# Mow-Bot: The Autonomous Lawn Mower

## Requirement Specifications

9/16/2014


Team: Lawn Stars

Members:

Brendan Boyle

Ty Silver

Yousuf Seraidy

Hadi Albanna

Connor McMahon

Mike Noble


### 1. Introduction

#### 1.1 Purpose

Modern technology has lead to several advances in key areas, such as energy efficiency and autonomous behaviors, which have aided the invention of new technologies. Invented in the early 19th century, the traditional lawn mower has faced continual improvement, leading from purely mechanical mowers to more modern electric models. Today, the lawn mower faces yet another key modification: the transition from manual operation to full autonomy. This improvement provides complete freedom to the common lawn owner to maintain their grass simply, efficiently, effectively, and remotely.

### 1.2 Scope

The Mow-Bot provides a service that replaces existing lawn mowers. Rather than manually operating a gasoline powered lawn mower, the electrically driven Mow-Bot trims lawns effectively and autonomously. The Mow-Bot is able to autonomously navigate through lawns of any shape using a pre- programmed route and return to its charging station. The Mow-Bot is able to navigate hills and operate in adverse weather conditions such as rain and heat. The Mow-Bot is able to detect unusual objects on the route and prevent damage. The Mow-Bot has a user interface to schedule the mowing and turn On/Off the system. The goals of the Mow-Bot are to provide the users with an efficient way to cut the grass since it is pre-programmed to go over specific areas of the lawn once and to grant the users the chance to use their time more efficiently rather than cutting the grass manually.

### 1.3 Definitions, Acronyms, and Abbreviations

Mow-Bot: The entire contained robot unit, containing the drive train, blade, motors, chassis, MCU, and control peripherals.

Mow-Bot Control Unit (MCU): The microprocessor and control logic onboard the Mow-Bot itself which interfaces with other subsystems and is responsible for all information processing in the overall system.

### 1.4 References

Patent: Robotic lawn mower
Patent#: US 4694639 A
Inventors: Sheng K. Chen, Shi Y. Horng, I-Ting Chen
Source: http://www.google.com/patents/US4694639

Patent: Automated lawn mower
Patent#: US 5974347 A
Inventors: Russel G. Nelson
Source: http://www.google.com/patents/US5974347

### 1.5 Overview

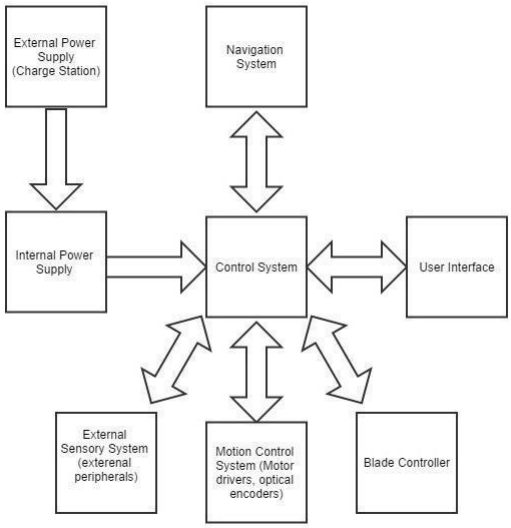
The remainder of this document contains information on the nature of the product (Overall Description) and the specific domain the product is contained within (Specific Requirements).

## 2 Overall Description

## 2.1 Product Perspective

Commented [1]: This should have blocks at the level of physically separable units -- lawn mower with your modifications, charging station, lawn, ...
You have shown a design decomposition. Doesn't belong in this document.

The product is independent and contained within four key units. The primary functional unit is the MCU which controls the drive train and blade motors. The MCU also interfaces with external peripherals to prevent damage to the Mow-Bot and other potentially unexpected objects on the lawn. The second unit is the charging station, which provides a docking location and battery charger for the Mow-Bot. The third unit contains the user interface and its required hardware; this sub-system provides route planning, scheduling, and operational alerts. Finally, the navigation unit interfaces with the MCU and provides information about location for route execution.




