Robotic Pole Inspection Collar

Team 505

“Team Southern Pine”

Department of Computer & Electrical Engineering
Department of Mechanical Engineering

FAMU-FSU Engineering

ME Team Introductions

Mathew Crespo
Mechanical Systems Engineer

John Flournoy
Design & Material Engineer

Angelo Mainolfi
Project Engineer

Carey Tarkinson
Mechatronics & Programming Engineer

EE Team Introductions

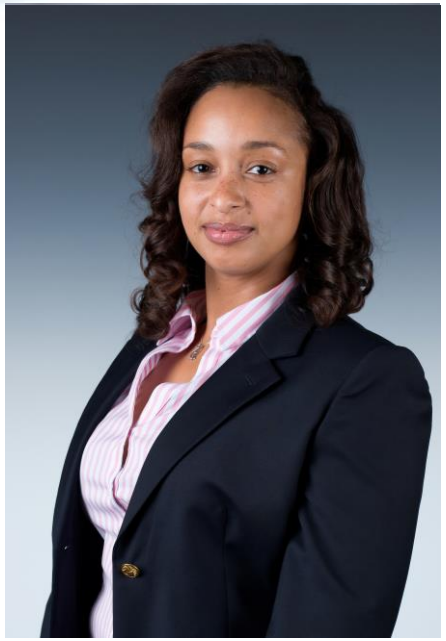
Corie Cates
Project Engineer

Alonzo Russell
Hardware Engineer

Leonardo Vazquez
Software Engineer

Thomas Williams
Hardware Engineer

Sponsor's and Advisor's



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
FAMU-FSU College
of Engineering

Engineering Professor
Shayne McConomy, Ph.D.
Teaching Faculty 1
FAMU-FSU
College of Engineering

Objective

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

Past Work

- Motivation
  - Safety of linemen
- Key Goals
  - Ascend and descend a wooden utility pole
  - Detect rot within the pole
  - Interface the readings to the linemen
- Functional Decomposition
- Rapid Prototype 1 and 2

Rapid Prototype One

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

Rapid Prototype Two

- Triangular frame allows for a simple prototype
- Easily opens and closes around utility poles of varying diameter
- Provides area to mount sensors and motors

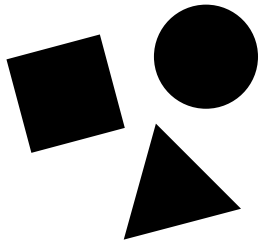
Targets and Metrics

Mission critical

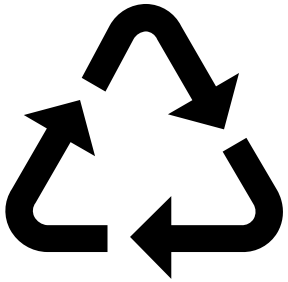
- ➞ Traverse utility pole
- ➞ Detect rot
- ➞ Interface data

