Construction of Agricultural Robot Platform

Dr. Yonghui Wang

Department of Engineering Technology
Prairie View A&M University

P.O. Box 519 Mail Stop 2530, Prairie View, TX 77446

Dr. Suxia Cui,

Department of Electrical and Computer Engineering
Prairie View A&M University

Dr. Jian-ao Lian

Department of Mathematics
Prairie View A&M University

Abstract

The wide use of agricultural robots in the agricultural industry demands qualified workers equipped with related expertise and skillful hands-on experience. Prairie View A&M University (PVAMU) is ready to take this responsibility in providing diversified and qualified workforce for the society. However, due to lack of agricultural robotics facility, agricultural and engineering students enrolled in PVAMU do not have the opportunities gaining hands-on experiences with agricultural robotics technology. This shortage further widen the gap between industry requirement and our students' skills, thus undermines their confidence as well as the local economy.

To offer our students these highly demanded experiences, a new agricultural robotics lab established on PVAMU campus that provides undergraduates with combined knowledge of agricultural science and engineering is needed. This has successfully been recognized by a federal sponsor with a grant support. As we know that the central component of robotics technology, such as embedded system, is also key technique for the electrical and computer engineering majors. In fact, an important section of the market for engineers nowadays is the biotechnological industry. Therefore, the construction of an agricultural robot can also provide training to our engineering students, help them understand the basics of the unit operations in this industry, and equip them with relevant expertise in pursuing a career in biotechnology. From the agricultural industry standpoint, this project can also attract new blood with diversified technical background.

In this project, a senior design group of Electrical Engineering students work with their advisors in constructing a remotely controlled mobile agricultural robot platform. This platform is the first step for building a real agricultural robot. The final robot should be a remotely controlled vehicle carrying a group of sensors for collecting and processing data in a real-time manner. Before accomplishing this final goal, this first step is to work on the vehicle itself in this project. The accomplishment of this work not only trains our engineering students with the cutting-edge technology, but also provides a step stone for the future success of the federal sponsored project.

1. Introduction

Agricultural industry is facing a tremendous challenge of sustaining the growing world population. The key to success is precision agriculture, where electrical and computer engineering techniques such as sensors, microcontroller, and robotics can play important roles. Future workforce is in great need of engineering graduates who have some knowledge of agriculture. A very efficient way to train engineering students with hands-on experience is through senior design projects. Faculty members from PVAMU successfully advised a group of electrical engineering students on developing a prototype of agriculture robot in their senior design. Students applied their knowledge in the system design along with their newly equiped agriculture concepts to achieve the goal. The process could serve as an example of training students to solve multidisciplinary problem.

PVAMU, the second oldest higher education institution in Texas, a Historically Black College and University (HBCU), is “dedicated to excellence in teaching, research and service. It is committed to achieving relevance in each component of its mission by addressing issues and proposing solutions through programs and services designed to respond to the needs and aspirations of individuals, families, organizations, agencies, schools, and communities — both rural and urban.” PVAMU “is a state-assisted institution by legislative designation, serving a diverse ethnic and socioeconomic population and a land-grant institution by federal statute”. The Roy G. Perry College of Engineering of PVAMU has six departments and a little more than one thousand students.

2. Project Description

The approach of treating crop and soil selectively according to needs by small autonomous machines is the natural next step in the development of Precision Farming (PF) as it reduces the field scale right down to the individual plant or Photo technology. One simple definition of PF is doing the right thing in the right place at the right time with the right amount. This definition not only applies to robotic agriculture (RA) and Photo technology but also implies a level of automation inherent in the machines. Automatic sensing and control (on-the-go) for each task is important and many research papers have shown that these systems are feasible but most are too slow, and hence not economically viable to be operated on a manned tractor.

Once these systems are mounted on an autonomous vehicle, they may suddenly become commercially viable. By taking a systems approach, in which we consider a system in terms of its actions, interactions and implications, we can develop a new mechanization system that collectively deals with all the crop’s agronomic needs in a better way. To do this we must stop defining plant care in terms of the current mechanization but in terms of what the plant needs [1]. When we have defined the actual plant requirements, we are then free to design a better way of dealing with them.

