Design and Development of Smart Intelligent Vehicle with Sensorial Data Acquisition System Integration

David Santiago Obando Ortegon, Jonathan Randall and Levi Mckinney
Faculty Mentor: Dr. Valentin Soloiu, Professor, Intelligent Vehicles Laboratory
Georgia Southern University, Department of Mechanical Engineering

PRESENTED AT

BACKGROUND

Integration of multiple exteroceptive sensors for enhancing safety in vehicles.
- Ultrasonic sensor HC-SR04, Infrared Avoidance Sensor, RPLiDAR sensor, Terabee 3D camera and Berry IMU module.

Automation of driving tasks
- Obstacle Avoidance, Object Recognition and Data Acquisition from the environment using different sensor modules.

Integration of algorithms for different tasks by using microcomputer (Raspberry Pi 4).
- Python programming language used for development of data acquisition algorithms integration.

RESEARCH HYPOTHESIS

Considering the multiple sensors available nowadays for integration in intelligent vehicles systems, it is possible to reduce the number of accidents and improve safety in vehicles by integrating a safety navigation system for corrective actions in unexpected scenarios.

LITERATURE REVIEW

Ultrasonic sensor is a sensor used for measuring distance to its surroundings using sonar (ultrasonic waves). Consists in two transducers, one of them send pulses of ultrasonic waves whereas the other one receives them after being triggered. Calculating the time of the reflection is possible to calculate the distance to the obstacles around the vehicle [2].

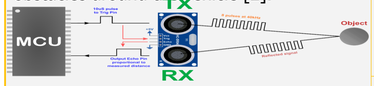


Fig 2. Ultrasonic Sensor HC-SR04 Schematic [6]

Equation used for Ultrasonic Sensor DAQ

Ultrasonic Sensor: $d = \frac{\Delta t * c}{2}$

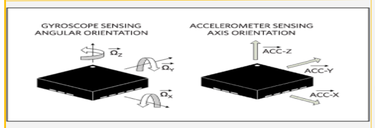


Fig 4. Accelerometer ad Gyroscope Schematic [8]

An accelerometer is an electromechanical instrument used for measuring acceleration forces. These forces could be static due to constant gravity or could be dynamic to sense different movements and vibrations in different devices [4].

Fig 1. RPLiDAR A3 Schematic [5]

LiDAR stands for Light Detection and Ranging. Remote sensing method that uses light as a form of a pulsed laser to measure ranges of distance. These light pulses have high speed and recreate shapes of the surroundings [1].

The infrared avoidance sensor is a component that uses infrared light for object detection. These sensors send out IR energy and looks back for reflected IR light detecting presence of obstacles in the range of action of the sensor [3].

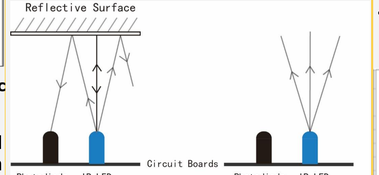
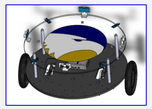


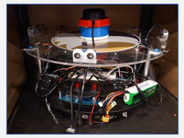
Fig 3. IR Avoidance Sensor Schematic [7]

METHODOLOGY

1. Design of the Vehicle
2. Assembly of Mechanical Components
3. Sensor Components Integration
4. Circuit's Development
5. Calibration Process for the sensors



The design of the car was created in SolidWorks and includes all the sensor and mechanical components of the assembly of the vehicle.

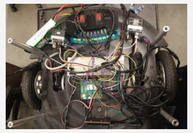


The assembly of the mechanical components included

12V DC Motor
Top Deck
Bottom Deck
Power Distribution Board
Wheels
Sensor Mounts

The assembly of the electronic and sensor components included

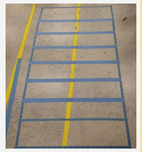
Ultrasonic Sensor
Ir Avoidance sensor
Accelerometer
RPLiDAR A3
Terabee 3d Camera
Raspberry Pi 4



The Development of the circuit including all sensor components was based on

Trigger shared for each sensor. Echoes were independent.

