Robotic Pole Inspection Collar

Team 505

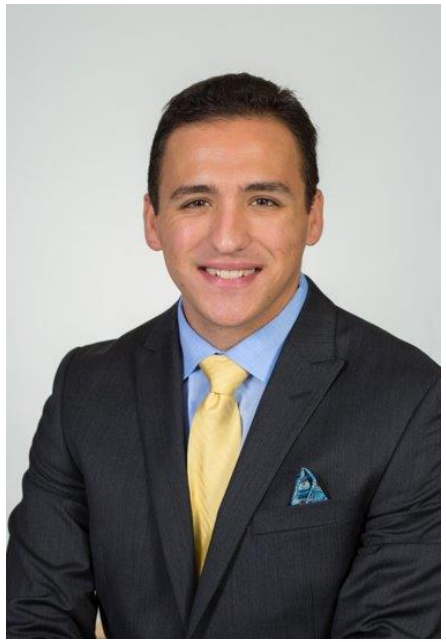
“Team Southern Pine”

ME Team Introductions

Mathew Crespo
Mechanical Systems Engineer

John Flournoy
Design & Material Engineer

Carey Tarkinson
Mechatronics & Programming Engineer



Angelo Mainolfi
Project Engineer

Carey Tarkinson

EE Team Introductions

Corie Cates
Project Engineer

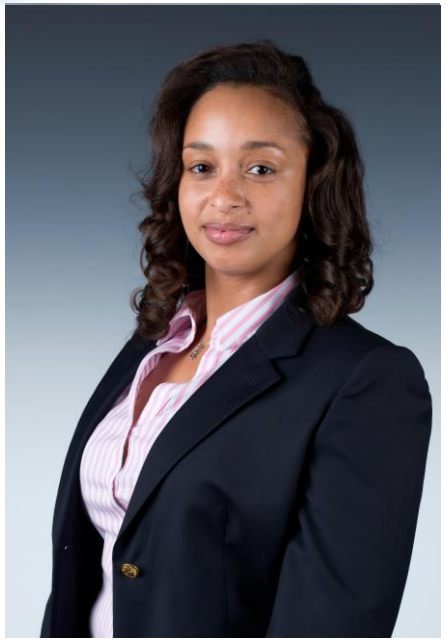
Alonzo Russell
Hardware Engineer

Leonardo Vazquez
Software Engineer

Thomas Williams
Hardware Engineer

Carey Tarkinson

Sponsors and Advisors



Engineering Sponsor
Genese Augustin
Lead Project Manager
Smart Grid & Innovation
Florida Power & Light

Engineering Sponsor
Troy Lewis
Engineer II
Smart Grid & Innovation
Florida Power & Light

Academic Advisor
Jonathan Clark, Ph.D.
Associate Professor

Engineering Professor
Shayne McConomy, Ph.D.
Teaching Faculty

John Flournoy

Objective

The objective is to design a mechanism that can climb a wooden utility pole and check its structural integrity

John Flournoy

Project Background

- FPL is Florida's largest utility company serving over 5 million customer accounts
- FPL's linemen interact with wooden utility poles daily to serve their customers
- Checking the structural integrity is crucial to keeping linemen safe
- We are motivated by a safety incident

John Flournoy

Developed Guidelines

Key Goals

- Ascend and descend a wooden utility pole
- Detect rot within the pole
- Interface the readings to the linemen

Targets & Metrics

- Climb a minimum of 15 feet
- Scan a minimum depth of 8 inches
- Interface readings within 60 seconds

Carey Tarkinson

Prototype One

- Using a bicycle-climber frame structure
- Large frame when built to suit a utility pole diameter
- A heavier load is beneficial to the design

