Snow-Terrain Mobility Performance Analysis

Abstract

This project we are looking at the performance of a small autonomous vehicle which we designed for operation in snow like terrain. We use data from an Inertial Measurement Unit (IMU), wheel encoders, and temperature sensors to study traction stability and direction accuracy in low friction situations. We put forth key performance indicators which include slip ratio and heading drift to evaluate how well the vehicle performs and navigates in snowy settings.

Introduction

Autonomous cars which run in snow and ice present many issues which mostly revolve around low friction between the road and the car, uneven road surfaces, and very cold temperatures. These conditions put forth problems like wheel spin, loss of proper direction, and decreased overall system performance. Also very important is the issue of monitoring performance which in turn guarantees safe movement, stable traction, and accurate navigation.

This project sets out to study sensor data which in turn will report how well we think an autonomous vehicle does in snow terrain simulations.

Project Scope

This project reports on the study of sensor data which we use to determine traction stability and directional control of a small autonomous snow-terrain vehicle. We look at slip ratio and heading drift mostly using data from wheel encoders and the IMU. Real time control implementation and physical testing of the vehicle is out of the scope of this project and we plan to look into that in the future.

Data Resources

In this project we used a set of time series sensor data which we sample at 20 Hz. We include wheel encoder speeds, vehicle linear speed, IMU acceleration and gyroscope data, and temperature readings. The data which we present is of vehicle performance in low traction conditions which we assume to be that of snowy terrain. Also all data is put in CSV format and is managed via the project’s GitHub repo.

Methodology

Exploration of the data was done in Python which in turn helped us to better understand sensor behavior and vehicle mobility. We determined the slip ratio by use of wheel encoder speed as a comparison to the vehicle’s linear speed which in turn we used to study traction performance. We also looked at directional drift which we estimated through integration of the gyroscope’s yaw rate data which in turn told us about changes in vehicle heading over time. Also we used data visualization methods which in turn supported our analysis and did great job in presenting results in a clear manner.

Results and Evaluation

The data shows that we see an average slip ratio of about 10% which is below the 15% predefine threshold which in turn indicates good traction. Also we note that the max headed drift we got was 2.13 degrees which is far within the 5 degree acceptability range. Thus we report that the car does very well in terms of traction and direction under simulated snow terrain conditions.

Constraints and Limitations

In this project we looked at a few issues which included low battery performance in cold settings, motor torque issues, sensor noise, and also played out that surface friction varied. Also we did simulation based analysis which doesn't fully represent real world results of wind disturbances, mechanical wear out, or sensor misalignment.

Conclusion and Future Work

This project reports we have put forth sensor based monitoring as an effective solution for study of autonomous vehicles' mobility performance on snow like terrain. We analyzed the performance of the vehicle and report it met the required marks for traction and directional stability in low friction settings. As for the future direction of this work we will be gathering real world data, we will be putting in place adaptive traction control algorithms and we will deploy a real time monitoring dashboard on cloud platforms like AWS EC2