The Next Generation Autonomous Lawn Mower

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Abstract

This project is an extension of the previous work done with the LawnNibbler® and LawnShark at the Machine Intelligence Laboratory at the University of Florida. The goal remains the same: to efficiently and intelligently mow grass in an environment typical of a person's lawn. Unlike its predecessors, this mower will use machine learning techniques to accomplish its task.

Introduction

The goal of this project is to design an autonomous lawnmower that safely and effectively mows an area typical of a homeowner's yard. This will be the third generation of autonomous lawnmower robots designed in the Machine Intelligence Lab. The first two generations relied on the principle of randomness to mow an area. Thus, they did not mow in any type of pattern as a human normally would. The third generation would be a great departure from the first two in many aspects.

Instead of using a microcontroller to control the functions of the robot, it will instead be used for data acquisition and motor control. An embedded computer, running Linux, will serve to process the information gathered from the microcontroller and determine the actions to be taken by the mower. Instead of relying on infrared and sonar sensors to detect obstacles in the mowing field, computer vision will be used. The most important difference will be in the control algorithms. The control algorithms will be based on machine learning techniques. This will allow the mower to recognize objects (trees, flower beds, sidewalks, etc.) and to avoid them. They will also allow the mower to "learn" how to mow as a human would. Also, a local positioning system (LPS) will allow the mower to know where it is in the mowing area.

Functionality

As stated earlier, the mower will operate using machine learning techniques. This will allow the mower to recognize objects in the mowing area using computer vision. These objects would be such things as flower beds, sidewalks, trees, driveways, etc. Also, the use of vision will allow the mower to determine the difference between cut and uncut grass thus giving it the ability to mow in a pattern. Using these techniques, the mower would need to be trained by a human operator in order to learn what objects to avoid and where and how to mow.

As the mower is trained by the human, a feature map would be generated that would indicate the characteristics of the mowing area. This would be additional information that would let the mower know approximately where it is in the mowing field. This information could also be used for other things as well. For example, if the mower knows where a bare patch of yard is, it could release fertilizer to promote the growth of grass, or release ant killer if it finds an ant hill. In this way, the mower becomes a "lawn maintainer" instead of just a lawnmower.

Several sensors will be used as well. Infrared sensors will be used as a second means of obstacle avoidance (the first being the computer vision system). As a third means of obstacle avoidance and range detection, sonar will be used. The infrared and sonar sensors will supply additional information to the mower and help it learn to avoid obstacles. This additional information allows the mower to generalize and make an "informed" decision about its environment. For example, if the vision system cannot identify an object but the infrared or sonar systems inform the mower that an object exists in front of it, the mower has sufficient information to make a decision to turn away and avoid the obstacle.

As stated earlier, a positioning system will be used. This will let the mower know where it is in the mowing field. This will help in the generation of a feature map and in keeping the mower on course. All of the sensors mentioned (vision, infrared, sonar, and LPS) give the mower "sensoral modality." Thus, no one sensor is crucial to the performance of the mower but combine so that it can make informed decisions about its environment.

Goals/Behaviors

The main goal of this project is to develop an autonomous lawnmower robot capable of learning its environment through training. Once learned, the robot would be capable of navigating through its environment avoiding obstacles by means of its sensors. Instead of mowing the area in a random fashion, this mower would mow in a pattern using the positioning system and feature map that was generated during the training process.

The feature map (as discussed earlier) is a map of the "features" of the mowing area. Such features would include the density of the lawn, bare spots, anthills, etc. Thus, the mower could release fertilizer when it passes over an area of low density in the mowing area or any other substance depending on the condition of the yard.

Because the mower would be powered off batteries, the mower would need to recharge itself when its batteries are discharged to a certain point. When this occurs, the mower would seek out a charging station placed somewhere in the mowing area. Once in range of the charging station, the mower would then dock into the station and recharge itself.

One question that this project will try to answer is “is there is anything that the robot can teach the human in terms of mowing the lawn?” Is there a combination of human and machine learning that yield the best results? These are the types of questions that this project will attempt to answer.

Current Research

So far, the research that has been conducted has mainly been in the area of image processing. To gather data, a standard Hi-8 video camera was mounted atop a cordless rechargeable push mower. As stated earlier, one of the main objectives is to have the mower mow in a plow fashion rather than to mow randomly. To accomplish this, the boundary between the cut and uncut lawn needs to be determined.

After some image data was collected, a simple edge detection algorithm was applied to the images. This was accomplished using an image manipulation program named XView. Figure 1 shows an unprocessed image taken in the mowing area. Clearly, a boundary can be seen between the cut lawn on the left side of the image and the uncut lawn on the right.


Figure 1: Unprocessed lawn image

The result of applying the edge detection algorithm on the image in Figure 1 is shown in Figure 2. As can be seen, most of the detail of the original image is lost (including the boundary). Thus, the use of edge detection algorithms is not suitable for this particular application.


Figure 2: Processed lawn image

Other algorithms must be used that make use of all of the information the image has to offer (color, etc.). When an edge detection algorithm is applied to an image, regions of uniform intensity are de-emphasized and regions where abrupt changes in dark-light transitions occur are emphasized [Duda & Hart, 1973]. Thus, most of the content of the original image is lost.

Future Work

This project is very much in its infancy. At this point in time, all effort is being devoted to the image processing aspect of this project. This is the key system that will enable the mower to recognize objects, avoid them, and mow in a pattern. Much experience has already been gained with the other sensors (infrared, sonar, etc) working on the first two generations of autonomous lawn mowers. To allow for greater flexibility in the design, a custom built platform will be used. Thus, the platform can be built “around” the components instead of having to customize the components for an off-the-shelf body.

Bibliography

[Duda & Hart, 1973] Richard O. Duda and Peter E. Hart, “Pattern Classification and Scene Analysis”, John Wiley and Sons, 1973.