Carey Tarkinson

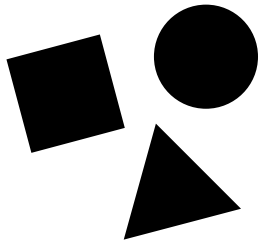
Prototype Two

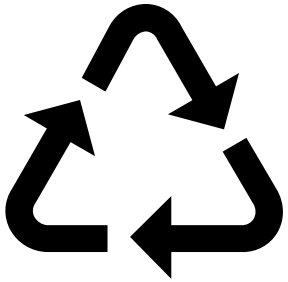
- Triangular frame helps keep complexity down
- Easily opens and closes around utility poles of varying diameters
- Provides area to mount sensors and motors

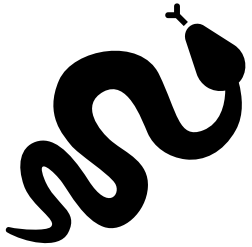
John Flournoy

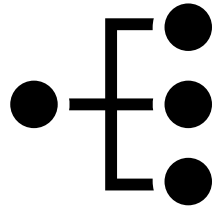
Concept Generation

- Crapshoot
- Scamper
- Biomimicry
- Morphological Chart



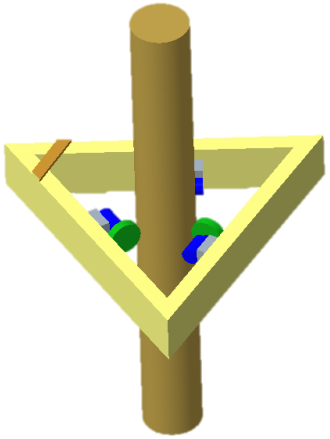


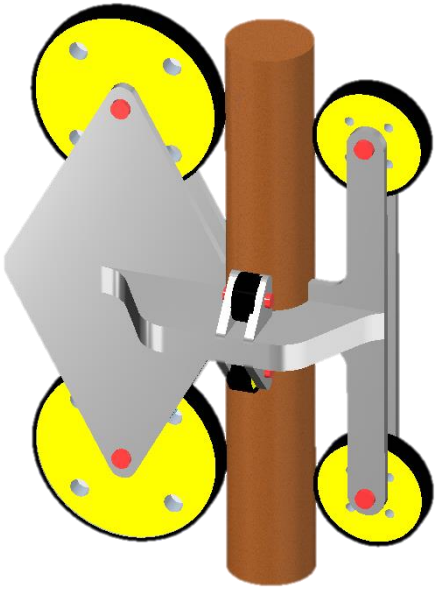


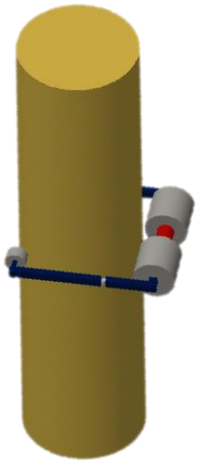


John Flournoy

High Fidelity Concepts





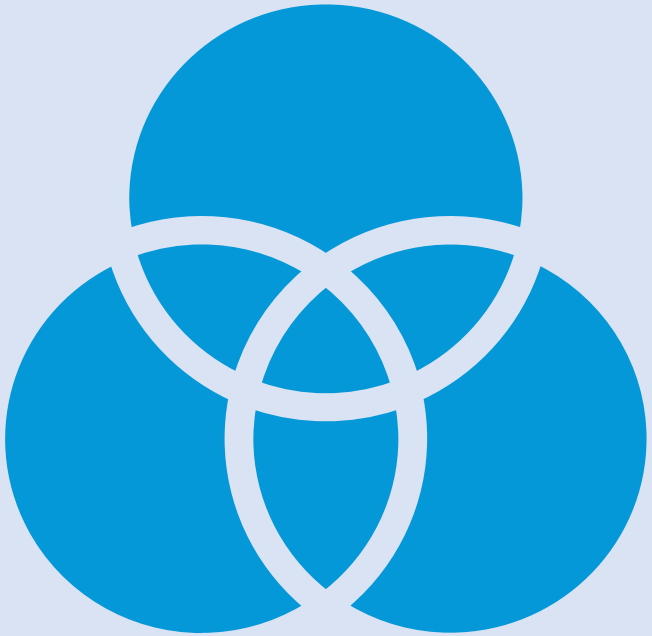


John Flournoy

Binary Pairwise Comparison

Evaluation Criteria Hierarchy

1) Rot Detection
2) Ability to Climb
2) OSHA Test Standards
3) Data Interface
4) Portability
5) Modularity



