Agricultural Drone Refilling System

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Objective
The Problem
• Agricultural drones, specifically for spraying (fertilizer, pesticide, seeds, etc.), are refilled manually
• Tedious process for large fleet of drones

Our Solution
• Automate drone refilling system
• Increase farm productivity
• Optimize drone fleet’s downtime
Design
Original Mechanical Design

Side view:
- 2 ft. pulley system
- Carriage
- Camera and distance sensor
- Weight

Top view:
- Counter-weight
- 90 degree rotation counter-clockwise
- Carriage rail
- Pivot
- 90 degree rotation clockwise

Nozzle bottom view:
- Nozzle replica
- Distance sensor
- Camera sensor
Final Mechanical Design

- Downsizing the entire system
PCB Design

- ATmega 2560
  - Numerous I/O pins
Software Design

- OpenCV
- Search algorithm
High Level Subsystems
Refilling System

Crane Subsystem
- Uses stepper motors to move the dispensing system in a controlled and precise manner

Alignment Subsystem
- Uses Raspberry Pi for image processing and a camera for accurately aligning to the drone’s fill port

Control Subsystem
- Controls crane movement and monitors the dispensing process with particular notifications

Power System
- Provides necessary power to the entire system

Drone Replica
- Represents a high level replica of the important parts of the drone
Requirements and Verifications
## Alignment Subsystem

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verification</th>
<th>Verified?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locate fill port of a drone located in the working area</td>
<td>The system notification should switch from displaying searching notification to the aligning notification</td>
<td>Yes</td>
</tr>
<tr>
<td>Align replica nozzle to the refill port on the drone</td>
<td>Before the replica nozzle is lowered, the replica nozzle should be above the refilling port</td>
<td>Yes</td>
</tr>
<tr>
<td>Do not crash the replica nozzle into the drone</td>
<td>The replica nozzle is properly lowered into the refilling port and not dropped anywhere else</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Alignment Subsystem
## Crane Subsystem

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Move the dispensing system to the correct location reliably</td>
<td>The crane's movement axes should move in a smooth fashion without getting caught or snagged</td>
<td>75% of time</td>
</tr>
<tr>
<td>Support the weight of the dispensing subsystem</td>
<td>The crane does not break and remains structurally sound</td>
<td>Yes</td>
</tr>
</tbody>
</table>
## Control Subsystem

<table>
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<th>Verified?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displays system notifications based on current action</td>
<td>The appropriate system notification is displayed for the current operating mode</td>
<td>Yes</td>
</tr>
<tr>
<td>Operates the crane in a controlled manner without overshooting end stops</td>
<td>1. The carriage on the crane arm does not fall off the front or back ends  2. The crane does not rotate beyond the designated 180 degree range of operation and cause damage to itself</td>
<td>Yes</td>
</tr>
<tr>
<td>Communicates with alignment subsystem to align replica nozzle to the refilling port</td>
<td>The crane’s axes move appropriately based on the output from the alignment subsystem</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Control Subsystem

```
ece445@ece445-desktop:~/Documents/ECE445$ python3 green.py
Motor Shield found.
Finished scanning for drone, Alignment in progress
```

```
ece445@ece445-desktop:~/Documents/ECE445$ python3 green.py
Motor Shield found.
Finished scanning for drone, Alignment in progress
Alignment complete
```
## Power Subsystem

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Power supply provides the necessary 5V and 12V with a ±15% margin of error</td>
<td>A digital multimeter will be used to measure the 5V and 12V lines to ensure that the appropriate voltages are being supplied</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Successes and Challenges
Alignment Subsystem
• Image processing
• Locating the fill port and stopping when necessary

Crane Subsystem
• Smooth travel and drive of carriage
• Precise control of crane arm

Control Subsystem
• Serial communication between Alignment Subsystem
• Controlled motors reliably
• Communication between distance sensor and display

Power Subsystem
• Maintained the proper amount of power for the entire system
Alignment Subsystem
- Filtering noise from camera frame
- Limited control of camera settings
- Reliability
- LEDs too bright

Crane Subsystem
- DC motor issues
  - Rotary encoder
  - Limited torque
- Servo horn stripped
  - Designing new adapter plate

Control Subsystem
- Serial communication with Raspberry Pi
- Non-blocking wait

Power Subsystem
- Voltage spike when testing arm control servo
Conclusions
Conclusions
• Start testing as early as possible
• Making sure all parts work properly beforehand
• Work on integrating subsystems earlier

Improvements
• Continuous running mode
• Automatic detection of drone arrival/drone notifying station on arrival

Advancements to our Project
• Working with a third axis
• Accounting for wind
• Adding solar panels to power entire system
• Real-time tracking
Thank you!

Questions?