Determining Tire characteristics through data driven modeling

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1 Introduction

We live in a world where a lot of car accidents occur. This is something everybody knows. A less known fact is that many of these accidents could have been avoided. This is because of the fact that a lot of these accidents happen due to the inability of divers to control the car at the limits of friction. Race drivers are taken as a reference point. They can handle the car at the limits of the tires without losing control. So if autonomous vehicles or driver assistance systems have these capabilities, a lot of accidents can be avoided. Until now, driver safety systems in modern-cars have focussed on keeping the car in the linear regime while driving. For example, ABS prevents the wheels from slipping and traction control prevents the car from â€˜breaking outâ€™ of its path. These systems keep the car in the linear regime. However, there is a serious need for safety systems which can operate the car in the nonlinear regime of driving, i.e., driving while the tires are slipping. Making evasive maneuvers is often the only way to prevent a collision, and this cannot be done without driving at the limits of friction.

2 Background

In order to achieve Model Predictive Control, it's important to build a valid model of the dynamics of the used RC car. In order to do so, it's important to understand the tire characteristics of this vehicle. This means there has to be a model for the tire characteristics as well. To build such a model, Data-Driven Model Design is used. To analyse the data of the test rig, a dynamical model is necessary. For this case, the Bicycle Model is chosen.

In the Bicycle Model, the car is represented as a rigid, two-dimensional, two-wheel vehicle. The front wheels are represented as one wheel and so are the rear wheels. Nevertheless, this model comes with some important assumptions so there are some restrictions to test settings as well. The car should not move in the vertical (z-) position, nor rotate in the pitch and roll directions (around the x- and y- axles). Furthermore, the longitudinal velocity needs to be constant for calculations in the linear regime.

3 Experimental

In order to determine the tire characteristics of the scaled vehicle, a good testbed is necessary. In this section the experimental setup used to gather the data needed for determining the tire characteristic is discussed.
The experimental setup consists of a modified scaled RC car with an on board IMU and a tachometer on each wheel. Moreover, a motion capture system or MoCap was used to provide millimeter precision locating.

The scaled RC car is a Losi TEN Rally-X. It is a 1:10

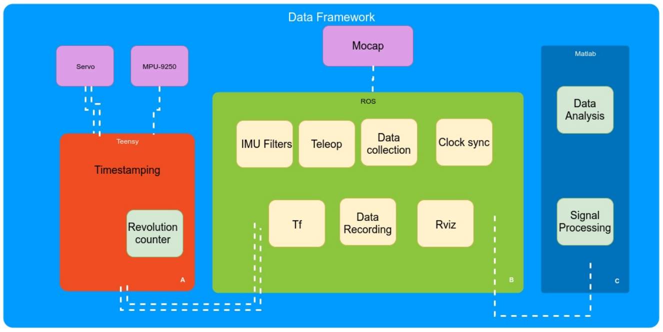

Figure 1. Data acquisition framework

scale car with 4WD. Each wheel was fitted with it's own hall effect sensor which generates a pulse every time one of the 24 magnets inside the rim passes it. Furthermore, a set of costum 3D printed wheels were fitted with 24 magnets inside to generate the tacho signal. Finally, the car's suspension is replaced with stiff turnbuckle rods to eliminate the degrees of freedom of roll and pitch, to meet the assumptions of the Bicycle model.

Data acquisition was done using a ROS (Robot Operating System) based system. The sensors were read using a Teensy 3.6 protyping board running a costum ROSserial node, connected to a Raspberry pi 3b running ROS. The MoCap connected to the system utilizig the labs Wi-Fi network. Further communication was done using a self written ROS package. After data collection further processing was done using Matlab.Figure 1 further eleborates the Data acquisition framework

The experiments that we conducted can be classified into three groups. The first set of experiments are the ones on the straight (longitudinal motion). During these we accelerated and braked while driving straight ahead. The second set are the steady state cornering experiments (lateral motion). Steady state cornering means cornering at a constant longitudinal velocity and constant steering angle. The first group of experiments focuses on longitudinal forces and slip ratios, while the second group focuses on lateral forces and slip angles. The tests were separated in order to distinguish longitudinal and lateral motion (Recommendation Barys Shyrokau). Finally, the third set of experiments are of combined motion. These tests take both lateral and longitudinal motion into account. Variables of the tests are acceleration/deceleration for longitudinal motion, longitudinal velocity and steering angle for lateral motion, and these three combined for combined motion. The variables were slightly increased each experiment in order to determine the 'borderline'between linear and nonlinear behaviour is.

4 Discussion

5 Conclusion