Budget Tesla: An Autonomous Solution for Campus Transportation

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Summary of Project

Designing and implementing the system took place in distinct blocks, assigned among the team members. To analyze camera data and detect obstacles, a convolutional neural network is paired with a short-range FMCW radar sensor. Based on the sensor input, a mini computer processes the data and computes what the motor control should do in order to get the golf cart from point A to B in a safe manner. The path between those points is calculated and tracked via an onboard GPS unit. These electronics are powered by a marine battery coupled with buck converters. A microcontroller-operated winch is used to activate the brake pedal and the throttle is controlled with a digital potentiometer. The steering is controlled using a teensy coupled with a stepper motor. The cart's power is supplied by a refurbished array of batteries, sufficient for several hours of operation.

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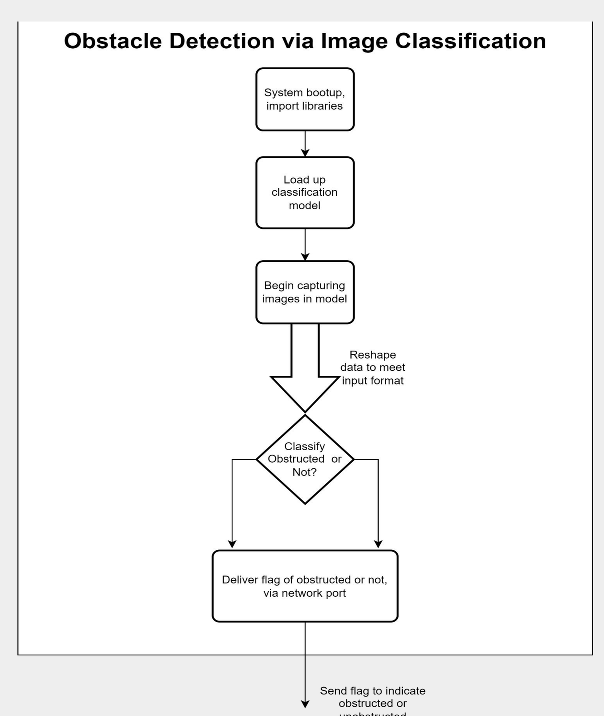
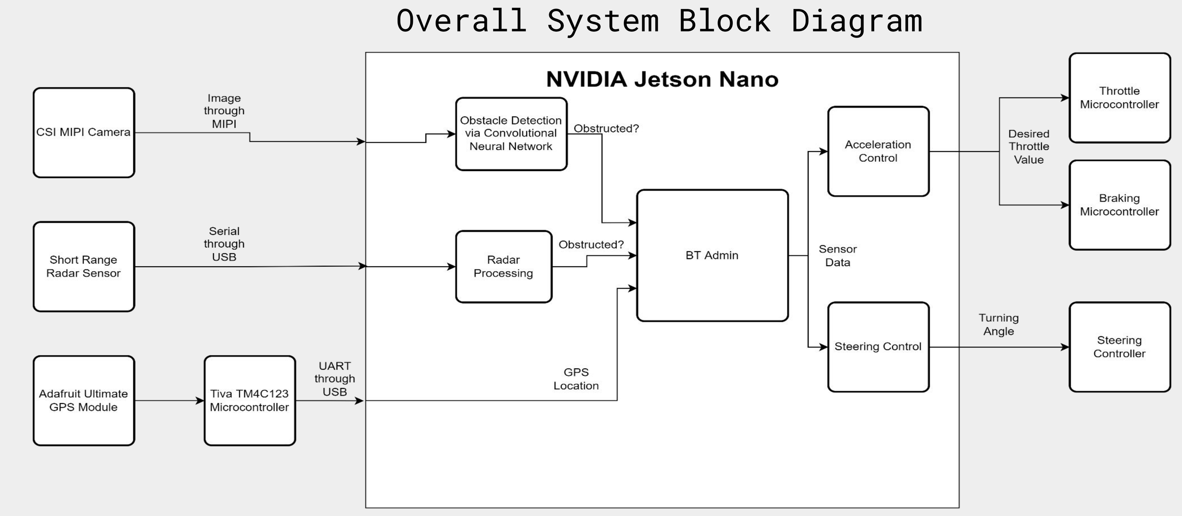
Overview/Background

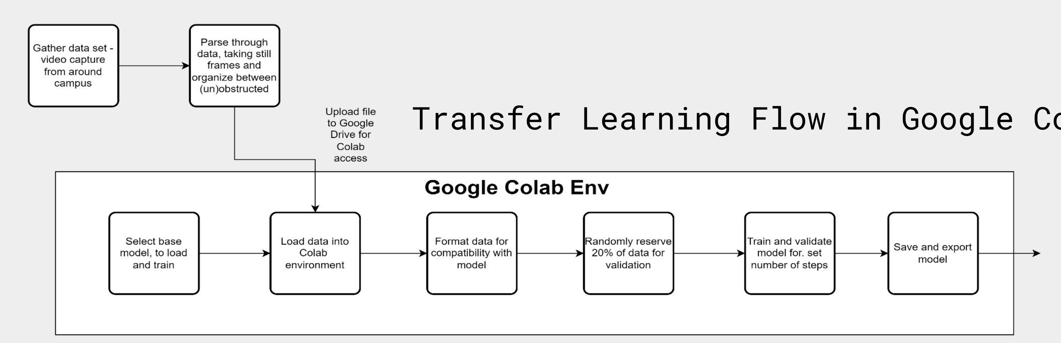
The goal of this project was to create an autonomous system that would enable the transfer of people around campus, specifically targeted towards those for whom travel is more difficult and time-consuming. To fill this niche, we refurbished an abandoned electric golf cart and rigged it with the processing and perceptive hardware necessary for automation.

