Autonomous Utility Mower

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ABSTRACT

A proof-of-concept utility mower will be built for the goal of constructing an autonomous mower capable of mowing predefined geometric regions such as a baseball field. The purpose of this project will be to satisfy the undergraduate curriculum requirements while simultaneously exposing the students to a hands-on engineering project. This paper will review all relevant sub-systems and describe the hardware and software systems used to complete the utility mower.

I. INTRODUCTION

The primary objective of the autonomous lawnmower team will be to design and build a prototype of an autonomous mower capable of mowing grass within a predefined geometric area. For purposes of this project, a baseball outfield will be used to test the accuracy of the mower. The lawnmower will be able to maintain any standard Major League Baseball (MLB), Minor League Baseball, softball, or recreational-league field and will produce visible patterns, as is common in the industry. This particular environment provides a unique geometric boundary that requires a non-trivial solution.

The budget allotted for maintenance of MLB, minor league, softball, and recreational-league fields yearly is typically between $50,000 and $200,000 (Cook, 2006). Benefits of the product will include consistent mowing patterns and competitive pricing. The mower will reduce the time required of the grounds crew, lower the total cost to maintain the field, and provide a high quality cut. A reel-type mower will be used to provide a high quality cut that meets the standards of baseball field maintenance. An intelligent navigation technique will be used to provide the location of the robot at all times.

II. LOCALIZATION TECHNIQUE

The autonomous nature of this utility mower dictates strict requirements on navigation, path planning, and absolute localization. In order to be consistent with the accuracy of human operators, the composite error in navigation must be less than five centimeters (Zeitzew, 2007). This will ensure that the quality and consistency of the autonomous mower provides acceptable results as a replacement for traditional lawn care techniques.The combination of pass-to-pass accuracy and cost limitations impose unique constraints on this project. These requirements will be achieved using a combination of a global positioning system (GPS), a digital compass, wheel encoders, and camera detection. Although currently unproven, this localization system should provide the accuracy needed and can be built so that costs are minimized and daily operation is trivial.

A residential GPS unit, positioned on the robot, will be used as the primary localization technique. Although this GPS unit is not extremely accurate and has an average accuracy in meters, it can easily provide an estimated location. The cause of this undesirable accuracy can be attributed to several factors. The signal from GPS satellites is often lost due to the signal being blocked or deflected. There is also a time delay in acquiring satellite signal, which is problematic for centimeter accuracy (Roth & Singh).This low accuracy dictates the need for a secondary localization technique to be combined with the use of the GPS unit.

In order to accomplish the high accuracy required by this application, the robot will utilize a digital compass as a secondary localization technique. The combination of the GPS unit and the digital compass will allow the robot to cut the field in straight passes assuming that the robot starts in a known location. After each pass, the robot will use the locations collected along the previous pass as the guiding line for the next pass. Camera vision techniques will be used to provide boundary lines at the edges of the field. Two cameras will be placed on the foul lines of the field and will detect and signal to the robot when it should turn and begin the next pass.

These localization techniques will be coordinated with a Raspberry Pi microprocessor. This microprocessor was chosen for its processing power relative to its cost effectiveness. The mower will also have a remote control option to provide the operator a convenient method of maneuvering the robot from storage to the field. The digital compass, the GPS, and the camera vision data will be processed and used to control the motion of the robot. At every new pass, new data collected from the three devices will be used to complete the next pass.

III. DRIVE SYSTEM

Industry standards dictate mower operating speeds between 1.5 and 2.5 m/s for safe and quality cutting (Zeitzew, 2007). The designed device will have an operating speed within this range. The drive system will consist of two AmpFlow DC motors with integrated 8.3:1 speed reductions and pneumatic 12.5” wheels. The drive units will be mounted at the two rear corners of the frame with two free-spinning caster wheels to support the front end of the frame and assist in turning. This drive system will operate in much the same way as a “z-turn” lawn mower.

A bumper sensor will be located on the front of the mower to sense obstacles on the field. This sensor will detect any large object in the path of the device. A secondary rake sensor will be added to detect smaller objects that may damage the mowing blades. If either sensor detects an obstacle, it will halt all motion. Due to the precise pattern requirements of this application, the mower will not continue to cut around the object (Zeitzew, 2007). After the object is removed by the operator, the mower can resume operation.

An emergency stop button will be placed in an easily accessible location on the device to ensure safety. Pressing the emergency stop button will result in power loss to the entire system. This will ensure a timely stoppage of the device.

IV. CUTTING SYSTEM

Design and manufacturing of the robot will be based upon a GreenWorks Tools Incorporated 20” reel-type mower. A reel-type blade system creates the highest quality and healthiest cut(American Lawn Mower Company, 2006). An electric motor will drive the blade assembly using a 1:1 pulley and V-belt system. A speed controller, allowing precise control of the cutting speed, will power the motor.The reel-type cutting system easily integrates with the electronics, but will take more effort to integrate with the frame compared to other mowing options.

V. POWER SYSTEM

The autonomous mower will be powered by two 12V DC lead-acid batteries. These batteries will power all hardware located on the robot including the navigation tools, the cutting system, and the drive system. All items that are not located on the robot, such as the cameras along the foul line, will be powered by separate power sources.

VI. CONCLUSION

As the autonomous lawnmower project is a work in progress, more details of the final device will be provided at the conference A localization system used for navigation will be designed specifically for this application using a combination of GPS estimation, digital compass readings, and camera vision techniques. A driving system and a cutting system were designed and built based on the needs and regulations of the project. Testing of each system will be completed and results and more details will be presented at the conference.

VII. REFERENCES

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