Model Based Systems Quadruped

Virtual Design Review 2

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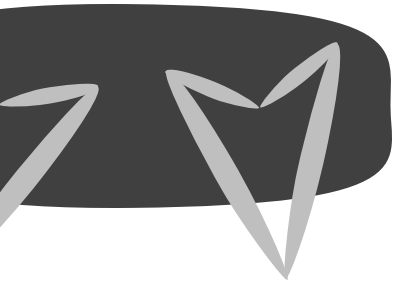

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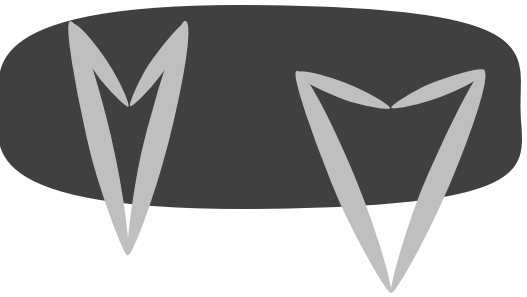

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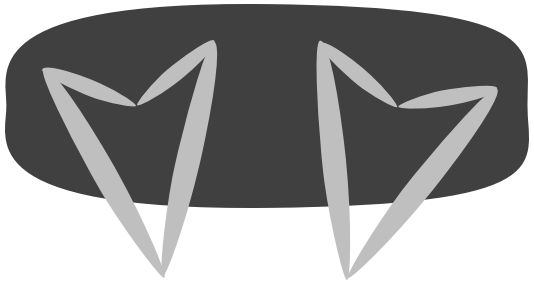

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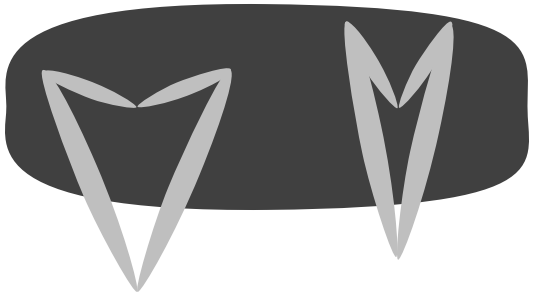

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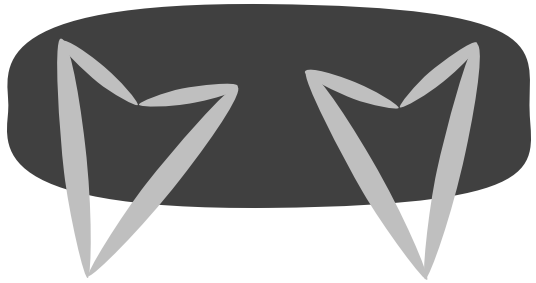

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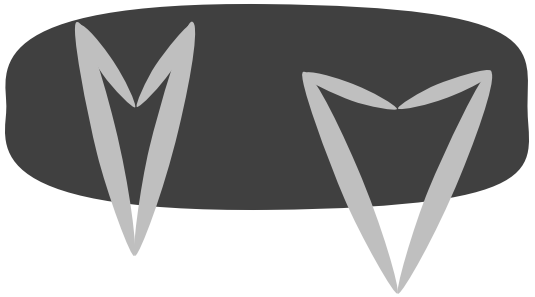

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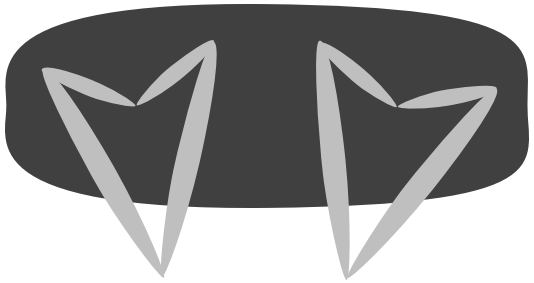

