Autonomous Self Driving Vehicular Project 2023

SCAMP: Self-guided Computer Assisted Mecanum Pathfinder

RUTGERS
WINLAB | Wireless Information Network Laboratory

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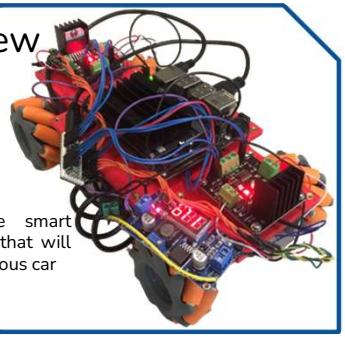
SCAMP Overview



Goal

Develop a remote-controllable car to mimic the path taken by a car in a real intersection.

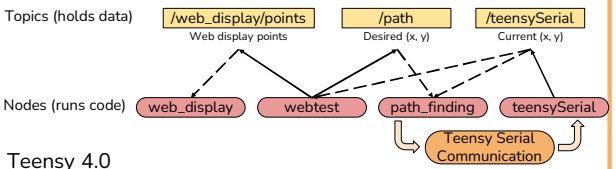
Purpose

Bring life to the miniature smart intersection with dummy cars that will simulate traffic for our autonomous car RASCAL.

Software

Jetson Nano

The software framework of the car is built on the Robotics Operating System (ROS) environment, which uses "nodes" to run different sections of code in parallel. Each node is responsible for its own concern and communicates with other nodes by "publishing" data and "subscribing" to global topics.



Teensy 4.0

The Teensy runs a main loop that receives desired position data from the Jetson Nano over serial. It then makes calculations based on its current position and angle before sending desired speeds to the four mecanum wheels.

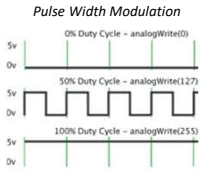
Handling Motor Speed

Motor speed is calculated by finding the time *t* it took for the wheel to rotate by *d* encoder ticks (usually small). Using such a small interval for distance is possible because of the Teensy's microsecond accuracy.

d encoder ticks	1 rotation	1,000,000 μs	60 s
t μs	~1420 encoder ticks	1 s	1 min

The motor controller sends power to the motor based on an analog signal achieved through pulse-width modulation (PWM).

Pulse Width Modulation

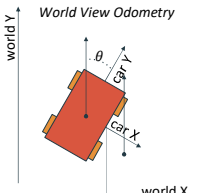


Proportional-Integral (PI) control is used to dynamically control motor power based on desired speed minus current speed. It is necessary because motor power for different motors do not necessarily correspond to the same speed due to manufacturing variability.

Relative vs World Coordinates

SCAMP is able to calculate its position relative to a world axis using encoders for relative forward-backwards and side-to-side movement and the IMU for orientation data. The world position is used for position adjustment and for display on the web server.

World View Odometry

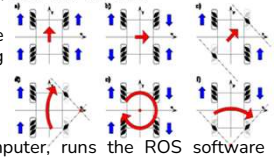


Hardware

Mechanical

The frame of SCAMP employs a 3D printed body with metal screw inserts. The bottom of the frame houses an **Anker 737 power bank**, which delivers power for on-board computer and motors.

Four **65mm mecanum wheels** give the car omni-directional motion, allowing for adjustments during path-following



Electronics

The **Jetson Nano**, the on-board computer, runs the ROS software platform, which handles calculations and communication between itself, the microcontroller, and a web display

A **Teensy 4.0 microcontroller** is connected with a micro USB cable, which provides power and allows for serial communication

The **Adafruit BNO005 Absolute Orientation Sensor** is an IMU (Inertial Mass Unit) that sends orientation data to the Teensy through I²C serial communication

Two **DR10002 MD1.3 2A Dual Motor Controllers** each control the front and back pair of **12V Brushed DC Motor with encoders**

Since the motors operate at 12 volts, the **DFR0379 DC-DC Buck Converter** is used to step down 15 volts from the battery


Anker 737 Power Bank


Mecanum Wheel


Jetson Nano

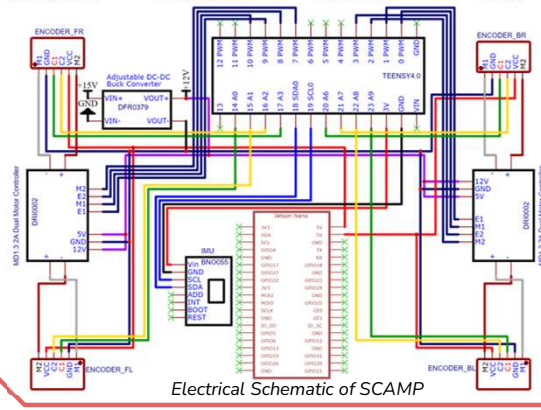

Teensy 4.0


Adafruit BNO005 Absolute Orientation Sensor


DR10002 MD1.3 2A Dual Motor Controller


12V Brushed DC Motor with encoders


DFR0379 DC-DC Buck Converter



Electrical Schematic of SCAMP

This work was supported in part by the NSF REU program and the donation from nVERSES CAPITAL

Web Display

Problem

Using SSH (Secure Shell) Protocol to access RASCAL and SCAMP's computers through command-line means that there is no visual interface. It would be better to have a way to display positions and paths visually.

Solution

Host a web server from the car to display a webpage for visual elements. This server can be accessed remotely using a browser through the car's Internet Protocol (IP) address.

Methodology

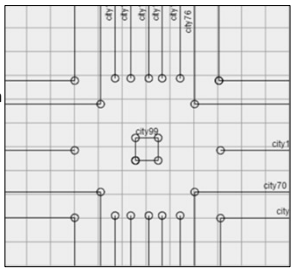
The web display runs as a ROS node which starts a Python Flask server. This node listens to various topics that allow any ROS node to publish to and listen from the web display.

ROS nodes can also publish commands that automatically populate the page with forms for the user to input parameters and run functions.

Features

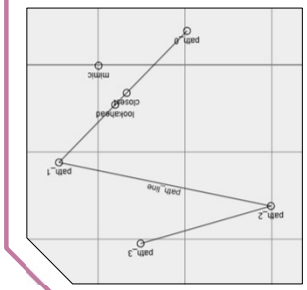
Interactive x-y graph:

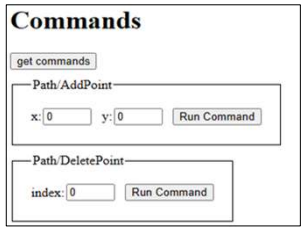
- Display points and lines
- Add, remove, and drag points
- Map of miniature city intersection



In-built and custom commands:

- Save and load points for paths
- Pure-pursuit point service
- Custom commands using ROS





Future Work and Improvements

→ Simultaneous localization and mapping (SLAM) using a Realsense Camera for self orientation

→ Path extraction from video

→ Instantaneous speed parameter

→ Integrate intersection cameras

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