Politecnico di Torino

Technical report

Freescale CUP 2015

Sumery

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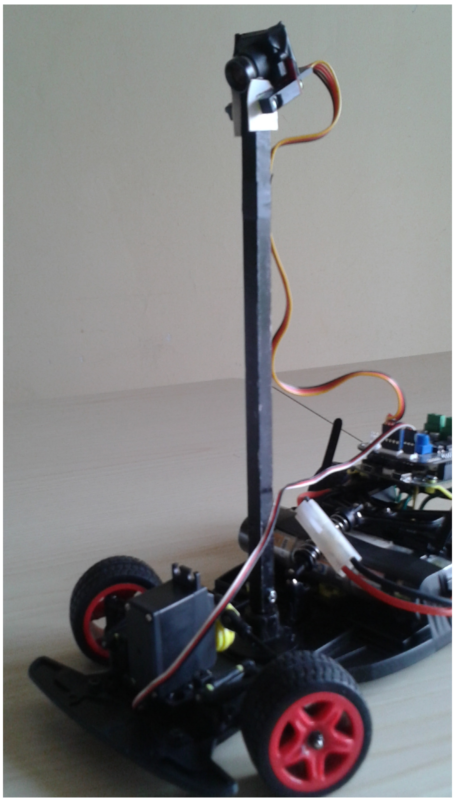
Introduction

The Freescale Cup is a global competition between university students. The goal is to develop an autonomous car fastest as possible. The car with minimum lap time wins.

The standard intelligent car components are the model car kit, servo motor, electric motors and a quick start guide. Below is a list of the specific elements by function:

- Chassis - 1/18 Scale Model
- Propulsion – 2 x 7.2V DC Motor
- Steering - Servo Motor
- Control System - Freescale Development Board
- Vision – Line Scan Camera



Mechanical design of vehicle model

Chassis

Standard Freescale chassis has been used to build the car, keeping DC motors in the back of the car opposite to the servo, used for steering. A negative camber has been adopted to give more stability in curves.

Add-on

A vertical aluminum pipe has been added to provide line scan camera support. A series of screws have been used to setup the tilt angle of the sensor. A piece of black tape covers the back of the camera to prevent light noise.

Battery

Sumery is powered by a standard 2000mAh 7,2V (1,2 x 6) Ni-Mh battery, housed in the center of mass of the car fixed with two zip ties.

Weight and dimensions

Lenght: 30 cm

Width: 17 cm

Height: 26,5 cm

Weight: 1,0 kg (including battery)

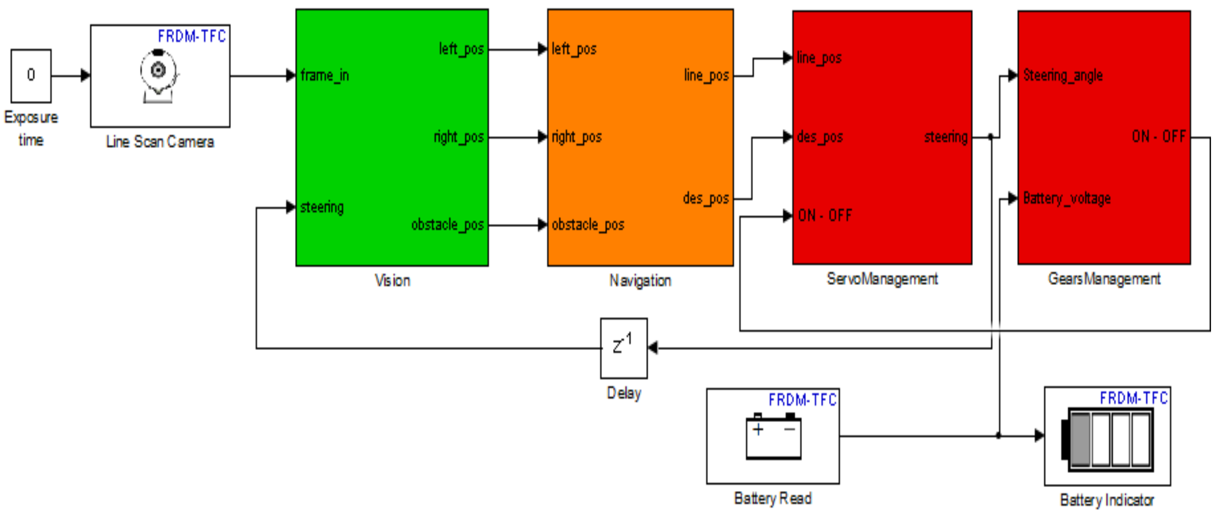
Electronics

Freescale boards

The FRDM-TFC is a convenient "shield" that can drive up to two DC motors (5A per channel), a servo and I/O for the Freescale cup line scan camera .

