Robotics Project 2015-2016 (v 1.0)

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"Il Kobra non è un serpente ..."
Donatella Rettore – 1981

Introduction

This year project is divided in steps; each of them is worth some points out of the 5/32 points available for the final mark.

Some preliminary important notes:

- We have decided to follow a sort of "homework approach" so you should do the homework to better understand some key concepts from the course … indeed a few questions come from your colleague observations so blame them!
- We have not decided yet how much each part is worth, we will decide depending on the overall distribution of results in the class to harmonize the overall score.
- Some data might be missing, some data might be useless, do not hesitate to write us by email, for instance, to ask the weight of the robot and learn that it is 14Kg.

Part 1 – Gazebo model for the Kobra robot

You have to create a model of an existing robot called Kobra

http://www.nuzoo.it/it/prodotti-robot/kobra-videosorveglianza-mobile

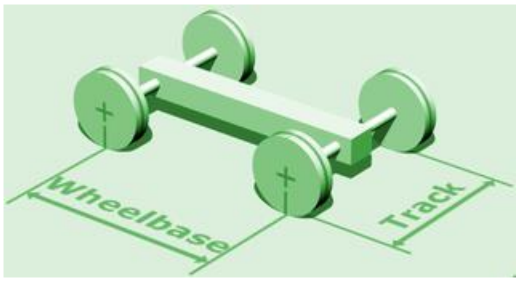
It is a mobile robot moved by a skidsteer system based on two paired wheels (we refer to the model with the wheels not the one with the trucks on the website). The minimum requirements for the model are:

1. Body of the robot with the correct shape and size.

2. Four wheels, each one actuated by its own motor. Wheels on each side are synchronized and must move together. This is necessary in order to simulate a skidsteer. (Other solution with the same behavior are accepter)
3. Straight vertical arm with a camera on top.
4. Pan tilt camera, it has to be placed at the end of a chain of two 1dof joints placed on the vertical arm.
5. Hokuyo laser on the front of the robot.

All the geometrical details (i.e., shape of the wheels, position of the sensor, etc.) of the robot are available on the robot website, and you can derive useful information from the video as well!

The missing info we have not been able to derive from the robot datasheet and the robot web page is the size of the wheels which we have measured being 4.5cm thick and have a 14.5cm diameter (wheelbase 18cm, track 49.5cm). The two links of the pan-tilt are obtained through dynamixel motors, but you just need to model reasonable joints with 3cm links, not the real servos.



Part 2 – Gazebo plugin and ROS setup

First of all you need to implement any kind of Gazebo plugin required to the correct operation of each element of the robot. Here the minimum requirements:

1. Odometry and control:
    a. Convert from the speed of the wheels to the linear velocity x and angular velocity ω.
    b. Integrate the velocity of the robot to estimate a relative displacement after each velocity reading.
    c. Convert from commands sent to the robot using linear velocity x and angular velocity ω to the wheel speed.
    d. Manage the four motors to achieve a proper skidsteer movement.

2. Camera control: manage the two joints controlling the camera to simulate a pan-tilt movement in terms of pan and tilt.
3. Laser: if necessary, manage the laser accordingly using a plugin.

Then you have to prepare the interface between Gazebo and the ROS architecture. It is strongly suggested to do this alongside the development of the plugins. Do your own choices for the name of the topics and the types of messages, but remember to follow standards and existing interfaces.

1. Odometry and control:
    a. /robot/odometry: publish the current speed of the robot and the relative displacement at the simulation frequency.
    b. /robot/cmd_velocity: subscribe to this topic to control the robot.
2. Sensors:
    a. /robot/image: publish images coming from the camera.
    b. /robot/camera_info: publish a topic with the characteristics of the camera.
    c. /robot/laser_scan: publish the scans from the laser.
    d. /robot/ptz: subscribe to a custom message defined as ptz.msg containing the pan and tilt commands as floats (radiants) plus a third float representing the zoom (not used)
3. tf:
    a. Publish a low frequency transform of the real pose of the robot taken form the simulator, available only for testing purpose /robot_gt.
    b. Publish the static transform for each sensor with respect to the /base_link frame.
    c. Publish the transform for each joint controlling the pan-tilt camera with respect to the proper frame.

Part 3 – Odometry ROS node

In this part, you have to develop a ROS node to manage the odometry measurements and integrate them to provide an high frequency absolute position estimate of the robot using tf from the /odom frame (initially the /base_link frame coincides with the /odom frame).

Three versions of the integration algorithm needs to be implemented and should be selectable through a ROS parameter from a launch file:

1. Simple integration using Euler method (Euler)
2. Runge-Kutta integration (Runge-Kutta)
3. Exact integration (Exact)

You can find the details of the three methods in these slides

http://www.dis.uniroma1.it/~oriolo/amr/slides/OdometricLocalization_Slides.pdf

Note: to control the robot around and test the camera, in the meanwhile, for your testing and debugging, you can use rostopic or the turtle_teleop node.
Note: you can initialize the integration for the odometry using the first pose in the /robot_gt transform.

Part 4 – Navigation

Now you have all the pieces to let your robot navigate autonomously using the ROS navigation package (http://wiki.ros.org/navigation). In this part you have to configure the navigation and the simulation in order to execute navigation commands:

1. Set up the simulation to use the willowgarage.world. It should work automagically otherwise you can find it here:

https://bitbucket.org/osrf/gazebo/src/a7d32ebe8e55d4756306da4dc661c3769acb81cf/worlds/?at=default

2. Build a map using the gmapping tool as described here by driving your robot in the simulation using a joypad or the teleop_node

http://wiki.ros.org/slam_gmapping/Tutorials/MappingFromLoggedData

3. Configure the navigation package using the setup described here

http://wiki.ros.org/navigation/Tutorials/RobotSetup

4. Modify your odometry node not to use the /robot_gt, but just using the information provided by amcl or by the initial pose which is sent through the rviz interface.

Now that the simulation is in place, you can use rviz to initialize the robot localization and navigate the robot around the environment … try this out for a while before you move to the next part.

Part 5 – Planning and monitoring (optional)

Dealing with the robot by sending manually all the destinations is quite boring and kind of useless if we want our robot to be autonomous :-) … lets implement a simple planner for a patrolling task.

1. Select 8 destinations scattered around your environment and put these destination in a text file one per line
2. Develop a node which reads the previous file with the patrolling plan; this node, implemented as an actionlib client, sends goals to move_base one after the other. A new goals is sent once the previous has been reached or the plan cannot be executed or failed.
3. Once the list of destinations is completed the robot restarts from the first one in an infinite loop.

What to deliver and how it will be evaluated.

The project should be delivered by email as single compressed file to Matteo Matteucci && Gianluca Bardaro. The archive should contain:

1. The gazebo model as a directory with SDF files and a ROS package with nodes sources and corresponding launch files (put your names in the directories names)
2. A max 4 pages report describing:
    a. The files provided
    b. The installation (if any) and compilation instructions
    c. Instruction to configure the execution (e.g., parameter setting)
    d. The instructions to execute the code and check that all the above has been done successfully

The evaluation will be performed by following your instructions, if these do not work, we assume the course project does not work (we suggest you to have someone else testing the whole on his/her computer before submitting the project).