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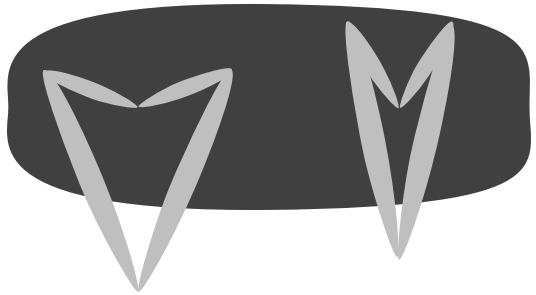

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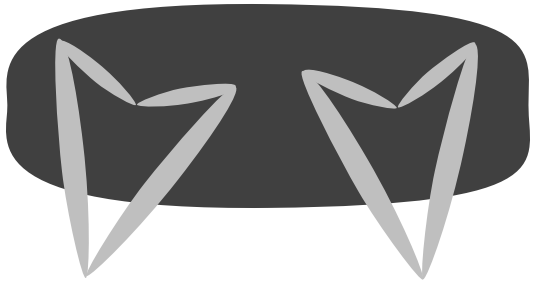

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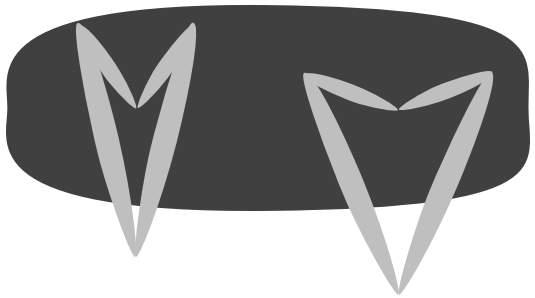

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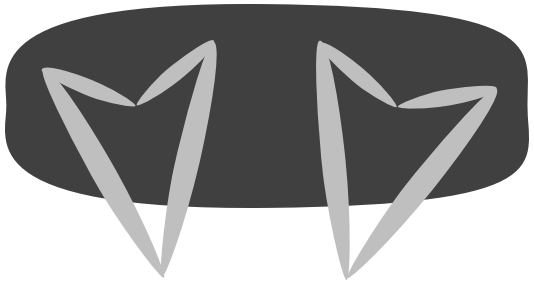

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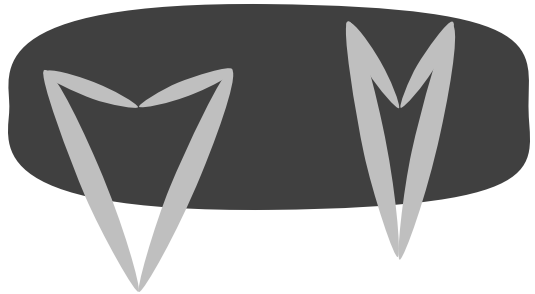

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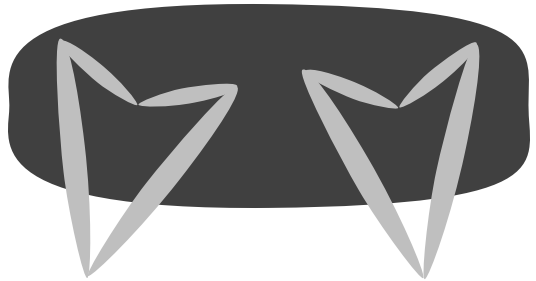

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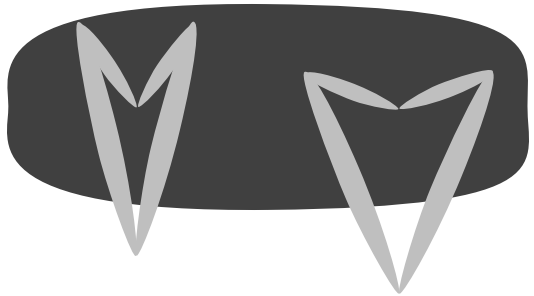

