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Autonomous Golf Cart

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Autonomous Golf Cart

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Abstract

Cedarville University's Autonomous Golf Cart Senior Design Project's mission is to provide engineering students with hands on experience with industry standard intelligent vehicle technologies, solve open-ended, multi-dimensional problems, and provide an autonomous transportation service to the greater campus community. Our autonomous technology will share the sidewalks; therefore, the public image of our autonomous routing service is critically linked with its technical performance.

The autonomous golf cart has two major design areas: the cart's hardware and its software. Within hardware, our team created functional braking and an H-Bridge for reversing. Within software, our team moved the codebase to a new software framework, implemented dynamic routing, and began obstacle avoidance using LiDAR.

Background

The primary motivation for our project was to provide students with an opportunity to learn and use autonomous transportation technologies.

Applications for our technology include shuttling people to buildings around campus, delivering goods, and publicizing the School of Engineering.

Our Cart

Automatic Braking

Braking implementation went through numerous iterations due to the weight of the manual brake and the feedback accuracy needed. Below are the revised designs for the feedback, which include a potentiometer attached to a 3D-printed lever, and the motor mechanism, which consists of a metal spool pulling down the brake using a simple pulley system.

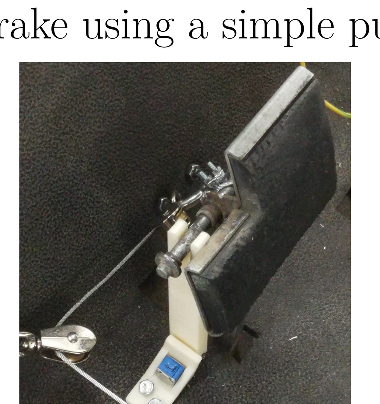

Figure: Brake Feedback

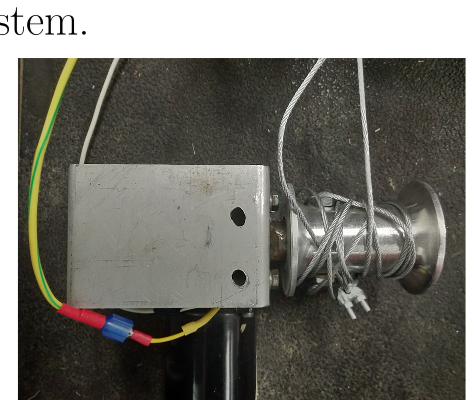

Figure: Brake Motor Mechanism

H-Bridge for Reverse Mode

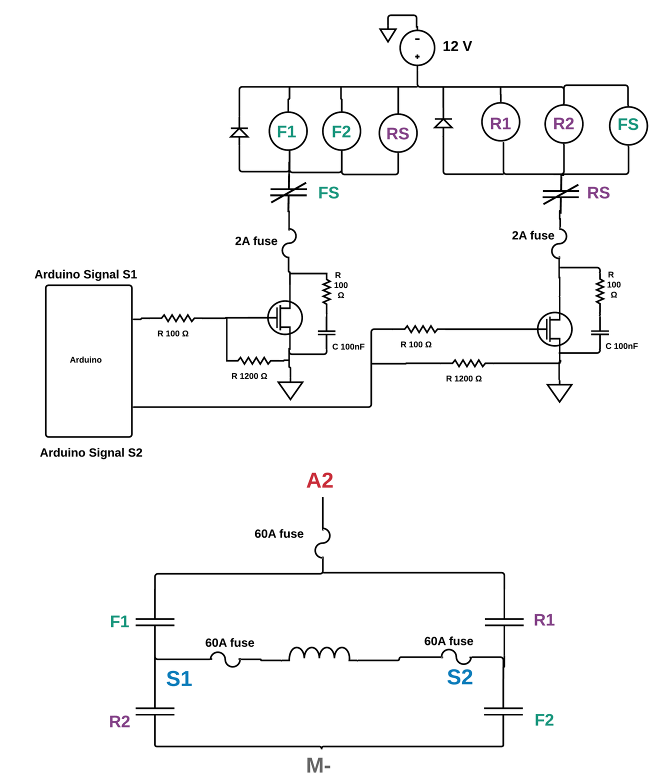

Figure: H Bridge Circuit

- The H-Bridge's purpose is to reverse current through the motor's field, by directing it through two separate branches on either side of the field.
- Our H-Bridge contains a mechanical interlock scheme, that prevents both branches of the H-Bridge from being closed at the same time.
- Our H-Bridge is low-side powered through an N-type MOSFET transistor, switched on and off by a control wire from the Arduino.
- Current and voltage spikes are prevented throughout the circuit by a combination of fuses, resistors and capacitors.

