Titan Chopper

CSUF Autonomous Lawnmower Entry 2011 ION Robotic Lawnmower Competition

Abstract: This year is California State University, Fullerton's second time competing in the ION Robotic Lawnmower Competition, again, with our mighty Titan Chopper. The Titan Chopper is an extensively modified lawn tractor. During the building process, we emphasis mainly on mechanical simplicity, durability, cost and power efficiency, while capable of rapidly and accurately complete the task of lawn mowing. In order to achieve our goals, we focus our software mainly on GPS navigation, obstacle detection and avoidance. With our goals in sight, we hope to further develop the Titan Chopper with more students from CSUF in the future. The report will contain more detailed information regarding every aspect of the Titan Chopper.

Introduction:

The Titan Chopper has competed in the 2010 ION Robotic lawnmower Competition, however due to our lack of sophisticated equipments the mower failed to pass the qualification test and did not compete well. However, this has provided the students at CSUF a good experience of the environment. This is the second time for CSUF and the Titan Chopper to compete in the ION Robotic Lawnmower Competition, many more sophisticated computer and sensors are fitted on the Titan Chopper, providing faster and more accurate calculations of obstacles and the position of the mower.

To participate in this competition has been one of the most exciting and technically challenging experiences for our team members and we hope that future students from CSUF strives to perfect the Titan Chopper.

We would like to thank our faculty and technicians at the EE department, and NavCom Technology, Inc. for their generous sponsorship.

Titan Chopper Team, 2011

Team Members

Dr. Jidong Huang (Advisor)

Ph.D. Electrical Engineering - Navigation Systems
Responsibilities: Supervising the project; and providing technical guidances.

Michael Yeh
BS Electrical Engineering
Responsibilities: Team lead; coordinating team efforts; equipment acquisition; low level hardware configuration and software development; documentation

Nizari Parikh
MS Electrical Engineering- Communication
Responsibilities: Research on sensor integration; high level software development; documentation

Kwadwo Amankwa-Poku
MS Electrical Engineering - Control Systems
Responsibilities: Research on path planning and control, high level software development

System Design

The objective of this project is to create a completely autonomous lawn mower. Using advanced navigation and guidance technology, the lawn mower will have the capability of mowing the grass of a predetermined area. All of the required movement will be controlled by preprogrammed hardware and all that is required from an individual is the coordinates of the desired location. In order for these goals to be met, this project requires a precise determination of mower position and velocity, and precision control of mower movements. By integrating GPS and IMU (Inertial measurement unit) and also the use of microcontrollers, these necessities will be met as shown below.

The system onboard the mower will communicate to the control station via Wi-Fi data links. This will increase the radius of operation, and as a result, the overall efficiency of the product is increased by allowing one lawnmower unit to operate for a longer period of time without any required adjustments. Moreover Wi-Fi data links will allow the user to control multiple units by one control center, which reduces the cost for larger operations.

In order for the final product to be reliable, a high accuracy GPS is required. We have used DGPS (Differential GPS) technology, which has one receiver at base station and one rover receiver which will be mounted on the mower. The coordinates of base station are known a priori and so this base station can be used as a reference station to generate corrections for the rover in the same geographic area. Using these corrections over the radio channel between the two receivers, the rover can maintain its accuracy from tens of meters to several centimeters.