Control software design

In the first time, we have developed a model-based control software using the Mathworks platform support package for the Freescale Cup. Thanks to this method we have had very quickly a running software with a little effort. The algorithm is vision-based.



The model-based approach presents some limitations , in fact the cycle time is too high and it is a problem at high speed. So we have decided to integrate the code generated by Embedded coder with our custom code. Also we wanted to add a wheel speed sensor to have the measurements of wheel speed to develop a more precise differential.

Vision algorithm

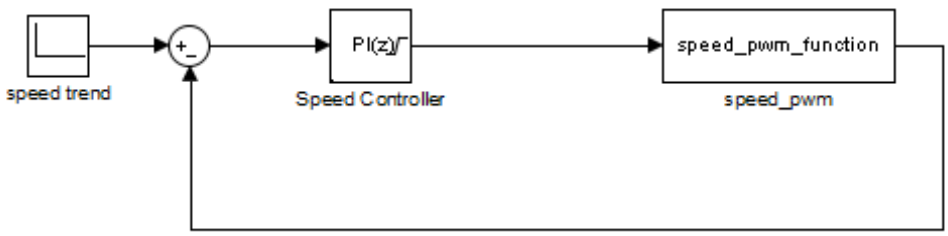
The line scan camera sensor is the only sensor used to detect the two lateral black lines. Thanks to line scan camera block, we can interact with the camera, every 8 ms this block returns the camera's frame. Then are calculated some thresholds to identify the black lines.

Steering control

Depending on the difference between the position of the lines and the desidered position , an error is calculated, and a P algorithm is used to control the vehicle movement. The movement is achieved by setting a correct value of PWM used to drive the servo.

Speed control

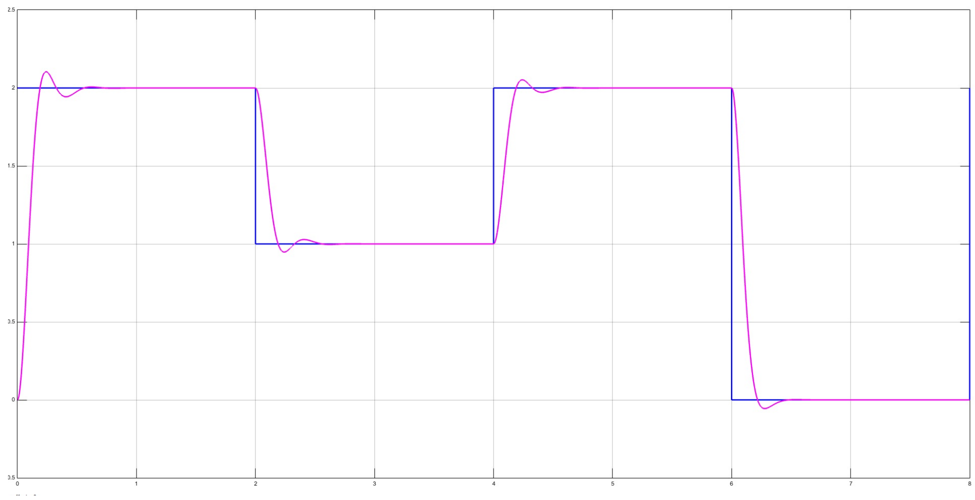
The control of DC motor is done with a single loop. This control loop takes as input the speed of vehicle and provides the PWM signal.



This control loop is used to improve the speed control of the vehicle using a PID control.

Kp is used to have a faster response. This parameter gives a correction needed to have the real value of speed more like to the theorical value (higher error correspond an higher correction needed). By using only this value the control results more faster but more unstable too. Because using only this value the trend became an oscillating trend and it gives a bad result on the real speed trend.
The parameter Ki is used with the sum of every errors during the trend. This parameter damps the oscillating trend given by the proportional term and add a delay of the response and so the result is to reduce the overshooting given by proportional term.

Here is shown the theoretical trend of the speed control (blue line desired trend, magenta line simulated trend):



And here is shown a real trend of the vehicle speed: