Rickshaw Robotics

2021 Winter Steerable Walker

Team Members: James Le, Jason Lai, Matthew Gelacio
Project Sponsors: Professor J. Michael McCarthy and Kevin Chen

Goal

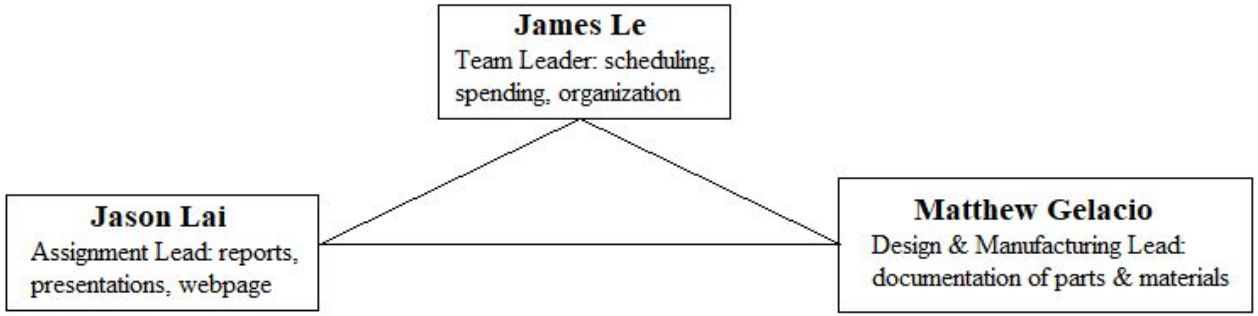
Design, build, and test a steerable mechanical walker.

James Le

Requirements

Attribute	O	C	F	M
Complete a Figure 8	x		x	
2 foot turning radius	x		x	
One drive motor		x		
One steering motor		x		
Speed of 1-1.5 ft/s	x		x	
RC controlled	x			
Fit in 12” x 18” planar envelope	x	x		
6” wheels		x		

Team Organization

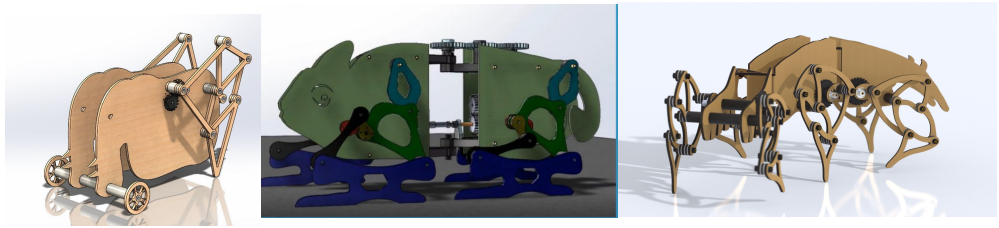


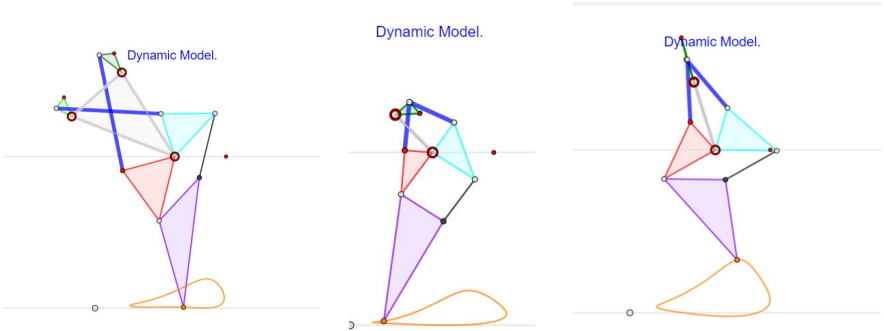
Electrical	Drive System	Chassis
James Le	**Jason Lai**	**Matthew Gelacio**
-coding -RC controller -electronics	-drivetrain -steering	-leg mechanism -frame