Project Goal

Design and build a remote control agricultural robot platform.

Project Objectives

- Design and implement of a hydraulic platform operated by a remote control.
- Amplify the motor of the agricultural robot to support new installed platform.
- Install and program multi-sensors on the robot for data collection.
- Improve the spring suspension to maneuver the robot on rough terrain.
- Design control panel that includes electronic circuits that control the robot.
- Platform design should be inexpensive.

3. System Design

A lot of ways that Engineer can improve the efficiency of agriculture robots. One approach is to utilize available information technologies in the form of more intelligent machines to reduce and target energy inputs in more effective ways than in the past. PF has shown benefits of this approach but we can now move towards a new generation of equipment. The advent of autonomous system architectures gives us the opportunity to develop a complete new range of agricultural equipment based on small smart machines that can do the right thing, in the right place, at the right time in the right way.

- Path

The robot will spend most of its operation time traversing a field by following the crop rows running the length of a field as seen in Figure 1.

Figure 1: Agricultural Field

These crop rows will have different distances between them and the field will be oriented differently geographically but the robot will typically traverse the field in the same way: Driving in straight lines along the length of the field and turning in circles at the ends of the rows as shown in Figure 2.

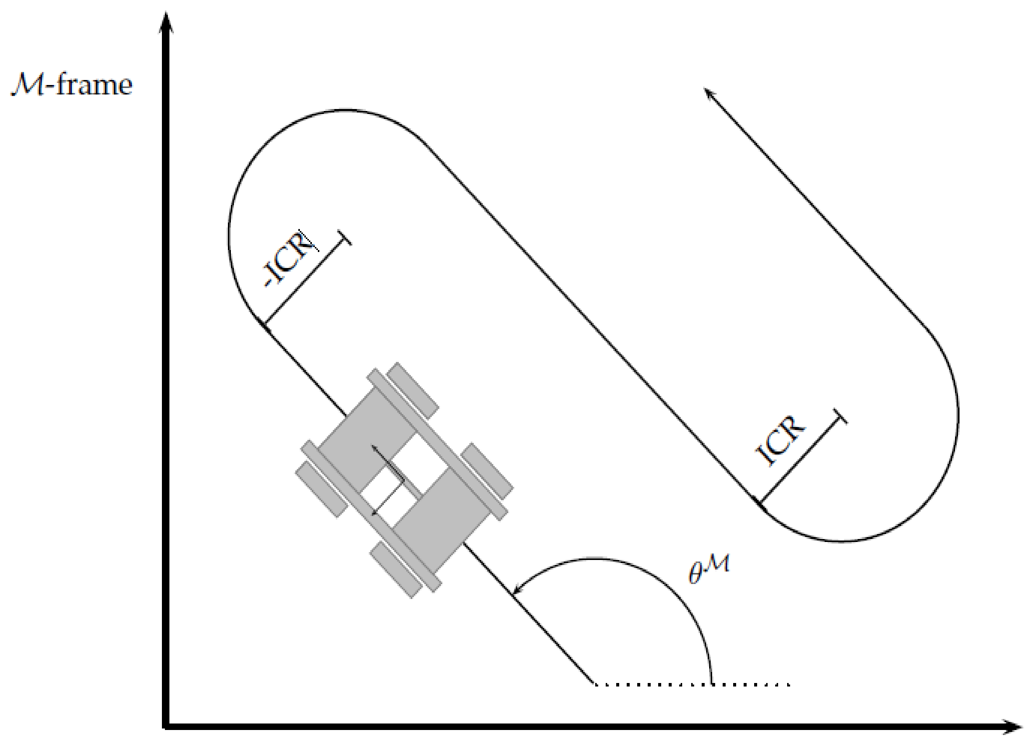


Figure 2: Typical Driving Scenario

When a path has been selected for the robot the next step is to approximate the nonlinear behavior of the model with a number of linear models. Figure 2 describes the path on which the robot will be travelling. It can also be described with straight lines and circle segments. The straight lines can be described by a single working point; the inherent non-linearity of the circle segments makes it necessary to have several working points to describe the robots behavior accurately.

