Real-Time Sensor Integration and Control for Autonomous Golf Cart

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Introduction

Autonomous and electric vehicle technologies are rapidly evolving. This project presents the implementation of a computer-controlled steering system in a small-scale electric golf cart, integrating GPS, LiDAR, and a microcontroller with MATLAB. Real-time data processing and control were used to enable autonomous navigation, providing a testbed for sensor-based control algorithms and future research in smart mobility systems.

Method

Key sensors were integrated into a MATLAB based system to enable partial autonomy in a golf cart.

- **GPS**: Provided real-time location via serial communication
- **LiDAR**: Generated point clouds for obstacle detection
- **Microcontroller board**: Executed control commands like steering and LED signals

MATLAB functions (serialport, pcshow, geoplot) were used to process, visualize, and validate sensor integration in real time.

Method continued

Power input to sensors confirmed

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Connect Sensors to PC

- Connect **LiDAR** to PC with **Veloview**
- Connect **GPS** to PC with **VectorNav Control Center**
- Connect **microcontroller board** to PC with **Arduino IDE**

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Connect Sensors to MATLAB

- LiDAR
- GPS
- Microcontroller board

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Design control algorithm

- **Send all sensors' data to Microboard**
- Obstacle Detection and Lighting System
- Trajectory Visualization Using GPS and Acceleration

Collected Data

Connect sensors to MATLAB

- **LIDAR(Velodyne 16):** Used for real-time environmental perception through point cloud generation

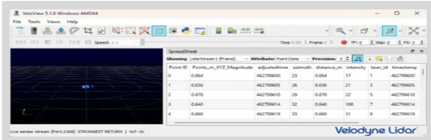
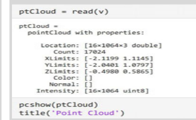
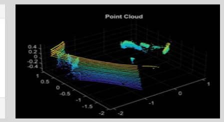


Figure 1: LiDAR visualization in veloview





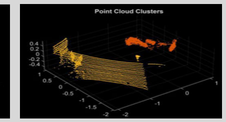


Figure 2: MATLAB code for LiDAR connection
Figure 3 & 4: Real-time LiDAR view in MATLAB

- **GPS(VN-300):** Provided real-time location tracking and trajectory visualization

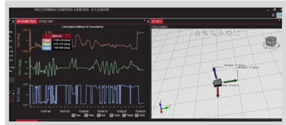


Figure 5: GPS data in VectorNav Control Center

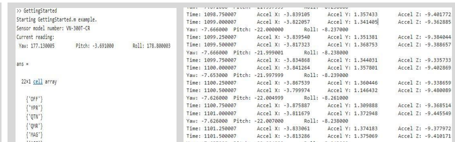


Figure 6&7: Real-time GPS in MATLAB

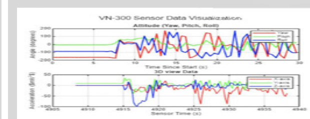
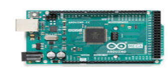


Figure 8: GPS path plotted in MATLAB

- **Microcontroller board(Arduino Mega 2560):** Received control commands for actuating steering and LED indicators



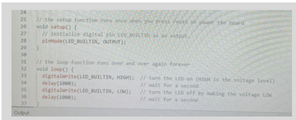
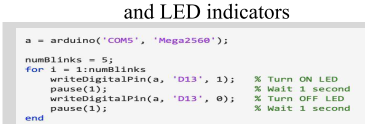


Figure 9: Arduino code for Microcontroller board setup



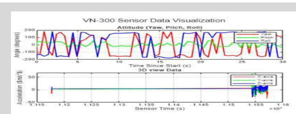
```
a = arduino('COM5', 'Mega2560');

numBlinks = 5;
for i = 1:numBlinks
    writeDigitalPin(a, 'D13', 1);   % Turn ON LED
    pause(1);                        % Wait 1 second
    writeDigitalPin(a, 'D13', 0);   % Turn OFF LED
    pause(1);                        % Wait 1 second
end
```

Figure 10: MATLAB microcontroller control code example

Figure 11: Microcontroller board with activated LED by using the example code

Results

Real-time communication was successfully established between MATLAB and all major components—GPS, LiDAR, and the microcontroller. GPS data was visualized on a 2D map to estimate paths and directions (Figure 13), while LiDAR point clouds enabled live obstacle detection (Figure 14). The microcontroller responded accurately to steering commands from MATLAB. A basic control algorithm was developed using acceleration and heading data, representing an initial step toward full closed-loop control.



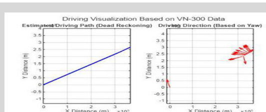
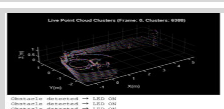
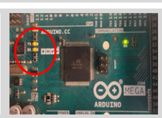


Figure 12: GPS attitude (yaw, pitch, roll) graph and 3D view data graph obtained after measuring the same GPS in real time
Figure 13: Estimated driving path graph and driving direction graph





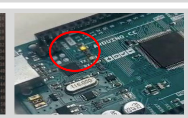


Figure 14: Real-time LiDAR Point Cloud with Obstacle Detection
Figure 15: Data transmission from MATLAB indicated by TX/RX LEDs
Figure 16: LED activated by microcontroller

Conclusions

This project achieved real-time integration of GPS, LiDAR, and a microcontroller with MATLAB, enabling computer-controlled steering in a golf cart. It demonstrated reliable data acquisition and control, establishing a strong foundation for future autonomous navigation and smart mobility research.

Future work

- Implement advanced path planning and obstacle avoidance algorithms.
- Incorporate vision-based perception (GoPro) for enhanced environmental understanding.
- Conduct testing in dynamic, real-world environments to validate system