Designing a Drive-by-Wire system for an Autonomous Electric Car

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1. ABSTRACT

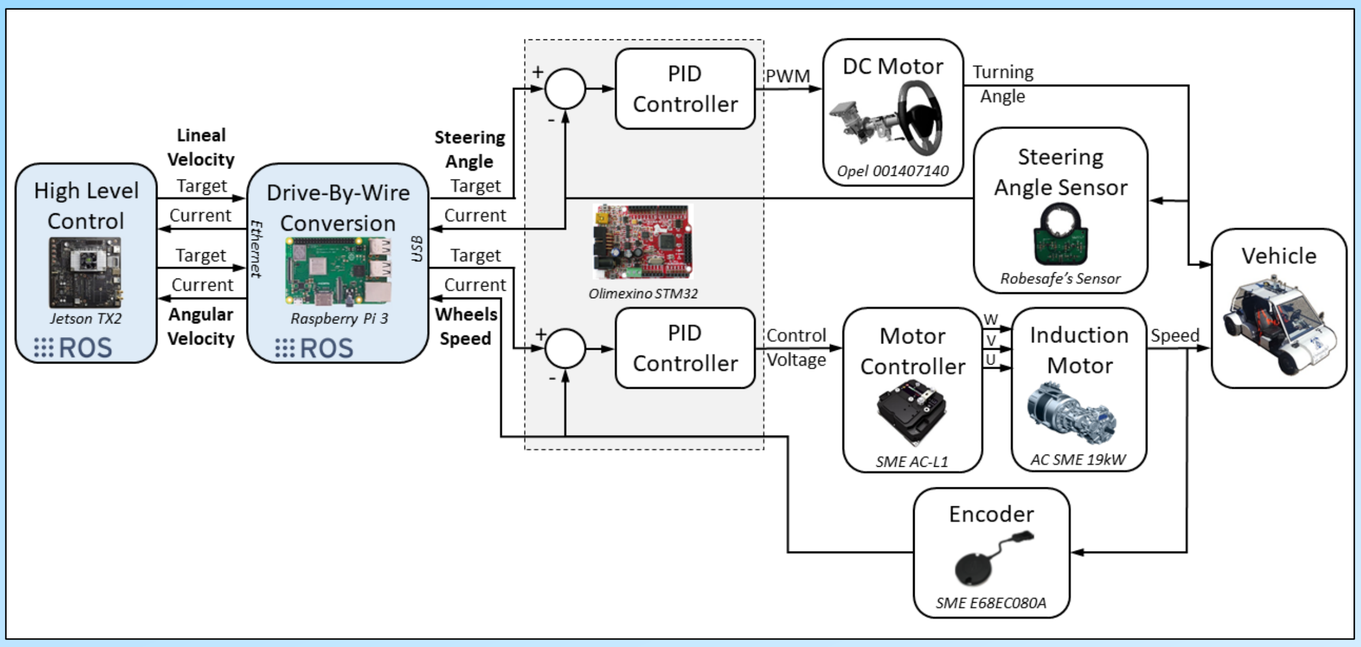
One of the first phases in the development of an autonomous car is the design of the Drive-By-Wire system, which replaces the manual control of the vehicle through traditional mechanical interfaces (steering wheel, brake, accelerator), with electronic systems capable of activating them automatically. In this paper we present the modular and ROS-based Drive-By-Wire system, designed and implemented for the autonomous electric vehicle developed by the RobeSafe research group of the University of Alcalá from an open-source chassis, which allows the car to be controlled from linear and angular speed commands. The proposal has been validated on a real vehicle in real controlled urban environments.

2. SYSTEM ARCHITECTURE

First, the Steer-By-Wire system was implemented. The factory mechanical steering column of the original chassis was replaced by an electric one using a commercial vehicle power steering. A magnetic angle sensor developed by the RobeSafe group was added to this new column. The closed loop system is controlled through a DC motor driver and a development board.

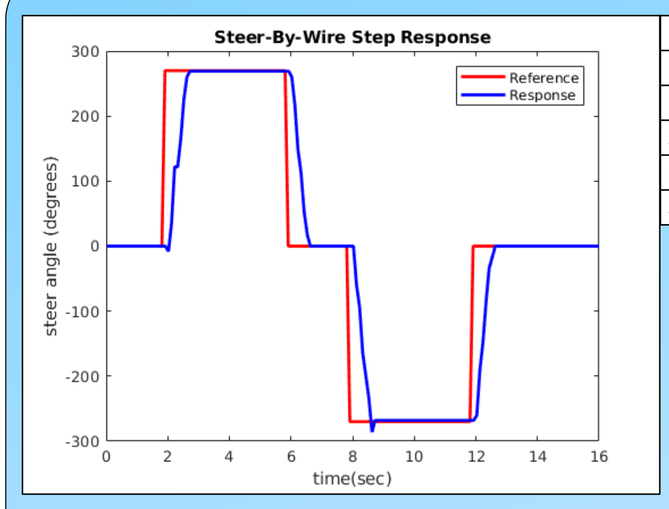
Next, the Throttle-By-Wire system was implemented. Being an electric car this stage was easier. The acceleration of the car is controlled by a continuous voltage that is sent to the AC Induction Motor Controller of the propulsion engine of the car. This control voltage is generated through the development board. An encoder was installed in the propulsion engine to feed back the motor speed.