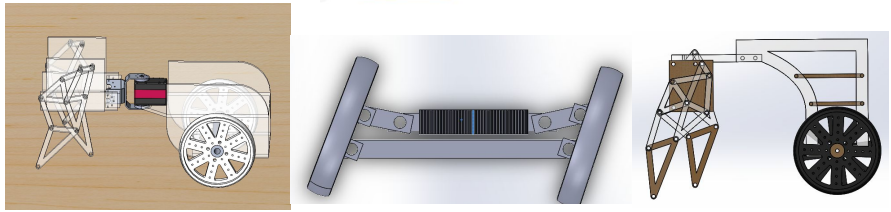
James Le

Key Design Decisions

- Number of Legs
  - 2 legs
  - 4 legs
  - 6 legs
- Leg design
  - Foot trajectory 1
  - Foot trajectory 2
  - Foot trajectory 3
- Steering axis location
  - Center hinge
  - Front hinge
  - Rear steering







Matthew Gelacio

Key Design Decisions: Number of Legs

Goal	Weight	2 Legs		4 Legs		6 Legs	
Feasibility	0.2	4	0.8	2	0.4	1	0.2
Originality	0.1	4	0.4	2	0.2	2	0.2
Challenge	0.2	3	0.6	3	0.6	3	0.6
Speed	0.2	3	0.6	2	0.4	2	0.4
Maneuverability	0.1	3	0.3	2	0.2	2	0.2
Ease of Assembly	0.1	3	0.3	3	0.3	3	0.3
Ease of Manufacturing	0.1	3	0.3	3	0.3	3	0.3
Total Points (Weighted)		3.3		2.4		2.2	

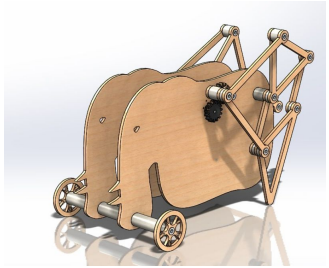


Figure: 2 Legged Walker

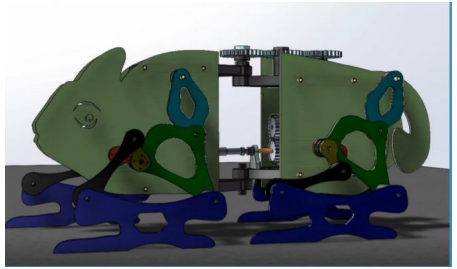


Figure: 4 Legged Walker

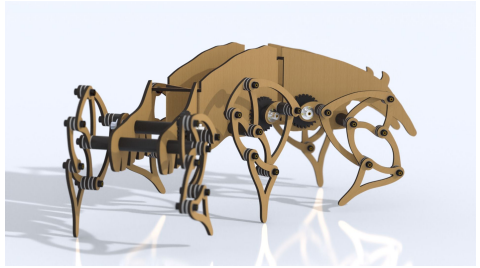


Figure: 6 Legged Walker

Relative Performance	Rating
Much worse than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

Matthew Gelacio

Key Design Decisions: Leg Design

Goal	Weight	Leg Design 1 (Reference)		Leg Design 2		Leg Design 3	
Step Height	0.2	2	0.4	3	0.6	5	1
Stride Length	0.1	4	0.4	4	0.4	4	0.4
Leg Proportionality	0.1	3	0.3	3	0.3	4	0.4
Structural Integrity	0.2	4	0.8	3	0.6	3	0.6
Ease of Manufacturing	0.2	1	0.2	4	0.8	4	0.8
Ease of Assembly	0.2	1	0.2	4	0.8	4	0.8
Total Points (Weighted)		2.3		3.5		4	
Ranking 1-3		3		2		1	

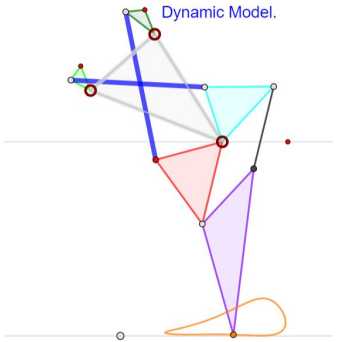


Figure: Leg Design 1, 2 crank

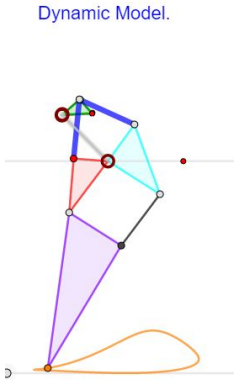


Figure: Leg Design 2, 1 crank

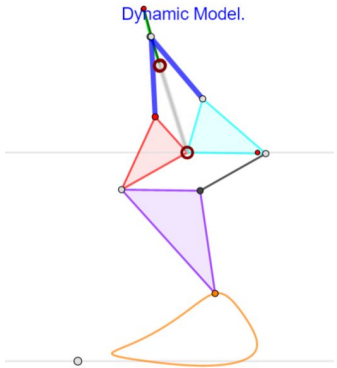


Figure: Leg Design 3, 1 crank

Matthew Gelacio

Key Design Decisions: Steering

Goal	Weight	Center Hinge (Reference)		Rear Wheel Steering		Front Hinge	
Turn Radius	0.2	4	0.8	2	0.4	3	0.6
Maximum Steering Angle	0.2	4	0.8	2	0.4	2	0.4
Reliability and Control	0.2	4	0.8	1	0.2	3	0.6
Design Proportionality	0.1	4	0.4	3	0.3	1	0.1
Ease of Manufacturing	0.1	3	0.3	3	0.3	3	0.3
Ease of Assembly	0.1	3	0.3	3	0.3	3	0.3
Weight Distribution	0.1	4	0.4	2	0.2	2	0.2
Total Points (Weighted)			3.8		2.1		2.5
Ranking 1-3		1		3		2	

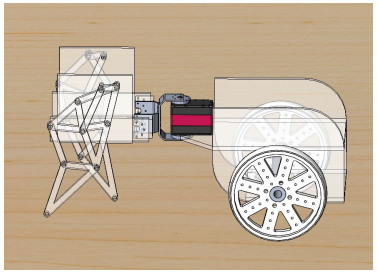


Figure: Center hinge

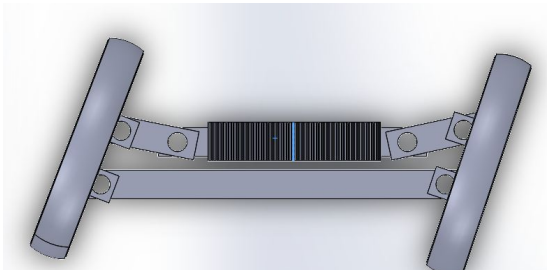


Figure: Rear wheel ackermann

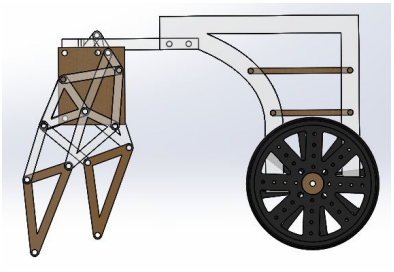


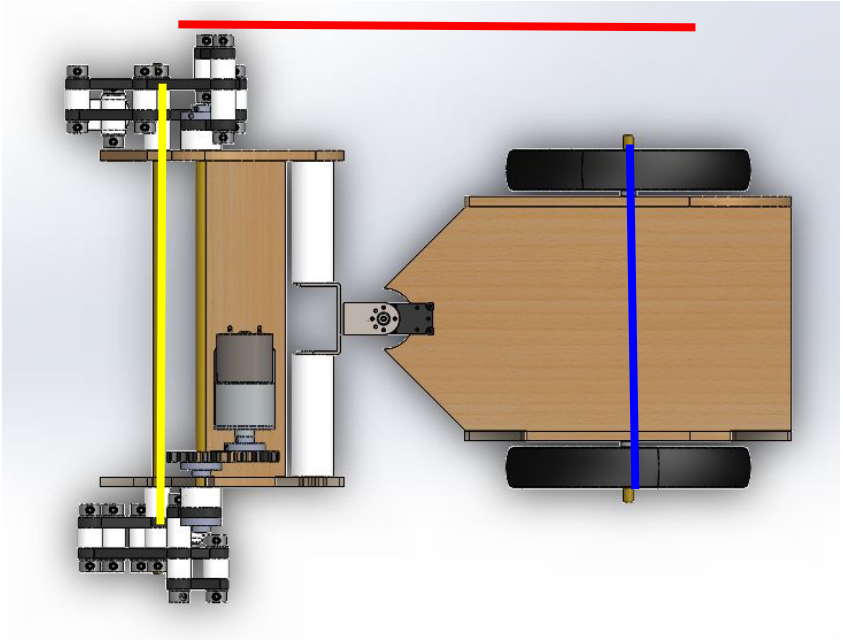
Figure: Front hinge

Matthew Gelacio

Parameter Study Using Digital Models

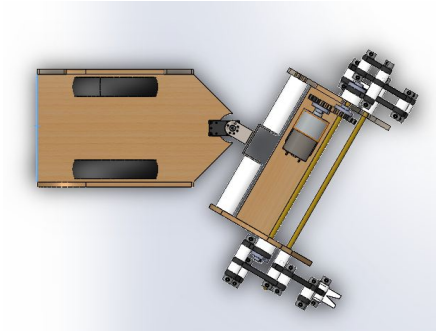
Tested 3 parameters to improve steering, turn radius, and overall performance:

- Width between wheels
  - Increase far beyond width between legs - lifting of wheels, rocking of walker
- Width between legs
  - Shorter than wheel width- tilting of walker, decrease in maximum steering angle
- Distance between legs and wheels

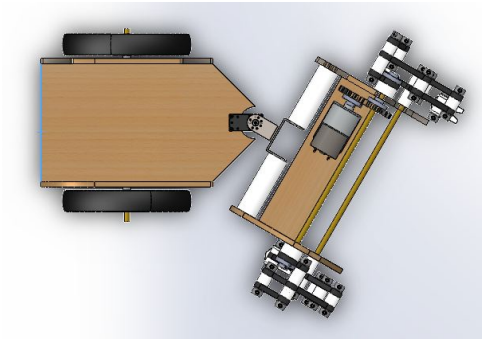


Jason Lai

Parameter Study: Wheel Track

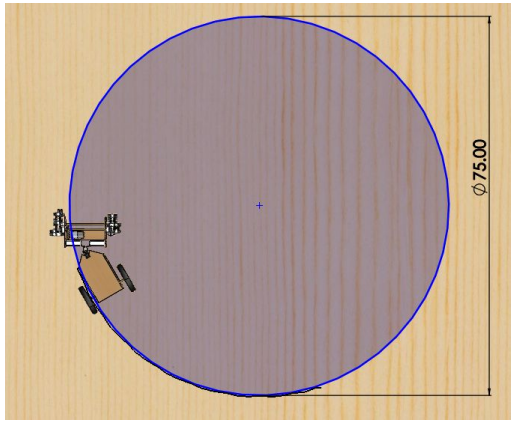


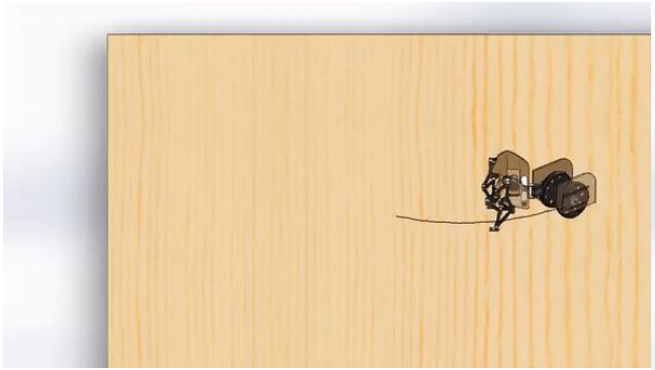
4”