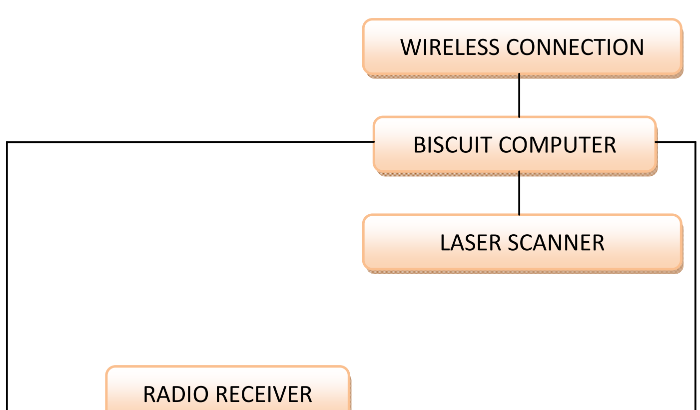
The GPS outputs will be decoded by a single board biscuit computer, one on board of the lawn mower and the other at the reference station. Using Wi-Fi data transfer, the DGPS correction message will be transferred to the biscuit computer on board of the mower. This computer will perform the corrections of the GPS position and provide the required movement to the microcontroller.

Since safety is the main concern of this project, there are a few additional systems included in the lawnmower. With that goal in mind, a remote control will also be used to provide the user with complete control of the mower's movements without going through the computer at the control center. This allows users to directly control the lawn mower when the control center or DGPS malfunctions.

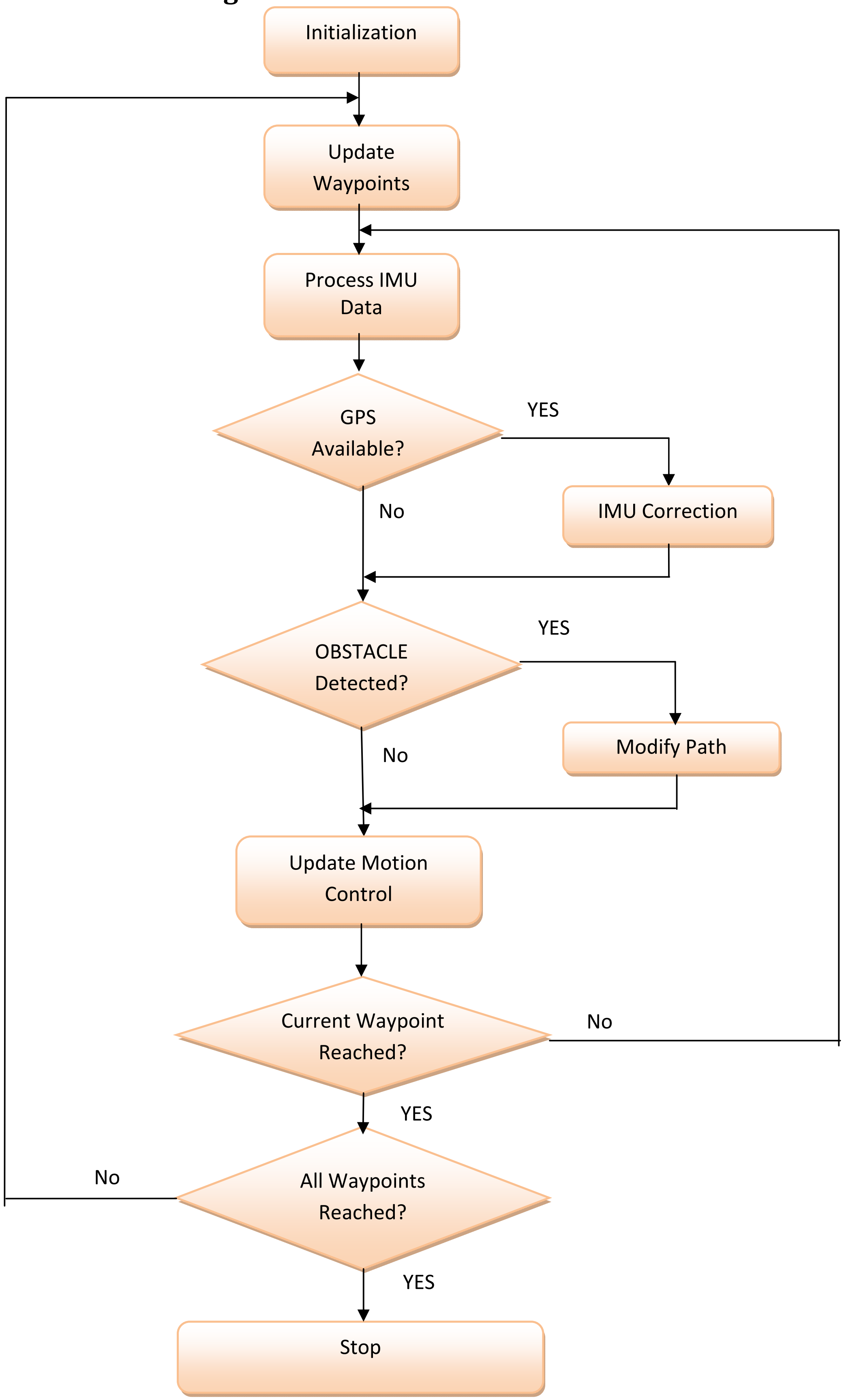
In order to meet our goals, the mechanical movement of the lawnmower will have to be integrated with our control software. This can be attained by using DC motors as the driving force for the required movements. The RMP of the DC motors can be controlled using a PWM signal which is controlled and adjusted by our software. A microcontroller and two PWM generators will be used to implement the software signals. Another advantage of using DC motors is the capability of combining our unit with Green Energy technology in order to reduce its carbon foot print.

