Solar Hydroponics Monitoring Vehicles

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Abstract

The ReEnergize Solar Hydroponics project at San Antonio College's Eco Centro needs tools to enable monitoring of growing plants while minimizing entry and exit from the outside (Lewis). A mobile robot that could stay in the container while allowing remote control and transmission of visual and sensor data would have substantial benefit.

Two remote monitoring vehicle prototypes were built to test the feasibility of an affordable, expandable and rugged mobile robot to be used within a hydroponic shipping container (HSC). The first vehicle is built from Tetrix parts and uses an Arduino microcontroller. The second vehicle, built from PVC and other common materials, is controlled by a Raspberry Pi single board computer. Both vehicles can be controlled remotely and stream video from an on-board camera, and both are large enough to accommodate additional equipment to extend functionality. The first vehicle is more rugged, but the second vehicle offers more flexibility at half the cost of the first. The project has met its primary objectives of having remote control drivability and camera visibility via WiFi.

Background

San Antonio College's Eco Centro is the home for a ReEnergize project developing a low-cost, solar-powered HSC to grow and supply food for local food deserts, global climate-challenged areas, or urban areas where food supplies are limited. In working with the ReEnergize Team, they discovered that the HSC should be accessed minimally to reduce exposure to pests and maintain optimal air, light, and water conditions for growing plants (Lewis). As cost-containment and long-term adaptability are essential for the HSC program, these concerns were incorporated into the goals of this project. Additionally, since the hydroponics teams would have limited access to the HSC for on-going monitoring and periodic surveillance, the solution needed to be controlled remotely and to be programmable for scheduled sensor reading in various locations. While the HSC will have a ventilation system, the atmospheric conditions will range from 70° - 90° F and from 60% - 85% humidity.

Introduction

Based on the climatic extremes, the vehicle needs to be corrosion resistant in the humid environment, energy efficient to minimize charging and downtime, provide a platform for attaching and running various sensor equipment and monitors, and provide wireless video capability for visual checks. The base of the vehicle needs to be large enough for future enhancements including a hoisting camera mechanism to view higher plant racks above or to attach interchangeable parts for harvesting or other equipment. These enhancements must extend to the full interior height of 8 ft. After assessing the requirements, it was determined that a remote-controlled monitoring vehicle not only met the needs of the ReEnergize Team but also addressed the environmental constraints and challenges.

Project Goal

The Hydroponics Monitoring Vehicles Team set out to compare two vehicles to determine which would be better suited to meet all needs, including end-user, environmental, and program requirements.

Materials

Tetrix Vehicle (V1) Components

Construction
- Tetrix kit parts and motors
- Tetrix Camera Kit

Controllers
- Arduino UNO
- WiFi Shield 101
- Motor driver

Programming
- Windows 10
- Arduino IDE
- Arduino standard libraries

Hybrid Vehicle (V2) Components

Construction
- Hardware store parts
- Tetrix motors

Electronics
- Raspberry Pi (RPi)
- Raspberry Pi camera
- Motor driver

Programming
- Linux
- Minibian
- Apache2

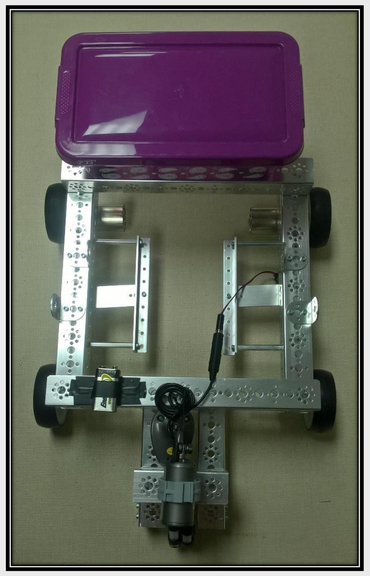

Figure 1: Tetrix Vehicle (V1)

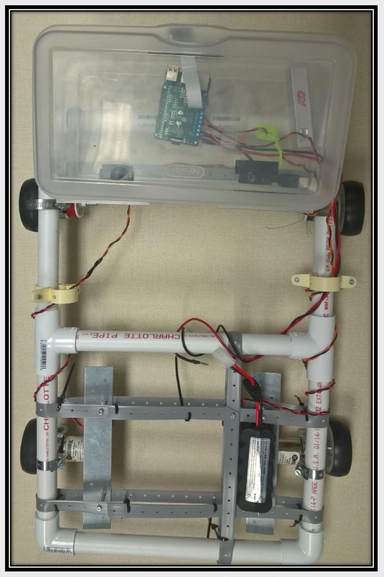

Figure 2: Hybrid Vehicle (V2)

Methods

Tetrix Vehicle (V1)

The Tetrix vehicle was constructed first as a means to learn the mechanics and the functionality of the components. Based on the standardized part sizes, the design was simplistic and completed in a few days.

An unused motor was used to complete the initial Motor Shield testing. The WiFi Shield was also tested independently. After successful testing, the Motor Shield was mounted to the Arduino with the WiFi Shield. A pin conflict resulted in only one motor functioning, but WiFi access was successful and used to drive V1.

Hybrid Vehicle (V2)

The Hybrid vehicle was designed and built after the Tetrix vehicle was completed in order to ensure similar functionality. The only construction issue was in the initial clamps used to anchor the wheels to the frame. These were replaced by sturdier conduit bolt clamps. This took a week to complete with the change of parts.

As WiFi is built into RPi, only the Motor Hat was added, with no pin conflicts, and it drove the motors successfully. The camera was attached directly to the RPi and sent video via WiFi.

Results

Tetrix Vehicle (V1)

Construction
- $420 for frame parts
- Parts limit size and adaptability
- Smaller frame limits future enhancements

Electronics
- Arduino UNO is adaptable and expandable using Shields

Programming
- Arduino used as self-contained Hotspot
- WiFi and Motor Shields conflicted resulted in circular driving patterns
- Arduino Shields discovered to require pin overrides
- Camera not WiFi accessible

Hybrid Vehicle (V2)

Construction
- $170 for frame parts
- Parts can be customize sized
- Larger frame accommodates future enhancements

Electronics
- Raspberry Pi is adaptable and expandable using Hats

Programming
- RPi used as self-contained Hotspot
- Full motor functionality for forward/backward motion via WiFi commands
- Includes emailing and scheduler availability
- Video transmitted over WiFi

Future Enhancements/Testing

- Line sensors for preprogrammed location sensor readings
- Swivel-mounted front camera for visibility without repositioning the vehicle
- Data tracking via WiFi
- Arduino-compatible camera
- Moisture-proofing
- Camera-hoisting mechanism and harvesting arm
- Improved drivability
- Battery-life testing
- Water-resilience and corrosion testing

Conclusions

In the end, V2 was the better option for meeting the needs of end-user, environmental, and program requirements and would prove to be a beneficial tool for assisting the ReEnergize Team in developing a low-cost hydroponic shipping container that could grow and supply food for local food deserts, global climate-challenged areas, or urban areas where food supplies are limited.

References

Lewis, Amanda (08 Apr. 2016). "Eco Centro's Hydroponics Container." Telephone interview.

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