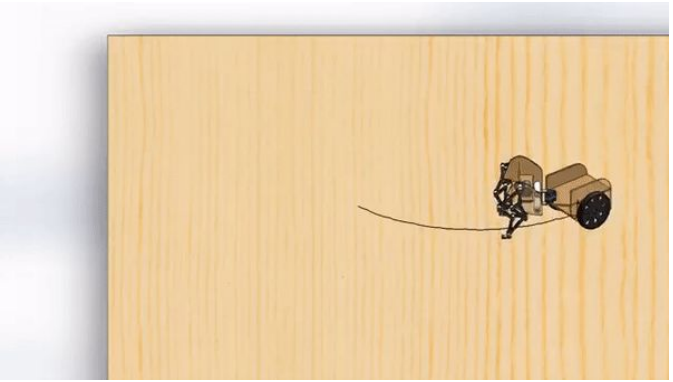


8”

Test each parameter on a digital model using motional analysis of the walker moving in a circle



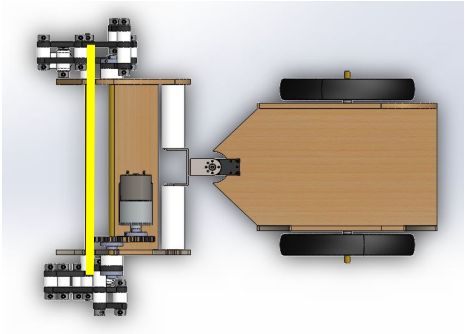




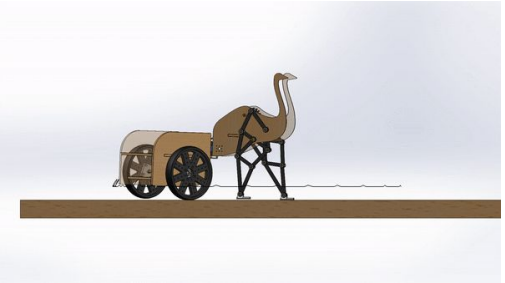
- Larger track resulted in smoother movement

Jason Lai

Parameter Study: Leg Width

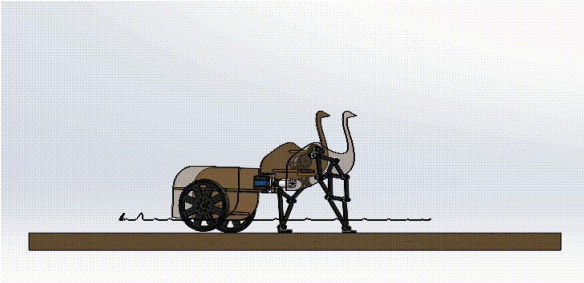


8”



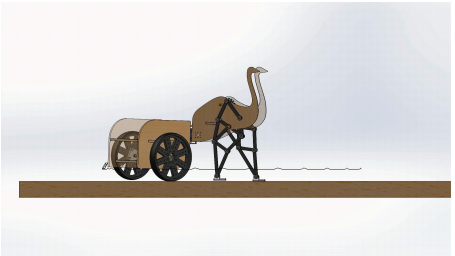
Leg Track = Wheel Track

10.5”



Leg Track > Wheel Track

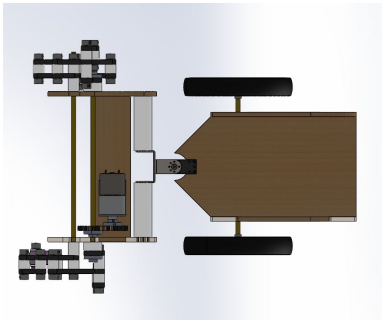
12”