The wireless communication will be realized by utilizing Wi-Fi modules equipped with RP-SMA antenna. This gives us the ability to transfer signals between control station and lawnmower without the any wires. One SBC will be stationed aboard the lawnmower, alongside the microcontroller, in order to convey the signals received from the control center to the microcontroller. The second SBC will be located in control station in order to convey the motion control commands to the lawnmower.

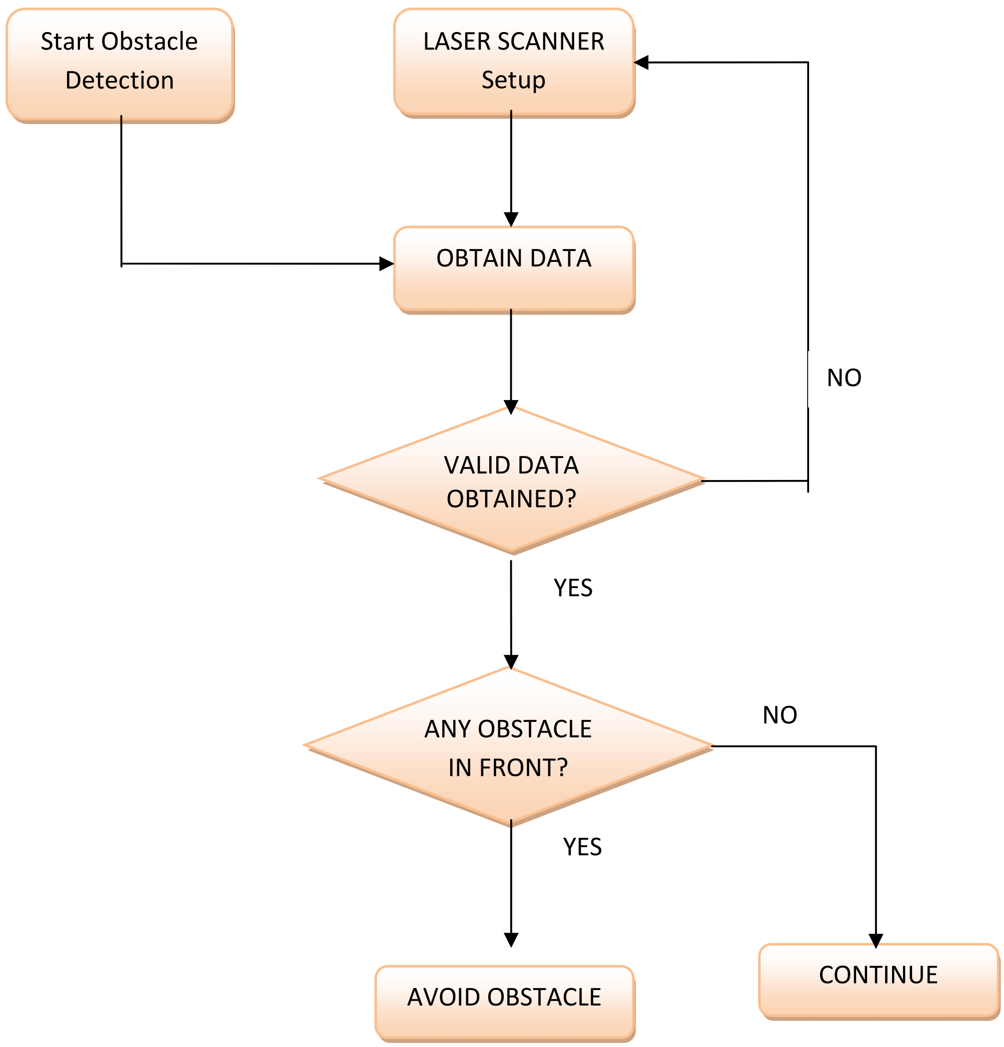