### 2.1.1 System Interfaces

The Mow-Bot's internal power supply sub-system interfaces to the external power supply to charge the battery while the Mow-Bot is docked. Software within the MCU will ensure the robot docks before the battery dies and that the battery is not over-charged.

The user interface connects to the MCU and allows for updates to critical route information the user provides. Further, the MCU generates critical runtime reports that can be viewed through the UI.

The navigational unit functions independently of the Mow-Bot control unit and provides location data to inform motion controls (both for docking and route execution).

### 2.1.2 User Interfaces

The user interface must have a schedule selector, allowing the user to choose the operational schedule of the MCU. It must have a selectable sleep mode, or vacation mode, allowing the user to postpone operation indefinitely. Lastly, it must have a route creation mode, which allows the user to set the operational route of the Mow-Bot.

The Mow-Bot will generate error messages that are sent to the UI. If the Mow-Bot encounters an unknown object in it's path that cannot be pushed out of the way, it generates an error message informing the user. If the Mow-Bot, for any reason, cannot locate the charging station, or is otherwise stuck, it generates an error message informing the user.

### 2.2 Product Functions

1. The user can program a route to mow their lawn.
2. The mower can track its position to follow the preset route as it cuts the lawn.
3. The mower returns to the charging station when the job is finished or it is low on battery.
4. The mower stops if it encounters an unexpected obstacle and notifies the user. The user can then move the obstacle and resume operation.
5. The user can signal the mower when they want it to cut the lawn.
6. The user can signal the mower to stop and return to it's station.
7. The user can create a schedule for the mower.

**Commented [2]:** High-Priority goals should include:
Mower is capable of cutting grass.
Mower has sufficient battery life to cut a small lawn.

**Commented [3]:** Explicitly include sections for High-, Medium-, and Low-Priority functions.

### 2.3 User Characteristics

| | |
|---|---|
| Representative | Brendan Boyle |
| Description | Brendan owns a lawn. |
| Type | Brendan is capable of operating a user interface, programming a simple route for the Mow-Bot, and installing the charging station by an outlet. |
| Responsibilities | Brendan must connect the Mow-Bot charge station to an electrical outlet. Then he must program the route of his lawn to the Mow-Bot. He also must either signal the Mow-Bot to mow, or set a schedule for the Mow-Bot to follow. |
| Success Criteria | Brendan casually enjoys a glass of lemonade while the lawn is mowed according to his specifications. |
| Involvement | Enjoyment of free time while lawn is mowed. Brendan should be available in case of an alert from the Mow-Bot. If Brendan does not respond in time the Mow-Bot abandons the route and returns to it's station. |
| Deliverables | The user's lawn is successfully mowed. |
| Comments/Issues | In the event of run time issues that prevent operation of the Mow-Bot, Brendan must be willing to reset the Mow-Bot and resolve unexpected errors in the mowing route. |

## 2.4 Design Constraints

- Cost
  - Funding and marketability limits Mow-Bot to using more cost-effective parts.
- System
  - The battery limits the operation time of the Mow-Bot.
  - Because power is limited, the components of Mow-Bot operate at reasonable power levels.
- Environmental
  - Certain components are exposed to heat and humidity and are able to operate in those conditions.
  - The wheel motors are powerful enough to push the Mow-Bot up hills and have the proper treads and weight distribution to maneuver on grass.

## 2.5 Assumptions and Dependencies

- Because Android is more accessible for programmers, the Mow-Bot uses an Android application for user input.
- There is no extreme terrain in the lawn.
- The user is capable of performing the necessary steps for setup and execution of the Mow-Bot.