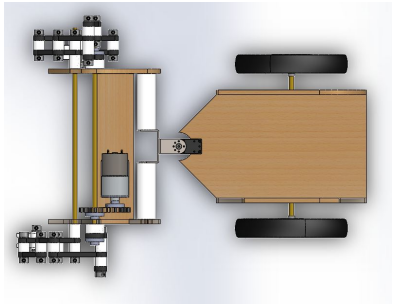
Leg Track >> Wheel Track

Jason Lai

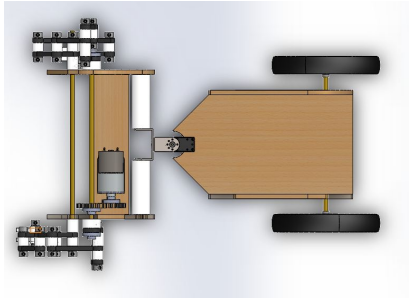
Parameter Study: Wheelbase



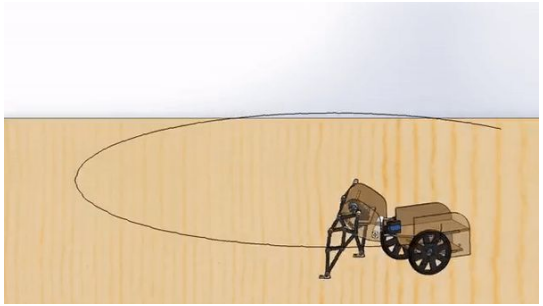
9”

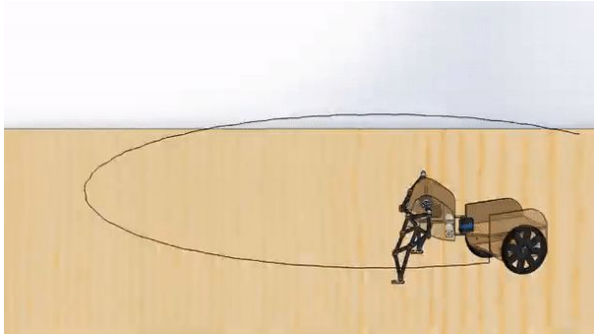


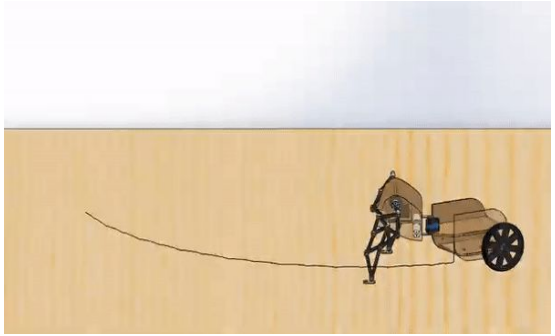
11.5”



13”







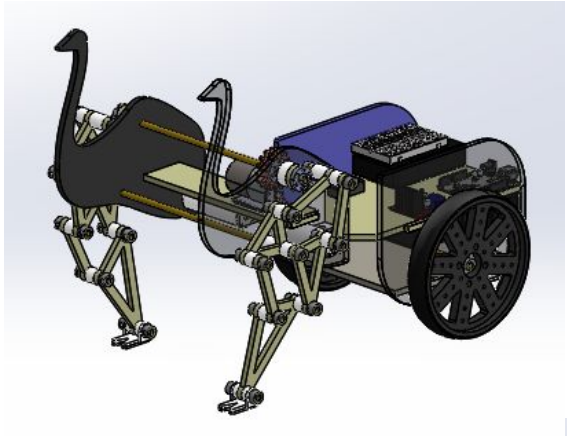
Increasing wheelbase results in larger turn radius, and less rocking