System Block Diagram



Navigation Software Design

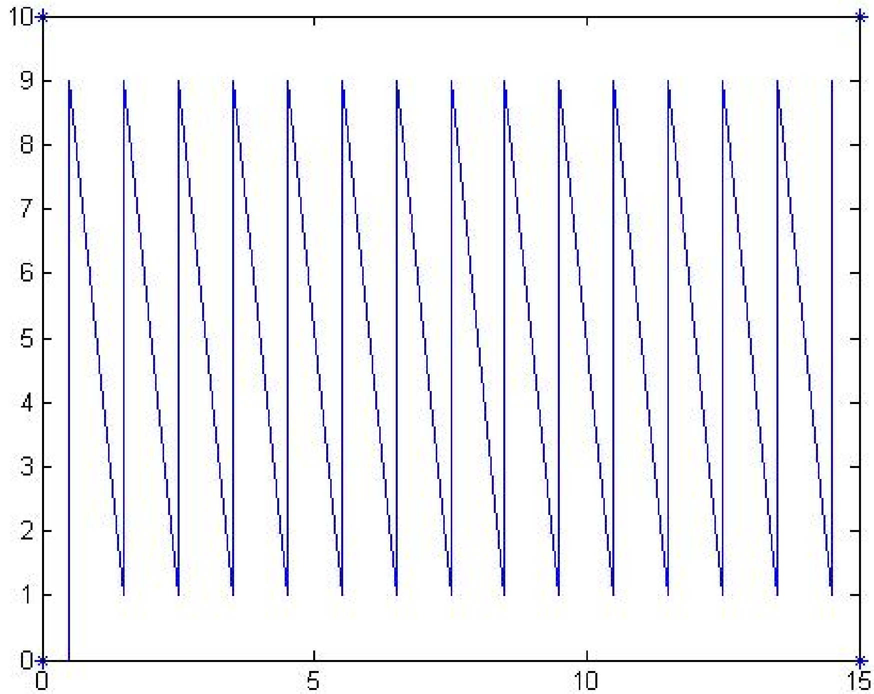


OBSTACLE DETECTION



Path planning

Due to the size and turning radius of the Titan Chopper, a zigzag motion will be used to perform the lawn mowing



(path of the Titan chopper for a sample 15X10 meters field)

Hardware Components

Drive Motor

Since our mower was quite heavy, a motor with large output power is required. Since the motor is not part of the supporting structure of the mower, the rigidity of the motor is not our concern.

