Wheeled Mobile Robots Courseware

"This courseware explains thoroughly various types of wheeled mobile robots, namely, differential-drive, Ackermann-based steering, articulated-based steering and wheeled pendulums."

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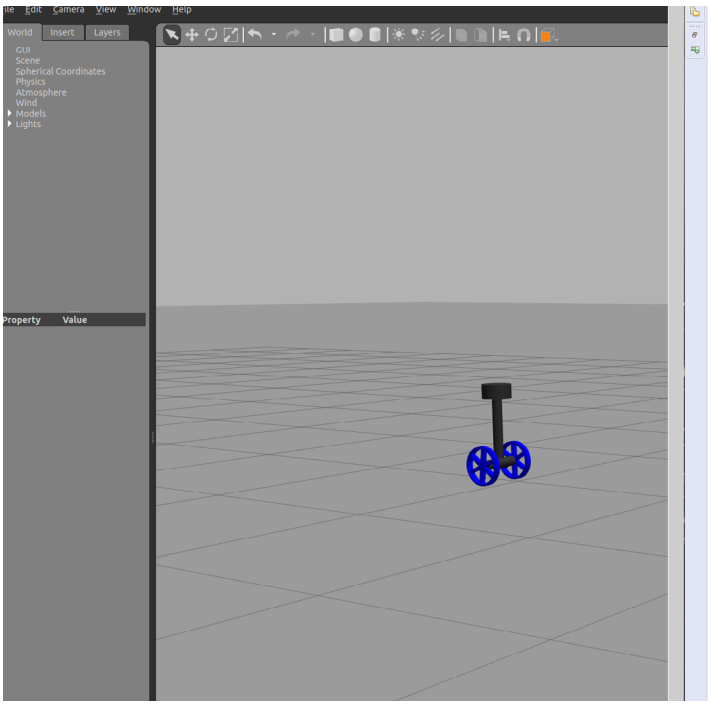
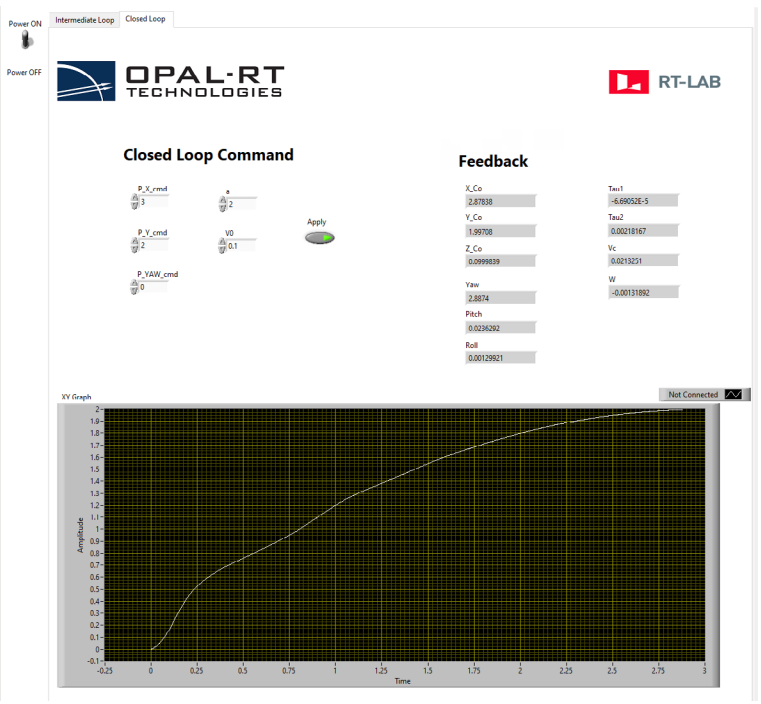
The courseware is intended to teach wheeled mobile robots to universities' students. Students grasp deep understanding of concepts such as: non-holonomic constraints, kinematics and dynamics models, open-loop and closed-loop control strategies for navigation. The architectures covered are: Differential-drive, Ackermann-based steering, Articulated-based steering, and Wheeled pendulums.

MAIN BENEFITS

- Covering thoroughly wheeled mobile robots, step-by-step, via interactive exercises where students are in-the-loop interacting with the virtual robot and analyzing / controlling its motion.
- Reproducing digital twins of wheeled mobile robots' prototypes, cars and tractors.
- Comparison of the performance of various control schemes in real-time and instantaneous observation of the changes in the displays.

INTERACTIVE PANEL





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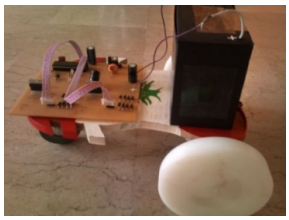
WHEELED MOBILE ROBOTS LEARNING OUTCOMES

Differential-Drive Robot: Build the kinematics model of a three-wheeled robot composed of a rear differential-axle and front caster wheel. Understand nonholonomic constraints, write the system in Pfaffian form, and define vector of independent speeds. Derive kinematics model. Use Gazebo as dynamics engine. Identify navigation coordinates. Control the robot using Lyapunov function for navigation and sliding mode control.

Ackermann-based steering robot: Build the kinematics model of the robot with Ackermann-steering based mechanism. Repeat steps listed above related to nonholonomy and dynamics. Apply the non-linear change of coordinates to put the robot in a one-chain system form. Generate a trajectory for point-to-point motion using polynomial inputs. Apply those inputs to the dynamics model and observe the drift due to dynamics, which was not considered. Re-inject those inputs in the kinematics model to generate the references for navigation coordinates. Control in closed-loop the navigation coordinates to obtain appropriate results.

Articulated-based steering robot: Repeat the steps related to kinematics model, nonholonomy, and dynamics. Apply closed-loop control strategy to navigate the robot.

Mobile Wheeled Pendulum: Repeat the steps related to kinematics model, nonholonomy, and dynamics. Notice that MWP is a subclass of DDR, where the caster wheel has been removed rendering the platform oscillating and introducing unstable zero-dynamics. Consequently, apply the non-linear change of coordinates to achieve global input-output linearization. Control the platform oscillation via heading speed and its orientation via steering rate. Implement upper layer of control for robot navigation as done in DDR.

Commercial Car	Tractor and Loader	DDR Prototype	InPeRo Prototype
			
Commercial Car's Digital Twin	**Tractor and Loader Digital Twin**	**DDR' Digital Twin**	**InPeRo' Digital Twin**