Concept Generation

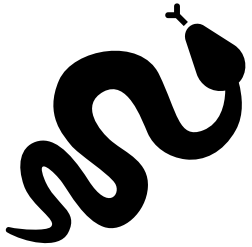
- Crapshoot



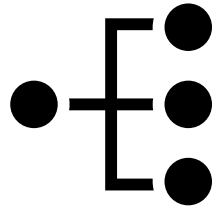
- Scamper



- Biomimicry

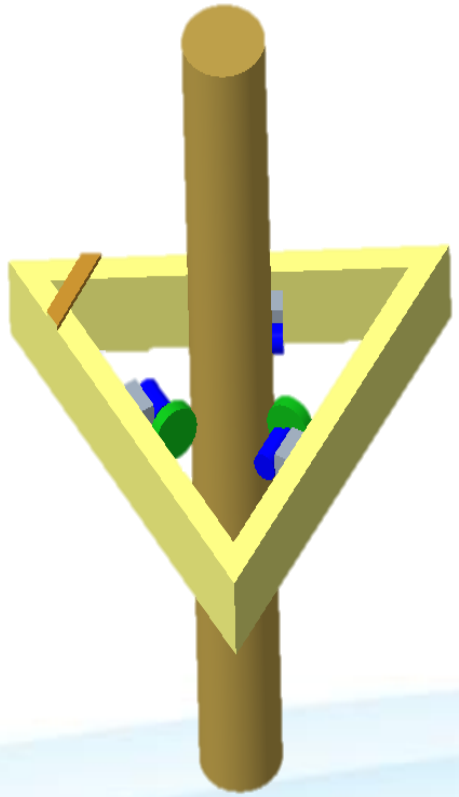


- Morphological Chart



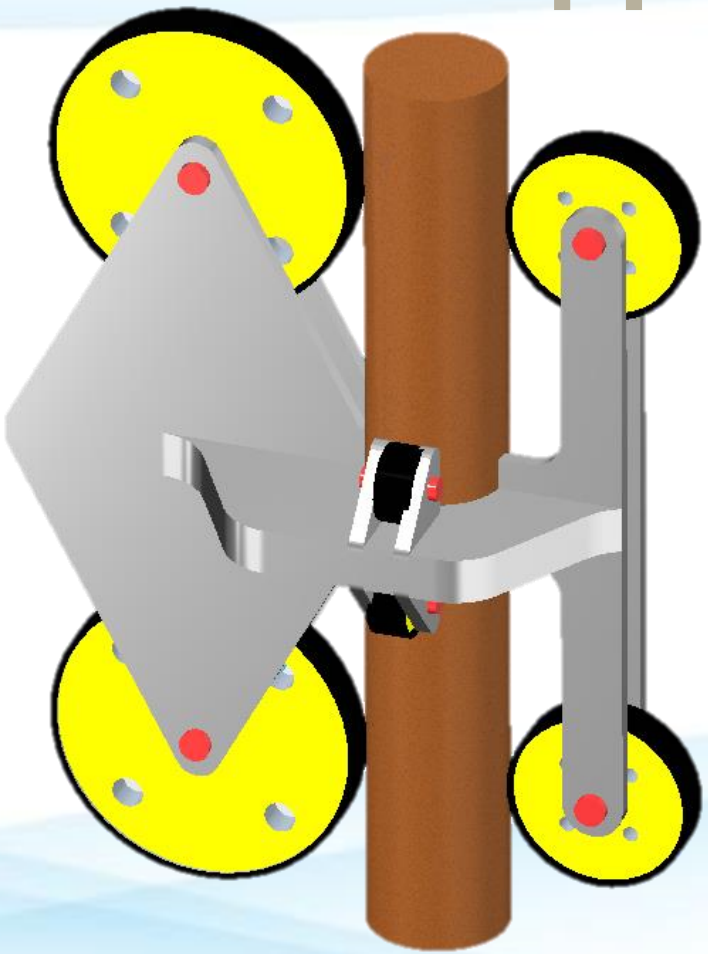
High Fidelity: Triangle Climber

- Triangular Aluminum Frame
- 3 Motorized wheels
- Ground Penetrating Radar



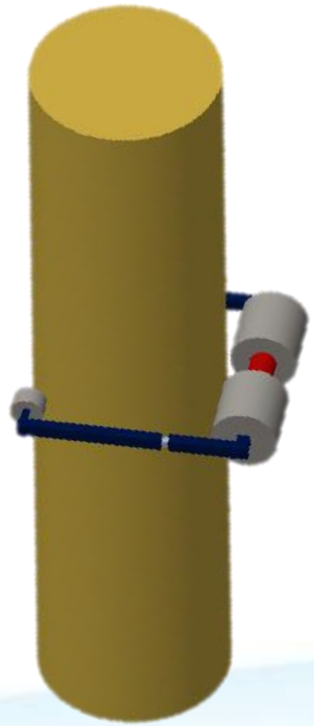
High Fidelity: Roller Coaster Gripper

- Roller Coaster Clamping
- 2 Active 4 Passive Wheels
- Ground Penetrating Radar