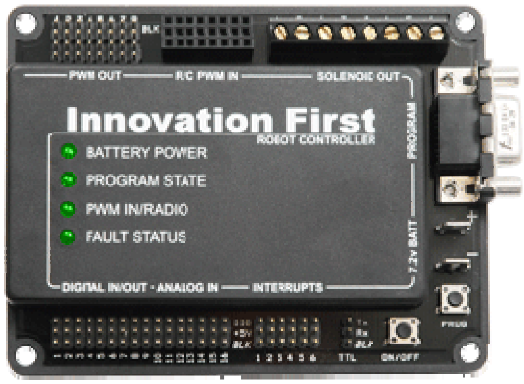
Speed Controllers

We have 2 speed controllers on the mower, a Victor 883, for steering, and a Victor 885, for Driving. During the first time competing, our speed controller would only spin in one direction. Therefore, Zig-zag motion was not achievable, however, with the new replacement; the mower can now go both Forward and Backwards. The Victor 883 is used for Steering.

Specs:

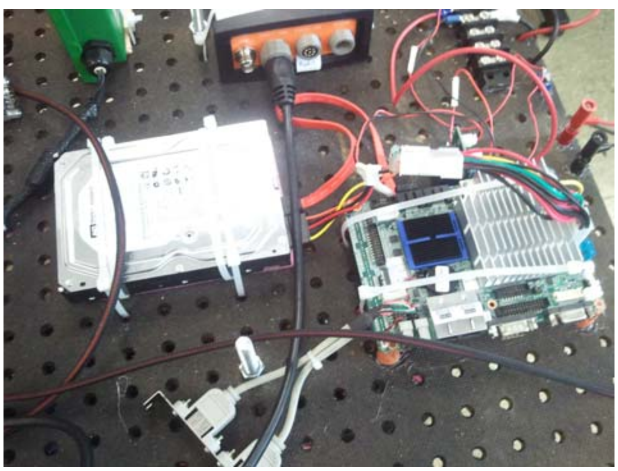
	Victor 883	Victor 885
Voltage	6V~30V	6V~30V
Current -	60A	120A

EDU Robot Controller



This is an advanced robotics development platform based on a PIC 18, while last year this microcontroller consist 100% of the process on the mower, this year, we reduced it's responsibilities to controlling Drive motor, Steering motor, Steering position feedback and receiving signals from our Remote controller. It is connected directly to the Single Biscuit board computer and performs no complex calculation task.

Single Biscuit Board Computer



A conclusion drawn from last year's competition is that, a single chip MCU will not be sufficient to perform all calculation tasks of the mower. So a single Biscuit Board computer and a hard drive with Linux operation system are included as the main calculator of every aspect of the lawn mower. This Single Biscuit board computer can be remotely controlled through Wireless internet connections and is powered with our onboard battery. The Laser Scanner, GPS receiver, and IMU are directly connected to this component.

GPS Receivers

The GPS receiver System sponsored by NavCom Technology is a great assets to our Lawn mower. The system includes 2 sets of GPS antennas, Receivers, and radios. One set will be on the Lawnmower while the other will be on a stationary location for differential GPS function. The GPS outputs are directly fed into the biscuit computer for high level navigation decisions.

Sick Laser Measurement System (LMS-200)

The Laser scanner will provide range data regarding the position, distance and size of the obstacle in front of the lawnmower, due to it's vulnerability to sunlight, a shelter will be used.

Range: 80m 180 degree (10m for objects with 10% reflectivity)

Maxbotix LV-EZ1 Ultrasonic Sensor

The Ultrasonic sensor provides proximity reading from any object up to 5 meters away. However, it does not provide the position and size of the object. This is used on the back side of the Lawn mower when the mower is backing up.

MIcroStrainn 3DM-GX1 Inertial Measurement Unit

The IMU will measure 3 axis of acceleration, 3 axis of rotation and 3 axis of magnetic field which provides heading reference for compensating gyro drift. The IMU can provide heading and position information to be integrated with GPS data, for producing continuous high-precision navigation information.

