Initial Project and Group Identification Document

Autonomous Lawn Mower

Senior Design Project

Group 2:

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Motivation for the Project:

The primary motivation for our project is to remove the chore of mowing your lawn. By creating a lawn mower that handles this task autonomously, the user is freed from this physically demanding and time consuming task. Our design helps those with physical limitations who could not otherwise mow their own lawn. Even without a physical limitation, the autonomous lawn mower provides the user with more free time. This freedom is provided in a worry-free platform in which little user interaction is required. Our project idea was introduced by group member Andrew Cochrum. His design idea was to create a fully autonomous lawn mower that maps the target yard and lawn mower locations using triangulation methods from RF receivers/transmitters. Our design is similar to the previous senior design project called iMow. It is also an improvement on existing consumer autonomous lawn mowers including the John Deere Tango E5.

Goals and Objectives:

In keeping with the motivation behind the project, the goal of our design is to reduce end-user work through the utilization of an easy-to-use device. The autonomous design eliminates the need to go outside and mow your lawn every week. The project will be designed to learn your yard in one initial session and then repeat the process indefinitely as needed. Our project improves on existing consumer products by removing the need to bury insulated wires to identify the boundaries of the lawn. This complies with our motivation to reduce work by eliminating this tedious, initial setup. The project design will be very easy to use with no user interaction required after the initial “learning” of the yard layout. This “learning” consists of the user pushing the mower along the entire perimeter of the lawn, during which the mower will ping the RF transmitter(s) located throughout the yard and save its two-dimensional coordinates (relative to the beacons) in its internal memory. Upon execution of its weekly cutting routines, it will reference these values to restrict its location to the area enclosed by the user’s path during the “learning” phase. Once the boundaries have been established, the user simply needs to program the mowing schedule, via a control panel on the mower chassis itself or wirelessly through some other interactive platform (i.e. smart phone, PC, etc.). The mower will then execute its cutting routine in accordance with this schedule and return to its charging station upon completion of its task or when the onboard batteries have reached critically low levels. If time permits, a moisture sensor will be implemented to monitor the amount of precipitation in the area. If the threshold values are exceeded, the mower will return to its sheltered charging station to protect its electrical components from water damage.

In addition to ease of use through automation, our goal is to create a project that is accurate and efficient. A majority of current, commercial products sweep the area enclosed by the buried perimeter wire in a random fashion. Once the mower reaches the perimeter of the yard, it rotates 180 degrees and proceeds in a straight path until it encounters a boundary location once more, at which point the process repeats itself. It is apparent that such a method could become quite inefficient due to a variety of factors. For instance, unnecessary redundancy would most likely occur in which the mower continually passes over a previously cut section of the lawn. To eliminate this problem, the mower will keep track of its previous positions during the current cutting session, and maneuver around these areas (possibly disabling the motor driving the cutting blades to conserve power if these previously-cut areas need to be traversed). The aforementioned straight-path navigation implemented by the commercially available mowers could still be implemented in this iteration, however using an improved sweeping method. To reduce this straight-path distance (especially in very long and/or wide lawns), the mower could divide (through software) the area to be mowed into sections. This could be implemented by temporary boundaries, established by the microcontroller, on-the-fly. Thus, the mower would sweep between the boundaries of this virtual section and proceed to each adjacent section once its current section has been fully mowed. This would in theory greatly reduce power consumption by minimizing unnecessary redundancy associated with the straight-path navigation method.

By implementing RF triangulation, the lawn mower will always know exactly where it is. By matching its location to the yard location determined from the learning mode, our lawn mower will give the same accurate cut each and every time. This is a great improvement in efficiency over available consumer devices which cut in a random pattern until the entire area has been covered.