High Fidelity: Batmobile Climber

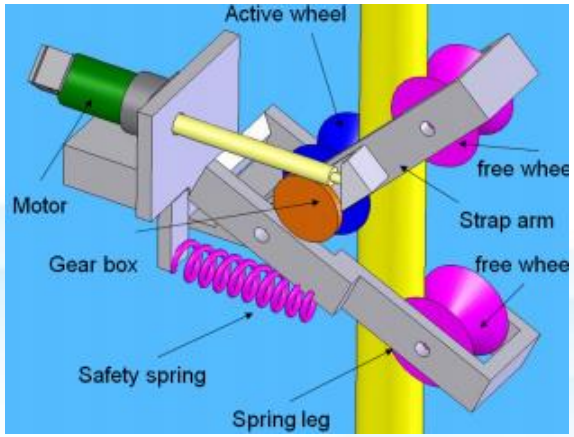
- Actuated Mobile Frame
- 4 Motorized wheels
- Ground Penetrating Radar



Medium Fidelity Ideas

Bicycle Climber

- Counterweight design to provide wheel traction
- Fast mount onto pole

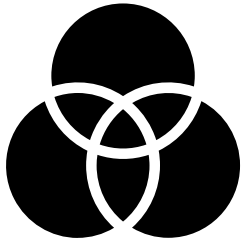


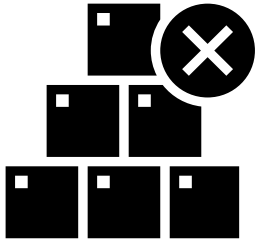
Serpentine Climber

- Rolling wheels used to contour pole
- Easily contorts to any size

Concept Selection

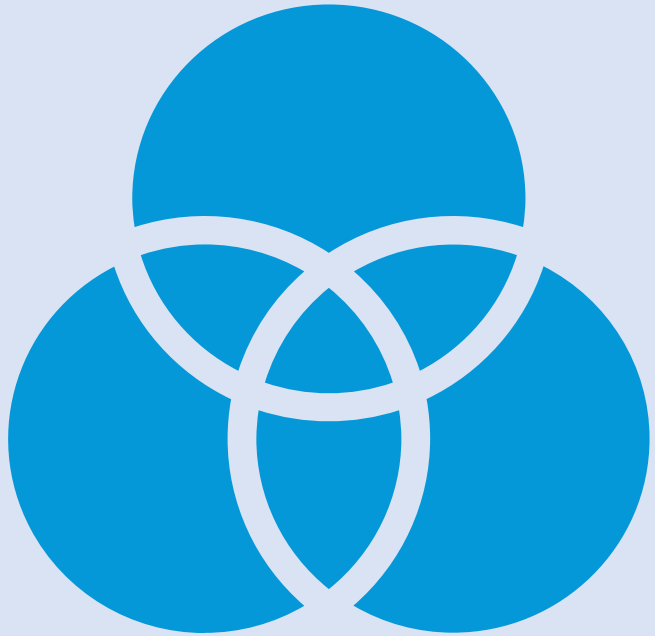
- Binary Pairwise
- House of Quality
- Pugh Matrices





