ELECTRICAL AND COMPUTER ENGINEERING
COLORADO STATE UNIVERSITY

GoKart

Electric GoKart and Outreach DTVC

Electrical Engineering:
Nikola Durand, Vani Kapoor, David Neitenbach, Rico Barela

Computer Engineering:
Andie Groeling, Ryan Guidice

Vertically Integrated Program Students
Patrick Donovan(EE), Matt Gilmore(EE)

Supervising Professor
Olivera Notaros

Engineer in Residence
Doug Bartlett

Summary

Electric GoKart is a fully electric small vehicle, built from the ground up, with a focus on highly modular and data collection to promote semi-autonomous actions. This year's iteration will include a new operating system, upgraded controls, and multiple new sensors. The GoKart will be developed by Electrical Engineering students focusing on controls and power systems, with Computer Engineering students focusing on operating systems, data management, and control programming. During this year's project development, it is important that we keep close records of our progress and decisions so we can use this vehicle to teach a younger audience about STEM and how these fields intertwine.

Importance

This project is important to the Electrical and Computer Engineering department as a tool for Outreach. The GoKart will be used as a demonstration and show piece for schools. The completed and working GoKart is used by the ECE department to gain interest in STEM fields at CSU. The culmination of different skills and disciplines included in the design and fabrication of this vehicle shows the reach of engineering projects and the importance of inclusion and teamwork.

Electrical Engineering Timeline			
Task	**Date Start**	**Date End**	**Team Member**
Research Components and methods	9/1	9/20	Vani, Rico, David, Nikola
Order preliminary parts	9/10	9/20	David
H-Bridge circuit integration	9/22	9/22	Vani,David,Rico
Design Step down voltage circuit	9/15	9/25	David, Rico
Design Solar Charging Circuit	9/25	10/15	David, Rico
Design Controls for buck/boost converter	10/13	10/30	Vani, Rico, David
Project Management Review	10/25	10/25	Everyone
Test and iterate step down design	10/30	11/15	David, Vani, Rico
Test and iterate Solar Panel	11/15	12/15	David, Rico, Vani
Project Progress Review	12/3	12/3	Everyone
Project Presentation	12/3	12/3	Everyone
Design Solar Panel Wiring Harness	12/15	1/1	David, Rico, Nikola
Create Solar panel setup	1/1	1/15	David, Rico
Power Delivery Design	1/25	2/9	David, Rico
Power Delivery Parts Ordering	2/9	2/9	David, Rico
Implement Power Delivery and final tests	2/10	2/30	David, Rico, Vani

Computer Engineering Timeline:			
Task	**Date Start**	**Date End**	**Team Member**
Research Components	9/1	9/10	Ryan,Andie,Vani, Nikola
Research Sensors: Ultrasonic Lidar, Sonar	9/7	9/15	Ryan,Andie,Vani, Nikola
Order Sensors	9/21	9/21	Anyone
Software Stack Architecture Design	9/21	9/21	Ryan,Andie,Vani, Nikola
Power Budget For Devices: Software Design	9/24	9/27	Vani, Nikola
Begin Coding UI	9/27	10/4	Ryan, Andie
Testing UI Code	10/18	10/25	Vani, Nikola
Distance detection	10/18	10/25	All
Begin new sensor integration	10/30	11/30	Ryan,Andie,Vani, Nikola
Send sensor data to raspberry pi display	10/30	11/10	Ryan, Andie, Nikola
Test GUI	11/1	11/5	Vani
Add sensors to front of GoKart	11/8	11/12	Anyone
Begin code for assisted braking	11/12	11/26	Ryan,Andie
Assisted braking code done	12/13	1/14	Ryan,Andie,Vani
Add underglow to Kart	1/21	1/25	Anyone
Add underglow controls to GUI	1/25	1/28	Ryan,Andie
Final Controls Validation	1/28	2/30	Ryan,Andie,Vani

EE Testing Requirements:

Electronic components will mostly be tested on the large kart with the exception of sensors which will first be tested on the small kart. Having access to a small scale of the vehicle makes it easier to troubleshoot before integrating the components into the final design. An additional feature of the smaller kart for testing is the ability to move it to different locations easily, so engineers will be able to take it with them, if the need arises, for more testing.

Electronics Testing Strategy		
Component	**Testing Strategy**	**Expected Result**
Solar Panel	-Use a multimeter to read the initial output of the panel and check each cell is working -Find the current incident radiation flux in the area and use the solar panels surface area to determine the theoretical maximum power output -Being as there is constant variation in the light observed, we need to use an artificial light force to determine the acceptable minimum power from the panel to still operate	The solar panel will be within an acceptable range of the theoretical maximum power and we can conclude it is operating well enough for demonstrations and operation(This value will never be the same and is calculated by the tester when using the panel). The solar panel does not need to produce power at all times, it is for charging and is not critical to any components of the vehicle. Minimum power to operate the solar panel is 600W, anything less in an hour will not charge the battery or power any electronics.
Batteries	-Connect a multimeter to the load and simulate low power operation on each battery -Check the readings periodically and ensure they are within expected ranges for 3+ hours -Connect a 1M ohm resistor to the leads of each battery, one-by-one, and observe the current and how long the voltage takes to drop. Do not perform this test for long, the resistor could be damaged	There should be 8 amps output and a slow decline until the batteries reach low safe voltage controlled by a PCB in the battery. With a large load connected, the current should be less than 1mA and voltage should be steady.
Buck Booster	-Use TI's GUI and adjust the voltage control -Connect a power supply to the input terminals send the voltage command in software, use multimeter to read output voltage -A function generator and oscilloscope can be used to flick the booster on and off between functions, the oscilloscope will show output and a multimeter can confirm the correct step down or up voltage.	There should be the desired output voltage with the given input from either the GUI or code. This is a situational value depending on what inputs are used in the GUI or code. Final design will step down to 5V or 50V +/- 1V.
LCD Display	-Connect the RPi to the display loaded with raspbian or other linux tool -Configure the screen	Once powered on, the screen will immediately display. Brightness will be adjustable and the touch screen can be calibrated. Display was purchased over the counter and will need very little testing, other than power on, from the team.