Safety is another factor that will be considered for our project. Implementation of obstacle avoidance is a primary objective for the safety of our project. Through the use of ultrasonic sensors, the mower will discern the location of obstacles present within the cutting area delimited by the border established during the "learning" phase. Once an object is detected in its current path of motion, the mower will change its directional orientation until the object is no longer in its "field of view," and proceed around the obstruction. If the mower fails to navigate around the obstacle, an onboard collision detection system will cause the mower to reverse its direction of motion or, in a worst case scenario, disable the mower completely. In the latter scenario, the mower would have to be manually restarted by the user. The collision detection system could be implemented through a variety of methods. A bumper could be affixed to the front and sides of the mower. This bumper would rest on springs, and in the presence of a suitable force, would be depressed enough to engage a lever/limit switch, thus notifying the microcontroller that a collision has taken place and to initialize corrective procedures (i.e. disable the motor driving the wheels and/or blades). An alternative method would involve suspending a heavy-duty string around the mower chassis. One end of the string would be anchored to a fixed point on the mower body, while the other end would attach to a sensor which monitors the tension in the wire. To further increase safety, an easily accessible kill switch will be mounted on the mower itself. If time permits, sensors to detect the mowers horizontal orientation will be implemented to disable the cutting blades, should the mower accidentally tip over.

One final, major consideration for our design will be to create this project in as low cost a way as possible. As of this writing, no funding and/or sponsorships are expected to help reduce our own costs for this project. Because of this, the total projects costs will need to be kept as low as possible resulting in a low cost final design.

Function of the Project:

Our design is for an autonomous lawn mower. The lawn mower will initially go through a "learning mode" run to map the yard to be cut. This "cutting map" will be stored in memory to be repeated thereafter by the lawn mower on future cuts. The lawn mower will include on-board obstacle detection to avoid cutting any unexpected impediments in its path. Upon completion of cutting the lawn, the mower will return to its charging station and notify the user that it is done. This entire process (with the exception of the learning mode) should be completed without any required user interaction.

Specifications and Requirements:

- Mower size:
  - 26" x 35" x 12.5" (W x L x H)
  - *Based off of Robomow RL850 Automatic Lawn Mower dimensions*
- Mower location accuracy:
  - Accurate to within 12"
- Forward speed:
  - 1 mph
- Obstacle detection distance:
  - 2 cm to 3 m
  - *Based off of Parallax PING Ultrasonic Sensor specs*
- Lawn size:
  - 0.33 acre (14374.80 square feet)
  - *Source: iMow overall project specifications*
- Time to cut test area:
  - Preferably ≤ 30 minutes
  - Realistically, actual time to complete is low priority. However, mower should cut entire area on one charge and have enough power to return to its charging station.
- Battery life:
  - At least one hour
  - Should sustain cutting blades, wheel motors and all other subsystems until the entire area has been cut
- Battery charge time:
  - Roughly 3 hours
  - Since grass is mowed usually on a weekly basis, the charge time is of low priority

Block Diagrams:

NOTE: All block statuses are "Research"