Connected to RPi 4



Calibration Process done by setting obstacles in the calibration range and using each sensor to test calibration

RESULTS AND DISCUSSION

- The safety of the intelligent vehicle was enhanced by using the multiple sensor modules integrated in the system.
- Having a display output from the sensors simulating the environment around the vehicle improved the safety of the device by detecting different obstacles and aiming for their avoidance.
- Calibration of every sensor allowed the vehicle to test the performance of every sensor locating different obstacles in the calibration range and calculating its distance to them.

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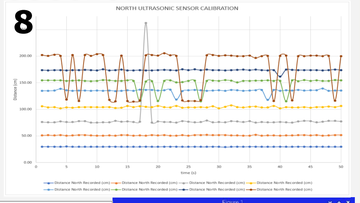

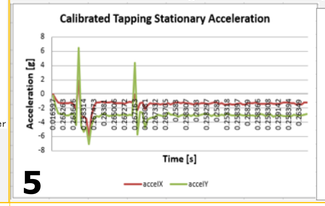

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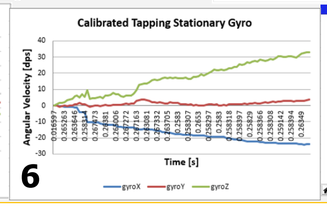

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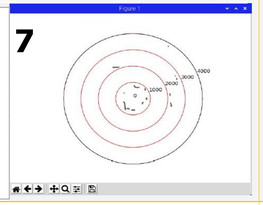

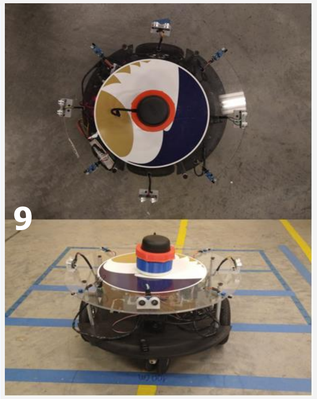

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Fig 5. Represents the calibration of the IMU device. It shows how the acceleration of the device is altered by tapping the intelligent vehicle a couple times. The graph shows the change of acceleration in [g] with respect of time.
Fig 6. The calibration of the IMU device, shows how there is not alteration in the direction of the vehicle measured in [dps] with respect of time. Since this is a low-cost efficient sensor. It is possible to see some noise that is clearly demonstrated in the graph.
Fig 7. This radar shape graph demonstrates the calibration of the RPLiDAR sensor and how obstacles around the vehicle are displayed in this graph with their respective distances.
Fig 8. This graph shows the calibration process of the North Ultrasonic Sensor of the vehicle. It is possible to detect some noise in some of the tests but in overall, the sensor had a good calibration behavior.
Fig 9. Final Assembly of the intelligent vehicles with sensors integration

DISCUSSION

- The data acquisition system will be able to display a live data simulation graph representing in real time all the data acquired by the sensors during working operation.
- The future work for this project is to develop a pathfinding algorithm where the vehicle will be able to autonomously navigate to a specific point by setting the obstacles detected from the sensors and then approaching the desired location while is avoiding the obstacles present in the driving environment.
- Future work will also include development of similar intelligent vehicle prototypes conforming a platooning and v2v communication system interacting between each other sharing the data acquired by the sensors integrated.

TOP FINDINGS

- Every sensor integrated in this project contributed to the data acquisition system used for enhancing the safety in the intelligent vehicle which was the objective of this project.
- These obstacles were detected by the multiple sensors implemented that complement each other in order to have a complete range of the exterior of the vehicle.
- The integration of the sensor modules allowed the car to have an autonomous driving mode by detecting obstacles and avoiding them.
- The system developed in this project was low-cost and efficient using different type of sensors to get accurate data acquisition from the environment to enhance the safety in intelligent vehicles. This principle can be applied and implemented in different fields. (Aerospace, automotive, Mechatronics, among others.)

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