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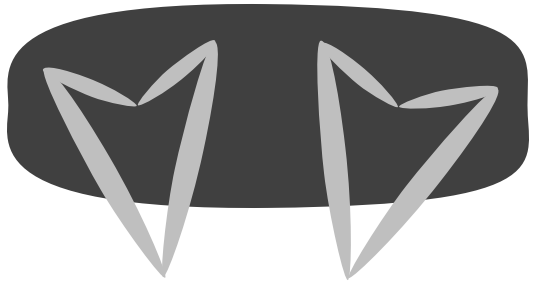

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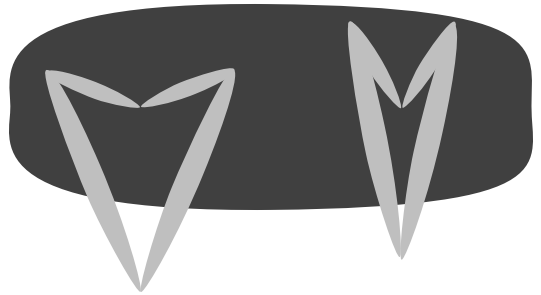

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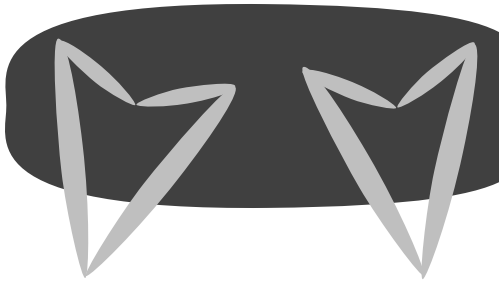

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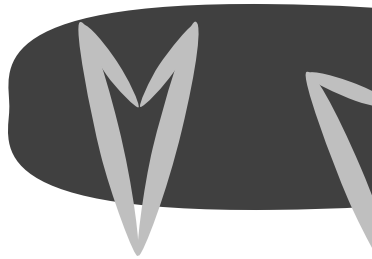

Model Based Systems Quadruped

Virtual Design Review 2

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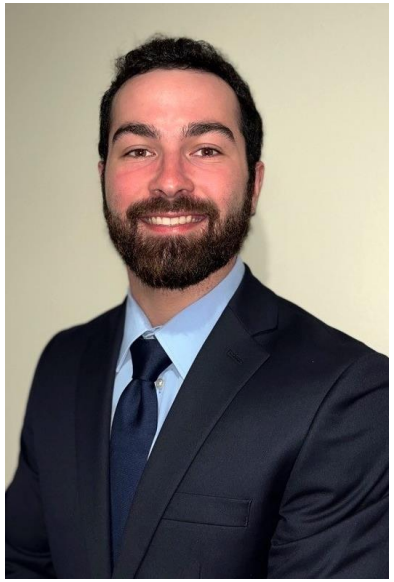
Model Based Systems Quadruped