Binary Pairwise Comparison

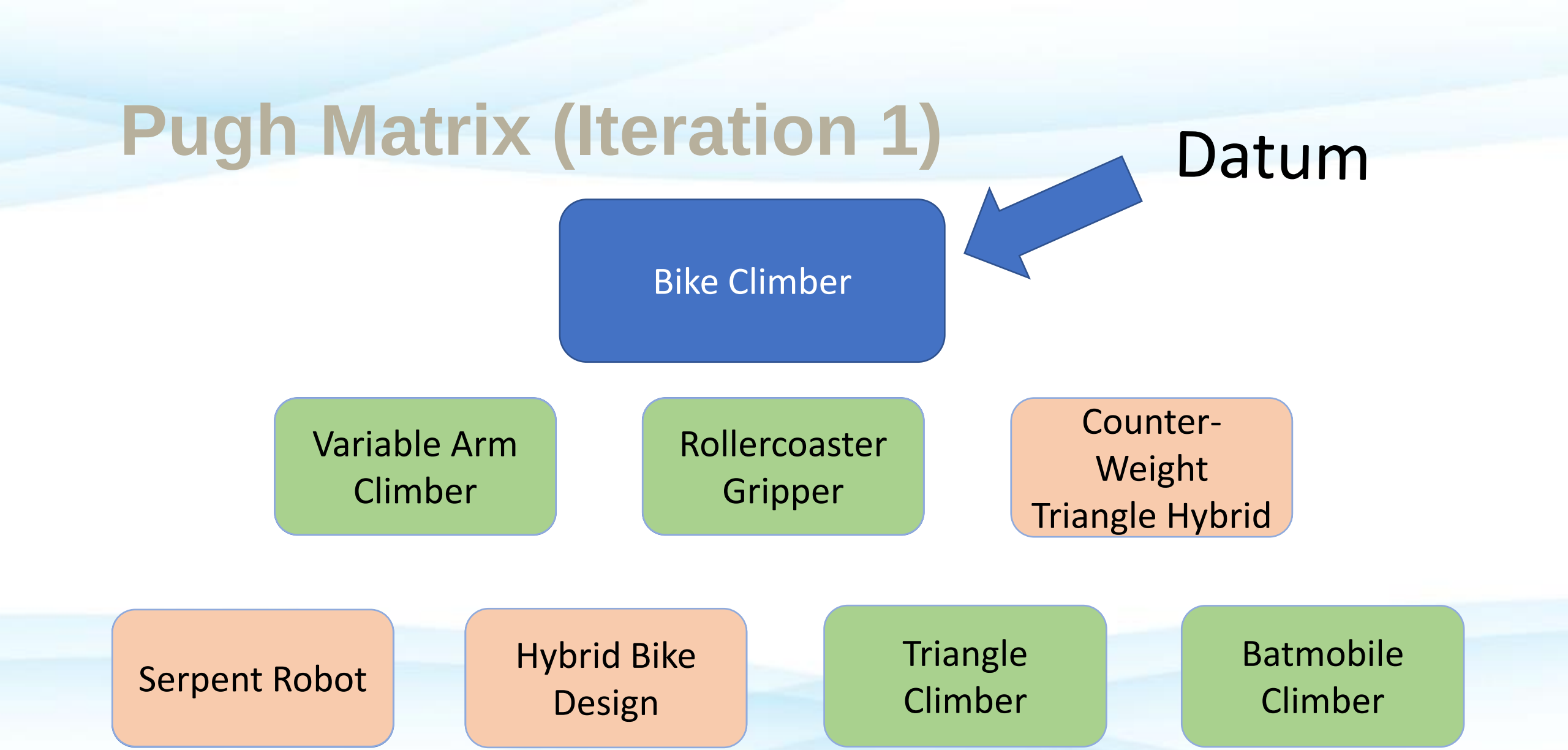
- Evaluation Criteria Hierarchy
  - Rot Detection
  - Ability to Climb
  - OSHA Test Standards
  - Data Interface
  - Portability
  - Modularity