- ***Motors***

The motors for the vehicle must be easy to control, supply and to install. It is also preferred, that they can be used indoors for test. DC motors best meet the above demands. DC-motors can be used indoors and be supplied by battery. We need to control the absolute position of the steering motors. As the friction to the ground varies a lot there must be an integrator in the controller to be sure that it can reach the wanted position.

- ***Sensor***

In the real agriculture robot system, expensive hyperspectral sensors will be used. For this project, we replaced it with a color sensor to detect the color green to trigger an action which will simulate the full function of s hyperspectral sensor.

Color Sensor: ADJD-S371

The ADJD-S371-CR999 is 4 channels (RGB+CLEAR) digital output sensor with a mere size of 2.2 x 2.2 x 0.76mm. Its spectral responses are shown in Figure 3. It is a CMOS IC with integrated RGB filters and analog-to-digital converter front end. This device is designed to cater for wide dynamic range of illumination level and is ideal for applications like portable or mobile devices, which demand higher integration, smaller size and low power consumption. Sensitivity control is performed by the serial interface and can be optimized individually for the different color channel.

Features:

- Fully integrated RGB+clear digital color sensor
- 10 bit resolution per channel output
- Built in oscillator/selectable external clock
- Low supply voltage (VDD) 2.5V
- Digital I/O via 2-wire serial interface
- Adjustable sensitivity for different levels of illumination

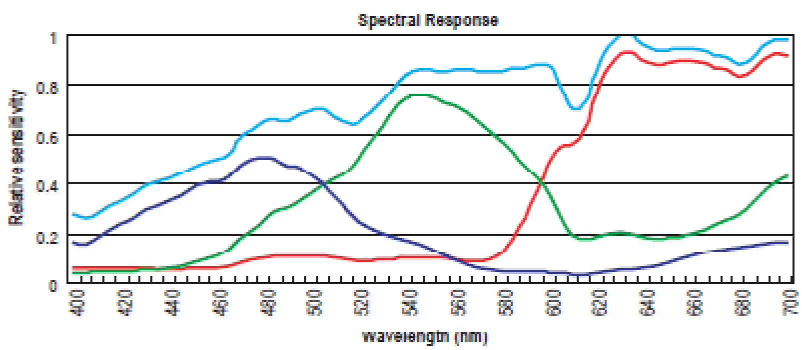


Figure 3: Typical spectral response when the gains for all the color channels are set at equal.

- ***System Diagram***

The hardware design blocking diagram is shown in Figure 4 and the circuit is shown in Figure 5.