Virtual Design Review 2

Team Introductions



Milton Bouchard
Fabrication Engineer

Michael Dina
Mechatronics Engineer

Onoriode Onokpise
Systems Engineer

Jackson Raines
Testing Engineer

Zachary Shapiro
Materials Engineer

Sponsors and Advisor

CISCOR

Center for Intelligent Systems, Control, and Robotics

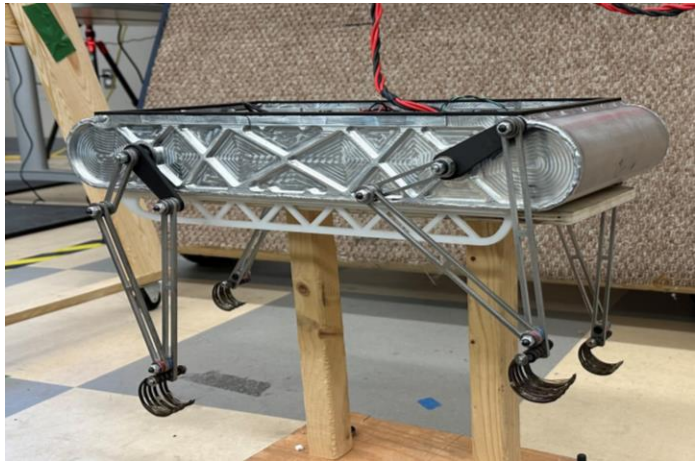
Dr. Jonathon Clark
Sponsor

Dr. Patrick Hollis
Advisor

Dr. Shayne McConomy
Sponsor

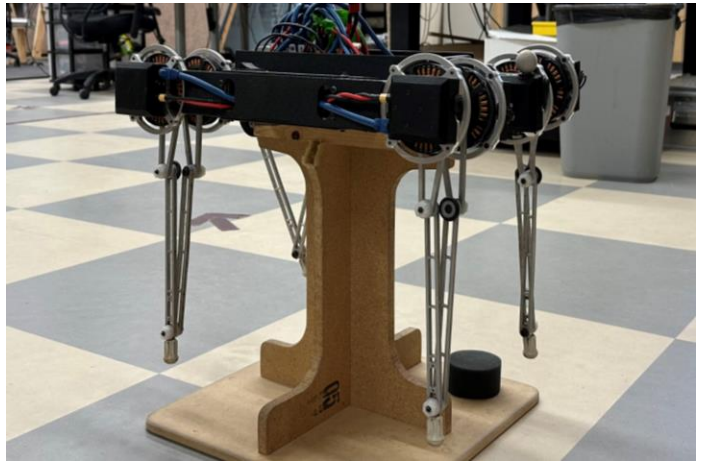
Objective

The objective of this project is to develop a tool that aids in the design of quadrupedal robots using the knowledge gained from previously built CISCOR robots.



ET-Quad

RHex



Minitaur

Primary Market

Professors

Graduate Students

Undergraduate assistants

Primary Market

Professors

Graduate Students

Undergraduate assistants

Primary Market

Professors

Graduate Students

Undergraduate assistants

Primary Market

CENTER FOR INTELLIGENT SYSTEMS, CONTROL, AND ROBOTICS

Professors

Graduate Students

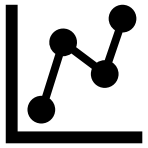
Undergraduate assistants

Secondary Markets

Oregon State University

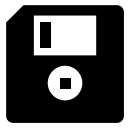
Key Goals

Develop a tool to assist new quadrupedal robot development



Return critical parameter values

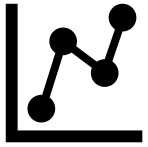
Reduce development time



Act as a database of knowledge for robot development

Key Goals

Develop a tool to assist new quadrupedal robot development



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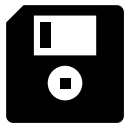
Reduce development time



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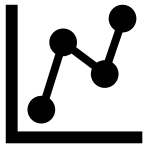

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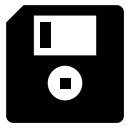

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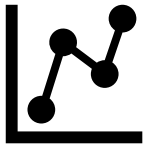

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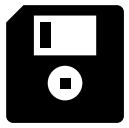