Taken these two systems the vehicle has been automated being possible to control it, through two kind of targets, one for the steering wheel angle and the second for the speed of the driving wheels.



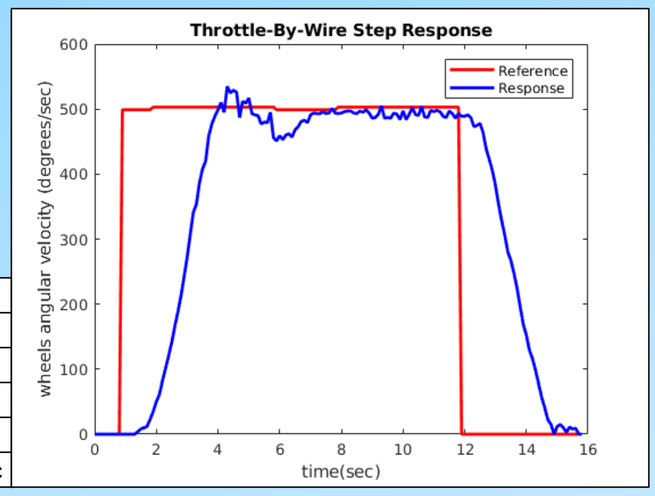
Since the entire autonomous car project is based on ROS (Robot Operating System), a Raspberry Pi 3 have been added to manages the system by using ROS packages. Considering this previous configuration, we have designed a modular ROS-based Drive-By-Wire system that allows to control the vehicle using the linear and angular speed targets that are sent through the local network.

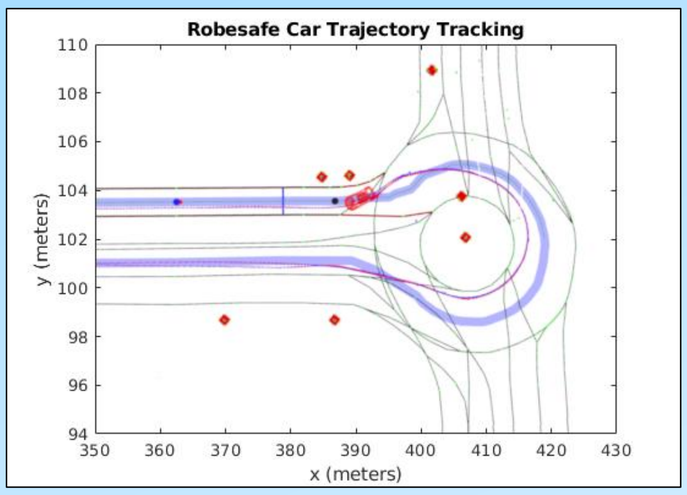
3. RESULTS



PARAMETER	VALUE
Deadtime	0.101 sec
Rise Time	0.649 sec
Setting Time	0.799 sec
Maximun Peak Overshoot	3.925%
Steady-State Error	± 4°

PARAMETER	VALUE
Deadtime	0.320 sec
Rise Time	2.201 sec
Setting Time	4.801 sec
Maximun Peak Overshoot	4.731%
Steady-State Error	± 20 °/sec





The Drive-By-Wire system has been tested throughout the development of the Techs4AgeCar Project. The Steady-State Error of the Steer-By-Wire system is ± 4° which is equivalent to an error of ± 0.1° rotation angle on the front wheels. The Throttle-By-Wire error is ± 20°/sec which is equivalent to an error of ± 0.360 km/h of linear speed. Using this system and a navigation architecture divided into a high-level executive layer, to manage the driving decision-making process, and a low-level reactive control, in charge with the motion local control, the car is able to follow a path defined by the local planner. Mapping and high-level planning is based on lanelets. Our decision-making is based on Petri Nets and our low-level control is based on the Pure Pursuit and the Beam Curvature Method (BCM) algorithms.

4. CONCLUSIONS AND FUTURE WORKS

A robust and ROS-based Drive-By-Wire system has been implemented and successfully tested throughout the development of the Techs4AgeCar Project. **Future guidelines**: development of the Brake-By-Wire system and a remote control interface of the vehicle based on ROS.

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