Carey Tarkinson

House of Quality

Impactful Engineering Characteristics

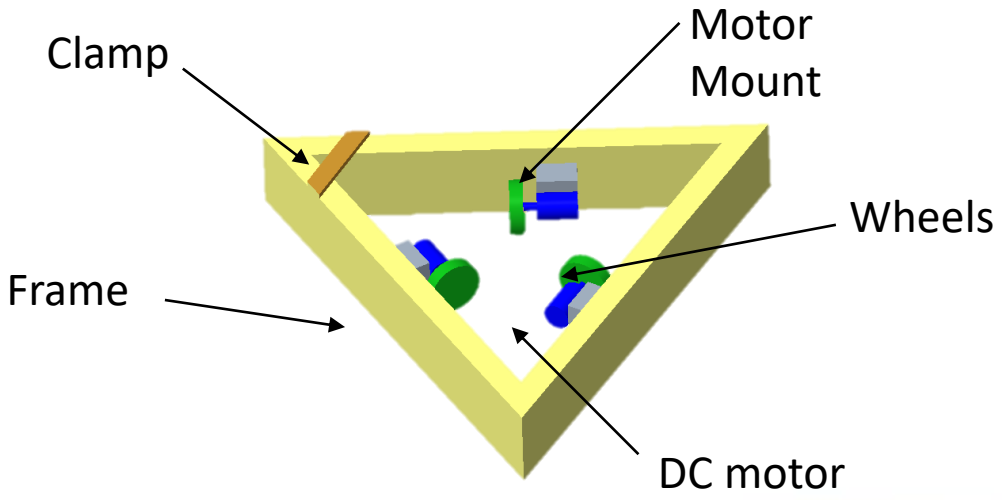
- Stability
- Safety
- Maneuverability
- Speed

Carey Tarkinson

Winning Concept

Triangle Climber

- Modularity
- Stability
- Easy to use
- Variable climbing



John Flournoy

Testing Prototype Three

Motorized Triangle Climber Prototype

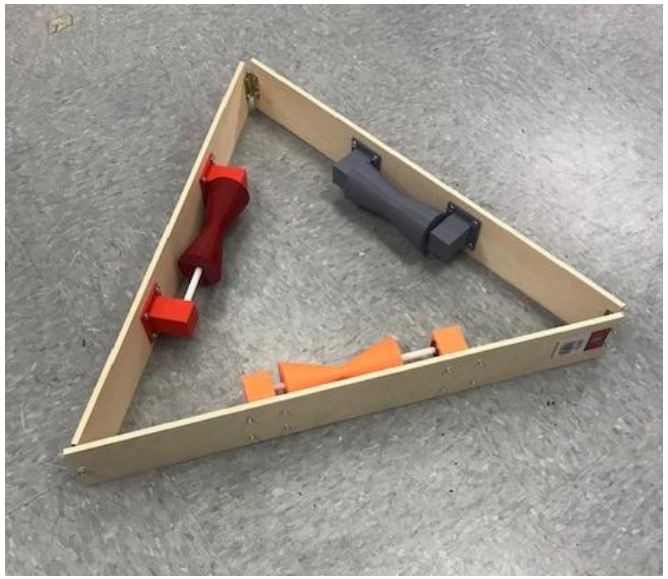
Revelations:

- Pinching caused by poor wheel mounting
- Motors were grossly underpowered
- Wheels struggled to maintain contact to pole

John Flournoy

Prototype Four Progress

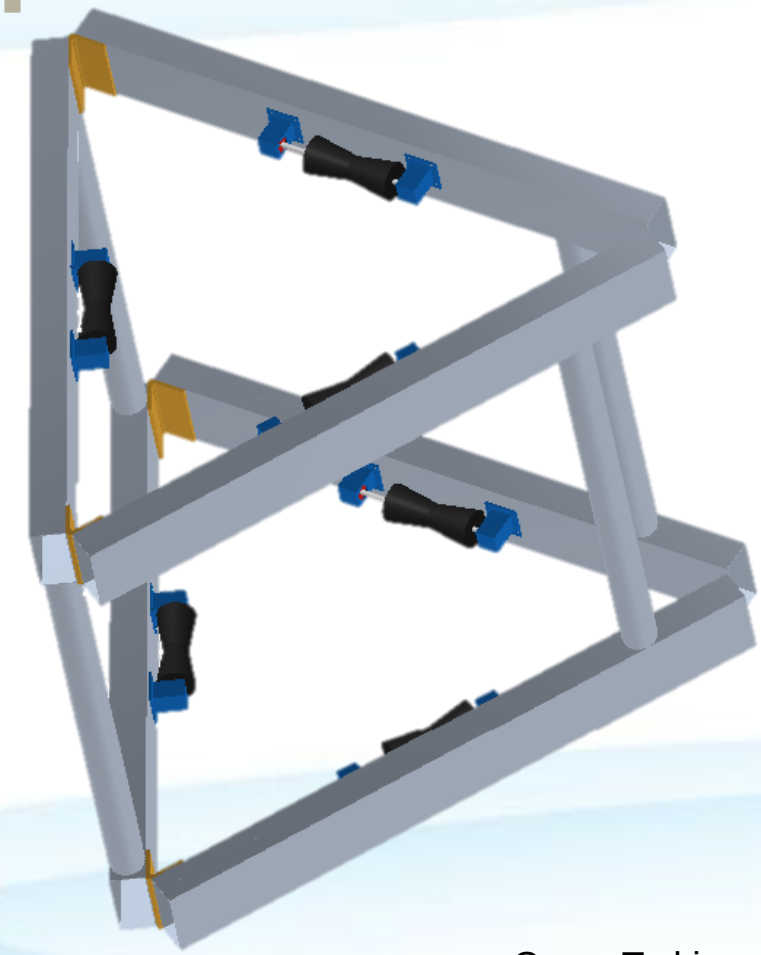
- 3D printed hourglass wheels to increase contact area
- 3D printed bearing mounts that attach to the inside of the frame
- Skateboard bearings allow smooth rotation of acetal wheel shafts
- Long passive wheel shaft for diameter compliance



Carey Tarkinson

Augmented Triangle Design

- Triangular prism climber
- Designed to combat potential stability and pinch issues
- Wrap around elastic band to allow variable tension



Carey Tarkinson

Prototype Testing Method

FPL provided pole samples for safe testing

- Samples included healthy and rotten power pole segments
- The rotten sample will facilitate sensor calibration

John Flournoy

Future Work

Begin testing on pole samples

Purchase final components

Develop sensor housing

Test automated climbing ability

Carey Tarkinson

Sources

- https://www.slunglow.org/event/new-show-cap-pie/
- https://journalnow.com/archive/so-metal-the-world-of-metal-detecting-is-changing-and-north-carolina-is-home-to/article_7bb241c8-ecac-11e6-a1f4-7f1a74729de1.html
- https://www.onlinewebfonts.com/icon/546768
- https://www.flaticon.com

Appendix

- The following slides have supporting information

Analytical Hierarchy Process - AHP

- Pairwise Matrix
- Normalized Pairwise Matrix
- Criteria Weights
- Weighed Sum Vector
- Consistency Vector