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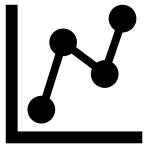
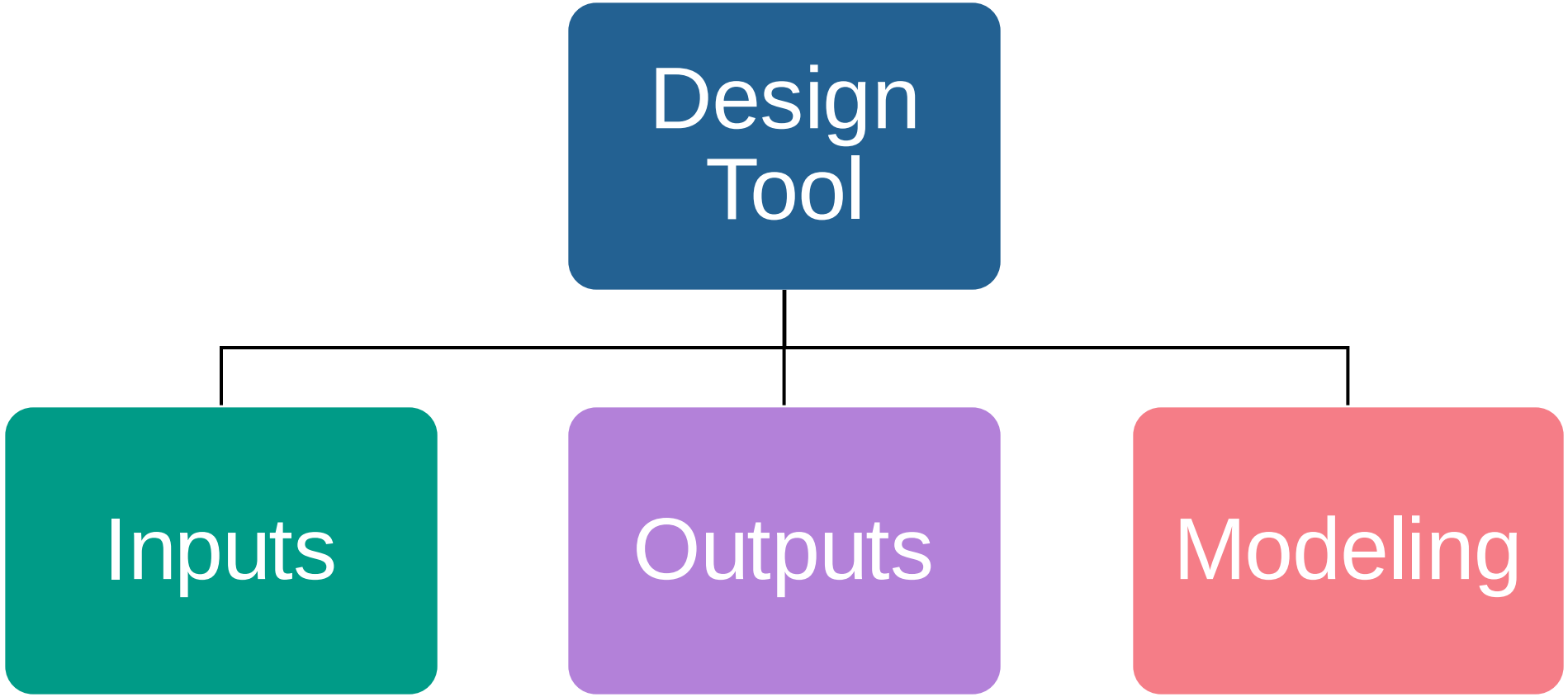