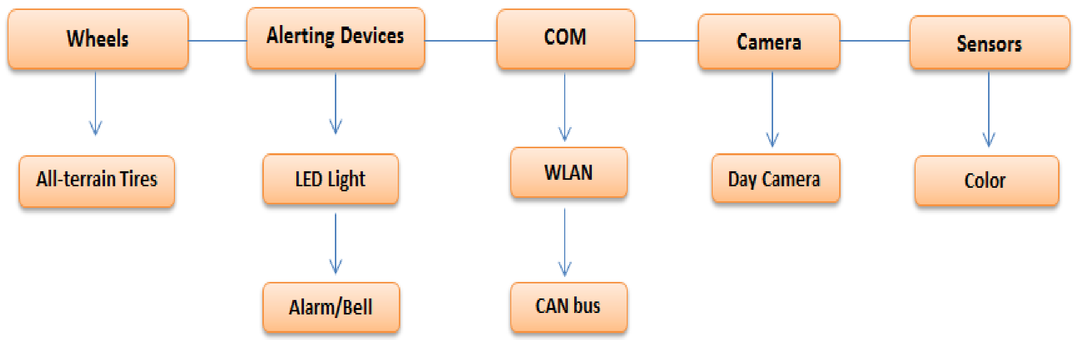
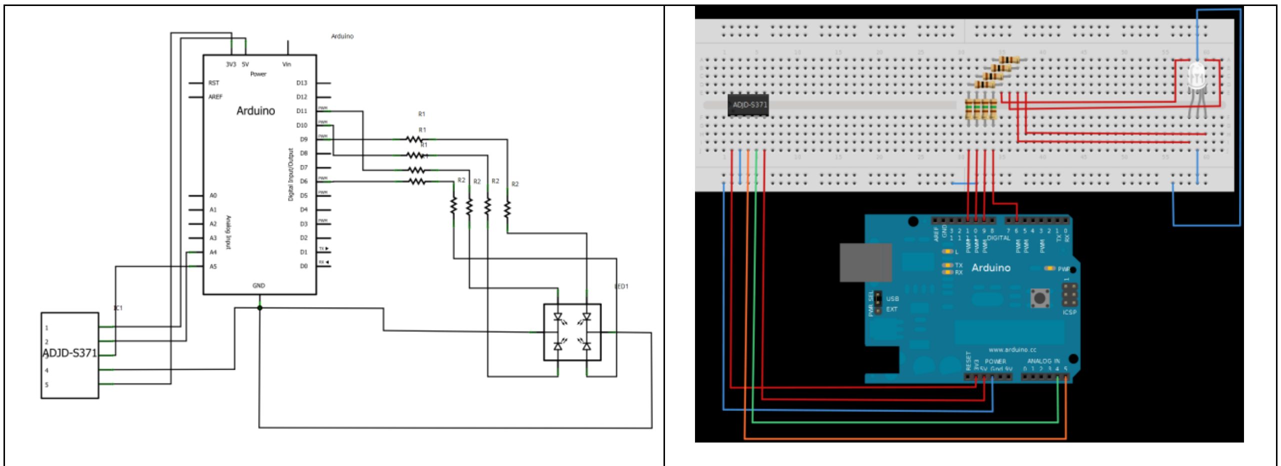


Figure 4: System Diagram

- ***Circuit Design and Simulation***



(a)	(b)

Figure 5: (a) Circuit Schematics (b) Circuit Simulation

- ***Software Flowchart***

The software controls the action related to the sensor detecting results is illustrated in Figure 6.

