2012 ASABE Robotics Competition Challenge

Introduction

In 2012, the ASABE Robotics Competition challenge will be entering its sixth year. To be held at the ASABE International Meeting in Dallas, Texas, the challenge seeks to simulate real-world agricultural production automation, and will be themed to the regional practices of the host region. In Texas, cattle production is one of the largest industries, accounting for nearly half of the state’s agricultural economic impact.

The challenge centers on automation of cattle feeding in a feedlot. Feedlot operations consist of many pens divided by fences, with roadways providing access to each. Figure 1 shows an aerial image of a typical feedlot in the Texas panhandle. Each pen in a feedlot contains a number of cattle that are all at similar stages in growth, approximately the same size, and requiring the same amount of food. However, adjacent pens may contain a different number of cattle, or cattle of a different age or size. As such, each pen requires a different feeding regimen. In most feedlot operations, the manager or a nutritionist prescribes the dietary requirements for each pen, and workers deliver the prescribed amount. It would be useful to have a robotic system to deliver the feed rations, freeing the workers to provide other care for the livestock. This is the stage for the 2012 ASABE Competition.

Figure 1: A typical feedlot outside of Hereford, Texas. (Google Earth Screenshot)
The Challenge

The competition board rendering.

The challenge will be held on an 8ft x 8ft flat, smooth board. The board will be divided into ‘cattle pens’ separated by fences. There will be roadways between pens allowing access to each pen from at least one side. The roadways will be marked down the center with standard 0.75inch black, vinyl electrical tape. Each pen will have a feed trough where the feed should be placed. The center location of the trough will be marked in the roadway with a 3-inch piece of 0.75inch electrical tape oriented perpendicularly to the tape marking the roadway. The trough will be a disposable aluminum, one-pound loaf pan. The exact pan specifications are in the Appendix. The feed will be simulated with Airsoft® pellets, which are 6mm spheres that weigh between 0.12g and 0.25g each, depending on the density purchased. The robot will be limited in size such that it fits into a cube 12in X 12in X 12in at the beginning and end of the run. During the run, it is permissible for the robot to use actuation that increase its overall size envelope beyond this limit. Multiple vehicles are allowed, but they must fit into the 12in cube at the beginning and end of the run.

Robots will be tasked to enter the feedlot, deliver feed to each pen based on a prescription, and return to the start point. Teams are permitted to use any of the four corners of the board as the start point, with the run ending when the robot returns to the corner in which it started. Robots are considered to have left the start area when they break the extended plane of the nearest set of cattle pens, and to have returned to the finish when they have broken that same plane. Additionally, the robot must pass through at least four of the red waypoints on the board for a time to be recorded. Points will be awarded for speed, accuracy, and elegance of design, while deductions will occur for
striking the fences, human assistance, or dropping feed outside pens. The feed rations for each individual pens will be randomized, requiring that the robot be capable of accepting input, either from human intervention, or by reading a text file from an SD card.

Each team will be allowed two runs, with the best score used for final standings. Teams will receive a feed prescription at the beginning of each run, both on paper and on a standard SD card. The prescription will be a simple, comma delimited table in ASCII format, as shown in table 1 in the appendices. On the SD card, the table will be the only file, and will be named “feed.dlm”. The run is timed, and the time starts when the prescription is given to the team. Each run will end when the robot returns to its starting position at one of the four corners of the board, or after five minutes, whichever comes first.

The prescription will include the pen number, and the amount of feed to be delivered. Feed delivery prescriptions come in four levels: 50g, 25g, 12.5g, and 0g. These levels will be signified in the prescription file as 3, 2, 1, and 0, respectively. Feed should be delivered into each corresponding trough. Feed delivered outside of the trough but inside the pen will not cause a deduction, but will not count toward the prescription target. Feed dropped in the roadways will be penalized.

The competition also included a report and presentation of the team’s design. The report should be limited to 10 pages. Each team should provide three printed copies of their report to the judges at least 48 hours prior to the competition. The presentation will be limited to 10 minutes per team. A computer and projector will be available with PowerPoint at the time of presentations. The presentation will be followed by a short question and answer period.

There are no limits to budgets or technologies utilized. Be creative.

**Scoring**

Points for speed are awarded based on time left on the five minute timer, with 2 points awarded per second.

Points for accuracy will be based on the percent error of the feed delivered in each pen’s trough. Each trough is worth 50 points, and which will be weighted by the percent error.

\[ e^{-\frac{(\text{Delivered} - \text{Prescribed})^2}{2\sigma^2}} \times 50, \text{ where } \sigma = 1.5. \]

Up to 500 points are available for elegance of design at the judges’ discretion.

Penalties include a 50 point deduction for human interaction once the robot leaves its starting position, up to 25 points for each robot-cattle pen collision, and 10 points for each gram of feed left in the roadways.
Table 1: Penalties.

