Autonomous Farming
Team Members

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Sponsors: Agricultural Research Initiative and Laserman

End User: Farming community
Background Information

- Farmers need to mark locations for planting crops.
- This process takes considerable time to complete.
- Currently stakes and strings are used to mark out seeding points.
Need Statement:
There is a need to reduce the amount of labor and time required to stake out seeding points in a field.

Goal Statement:
Develop an automated way of marking seeding points and reducing cost of labor and time.
Problem Definition

Customer Requirements:
- Rugged
- Autonomous
- Easy to operate
- Weather-resistant
- Mark points
- Precise
- Navigate given a map of points
## Quantitative

<table>
<thead>
<tr>
<th>Engineering Specification</th>
<th>Precisely Mark Seeding Points</th>
<th>Avoid Obstacles</th>
<th>Efficiency</th>
<th>Compact</th>
<th>Easy to Setup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>Distance</td>
<td>Time</td>
<td>Width</td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>Metric</td>
<td>Inches</td>
<td>Inches</td>
<td>Minutes and Seconds</td>
<td>Inches</td>
<td>Minutes and Seconds</td>
</tr>
<tr>
<td>Method Device</td>
<td>Tape measure and String</td>
<td>Tape measure</td>
<td>Stopwatch</td>
<td>Tape measure</td>
<td>Stopwatch</td>
</tr>
<tr>
<td>Target</td>
<td>within +/- 5” of the GPS point</td>
<td>width of object is greater than one inch</td>
<td>1 Acre per hour</td>
<td>Less than 6' wide</td>
<td>Less than 15 minutes</td>
</tr>
<tr>
<td>Condition</td>
<td>Contingent upon accuracy of GPS unit</td>
<td>All sensors are operating nominally</td>
<td>Cumulative at 6' x 6' Spacing</td>
<td>inclusive of all parts</td>
<td>All hardware and software are functioning nominally</td>
</tr>
</tbody>
</table>

*Standard sizes for super high density field spacing
Qualitative

- Navigate given a map of points
- Traverse typical farm terrain
- Avoid obstacles
- Easy to operate
- Be weather-resistant
- Calculate and map out its own GPS points given boundaries
- Be electrically powered
- Receive standard "GIS" file formats
- Carry a payload
- Have auxiliary, modular output
- On-board HMI (Human Machine Interface)
- Operate at night
- Physically mark seeding points
Changes from Last Semester

• Additional servo drive added
• Additional encoder added
• Sonar sensor being used for obstacle avoidance
• Marking mechanism is now paint-based
Final Design
Control System Overview
Proposed Control System

- GPS (1 Hz stream)
- Compass (20 Hz stream)
- Encoder (50+ kHz stream)
- Webcam 1 (15 Hz stream)
- Webcam 2 (15 Hz stream)
- Touch Sensor (Interrupt event)

Navigation Loop (20 Hz) Core 1

Microcontroller (Event: Mark, Enable)

Motion Control (20 Hz)

Avoidance Loop (20 Hz Preemptive) Core 1

Stereo Vision (5 Hz) Core 2
Actual Control System

GPS (5 Hz stream)
Sonar (5 Hz stream)
Encoder (50+ kHz stream)

Navigation Loop (20 Hz) Core 1

Microcontroller (Event: Mark, Enable)
Motion Control (5 Hz)
Navigation Loop

- Current distance and direction to GPS target calculated 3-5 times per second
- Angular error used in PID heading loop
- Distance offloaded to microcontroller for concurrent marking operation
Software Design and Highlights

• Serial buffers (FIFO) can cause lag
  – Soln: Data packets parsed from end of buffer
  – Note: Removal of lag can cause loss of data
• Compatible on any 32+ bit Windows machine
• Multithreaded
  – Inter-process communication via Mutual Exclusion
  – Thread synchronization via Software Interrupts
User Interface

• Rows defined by:
  – Two GPS points (Starting and Ending Locations)
  – Row Spacing

• GPS points entered:
  – Manually, or
  – By marking points with the vehicle
Fabrication

Chassis Repair
Fabrication

New Drive Motor Gearing
Fabrication

New Component Mounts
Fabrication

Electrical System
Testing Procedures

- Subsystems individually tested:
  - Arduino microcontroller
    - Compass
    - Sonar
    - Spray Paint Mechanism
  - Main computer
    - GPS
    - Control system
    - Stereo vision
  - Galil motion controller
Testing Procedures

• Compound tests:
  – Heading tracking
  – GPS tracking
  – Obstacle avoidance
  – Seeding point marking
Testing Results

• Unit drives autonomously to GPS points
• Marking mechanism connection needs to be shielded
• Obstacle avoidance using ultrasonic sensor detects obstacles up to 3 feet +/- 6 inches
• Unit operates for up to 3 hours +/- 10 minutes on a single charge
Testing
Budget
Conclusion