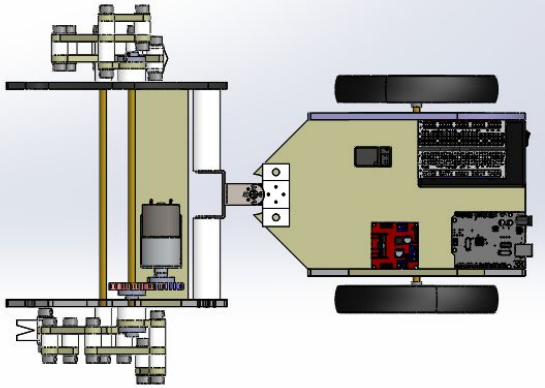
Jason Lai

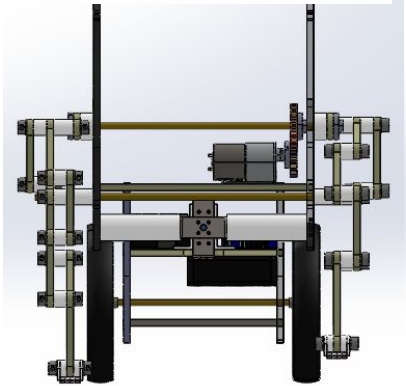
Prototype A

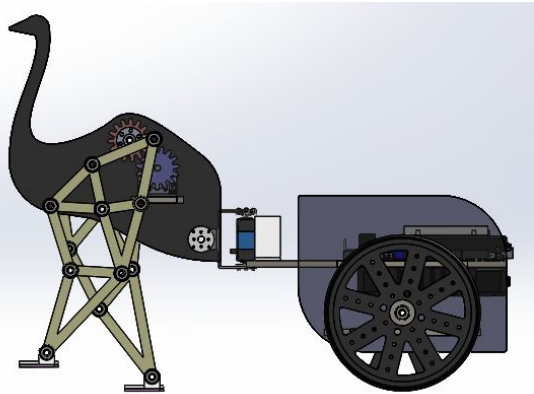
Manufactured Parts
- 3D print (PLA)
  - Foot
  - Servo mount
  - Leg Spacers
- Laser Cut Acrylic
  - Legs
  - Chariot
  - Chassis
  - Gears

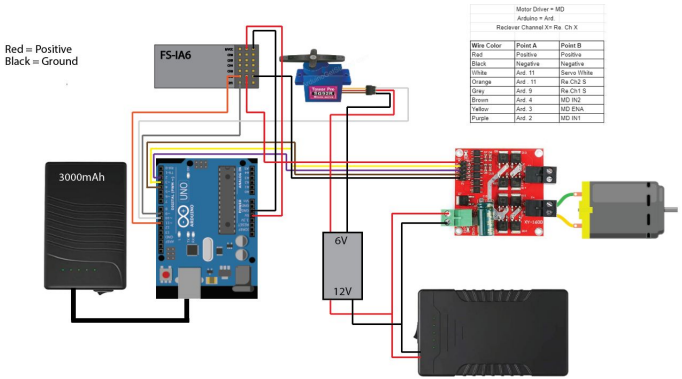
Purchased Parts
- 30kg Servo motor
- DC Motor
- Mounting Brackets
- Voltage Converter
- Arduino UNO
- RC Controller (IF-IA6)