## 3 Use Cases

Use Case 1.1: Initial Set Up (Manual)

Scope: Mow-Bot: Autonomous Lawn Mower
Level: User Goal
Primary Actor: Lawn Owner/User
Stakeholders and Interests: User would like to complete initial set-up for Mow-Bot, including charging station setup (precondition for route initialization)
Preconditions:
- User possesses all components of Mow-Bot and intention to set it up

Success Guarantee:
- Charging station is installed correctly and powered sufficiently
- Mow-Bot connected to charging station

Main Success Scenario:
1. User locates ideal location for charging station based on given conditions (TBD, will depend on design implementation)
2. User installs charging station and supplies power
3. User connects Mow-Bot to charging station
4. Mow-Bot indicates that it is connected/charging

Extensions:
4a. Mow-Bot does not indicate that it is charging
- Lawn Owner checks connections, potentially replaces faulty unit

Special Requirements:
- Charging Station positioning requirements and connection instructions are explicit and, if followed, ensure proper initialization of the Mow-Bot system

**Commented [4]:** Given that this is a portable application, it is subject to the general issues you've listed here. However these are not specific or unique issues that limit your implementation decisions. Would be different if your customer(s) required you to use alkaline batteries, or a certain chassis, or wheel motor... What you have listed here are marketing requirements, generally.

**Commented [5]:** Sounds more like an implementation choice by your team (i.e. engineering requirement) in order to meet an ease-of-use marketing requirement (which should be in your missing Specific Requirements section below:).

**Commented [6]:** Generally a good assumption, although you may attempt to better define "extreme terrain."

**Commented [7]:** You correctly covered this item above under User Characteristics.

**Commented [8]:** has been

**Commented [9]:** This is a good item for this section.

Technology and Data Variations List:
Frequency of Occurrence: One time setup
Open Issues:

Use Case 1.2: Route and Schedule Initialization/Modification

Scope: Mow-Bot: Autonomous Lawn Mower
Level: User Goal
Primary Actor: Lawn Owner/User
Stakeholders and Interests: User would like to specify intended route and schedule for Mow-Bot
Preconditions:
- Mow-Bot initial setup is complete (see 1.1: Initial Setup)
- Mow-Bot is charged

Success Guarantee:
- Route and schedule are provided to Mow-Bot

Main Success Scenario:
1. User identifies and turns on user interface
2. Options to modify route information and schedule information are provided to the user.
3. User indicates that setup is complete

Extensions:
2a. User selects option to specify route
    1. User interface provides instructions to user about route specification
    2. User completes instructions
    3. User indicates that route specification is complete
2b. User selects option to specify operation schedule
    1. User specifies operation schedule
    2. User indicates that operation schedule is complete

Special Requirements:
- Route specification instructions, if followed, provide an accurate and reliable route for Mow-Bot
- Operation scheduler provides accurate information to Mow-Bot for reliable, punctual operation

Technology and Data Variations List:
Frequency of Occurrence: As often as user requires
Open Issues:

**Commented [10]:** have been

**Commented [11]:** This is passive voice (grrrr...!). "Mow-bot displays options to modify route information and schedule information." (Actually, I can't tell if this info is on a display on Mow-bot or if it's on the user's phone or ... but SOMETHING has this display and that should be named in the sentence.)

Use Case 2.1: Charge Mode

Scope: Mow-Bot: Autonomous Lawn Mower
Level: Subfunction level
Primary Actor: Mow-Bot
Stakeholders and Interests: Mow-Bot is not in active operation and would like to charge/wait in the charging station until active mode resumes.
Preconditions:
- Initial Setup (Use Case 1.1) and Route setup and schedule (Use Case 1.2) are completed
- Mow-Bot occupies and has a firm connection to the charging station

Success Guarantee:

- Charging station remains powered for duration of charging period
- Mow-Bot maintains firm connection to the charging station

Main Success Scenario:

1. Charging station supplies power to the Mow-Bot

Extensions:

1a. Mow-Bot is fully charged
    1. Mow-Bot informs charging station that it is fully charged
    2. Charging Station regulates power delivered to maintain efficiency

