BOT-DRIVES-TO-WAYPOINT PROJECT

Objective: Have the car drive through the gate, autonomously.
Duration: 1.5 weeks. (depends on how fast you do the preliminary ROS tutorials)

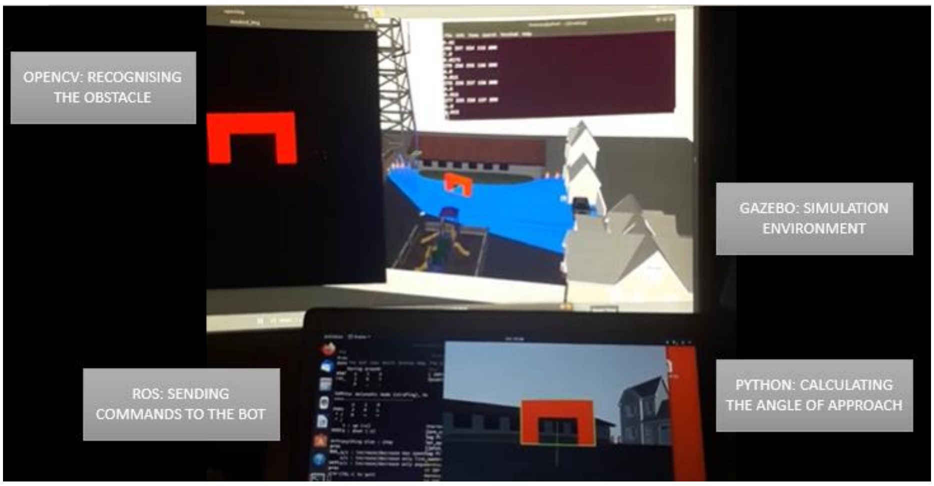
This project uses a wheeled bot in Gazebo and programs it to detect and approach a gate. This project, for me, was a primer in the use of a simulator, **Gazebo** with a programmable middleware, **ROS** in a field that interests me, **waypoint following for robotics**. This project is therefore clearly linked to autonomous drones, as they also can navigate by following waypoints. However, the specific usecase here is about:

- **coding bot behaviours within the Gazebo simulator based on what the bot observes**,
- while also creating a modular environment intuitive enough for other functionality to be added later.

Various functionalities are designed and we will be able to explore them in greater depth in a series of tutorials. This page, instead, looks at what was achieved in the project. See these pages on the site for introductory information.

- *Robot behaviour planning*
- *Basic computer vision for robots*
- *Linux and ROS background*
- *Creating applications with ROS*

The final demo is accessible at https://www.youtube.com/watch?v=rdJYIxeUt-o . It incorporates the technologies shown below.



Note: this document was last updated in October 2020. Please signal any issues at thomas.carstens@edu.devinci.fr .

1. Why ROS?

<u>Usefulness of:</u>

- A networked environment
- A Middleware

1. Niveau Débutant

   1. Installation et Configuration de Votre Environment ROS

      Ce tutoriel vous guide à travers l'installation de ROS et la configuration de votre environnement ROS pour votre ordinateur.
   2. Navigation dans le Système de fichier ROS

      Ce tutoriel introduit les concepts du système de fichiers ROS, et couvre l'usage des commandes de roscd, rosls et rospack
   3. Créer un package ROS

      Ce tutoriel présente l'utilisation de roscreate-pkg ou catkin pour créer un nouveau package et rospack pour lister les dépendances des packages.
   4. Construire un package ROS

      Ce tutoriel détaille la création d'un package ROS à l'aide d'un ensemble d'outils ROS.
   5. Comprendre les 'nodes' ROS

      Ce tutoriel introduit les concepts de ROS graph et l'utilisation des outils en ligne de commande roscore, rosnode, et rosrun.
   6. Comprendre les Topics ROS

      Ce tutoriel introduit les concepts de Topics sous ROS ainsi que l'utilisation des outils en ligne de commande rostopic et rqt_plot.
   7. No Title

      No Description

Project

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1. Driving a car in Gazebo

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Duration: 1 week. (depends on how fast you do the ROS tutorials)

Steps

Step 1: set up ROS, then Gazebo simulator.
Step 2: set up the environment (the gate)
Step 3: Setting up the car
Step 4: Setting up a ROS script to control the car's wheels.
Step 5: Setting up a camera on the car (and rqtplot)
Step 6: Connecting OpenCV node to recognise obstacles.
Step 7: Making the car move to the gate.

ROS tutorials

Il est toujours bon de réviser ses fondamentaux et je conseille de faire les tutos Débutant, Intermédiaire et On Your Custom Robot pour découvrir toutes les nouvelles fonctionnalités: http://wiki.ros.org/fr/ROS/Tutorials

***Si vous êtes nouveau sur Linux**: Vous trouverez peut-être utile de commencer par faire un rapide tutoriel sur les outils communs en ligne de commande pour Linux. Un bon est ici.*

Pour toute fonctionalité à implémenter sur Gazebo, voir http://gazebosim.org/tutorials

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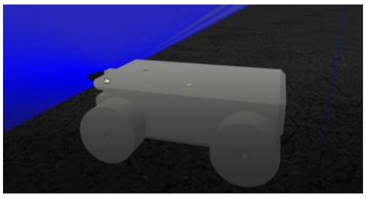
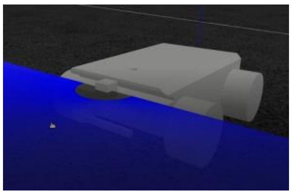
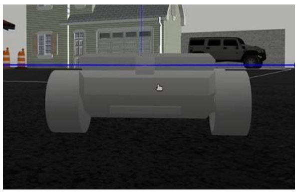
DESIGNING A WHEELED BOT

First we test the URDF in an empty simulator.

The Unified Robotic Description Format (URDF) is an XML file format used in ROS to describe all elements of a robot. I followed a tutorial provided by the ROS documentation to create the URDF format, and another from the Gazebo documentation be able to convert it to SDF (XML file format that is readable by Gazebo).

Read the theory to better understand what URDFs consist of.

- **Modelling the robot base:**
- **PG106 OF ROS TEXTBOOK**

As you can see, the front two blocks house the lidar sensor (from which emanates the blue rays) as well as the RGB camera (elongated block).

Note: do not spend too much time on this stage. If needed, ask for help.

GETTING STARTED

I used the ROS manual for this, which you can find in our ROS Resources Page.

You can easily get up and going with the finished version of the URDF accessible on the ROS textbook's github. (contact a friend to learn to use github)

- Git clone https://github.com/PacktPublishing/ROS-Robotics-Projects-SecondEdition
- For your info: Urdf and other file formats found here: **https://github.com/PacktPublishing/ROSRobotics-Projects-SecondEdition/chapter_3_ws/src/ robot_description/**

This workspace (chapter_3_ws) needs to be compiled as a ROS package. Follow instructions from the ROS Textbook:

- **Testing the robot base**
- **PG100 (stop at "Modeling the robot arm")**

SETTING UP POSTOFFICE WORLD

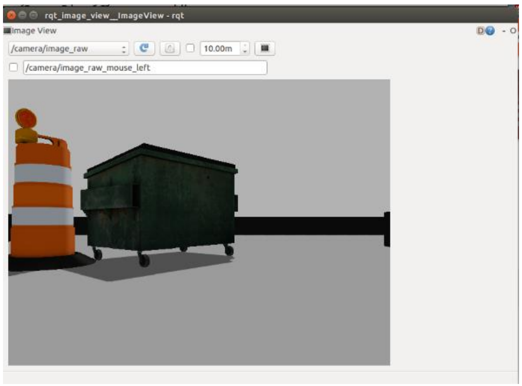
A template world can be loaded from the gazebo libraries.

Follow instructions from the ROS Textbook:

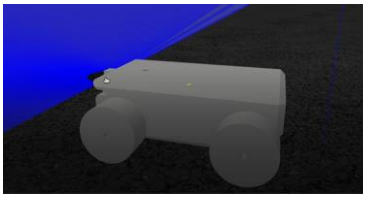
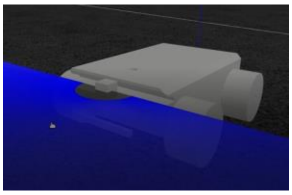
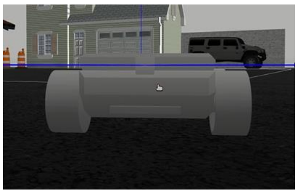
- **Setting up the environment in Gazebo**
- **PG168 (stop at "Making our robot base intelligent")**
- **Be careful to spawn the robot base and not mobile_manipulator as they do. You can compile chapter_5_ws as they do, or keep the previous workspace.**

ADDING A CUSTOM CAMERA TO THE BOT

Gazebo allows the integration of cameras in order to visualise the simulation environment.



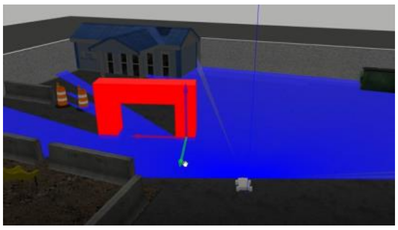
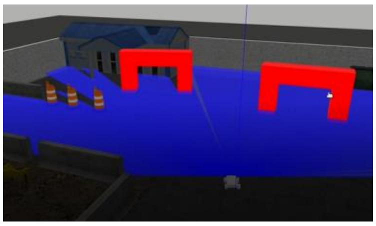
I followed a tutorial provided by Gazebo documentation in order to integrate a custom camera (top). Do similarly to integrate a custom lidar (bottom).

MAKING A RED GATE

In order to make the waypoint itself, it was important to examine how textures and colours are created in the Gazebo world, which I discovered in this tutorial.

Interesting note: Adding colour textures, but also custom images, onto an object in Gazebo, actually requires the addition of a separate package for texturing, and it seemed simplest for me to fetch the model from any simulator instance by storing it in the full object in the root /.gazebo/models folder.

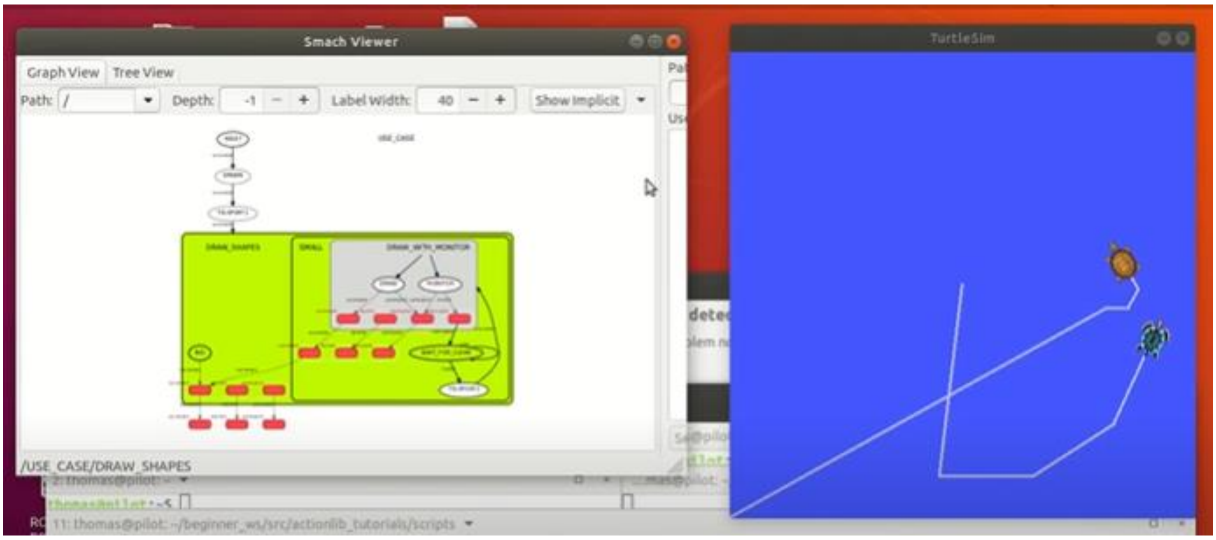
USING A STATE MACHINE TO CONTROL A SEQUENCE OF ACTIONS

Choosing the state machine

My experience previously consisted of designing **digital electronics** state machines. I went on a search for the best framework for my particular case. The different programs that I reviewed were ROSPlan, RSM and Python Smach. The solution needed to work with ROS nodes, but also function independently for the sake of modularity. However, it was not necessary to have a performance-oriented state machine such as ROSPlan, rather one that would be useful for quick prototyping. An added plus would be integration into server-client setups for smooth demoing. The Python SMACH library promised all these elements.

Learning to use the state machine

I followed the official set of tutorials for the Smach documentation. These tutorials work in conjunction with TurtleSim, frequently used to test ROS functionality. The final result of this process is a simulation that is better viewed as a video rather than in pictures, please access it here.



Integrating the state machine into the behaviour script

The behaviour script is available in the github linked in the first page.

Using the behaviour script, we were able to create the demo which you will view on our video.