Software Move to ROS

We inherited an in-house software framework. After researching and talking with professionals, we chose to migrate our software to an industry standard open-source framework, Robot Operating System (ROS) [3].

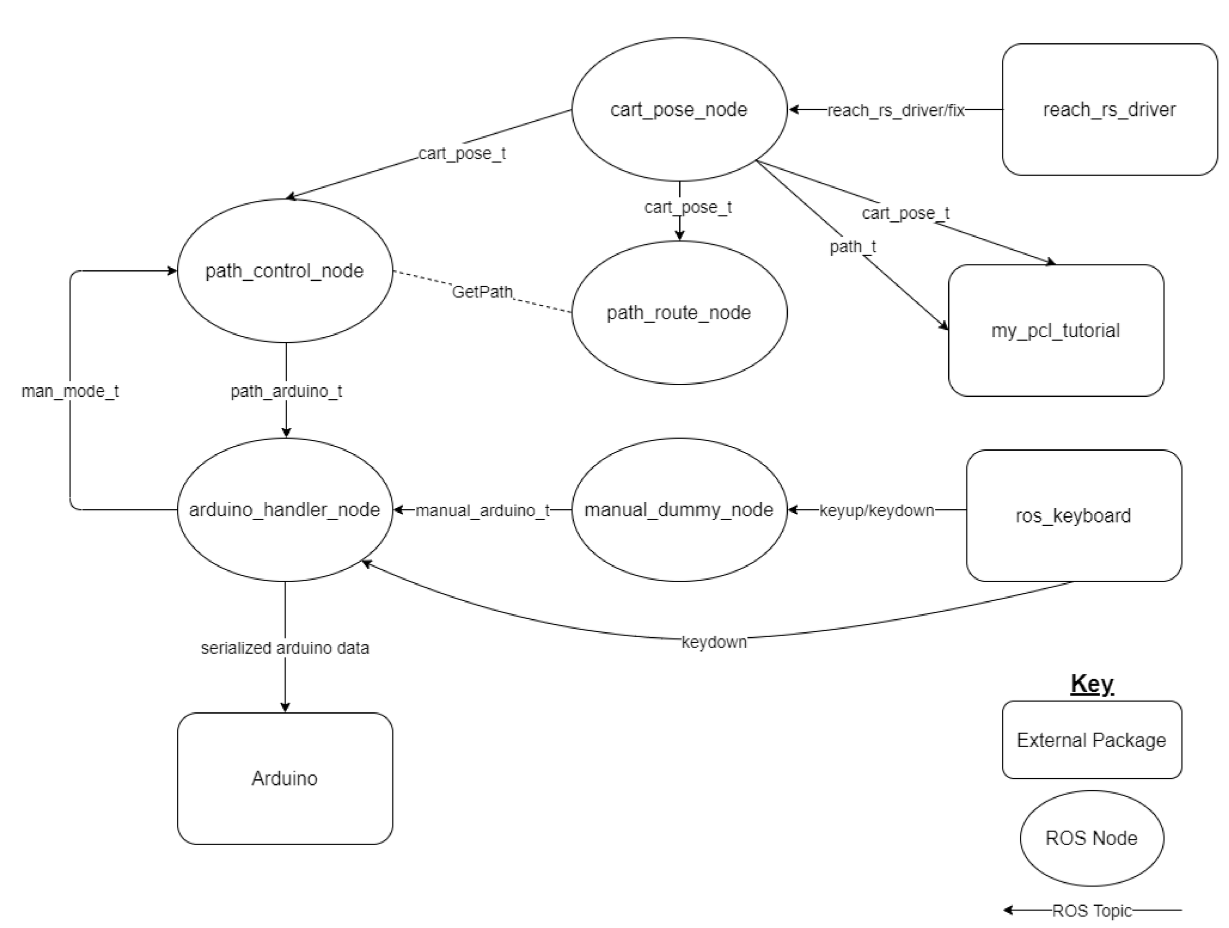

Figure: golf_cart_control ROS Package Flow Diagram

ROS Functionality

- External packages (code written and maintained by other developers)
- Communication between nodes using ROS topics
- Straightforward integration with external software, including:
  - Livox LiDAR driver
  - ROS keyboard driver
  - Reach RS GPS driver

Dynamic Routing

Our dynamic routing system solves the issue of route choice on campus. Routing software starts with a map of GPS waypoints located along every path the golf cart must drive on and consists of:

- *Optimized trip calculation* using Dijkstra's Shortest-Path-First algorithm. [1]
- *Heading-aware trip calculation*: never try to take a turn that we cannot make with the golf cart's steering radius.
- *High precision GPS* for guiding the cart on the route. [2]

Figure: Routing from ENS to SSC

Obstacle Avoidance

The golf cart uses LiDAR (Light Detection and Ranging) for obstacle detection. Raw point cloud range and reflectivity data can be filtered to determine which points represent the ground and which represent a potential obstacle. The approach to detecting an obstacle is as follows:

- Use a standard point cloud library (PCL) to filter out the ground points using a technique called planar segmentation.
- Flatten the remaining points into a grid representing an aerial view of the area in front of the cart by combining coordinates with the same (x,y) value.
- Occupied (Black) cells in the grid represent obstacles.
- Obstacles which are closer than 1.5m to the path are considered obstacles and the distance to the closest is reported.

Total Costs: Items Purchased this Year

1984 Club car: $1700
Livox LiDAR: $1500
H-Bridge: $400
Maintenance/Upkeep: $150
Year 1 Development Costs: $2419.91

Conclusion

CU Engineering's senior design has delivered a functioning golf cart possessing the minimum functionality needed to autonomously shuttle university residents around campus. Achieving this goal meant overcoming significant hardware and software challenges. The vehicle is fully drive-by-wire with operational throttle, steering, braking, and reversing, and software capabilities including GPS waypoint following, obstacle detection, and dynamic routing around campus. Additionally, our robust and documented software is easy to understand, follows standard conventions, and is part of a larger platform that next year's team will easily be able to pick up. This platform will allow our team to integrate with other senior design projects, like the computer vision camera team, in the coming years.

References

[1] Edsger W Dijkstra. "A note on two problems in connexion with graphs". In: *Numerische mathematik* 1.1 (1959), pp. 269–271.

[2] Richard B Langley. "Rtk gps". In: *GPS World* 9.9 (1998), pp. 70–76.

[3] Morgan Quigley, Brian Gerkey, and William D Smart. *Programming Robots with ROS: a practical introduction to the Robot Operating System*. 2015.

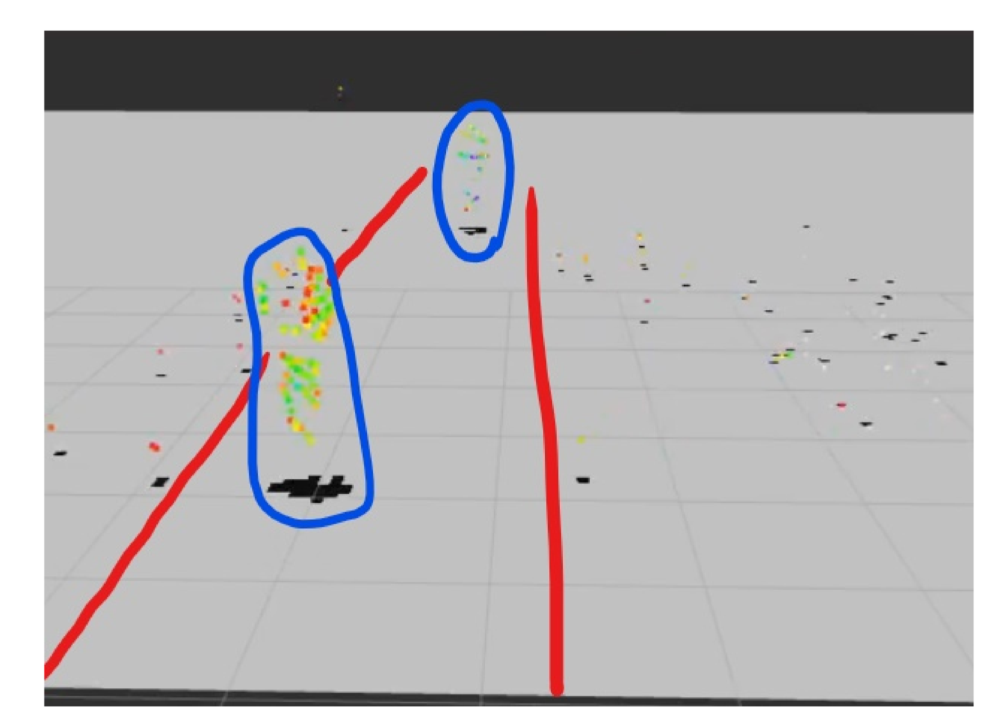

Figure: LiDAR Object Identification