Return critical parameter values

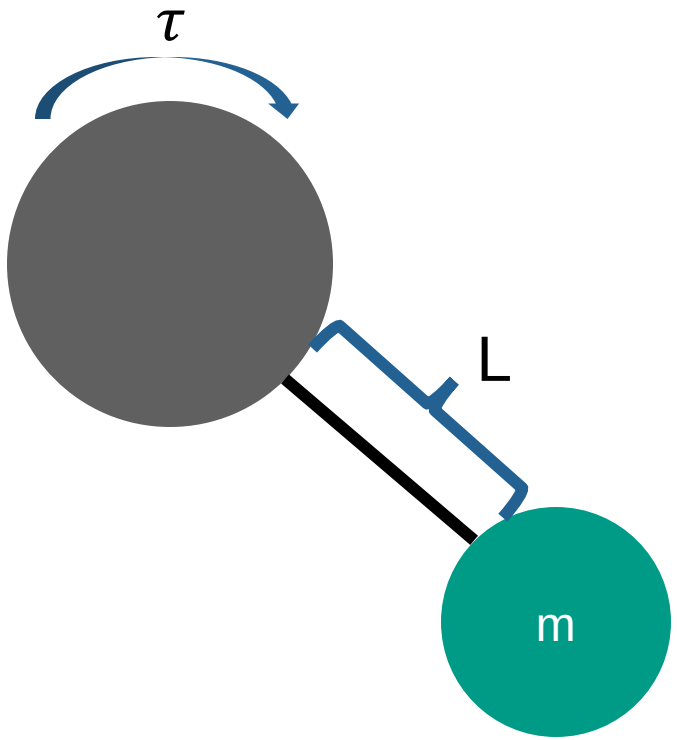
Reduce development time

Act as a database of knowledge for robot development