Functional Decomposition



Overall System Block Diagram





Transfer Learning Flow in Google Colab

Results/ Analysis

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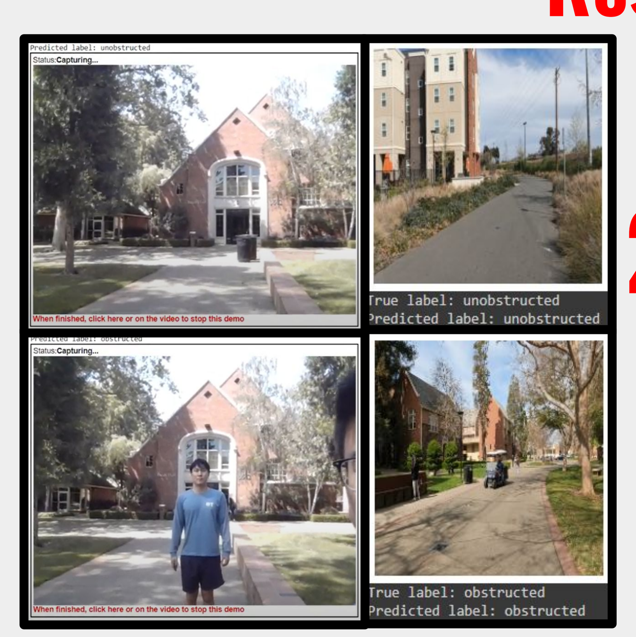

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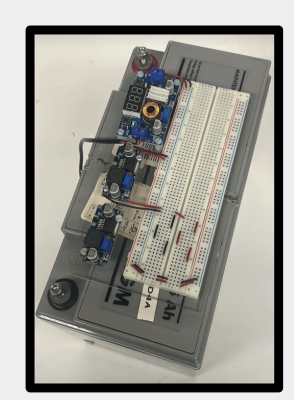

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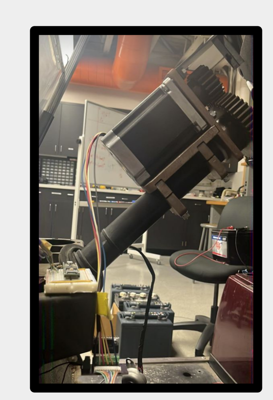

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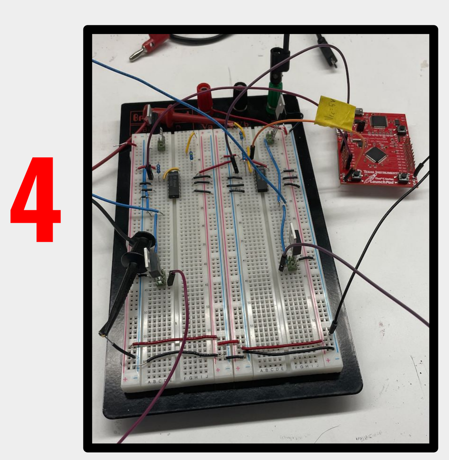

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Figure 1: Trained Nasnet_mobile model for obstacle detection
Figure 2: Buck converter circuit with battery for hardware power
Figure 3: Steering system utilizing stepper motor and Teensy
Figure 4: H-Bridge circuit that powers winch for braking
Figure 5: Camera and image processing running on NVIDIA Jetson

Design Components

Hardware

- NVIDIA Jetson Nano 2GB/4GB
- MIPI CSI Raspberry Pi Camera
- TM4C123G Microcontroller
- OPS241-B-FM-RP Short Range Radar
- Adafruit Ultimate GPS Breakout v3
- Adafruit Digital Potentiometer
- Teensy 3.6 Controller
- DC-DC Adjustable Buck Converter
- LT2000 Superwinch
- H-Bridge Circuit

Software

- Transfer Learning for Image Processing with Nasnet_mobile model (using TensorFlow/Keras) in Google Colab Environment
- State machine for system administration and decision-making
- BTComms for inter-module communication
- Ubuntu Linux Distribution on Jetson
- Radar data processing for object detection
- I2C communication for throttle control with microcontrollers
- Node graph based on OpenStreetMap data

Future Work

- Safety measures, such as an emergency stop button
- New batteries with higher amp-hour ratings for a longer operation time (140 AH would be ideal)
- Additional computer vision for increased FOV, safety, and detection (more radars and ultrasonic sensors)
- Design the circuits on a PCB to reduce size and add protection
- For braking, implement a PWM signal instead of a GPIO
- Deliver more current to the stepper motor
- Replace the fried 4GB Jetson Nano