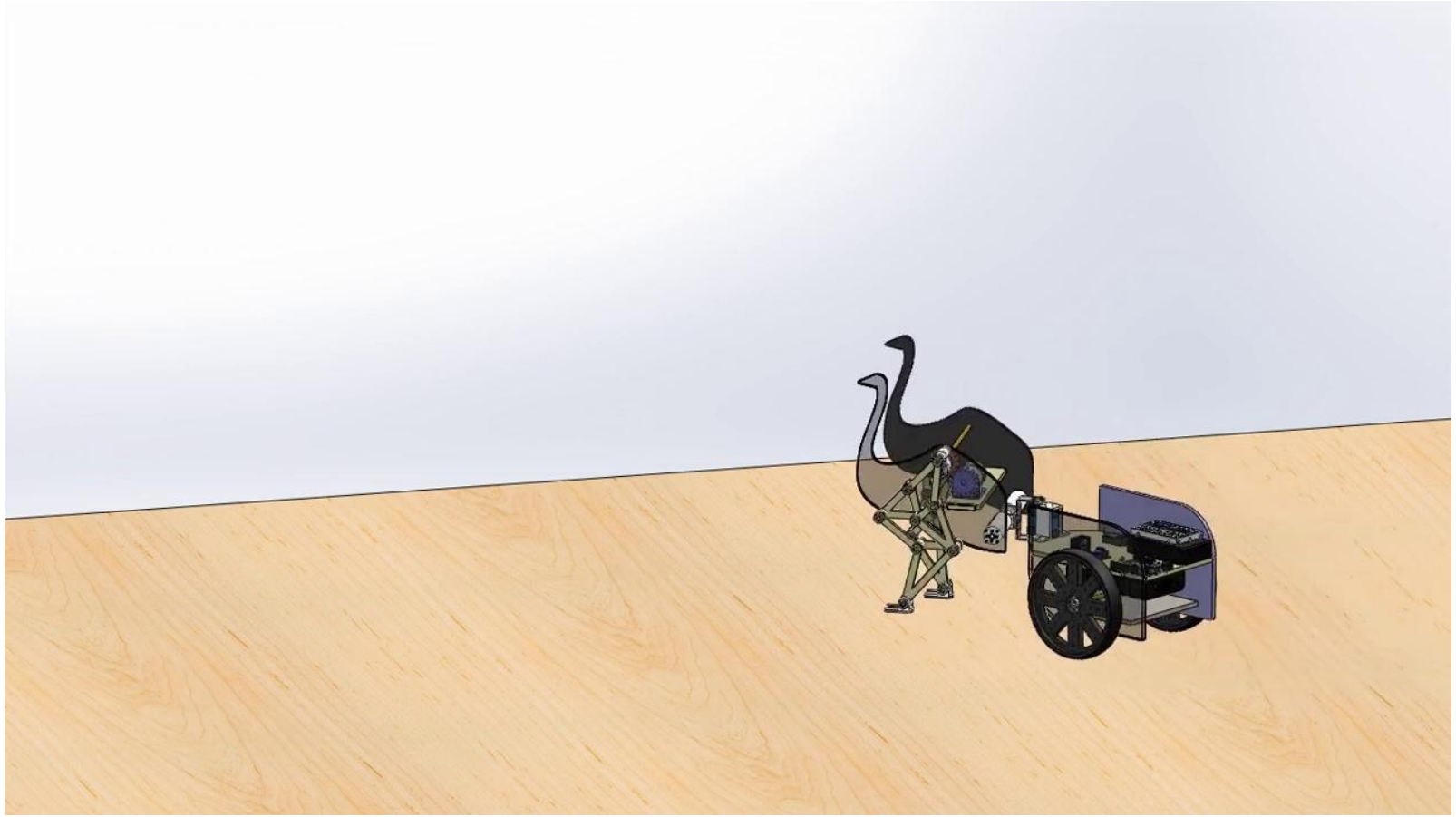




Wheel Track: 8”
Leg Track: 10.5”
Wheelbase: 11.5”

James Le

Prototype A Solid Model Demonstration



Matthew Gelacio

Detailed Schedule

Week 5 - Complete solidworks model and motion study of first prototype (Prototype A) and order parts

Week 6 - Manufacture Prototype A

Week 7 - Test physical model of Prototype A, evaluate performance

Week 8 - Finalize design of Prototype B

Week 9- Manufacture and test Prototype B

Week 10- Demonstration of Prototype A versus Prototype B and improvements

Testing and Verification

Design Verifications

- Walker drive and steering via RC controller and Arduino UNO
- Reliably maneuver in a figure 8 to show control over steering

Design Testing/Experimentation

- Foot Design effect on movement and turning
  - Foot Material
    - Rubber
    - PLA
  - Test without foot
- Maneuverability over different surfaces

James Le

Summary

- As a result of this study, we will focus on a two legged walker pulling a chariot
- Parameter study resulted in the three primary dimensions being
  - Wheelbase: 11.5”
  - Wheel width: 8”
  - Leg width: 10.5”
- Motion studies for prototype A predicts success
- Electronic prototype has been tested and verified
- Expect to demonstrate one possibly two steerable walkers by the end of the quarter

Thank you!

Jason Lai