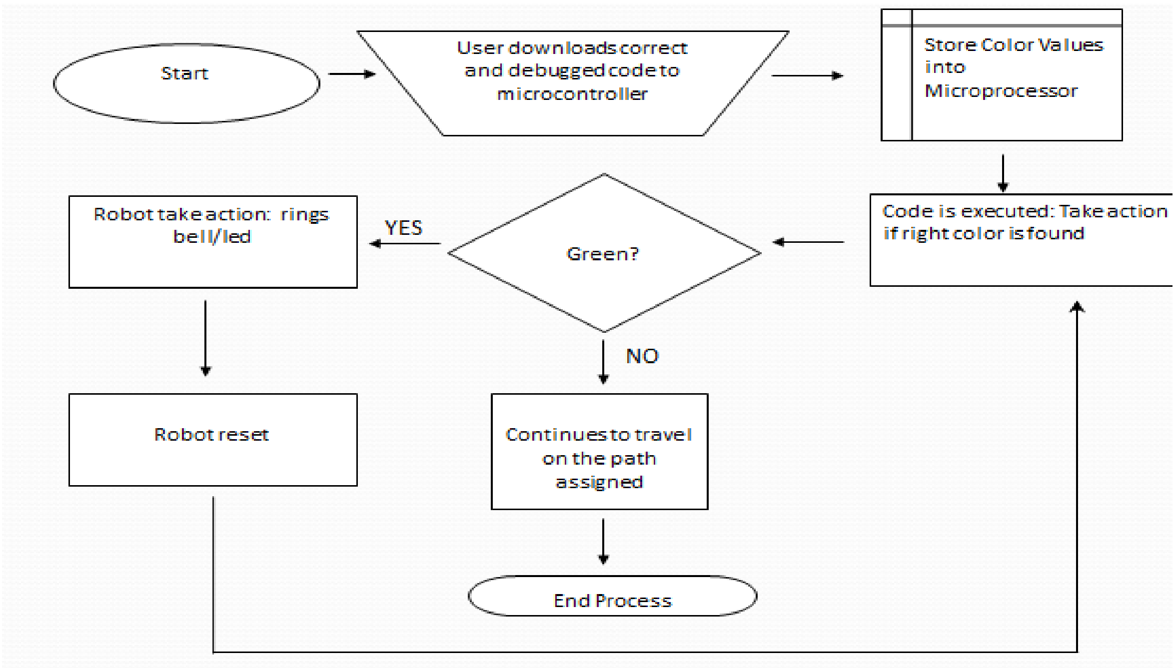


Figure 6: Color Sensor Flowchart

4. Project Result

The sensor is attached to the front of the robot. Consideration of social aspects shows that the public are ready for small intelligent machines to be used in food production, by the level of interest shown by the media and when being demonstrated. Insurance and liability will be a lot easier with smaller autonomous machines. Safety is another important factor. Any autonomous vehicle is going to go wrong at some time and the chance of catastrophic failure should be minimized within the design process. A small light vehicle is inherently safer than a large one. Redundant, self-checking systems should be built into the system architecture to allow graceful degradation.

The sensor outputs a voltage proportional to all the light that it sees, weighted by the curve. When a subject is illuminated with a Green LED only, it will respond with a voltage proportional to the green component of the subject's color. When there is ambient light mixed in with the LED, its effect can be eliminated by sampling then subtracting this reading. The future projected robot will have10" wheels to maneuver through uneven field this tire is designed to maneuver on all surfaces, able to withhold weight of 50lb's or more.

The robot prototype, as shown in Figure 7, is built by revising an existing robot system. By applying the sensor and revise the functions, it can correctly detect the color and LED will be lit if the color is found.

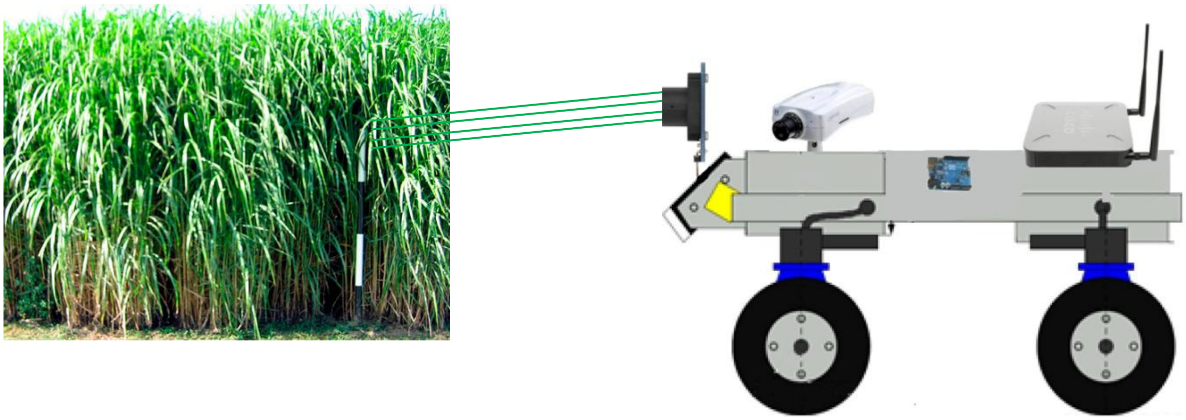


Fig 7: Robot detecting the color green

5. Conclusions

This project has trained a group of engineering students to be familiar with real agricultural applications. And made it possible for undergraduate students to set out a vision of how aspects of crop production could be automated in the future. Although existing manned operations can be efficient over large areas, there is a potential for reducing the scale of treatments with autonomous machines that may result in even higher efficiencies. The development process may be incremental but the overall concept requires a paradigm shift in the way we think about mechanization for crop production that is based more on plant needs and novel ways of meeting them rather than modifying existing techniques.

Acknowledgments. This work was partially supported by the U.S. Department of Agriculture's 1890 Capacity Building Program award # 2010-38821-21461.

References

[1] Simon Blackmore, Bill Stout, Maohua Wang, and Boris Runov, "Robotic Agriculture—The Future of Agricultural Mechanisation," the 5th European Conference on Precision Agriculture, Uppsala, Sweden, 9-12th June 2005