<table>
<thead>
<tr>
<th>Human Interaction</th>
<th>Collision</th>
<th>Spillage</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 per incident</td>
<td>Up to 25 per incident</td>
<td>10 per gram.</td>
</tr>
</tbody>
</table>

Table 2: Positive Scoring System

<table>
<thead>
<tr>
<th>Item</th>
<th>Scoring Methods</th>
<th>Potential points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prescription Delivery (Accuracy)</td>
<td>$50 \cdot e^{-\frac{(Delivered(x) - Prescribed(x))}{2\sigma^2}}$</td>
<td>1200</td>
</tr>
<tr>
<td>Time Remaining (Speed)</td>
<td>900-Time to complete Competition (seconds)</td>
<td>600</td>
</tr>
<tr>
<td>Elegance of Design</td>
<td>Judges’ Discretion</td>
<td>500</td>
</tr>
<tr>
<td>Report</td>
<td>Judges’ Discretion</td>
<td>500</td>
</tr>
<tr>
<td>Presentation</td>
<td>Judges’ Discretion</td>
<td>500</td>
</tr>
<tr>
<td>Answers to Questions</td>
<td>Judges’ Discretion</td>
<td>500</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3800</td>
</tr>
</tbody>
</table>

Frequently Asked Questions, Hints, Tips, and Clarifications

What is “Human Interaction,” and how does it apply to the prescription phase?

Human interaction occurs when a person interferes with or assists the robot. For example, if the robot is following the electrical tape and loses its way, a human moving it back to the line would cause a penalty.

At the beginning of the run, the teams will be given a prescription on paper and SD card. There are many ways that the robot could use the prescription, and most require the team members to do something. Possibilities might include two DIP switches for each trough set at the beginning of the run by the team members, an SD card slot on the robot that reads the files automatically when the card is inserted, using the SD card in a PC to compile new binaries for the specific prescription, or anything else that lets the robot know what the prescription is. Put a camera on your robot, snap a picture of the paper prescription, perform optical character recognition, and use that to inform the robot of the desired feed rates. If you can think of it, you can do it, as long as it’s done before the robot “starts” the run.

It is permissible to interact with the robot in any way at the beginning of the run. However, once the/a robot leaves the starting point (breaks the plane of the pens); further human interaction will be penalized.

What if we use two robots?
Nothing much changes. The run, and penalties for human interaction, both begin when the first robot breaks the plane and end when both robots have broken that same plane. Both must also pass through at least four waypoints. However, a pass over the same waypoint in two different directions does count as two waypoint passes.

This challenge is too easy / difficult. Why?

The challenge designed to have multiple objectives with different levels of difficulty, and to reward success in each of the objectives. If you can build a line following robot and get it to travel around the track and back to base really quickly, you earn some points. It won’t likely be enough to win, but it’s a start. The paper and SD card format for the prescription is similar: figure out a quick way to instruct the robot what the prescription is, and you saved time and scored points. But, if you can’t interface the SD card, it doesn’t preclude participating in the contest.

How about precision? How will the mass-based scoring proceed?

Troughs will be pre-weighed on a mass balance. At the end of the run, each trough will be weighted on a balance. The weight of the trough will be subtracted from the total weight for each, and the mass will be rounded to the nearest gram. The scoring formula will be applied for the trough, and the point value rounded to the nearest round number. The chart below shows the scoring curves provided.

![Points awarded for different mass delivered](chart.png)

Point deductions for feed dropped in the roadways will be measured in the same way, with the mass rounded to the nearest gram, and a 10pt deduction for each gram.
How is the competition board constructed? What do we need to know to build our own?

The board will be constructed of ¾” Medium-Density Fiberboard (MDF), available from any building supply store. The side rails will be standard 2x4 dimensional lumber, ripped to 1inch by 3.25inch. The board and rails will be painted with a white paint available from Lowes. If your local Lowes doesn’t have it in stock, you can special order it and pick it up within three days, typically. Lowes item 346385.

Standard sheets of MDF are 49” X 97”. This is important to note: you will either have to cut the sheets, or put your rails inside the edges. Also, get a gallon of paint if paint fresh MDF. A quart won cut it because the MDF soaks it up.

The board will be built of four pieces of MDF to make it easier to move and to store. Dimensions for building a board that can be nested to take up less room will be available soon.

How do the penalties for collisions work?

Penalties for collisions are included to make sure that the pens stay intact through the competition, and are left to the discretion of the judges. Tactile or touch sensors that navigate by riding the walls should be fine as long as they work properly. A head-on, full speed collision would cost 25 points, a less severe crash might 10, and a brush or tap might not cause a penalty. It’s similar to a referee’s decision: was it roughing the punter, running into the punter, or no penalty at all.

Why are you mixing between SI and British units?

Mainly for simplicity, as the construction supplies are available in British units, but the airsoft pellets are specified in SI units. Agricultural and Biological engineers in the USA might be the last group around that this would even be remotely permissible. However, round numbers are prettier than those that arise from unit conversions.

What happens if our robot can’t complete the task in five minutes?

The scoring schema was set to reward accuracy, speed, and design elegance, in that order. If you’re robot is not back to the start at the end of five minutes, the accuracy of you prescription applied up to that point in time will still be awarded.
Appendix

feed.dlm

1,0
2,3
3,2
4,1
5,1
6,0
.
.
.
24,0
Board Overview: The cube in the lower right is the 12" cubic envelope.
All Dimensions in Inches

SEE DETAIL A

SEE DETAIL A
Construction material is foam-core poster panel. Black, 0.2" thick. May be sourced from Staples, Office Depot, Hobby Lobby, etc.

All Dimensions in Inches
Mainstays Mini Loaf Pan
Sold at Walmart in 5pk

All Dimensions in Inches