Chapter 33
Simulator for Teaching Robotics, ROS and Autonomous Driving in a Competitive Mindset

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ABSTRACT

Interest in robotics field as a teaching tool to promote the STEM areas has grown in the past years. The search for solutions to promote robotics is a major challenge and the use of real robots always increases costs. An alternative is the use of a simulator. The construction of a simulator related with the Portuguese Autonomous Driving Competition using Gazebo as 3D simulator and ROS as a middleware connection to promote, attract, and enthusiasm university students to the mobile robotics challenges is presented. It is intended to take advantage of a competitive mindset to overcome some obstacles that appear to students when designing a real system. The proposed simulator focuses on the autonomous driving competition task, such as semaphore recognition, localization, and motion control. An evaluation of the simulator is also performed, leading to an absolute error of 5.11% and a relative error of 2.76% on best case scenarios relating to the odometry tests, an accuracy of 99.37% regarding to the semaphore recognition tests, and an average error of 1.8 pixels for the FOV tests performed.

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INTRODUCTION

Interest in autonomous vehicles (AVs) have grown in the past years and represent an important innovation for the automotive industry. Self-driving cars pave the way for myriad relevant applications across multiple fields. In such a dynamic context, work and research in this area has grown greatly over the last years (Carvalho & Borrelli, 2015). This topic has even raised interest within the robotics community and was the target focus of many robotic competitions around the world. An autonomous intelligent vehicle has to perform a number of tasks, sometimes in a limited amount of time. The most critical task is the perception and mapping of the surrounding environment. This involves being capable of identifying and tracking road lanes, being able to process traffic lights and road signs, and being consistent at identifying and avoiding obstacles (Häne, Sattler, & Pollefeys, 2015). The interest in robotics field as a teaching tool to promote the STEM areas - Science, Technology, Engineering and Mathematics has grown in the past years. Some initiatives like RoboCup contest (RoboCup, 2016) that have its first edition 1993, RoboParty (RoboParty, 2016) going in the 10th edition in 2016, the CEABOT (CEABOT, 2016) since 2006, ISTROBOT (ISTROBOT 2016, 2016) since 2000, "Micro-Rato" (Micro-Rato, 2015) since 1995, Micromouse Portuguese Contest (Micromouse, 2016) since 2011 focus on promote robotics challenges. In 2015, the car brand Audi has proposed a challenge called Audi Autonomous Driving Cup (Audi Autonomous Driving Cup, 2016) aiming to promote the autonomous driving challenges. This competition is orientated to students of computer science, electrical engineering, mechanical engineering or similar disciplines. The participants are asked to develop fully automated driving functions and the necessary software architectures. For this task, a hardware platform model vehicle, with a scale of 1:8, is provided. This vehicle was developed specially for the competition. Giving the last year success, Audi has repeated the competition in 2016, offering a cash prize of 10,000 euros. As such, the autonomous driving paradigm is well-suited to incentive robotics students in those competitions, such as the Portuguese National Robotics Festival (PNRF) - "Festival Nacional de Robótica."

LITERATURE REVIEW

In order to properly prepare the contestants for a successful participation, some authors have presented strategies to teach and enthusiasm students into the robotics area using hardware based platforms. A major point to support this solution is the integration of Robotics classes' exercises with real-world problems, with the output of the working project interacting directly with a real setup, thus motivating students (Cardeira & da Costa, 2005; Lenskiy, Junho, Dongyun, & Junsu, 2014). To reduce complexity, they can be based on off-the-shelf components. By skipping the complications of hardware development, which students in their first graduate years do not have, development in autonomous driving robotics is much more accessible (Cardeira & da Costa, 2005). They can also permit online development, making possible to create online classes, giving greater accessibility to the platform (Lenskiy et al., 2014). Usage of this manner of platform as a learning tool can prove to be costly and potentially difficult to distribute between potential students. Being a physical solution, it is prone to malfunctions, thus requiring maintenance and it is harder to share, unlike software. Unless it is a modular setup, the robots will be tailored to specific tasks, limiting their usage in different scenarios (Yusof & Hassan, 2012).