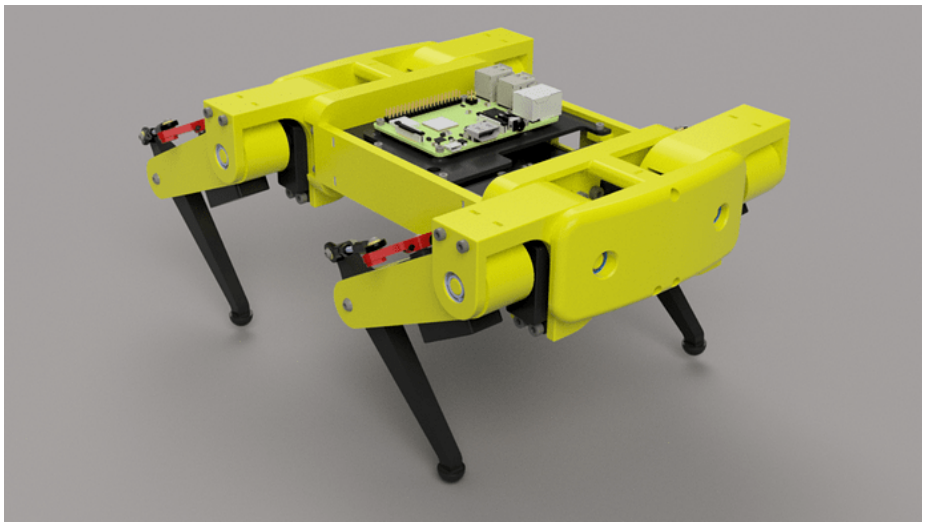

Figure 2: Example of Quadruped Robot.

joint, an IMU positioned on the "back" of the robot and 1 camera. The pose of the camera is arbitrary. The 4 tasks are:

1. **Simulation Task**: In this subgroup, you have to simulate the entire environment (robot model, sensors, objects and obstacles etc.).
2. **Control Task**: In this subgroup, you have to control your quadruped robot. You can use whatever controller that you want. One of the most famous controller for legged robot is the Whole Body Controller (WBC).
3. **Estimation Task**: In the estimation task, you have to implement a sensor fusion algorithm (ex. Extended Kalman Filter), in order to estimate the pose and the velocity of quadruped robot. Can be useful to estimate also the contact forces between feet and ground.
4. **Reinforcement Learning**: An alternative to model-based control approach can be the model-free control approach, like Reinforcement Learning. Try to implement this type of controller and compare the performance with the controller developed by the **Control Task**.

2.3 Adaptive-shape Swarm in Structured Environment

In this project, you will work on a swarm of mobile robots, that can change the shape of the formation. This swarm is composed by 3 types of vehicles:

- Swedish Wheel.
- Unicycle.

- Car-like.

There are 4 possible shapes: Triangle, Line, Circle and Square. The total number of robots in the swarm is arbitrary. The tasks are:

1. **Simulation Task**: In this task you have to create the entire environment (robots, sensors, obstacles etc.).
2. **Control Task**: In this task, you have to implement the low-level control of this type of mobile robots, in order to execute the commands come from the **Planning Task**.
3. **Distributed algorithms and Planning**: In this task, you have to implement the high-level control algorithm, in order to create the adaptive-shape swarm.
4. **Sensing and SLAM**: In this task, you have to implement a sensor fusion algorithm and the SLAM algorithm, in order to map the environment.

3 Individual Projects

If you want to do an Individual Project, you can implement in ROS and Gazebo a control algorithm explained in the course. An example, you can implement *Coverage* on a distributed robotic system or an *Adaptive Controller* on a robotic arm with $n_{DOF} \geq 3$. You can propose a project, that has to be accepted.