AHP Chart

Table 1: Analytical Hierarchy Process

Pairwise Comparison							
Customer Needs	Ability to Climb	Rot Detection	Data Interface	Portability	OSHA Test Standards	Modularity	**Total**
Ability to Climb	-	0	1	1	1	1	**4**
Rot Detection	1	-	1	1	1	1	**5**
Data Interface	0	0	-	1	0	1	**2**
Portability	0	0	0	-	0	1	**1**
OSHA Test Standards	0	0	1	1	-	1	**3**
Modularity	0	0	0	0	0	-	**0**
Total	1	0	3	4	2	5	

AHP 2

Table 2: Normalized Analytical Hierarchy Process

Normalized Pairwise Comparison							
Customer Needs	Ability to Climb	Rot Detection	Data Interface	Portability	OSHA Test Standards	Modularity	**Weight**
Ability to Climb	-	0	0.33	0.25	0.5	0.2	**1.28**
Rot Detection	1	-	0.33	0.25	0.5	0.2	**2.28**
Data Interface	0	0	-	0.25	0	0.2	**0.45**
Portability	0	0	0	-	0	0.2	**0.20**
OSHA Test Standards	0	0	0.33	0.25	-	0.2	**0.78**
Modularity	0	0	0	0	0	-	**0**
Total	1	0	1	1	1	1	

HOC

Table 3: House of Quality Relationship Matrix

Relationship Matrix between Engineering Characteristics and Customer Needs							
		Engineering Characteristics					
Improvement Direction		↓	↑	↑	↑	↓	↑
Units		lb.	ft/s	N/A	N/A	s	N/A
Customer Needs	**Importance Weight Factor**	Weight	Speed	Stability	Safety	Ease of Mounting	Maneuverability
Ability to climb	**5**	9	7	9	8	5	7
Rot Detection	**5**	4	5	8	9	4	8
Data Interface	**4**	2	9	9	8	3	5
Portability	**3**	9	3	5	3	9	8
OSHA Test Standards	**5**	3	2	7	8	5	5
Modularity	**2**	4	1	2	4	6	4
Raw Score (887)		123	142	175	174	121	152
Relative Weight %		13.9	16.0	19.7	19.6	13.6	17.1
Rank Order		5	4	1	2	6	3

Pugh Chart 1

Table 4: Initial Pugh Chart

Selection Criteria	**Datum**	Variable Arm Climber	Rollercoaster Gripper	Counter-Weight Triangle Hybrid	Serpent Robot	Hybrid Bike Design	Triangle Climber	Batmobile Climber
Vertical Traversal Speed	**Bike Climber**	-	+	-	-	-	-	+
Stability		S	+	S	+	+	+	-
Weight		-	-	-	-	-	+	+
Ease of Mounting		-	-	-	-	-	-	+
Portability		S	-	-	-	-	+	+
Modularity		S	+	+	-	S	+	-
Simplicity		-	-	-	-	-	-	-
Number of Pluses		0	3	1	1	1	4	4
Number Minuses		4	4	5	6	5	3	3
Number of S's		3	0	1	0	1	0	0

Pugh Chart 2

Table 5: Second Pugh Chart

Selection Criteria	**Datum**	Triangle Climber	Batmobile Climber	Variable Arm Climber
Vertical Traversal Speed	**Roller Coaster Gripper**	+	+	-
Stability		+	-	S
Weight		+	+	+
Ease of Mounting		+	+	+
Portability		S	+	-
Modularity		+	-	S
Simplicity		+	+	-
Number of Pluses		6	5	2
Number Minuses		0	2	3
Number of S's		1	0	2

Project Management

Most Important Points

1. The quick brown fox jumps over the lazy dog.
2. The quick brown fox jumps over the lazy dog.
3. The quick brown fox jumps over the lazy dog.
4. The quick brown fox jumps over the lazy dog.
5. The quick brown fox jumps over the lazy dog.
6. The quick brown fox jumps over the lazy dog.

Lessons Learned

Reference

Questions (be sure to design your own)

Backup Slides