Design and Realization of an Intelligent Unmanned Ground Vehicle

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Abstract

Intelligent unmanned ground vehicles (UGVs) are being widely used in applications that are dangerous for human-beings, such as roadside bomb detection, weapons transport, and disaster rescue missions. This project focuses on designing and building an intelligent UGV which will become WPI's first entry to the Intelligent Ground Vehicle Competition (IGVC) in June 4-7, 2010. IGVC challenges undergraduate and graduate students to design and program a fully autonomous UGV that can locate and avoid obstacles, stay within the boundaries of a lane, and navigate to GPS waypoints. The Mechanical Engineering team designed and constructed a vehicle chassis to effectively integrate the sensor, computer and electrical power systems within the design constraints specified by the IGVC. The completed UGV features a welded aluminum 3-wheel chassis, rear differential drive, a steered front wheel, a compartmentalized design and a waterproof housing for the electronics. The small size, zero-turning radius, and powerful drive motors provides a dynamic performance desirable for the competition. The project team has completed the design and construction of the chassis, performed the stress analysis and a dynamic analysis of the vehicle, and verified experimentally that the chassis met the design specifications.

Objective

To design and build the chassis, power train, and the steering mechanism of the vehicle within the dimensional and speed constrains set by the IGVC rules while achieving optimized performance in maneuverability, durability and power efficiency.

Design Specifications

IGVC Specifications

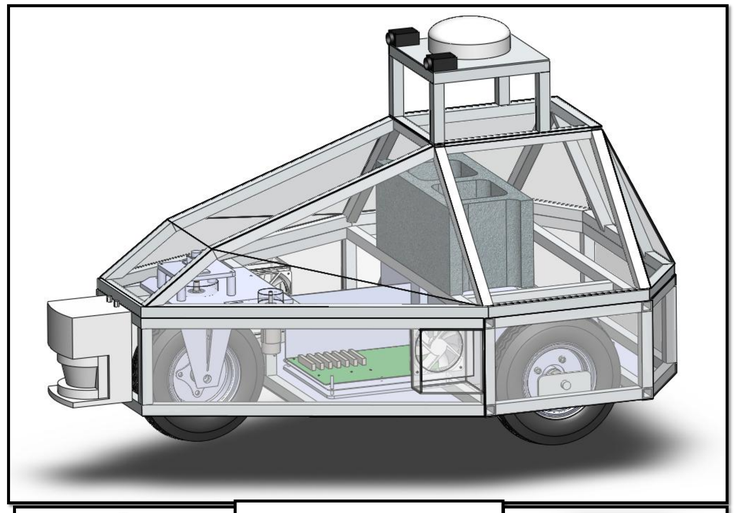
- **Maximum speed:** 5mph
- **Length:** 3-7 feet
- **Width:** 2-5 feet
- **Height:** under 6 feet
- **Maximum Course Incline:** 8.53º

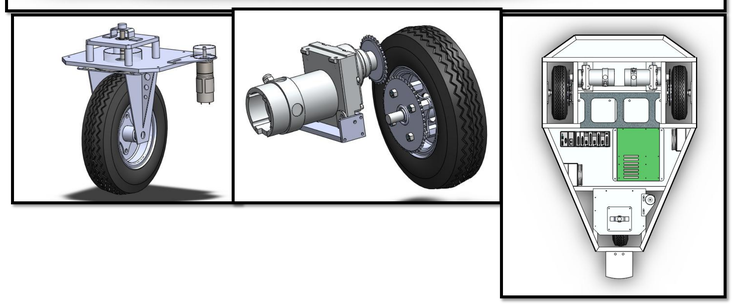
Team Specifications

- Minimum vehicle size
- Minimum turning radius
- Efficient use of space
- Custom-built chassis
- Weatherproof vehicle

Design

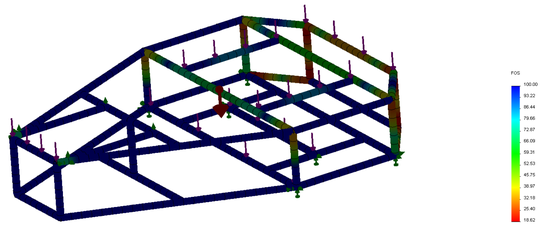
- Lightweight and strong chassis frame made from welded aluminum
- Rear differential drive coupled with steered front wheel for precise steering
- Tight Vehicle Dimensions: Xheight, Xlength, Xwidth
- Low center of gravity: 11.01 in
- Ground Clearance: 4.05 in
- Zero turning radius



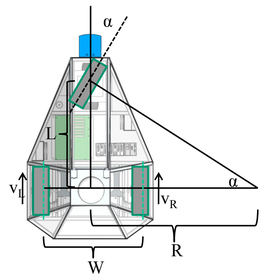


Analysis

FEA analysis of the chassis base which showed a safety factor of 19

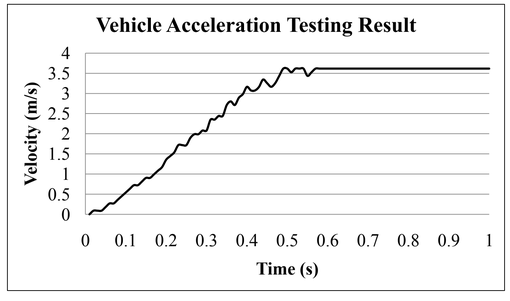


Front Wheel Turning Angle α as a function of left rear wheel speed, v_L, and right rear wheel speed, v_R, the equation was implemented in the control algorithm.



$$\alpha = tan^{-1}\left(\frac{L}{R}\right) = tan^{-1}\left[\frac{2L(v_L - v_R)}{W(v_L + v_R)}\right]$$

Vehicle Performance in Linear Acceleration on grass as measured by the optical encoders on the drive motor:



Conclusions

With the sensors, controls system, and chassis successfully integrated, the vehicle meets the design specifications decided on at the onset of this project. The vehicle functions properly on grass, concrete, and asphalt and efficiently climbs the 8.52 degree incline. The welded aluminum cover attributes to a light-weight, robust chassis that is both weather-proof and space-efficient. In addition, the vehicle had the capability to drive over rough terrain. With a successfully built vehicle, the WPI IGVC team is prepared for the competition.