Drones for Tree Trimming

ECE 4872 Senior Design Project
Sponsored by: Florida Power & Light
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Background

- Florida Power & Light Aerial Intelligent Response (FPLAIR) department oversees all aerial inspections of the company's overhead transmission and distribution facilities.

- The specific use of drone technology in these aerial inspections gave birth to the idea of drone usage in vegetation pruning for customers

- As a result of Hurricane Dorian , FPL deployed new "drone in box" technology that can quickly focus on hard-to-reach spots up to 2 miles away, assessing damage in surrounding areas

Motivation

- Florida Power & Light is currently the largest energy company in the United States, providing service to more than 10 million people across the state of Florida.

- The motivation stems from FPL having the vision to implement the use of drones in order to provide faster and safer services to their customers in the area of removing vegetation in close proximity to service wire poles.

- Our team is determined to develop a prototype that will deploy to a customers home and clear the impending vegetation

Objective

- The team will design and prototype an optimal end effector configuration that can integrate with a DJI Inspire Drone in order to perform light trimming and pruning of vegetation surrounding power lines.

- The end effector will be impact resistant and will be able to withstand repetitive impact with grass and dirt from a height range of 30 -50 feet.

- In the event the end effector becomes entangled on a piece of vegetation, the end effector will disconnect from the drone, allowing the drone to safely fly away and return to the tethered area

End Effector Technical Specifications

- Battery Lifetime
  - >= 10 Minutes or >= 10 Cuts
- Fall Survival Height
  - <= 50 Feet
- Signal Range
  - >= 200 Feet
- Size
  - 5” x 5” x 5”
- Weight
  - < 3 Pounds
- Cutting Size
  - .10”-.50”
- Cutting Range
  - +/- 30 Degrees Vertically
  - +/- 30 Degrees Horizontally

Table 1. End Effector Specifications

Feature	Specification
Battery Time	>= 10 Minutes or >= 10 Cuts
Fall Survival Height	<= 50 Feet
Signal Range	>= 200 Feet
Size	5” x 5” x 5”
Weight	< 3 Pounds
Safety	No Open Blades
Cutting Size	.10”-.50”
Vertical Vegetation Range	+/- 30 Degrees
Horizontal Vegetation Range	+/- 30 Degrees

Drone Technical Specifications

- Battery Time
  - >= 10 Minutes
- Payload
  - <= 3 Pounds

Table 2. Drone Specifications

Feature	Specification
Battery Time	>= 10 Minute
Payload	<= 3 Pounds
Number of Cameras	1
Safety	Must Be Tethered

Safety Guidelines

- Prototypes must be approved by FPL before fabrication
    - No open saw blades, sharp edges, or rotating chains
- Drone must be tethered when testing
- Team must wear proper PPE during testing
    - Hard Hat, Safety Glasses, Closed Toed Shoes, Long Sleeve Shirt, Work Gloves

Covid Guidelines

- Outside of Meetings
  - Wearing Masks/Social Distancing
  - Getting tested by GA Tech Weekly
  - Avoiding large gatherings/events

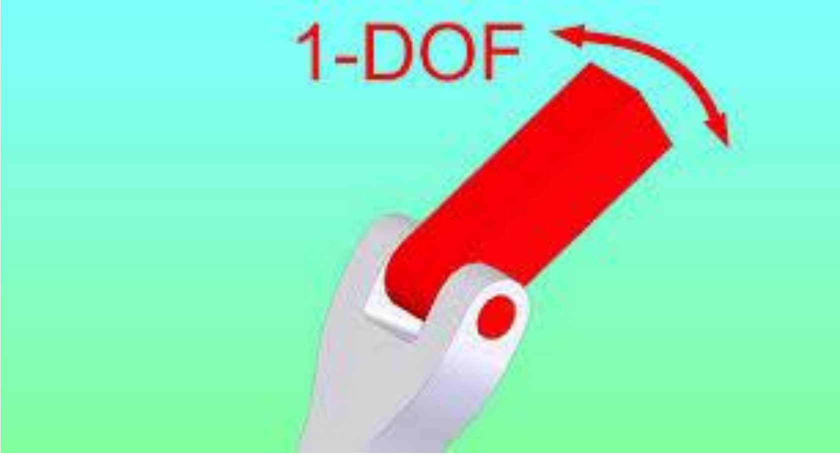
- During Meetings
  - Properly sanitizing equipment
  - Wearing Masks
  - Meeting in large, open-space areas

Design Approach

- The first step in the design approach is attaching the end effector to the limb.

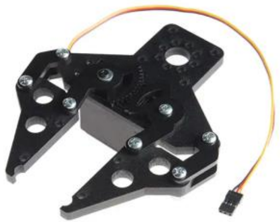
- To solve the issue of vertical and horizontal cuts, the implementation of a pin joint will attach the end effector to the drone.

- This will allow the end effector to pivot between 0 and 90 degrees.



Example of pin joint allowing for unidirectional movement.

Design Approach



- After positioning, the end effector must clamp onto the branch allowing for the drone to detach.

- This will be accomplished by a clamp driven by a geared motor.

- The geared motor will actuate the clamp onto the branch positioning the end effector in place allowing the drone to leave.

Sample clamp and geared motor from Sparkfun and Amazon, respectibly.

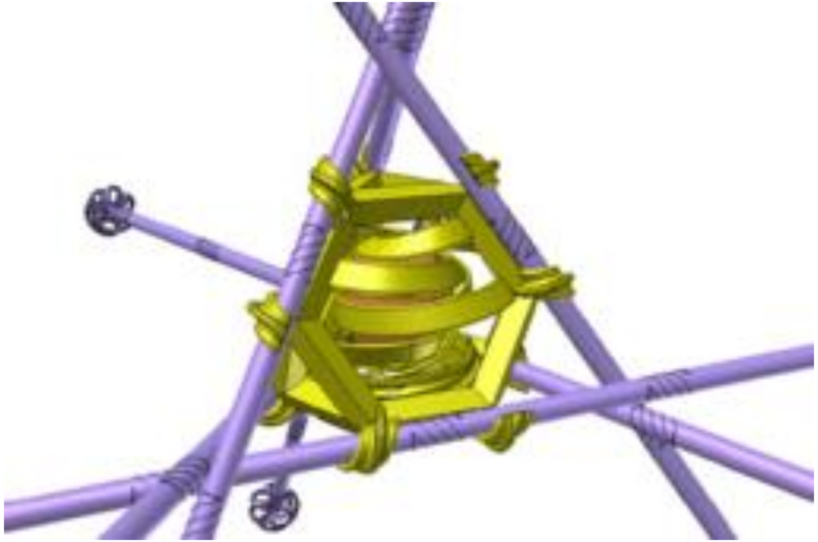
Design Approach

- After the drone is a safe distance from the limb, the end effector is ready to cut.
- This will be accomplished by a mirror copy of the motor driving the clamp.
- This second motor will drive a pair of shears to open when in proximity of the branch and, after a short delay from detachment, cut the branch.

Ratcheting lopper heads that will require less motor.

Design Approach

- The final consideration for design is the fall contingency.
- The end effector must be able to survive multiple falls of up to 50 feet.
- This will be accomplished by 3D printing a cage for the end effector that protects the motors, clamp, shears, and battery when falling.



3D printed egg drop challenge that shows how to protect key elements like batteries.

Project Demonstration & Testing

- For any demonstrations or testing, safety considerations outlined by FPL in the Scope of Work document will be followed
    - Drone is tethered to a ground anchor
    - No flight within 500 feet of live power lines
    - Flight area clear of traffic
    - PPE
    - Compliance with FAA airspace restrictions

- Any testing apparatuses will be approved by FPL before use (e.g. stand to mount test branches on)

Project Demonstration & Testing

- Any demonstrations to a public audience will be done with ample space
  - Flight area (~10 ft radius circle)
  - Spectator area (outside of radius)

- Drone flight area will be clearly marked with tape during public demonstrations
  - Drone tethered to center of marked circular area to prevent flight accidents outside of the area

- Anyone inside of flight area will wear PPE as described in the safety guidelines

Project Demonstration & Testing

- For either purpose, the drone does not need to fly at an altitude greater than 10 feet
    - Higher visibility of drone during demonstration
    - Less damage to drone in the event of an accident

- Drone trimming demonstrations/testing will be done on a branch mounted to a secure stand
    - 1/2 inch diameter branch
    - Purchased from a suitable vegetation retailer

Capstone Design Expo Demonstration

- The following will be demonstrated to a public audience:

  1. Horizontal (0-30 deg.) branch trimming, assisted by the on-board feed.

  2. Vertical (60-90 deg.) branch trimming, assisted by the on-board feed.

  3. End effector detachment during cutting and ease-of reattachment afterwards.

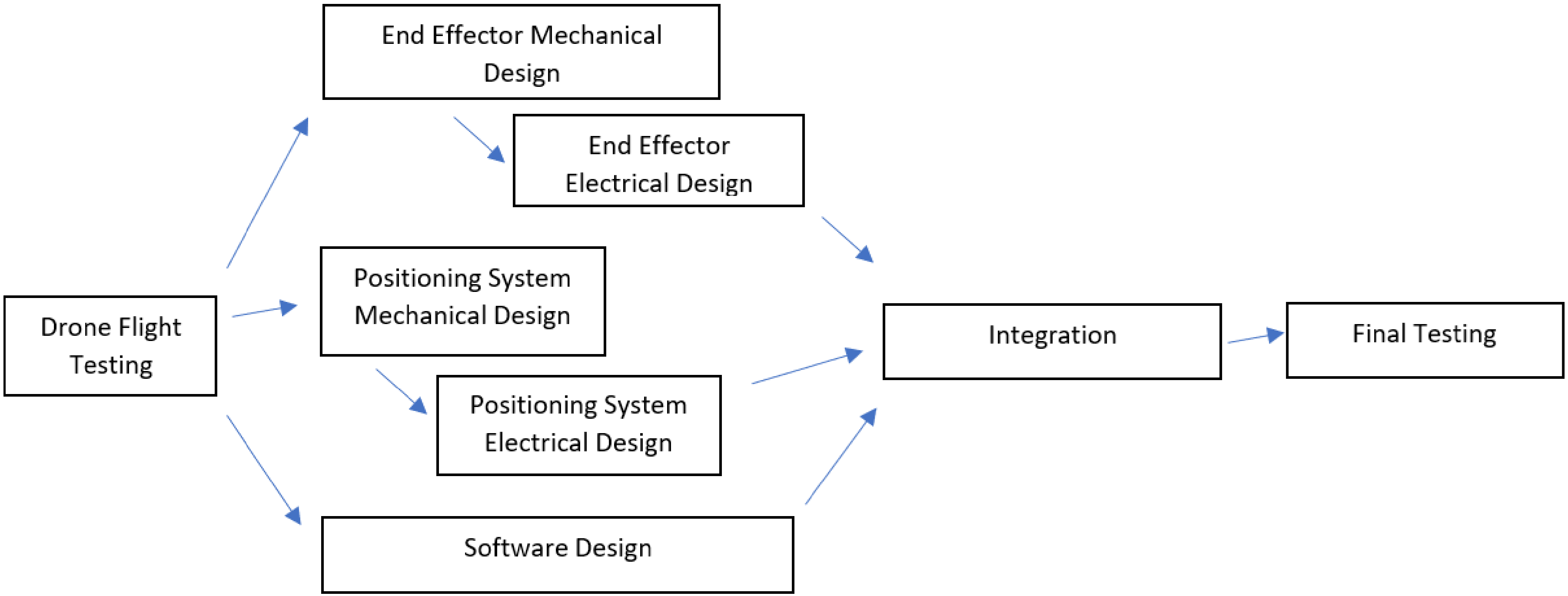
  4. Drone maneuverability with end effector

- Features such as range and end effector drop resistance cannot be demonstrated in an expo setting

Schedule, Tasks, and Milestones

- Drone operation and load testing:
  Jan 31 - Feb 14.
- End effector mechanical design:
  Feb 14 - March 4.
- End effector electrical design:
  Feb 28 - March 18.
- Positioning system mechanical design:
  Feb 14 - Feb 28.
- Positioning system electrical design:
  Feb 21 - March 11.
- Software design:
  Feb 14 - March 18.

Schedule Flow Chart



Cost Analysis

Approximate total cost for components (excluding microprocessor) will be $206.91.

Table 3. Component Costs for Prototype

Product Description	**Quantity**	**Price**
Lithium Ion Polymer Battery - 3.7v [6]	3	$44.85
DC 12v 10RPM Gear Motor [7]	1	$13.99
Bypass Pruning Shears [8]	1	$19.95
RF Module [5]	1	$17.95
Mechanical Clamp Arm with MG996R Servo Motor [4]	1	$35.19
Servo Driven Payload Release Mechanism [9]	1	$57.99
High Torque Servo Motor [10]	1	$16.99
Total Cost		**$206.91**

Leadership Roles

Nikhil Patel - Software Team Lead, Document Coordinator

Matthew Ramberger - Testing Team Lead

Darrell Fambro - Document Editor, Webmaster

Keith Liang - Hardware Design Team Lead

Tyler Bryant - Director of Communications, Expo Coordinator