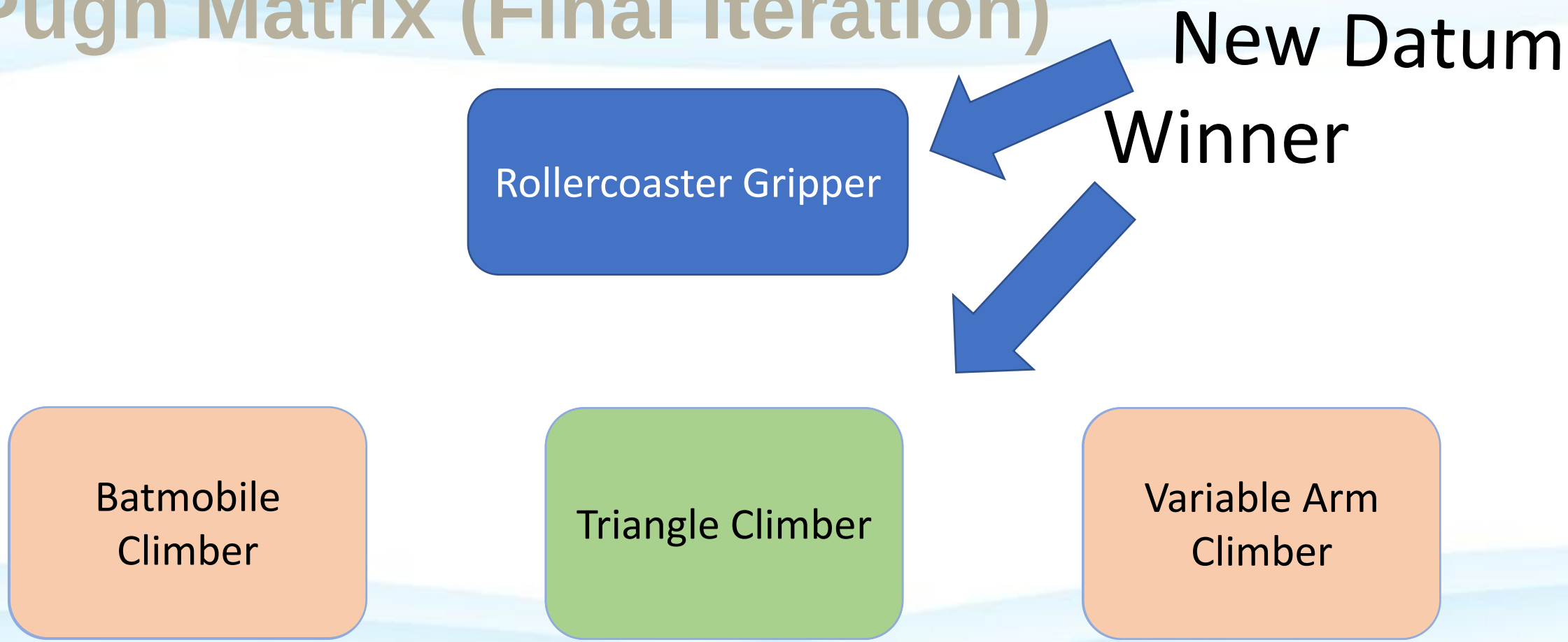
House of Quality

- Impactful Engineering Characteristics
  1. Stability
  2. Safety
  3. Maneuverability
  4. Speed

Pugh Matrix (Iteration 1)

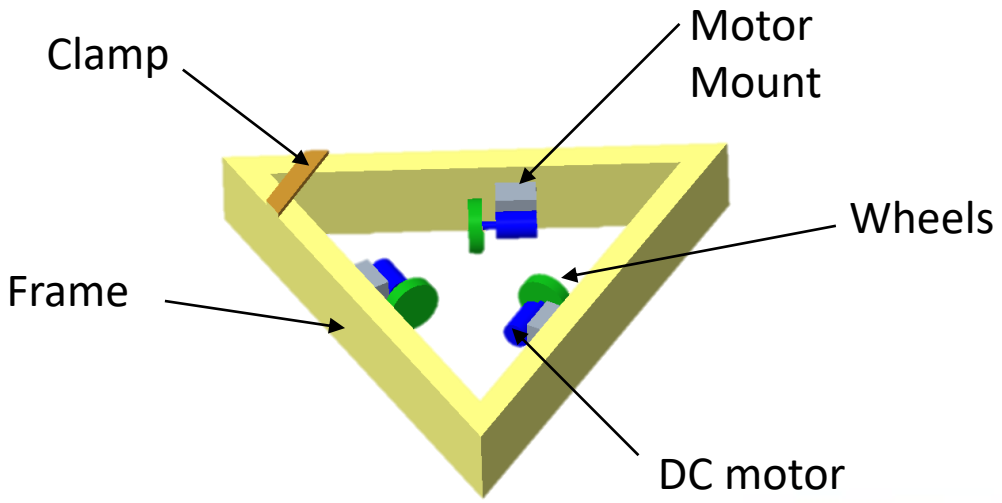


Pugh Matrix (Final Iteration)



Winning Concept

- Triangle Climber
  - Modularity
  - Stability
  - Easy to use
  - Variable Climbing



Future Work

Motorize Prototype 2

Test automated climbing ability

Make necessary adjustments

Develop sensor housing

Retest climbing ability

Questions

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