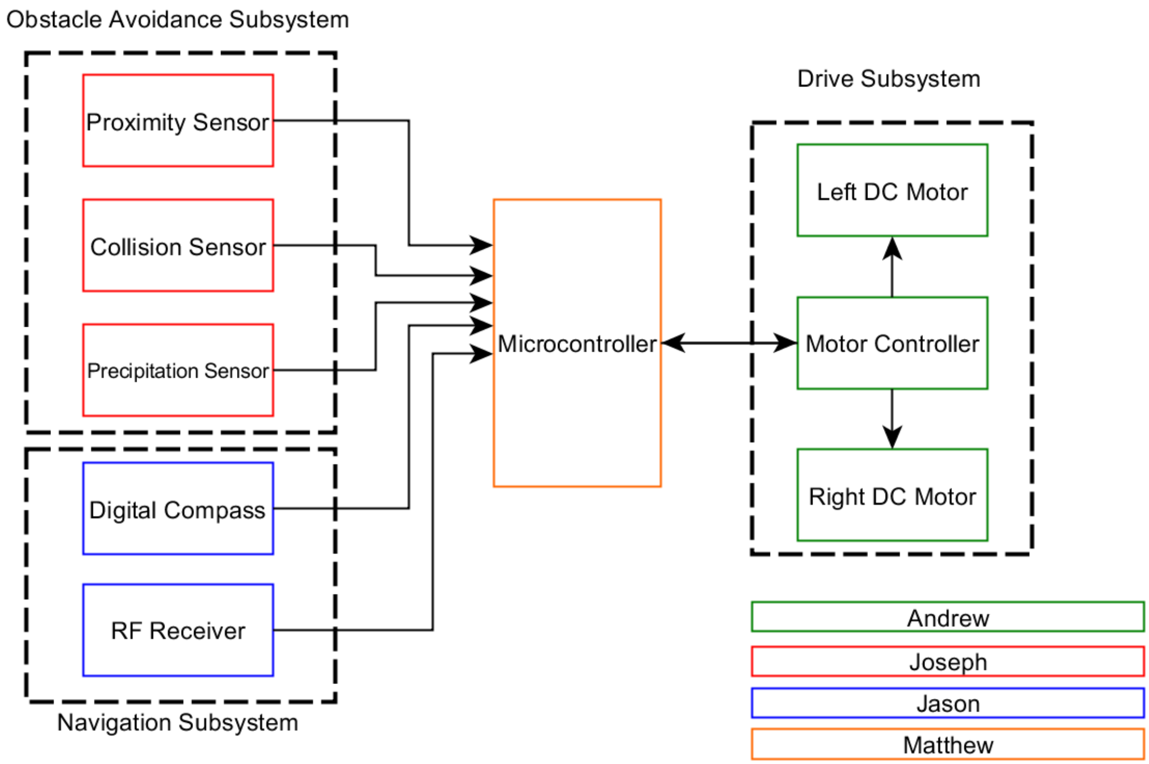

Figure 1: General system overview

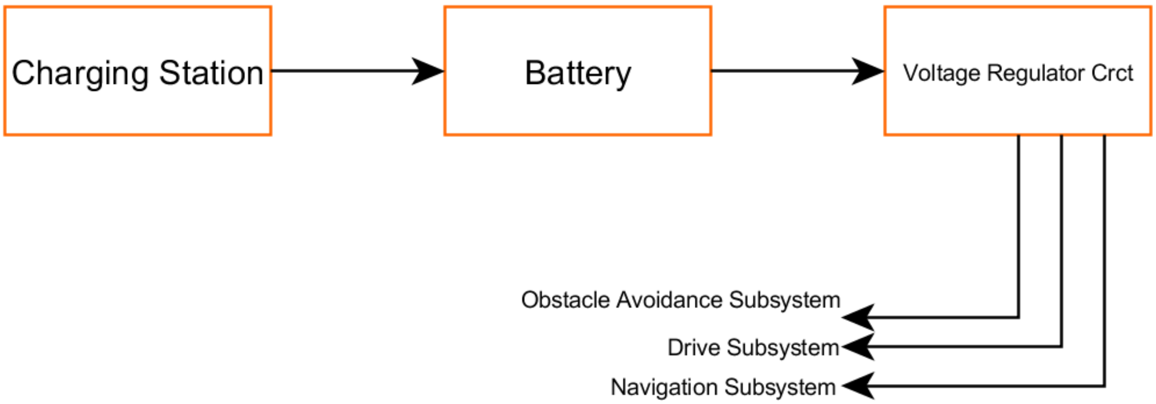

Figure 2: Power Subsystem

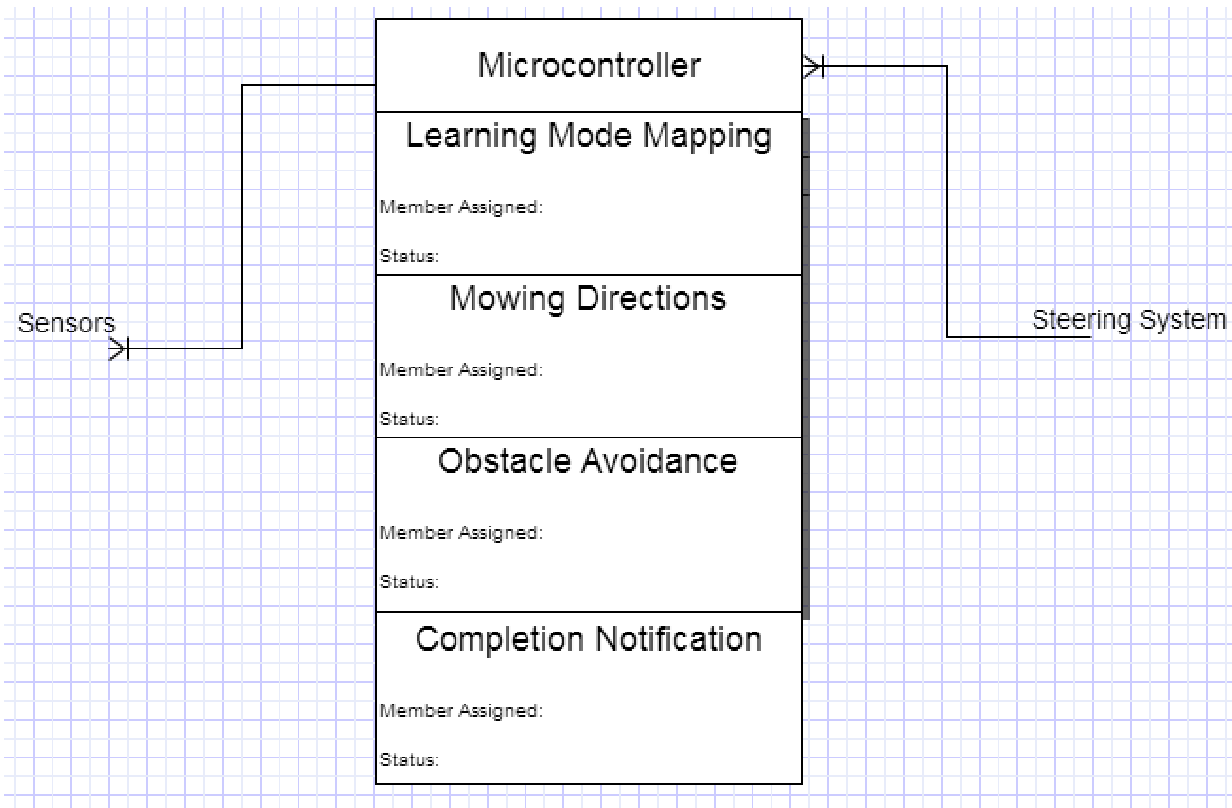

Figure 3: Software map

Project Budget:

Part	Quantity	Unit Price
Cordless electric lawn mower	1	$100.00 (used), $400.00 (new)
electric scooter, permanent magnet, DC brush motor	2	$150.00
Microcontroller (MINI-MAX/51-C2)	1	$60.00
PING Ultrasonic Distance Sensor	1	$30.00
Devantech CMPS03 Magnetic Compass Module	1	$45.00
RF wireless transmitter WRL-	3	$4.00

10535		
RF receiver	1	$30.00
Battery Charger	1	$30.00
Batteries	2	$100.00
Dual Channel Motor Controller	1	$125.00

Estimated Total: $1231.00

Project Milestones:

- Spring 2013
    - Research existing designs similar to our project
    - Finalize project outline
    - Research parts to be used
    - Finalize parts list with suppliers and pricing
    - Complete design paper
    - Begin obtaining parts necessary for design

- Summer 2013
    - Acquire remaining required parts
    - Setup and program mapping and obstacle avoidance
    - Build mower steering system and shock bar
    - Complete initial prototype
    - Complete successful test runs
    - Finish final project documentation