Spektrum DX6i Radio System

Since our lawn mower is relatively heavy, we cannot transport the lawn mower from various locations in any methods but driving it. The radio is the tool to drive the lawn mower. We can also trigger the emergency stop, autonomous mode, and turn on and off the blades from the radio.

Hardware/Parts list/Cost analysis

2004 EDU Robot Controller -$200

883 Victor Speed Controller -$149

885 Victor Speed controller -$199

10K ohm potentiometer

12 Volts batteries (X3) - $148

Emergency Stop Switch - $120

Biscuit Computer - $220

Western Digital Hard Drive - $100

Rabbit Board - $200

Laser Sensor - Sponsored by NavCom ($6,500)

Maxbotix LV-EZ1 Sensor(x2) - $37

Spektrum DX6i Radio System -$198

MIcroStrainn 3DM-GX1 Inertial Measurement Unit - $ 950

Navcom SF- 3050 GPS receiver system with Radio Antenna system -$10,000

Total Cost: $19,021

Physical Specifications

Length: 200cm

Height: 90cm

Width: 100cm

Cutting Radius: 95cm

Weight: 550lb

Engine: 10.5 HP Kohler

Max Speed: 6 miles/hr (Forward and Reverse)

Turning Radius: 150cm

All the interior wiring is retrofitted. The manual steering wheel is replaced by a DC motor. The engine powering the blades can be turned on and off via the commands generated by the control center.

The overall cost of this project is about $2000. Most of the money is spent on electrical components of the mower. The physical mower was salvaged and the entire repair was performed by the team members. To ensure safety and durability, the mower has taken to a university machine shop multiple times for maintenance .

Improvements:

With the increasing electronic components, the mower is now featuring a second layer for more calculation based electronics, while the bottom layer is for power electronics and low level control units.

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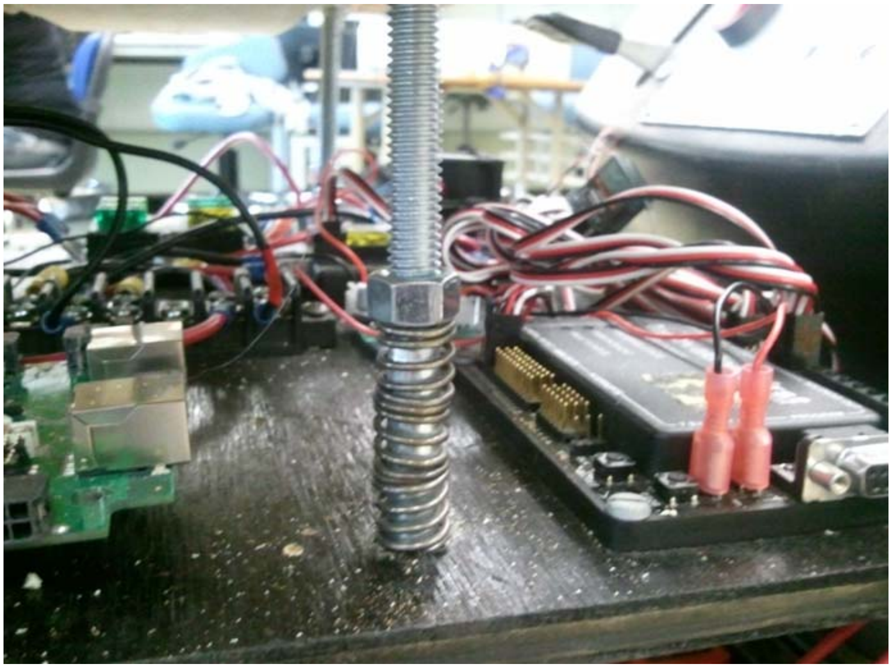
(Mower Side View)

(Mower Front View)



The suspension system for the second layer made so that the top layer electronics will not suffer vibration from the ground and the internal combustion engine for the blades.