GIFTS: Tools to Help Students Prototype and Test Autonomous Robot Navigation Algorithms

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GIFTS: “Navigating Success: Innovative Instructional Tools for Small Scale Autonomous Over Terrain Vehicle (OTV) Prototyping"

At the University of Maryland, students enrolled in an Introduction to Engineering Design course are tasked with designing, building, and testing small-scale Over Terrain Vehicles, also known as OTVs, capable of autonomous navigation within a designated arena, utilizing an internally developed Vision System. However, students often face downtime during the OTV assembly phase, delaying the commencement of algorithm development and testing. To address this challenge, the University of Maryland has devised three instructional tools: Clipboard OTVs, TF OTVs, and an Online Simulator. These tools serve as educational aids, providing students with opportunities to grasp the fundamentals of navigational algorithms and engage in practical programming exercises throughout the course. In this paper, we highlight the design and functionality of these instructional resources, emphasizing their role in facilitating student education and progress in navigating the complexities of autonomous OTV design.

The experimental approach employed by the University of Maryland to support student learning in the first-year engineering design course is strategically formulated to cater to different learning styles and stages of the course project. Clipboard OTVs are physical clipboards equipped with an ArUco marker, Arduino Uno, and a Wi-Fi Module. They provide a tangible platform for students to conceptualize and understand communication between basic Arduino code and our unique Vision System, this being a camera with an eagle-eye view of our arena that creates a coordinate system that tracks the location of students’ chosen ArUco IDs. TF Tanks, built by the Teaching Fellow assistants for the course, offer hands-on experience, allowing students to interact directly with a small 3D printed pre-built OTV to upload and test their navigational algorithms in the arena. These TF Tanks are assembled with an Arduino Mega, various sensors, interchangeable drivetrains, a Wi-Fi module, and a designated ArUco ID. Complimenting these TF Tanks is a precoded library with a set of functions designed by the Teaching Fellows to help students who are unfamiliar with coding, understand and learn the basic foundation to create autonomous navigational algorithms. Finally, an Online Simulator serves as a virtual arena, enabling students to experiment with various algorithmic approaches and receive immediate feedback on their performance remotely from any environment they may be working in. Students also have the option to scale their OTVs in this simulator and equip certain sensors, mimicking their proposed physical OTVs. This leads to more accurate physical attempts when their OTV is assembled and tested. Together these instructional resources form a comprehensive framework that empowers students to acquire theoretical knowledge, apply programming skills, and iterate on their designs throughout the course project.

Through these instructional tools, students have demonstrated increased engagement and proficiency in navigating the complexities of autonomous OTV design within the course. Furthermore, the iterative nature of using these instructional resources has promoted a culture of continuous improvement among students, encouraging them to refine their algorithmic approaches and troubleshoot challenges effectively. As a result, students have shown significant progress in their ability to develop and test autonomous navigation algorithms, culminating in successful OTV navigation within the designated arena. Overall, the integration of Clipboard OTVs, TF Tanks, and an Online Simulator has proven instrumental in enriching the educational experience of first-year engineering students at the University of Maryland.