1b. Mow-Bot enters scheduled run-time
    1. Mow-Bot exits charging mode and begins scheduled route (See Use Case 2.2: Route Execution Mode)

Special Requirements:
Technology and Data Variations List:
Frequency of Occurrence: Potentially constant duration
Open Issues:

Use Case 2.2: Route Execution Mode

Scope: Mow-Bot: Autonomous Lawn Mower
Level: Subfunction level
Primary Actor: Mow-Bot
Stakeholders and Interests: Mow-Bot enters scheduled route time and would like to execute it's route and return to the charging station
Preconditions:

- Initial Setup (Use Case 1.1) and Route setup and schedule (Use Case 1.2) are completed
- Mow-Bot is charged and initially located at the charging station

Success Guarantee:

- Route does not contain any immobile obstacles which would prevent route execution.
- Mow-Bot remains charged for the duration of it's route
- Mow-Bot returns to the charging station

Main Success Scenario:

1. Mow-Bot begins provided route.
2. Mow-Bot executes provided route.
3. Mow-Bot completes provided route.
4. Mow-Bot returns to the charging station.

Extensions:

2a. Mow-Bot encounters immobile obstacle that prevents route execution
    1. Mow-Bot generates an error containing information about the obstacle it encountered.
    2. Mow-Bot cancels route execution and skips to step 2.2.4 in the main success scenario.

2b. Mow-Bot's battery becomes critically low.
    1. Mow-Bot generates an error containing information about run-time battery depletion
    2. Mow-Bot cancels route execution and skips to step 2.2.4 in the main success scenario.

4a. Mow-Bot encounters immobile obstacle that prevents return to the charging station.
    1. Mow-Bot attempts to subvert the obstacle.

2. If attempts fail, Mow-Bot generates an error containing information about the obstacle it encountered and enter error mode (See Use Case 2.3: Error Mode).
3. Else the Mow-Bot continues to return to the charging station.

Special Requirements:
- Mow-Bot must be able to generate information that can be used to resolve route errors.

Technology and Data Variations List:
Frequency of Occurrence: As frequently as specified by the user
Open Issues:

Use Case 2.3: Error Mode

Scope: Mow-Bot: Autonomous Lawn Mower
Level: Subfunction level
Primary Actor: Mow-Bot, Lawn Owner/User
Stakeholders and Interests: Mow-Bot is unable to return to the charging station and must provide information to the user
Preconditions:
- Mow-Bot has encountered critical errors during execution and has entered error mode

Success Guarantee:
- Mow-Bot's battery is not depleted
- User resolves errors and returns Mow-Bot to charging station

Main Success Scenario:
1. Mow-Bot goes in to low-power mode, produces alerts and waits
2. User rescues Mow-Bot
3. User resolves errors based on error messages accessed on the UI
4. User indicates that errors have been resolved
5. Mow-Bot is returned to the charging station
6. Mow-Bot returns to full charge before exiting error mode and returning to charge mode.

Extensions:

2a. Mow-Bot encounters immobile obstacle that prevents route execution
3. Mow-Bot generates an error containing information about the obstacle it encountered.
4. Mow-Bot cancels route execution and skips to step 2.2.4 in the main success scenario.

2b. Mow-Bot's battery becomes critically low.
3. Mow-Bot generates an error containing information about run-time battery depletion
4. Mow-Bot cancels route execution and skips to step 2.2.4 in the main success scenario.

4a. Mow-Bot encounters immobile obstacle that prevents return to the charging station.
4. Mow-Bot attempts to subvert the obstacle.
5. If attempts fail, Mow-Bot generates an error containing information about the obstacle it encountered and enter error mode (See Use Case 2.3: Error Mode).
6. Else the Mow-Bot continues to return to the charging station.

Special Requirements:

- Mow-Bot must be able to generate information that can be used to resolve route errors.

Technology and Data Variations List:
Frequency of Occurrence: Potentially only as frequently as the route is scheduled
Open Issues: