BUILDING A SELF-DRIVING VEHICLE @ HPU

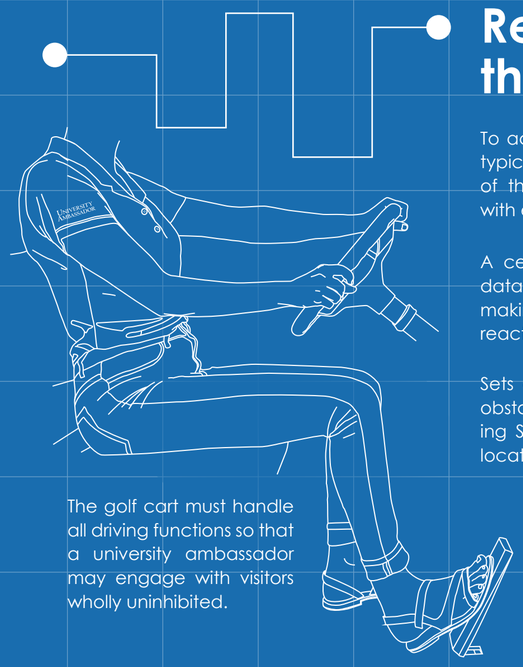
HPUMINDS, a High Point University student organization made up of physics and computer science students, has spent three years designing, building, assembling, and programming components to convert a typical electric, 6-seater EZ-GO golf cart into an extraordinarily high-tech, self-driving vehicle. Using Arduino microprocessors, linear actuators, servos, and 3D printed materials, the HPUminds team members have replaced the manual steering, acceleration, and braking with state-of-the-art programmable electronic controls. These controls, paired with environment-monitoring, path- and obstacle-detecting cameras and sensors, allow a central computer to elegantly maneuver the vehicle around campus while also actively avoiding collisions.

SELF-DRIVING AT A GLANCE

What does "autonomous driving" really mean?
In 2013, the US Department of Transportation's National Highway Traffic Safety Administration (NHTSA) defined five different levels of autonomous driving.

0	The driver (human) controls it all: steering, brakes, throttle, power, etc.
1	Most functions are still controlled by the driver, but a specific function (like steering or accelerating) can be done automatically by the car.
2	The driver is disengaged from physically operating the vehicle but must always be ready to take control of the vehicle.
3	The driver is still present and will intervene if necessary, but is not required to monitor the situation.
4	Fully autonomous: vehicles are designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip.
5	A fully-autonomous system that expects the vehicle's performance to equal that of a human driver, in every driving scenario.

Replacing the Driver



To achieve **Level 4** autonomy, the typically driver-controlled functions of the vehicle must be replaced with electronic mechanisms.

A central computer performs the data processing and decision-making, essentially replacing the reactive mind of the driver.

Sets of light-based sensors detect obstacles while a Global Positioning System (GPS) monitors current location and routes.

The golf cart must handle all driving functions so that a university ambassador may engage with visitors wholly uninhibited.

Mounted with machined and 3D-printed components, motors maneuver the steering, acceleration, and braking systems.

CART MECHANICS

In order for a mechanically-controlled golf cart to take commands from a computer, the components that maneuver the vehicle must first be replaced with electronically /remotely-controlled systems. The steering wheel is replaced with a linear actuator attached to the cart's steering column; a separate linear actuator is required to engage the brake line; and a small sensor in the motor controller is manipulated directly to manage the cart's speed. A separate power supply is required to power these electronics.

CAMERA/VISION

Located at the front and rear of the golf cart is a camera (left). The feed from these cameras is filtered and processed by another computer before communicating path and obstacle detection information to the brain computer.

WHAT MAKES IT DRIVE?

ARDUINO CONTROLLERS

An *Arduino Uno* microcontroller (pictured above) is essentially a small computer that can perform simple input and output tasks. The Arduino is programmed to recieve commands from the brain computer and maneuver the cart's mechanical systems as commanded.

STORAGE

Conveniently, the golf cart's additional electronics have all been stored beneath the driver's seat.

DRIVER COMMUNICATION

Although the cart itself is self-guiding, the passengers riding the cart must be able to communicate with the cart to tell it their desired destination. Using an iPad as the interface, a mobile app provides a simple and elegant way for the passengers to choose their destination.

GPS/IMU NAVIGATION

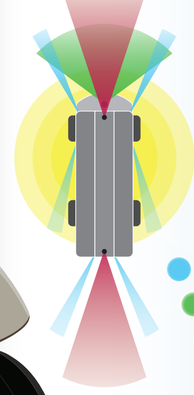
An Inertial Measurement Unit (IMU) turns sensor data from an accelerometer, gyroscope, and magnetometer into 3D space orientation. Comparing the cart's orientation and GPS position to the destination location determines where the cart should go.

LIDAR DETECTION

LiDAR is an acronym for Light Detection and Ranging and functions as a remote sensing technology which uses the pulse from a laser to collect measurements, which can then be used to create 3D models of objects and environments. LiDAR serves as a reliable method for detecting obstacles that the cameras fail to detect. Stationary LiDAR can detect obstacles only in a single direction, while spinning LiDAR (pictured left) can detect obstacles in an entire plane.

AERIAL VIEW

Summary of the cart's detection "zones" organized by color.



BRAIN COMPUTER

To determine the required guidance instructions for a given situation, the "brain" computer must gather information from all navigation and detection sources (mobile app, cameras, stationary and spinning LiDAR, GPS, IMU) and process their data by safety priority. A way to organize priority is by the instrument's confidence in the measurement it's making. As shown in the Aerial View section above, the spinning LiDAR has the widest spanning high-confidence zone, therefore the brain prioritizes its data. After prioritizing and processing, the brain sends driving instructions on to the Arduino Uno which then mobilizes the cart.

CITATIONS

Reese, Hope. "Updated: Autonomous Driving Levels 0 to 5: Understanding the Differences." *TechRepublic*, 20 Jan. 2016.
"What Is LiDAR | What Does LiDAR Stand For." *3D Laser Mapping*.

HPUminds would like to acknowledge High Point University – especially the Physics, Computer Science, and Communications Departments, the Student Government Association (SGA), and the Undergraduate Research and Creative Works (URCW) committee – as well as Steve Wozniak for their financial and intellectual contributions.