ESC	-Connect a motor to the ESC off the kart, on the motor mount -Connect the ESC to VESCtool and configure the PWM -Simulation software can be used in VESCtool, or CAN data can be collected to ensure proper communication -Placing a 120ohm resistor to terminate the CAN bus can force a constant data stream	The VESC tool will allow us to read the output from the motor to the ESC, we expect adjustable PWM within spec and adjustable speed from 0-9000rpm. The PWM should be configurable to allow the motors to operate together on the single rear axle, it is an automated process in VESCtool to configure the PWM. CAN data should be hex, expect [ff] if powered on at 5v with 120ohm load, expect CANopen protocol
LED lights	-Power on the lights on the test bench -Use controller to run through colors	Lights will turn on and be able to change to RGB depending on what color we send. Lights were purchased over the counter, they will need no testing other than a power on test from the team.
Transformer	-Mathematically compute the expected output before simulating for expected results -Apply a voltage to the transformer and measure it's output -Compare results and decide if simulated results are optimal for the kart	The transformer should double the voltage that is being inputted into it (12V-24V or 24V-48V). This depends on the number of windings that was previously solved for. For our kart we need a transformer to output roughly 50V using a 24V input.

Physics Testing Requirements:

To ensure the safety of the vehicle's more mechanical components, physical safety tests will be conducted. These tests will focus on component verification, meaning we want to be sure these parts of the kart are working before operation.

Physical Testing Strategy		
Component	**Testing Strategy**	**Expected Result**
Brakes	-Elevate the rear wheels on blocks -Either turn on the vehicle when elevated, or have someone wear gloves and begin to spin them by hand -Apply the brakes and observe the wheels come to a stop. -Alternatively, insert a clean syringe into the bleeding nipple of the braking system and apply the brakes and make sure the syringe plunger moves out of the syringe.	The wheels will slow down to a stop, it is not a bad idea to depress the brakes at different levels and see if the wheels slow faster or slower depending on the force applied. Alternatively, the syringe should fill with brake fluid when the brakes are applied. Just push the plunger down after you release the brakes so no air is added to the system
Throttle Control	-Similar to the brake system, just electronically, Power on the kart and attach an oscilloscope to the throttle at power and Rx/Tx -Observe the response when the kart has no throttle and at different points of depression -Alternatively, you can measure the resistance of the throttle when pressed and when static	We should see a dead line at the voltage point when the throttle is not depressed at all. When pressing the throttle, a square wave of varying amplitude will appear. If the second approach is used, the resistance will increase slightly when pressed
Wiring	-Power the kart on and run it at a higher amperage than usual (0.5-1A more) -Ensure that wires are not melting or anything is arcing -Observe the kart for an hour and periodically check the resistance at random places to make sure nothing has gone bust	There should be a minute change in power, if any. The main expectation is that the wires do not exceed 70 degrees celsius at any point. If something goes wrong turn the kart off, discharge the vehicle and let sit before troubleshooting
Dashboard	-Power on the vehicle and check the voltage in the RPi and LCD display	The voltage should be 5V from the RPi to display, the screen should boot and display the UI

CE Testing Requirements:

The control systems will be tested with automated tests and by hand, by interacting with the kart. For some components, automated testing will not be necessary, and particularly so as we are in the prototyping phase. As we near the end of the project, spare time can be used to implement automated testing.

Electronics Testing Strategy		
Component	**Testing Strategy**	**Expected Result**
Pedestrian Detection Demo	-Test detection model using Keras and TensorFlow tools, and hand-test the live view in the UI -Use different sized, shaped, and opacity objects to determine if the camera and software are properly operating	Demo should detect and show a live view of pedestrians, or larger object
Throttle Control	-Adjust throttle through various positions to ensure data accuracy for range of motion -Plug computer into ESC and use VESC to determine if the throttle response is communicating with the device	Throttle data should be consistent with the position of the pedal throughout the pedal's range of motion
UI	-Hand testing & QT testing framework -Get other people outside of GoKart to test the UI for bugs and if data placement is efficient for people	Buttons should work and accurate information should be displayed
CAN bus	-Simulate and send CAN messages targeting particular functionality, automated testing by sending random input data -Can insert simulated CAN data at multiple points on the vehicle, ESC, Pine64	Bus should support the volume of traffic we expect and devices should receive all messages targeted for them. There should not be any ambiguity or change in the data as long as the protocol being used is CANOPEN
Serial-to-CAN	-Craft specific serial data, automated testing by sending random input serial data simulating sensors -Check the CAN output through the ESC or Pine64 on the test bench or in the kart	CAN side of conversion maintains the same data as the serial side, regardless of location it is pulled from on the kart