Functions Hierarchy Chart

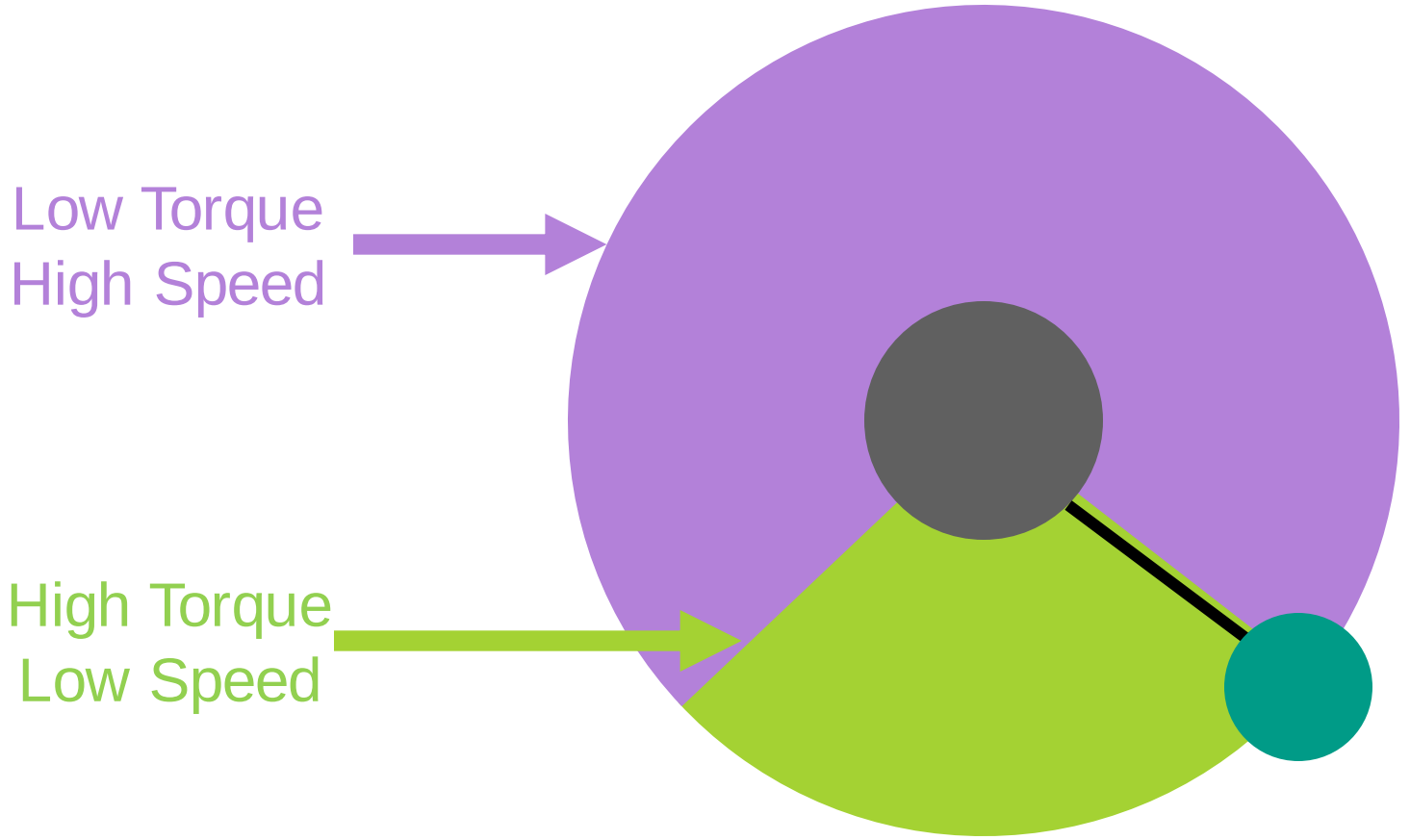


Starting Motor Model - Simple

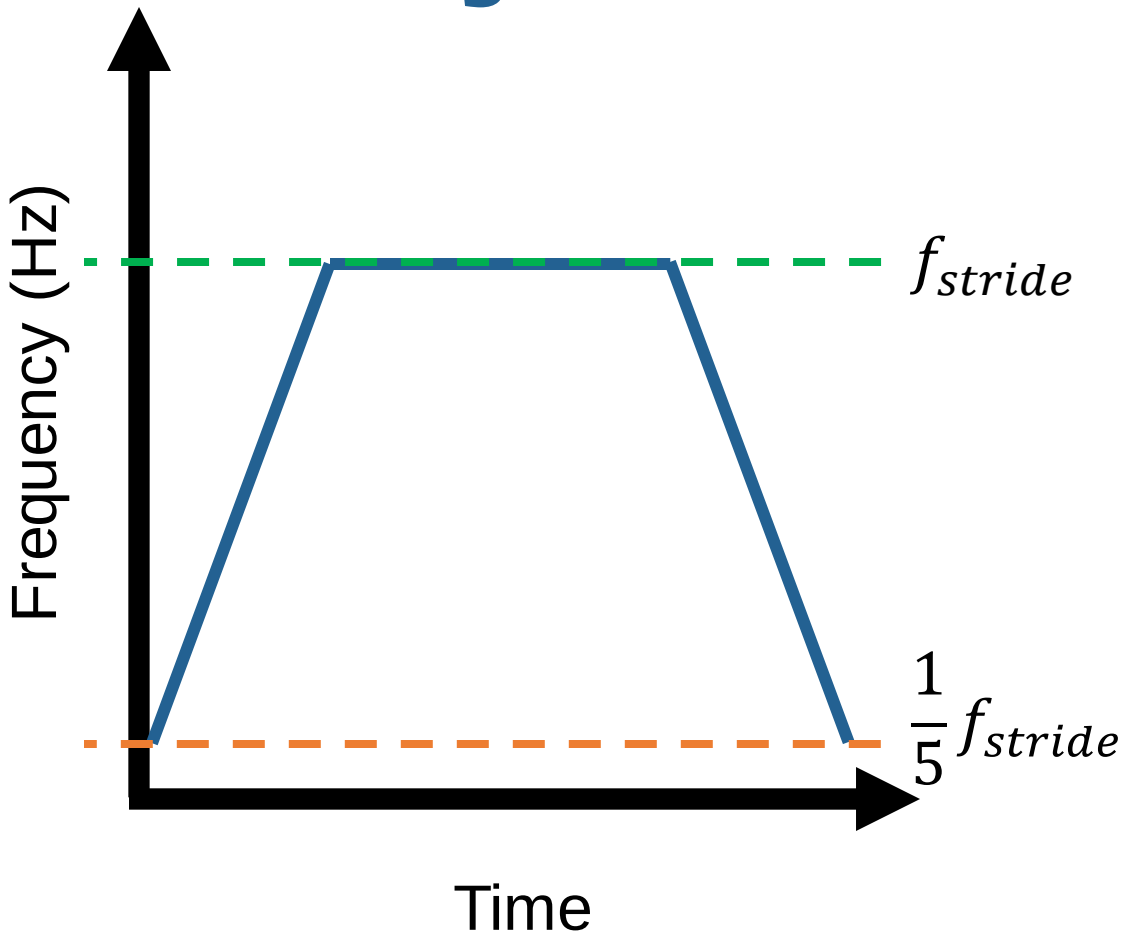


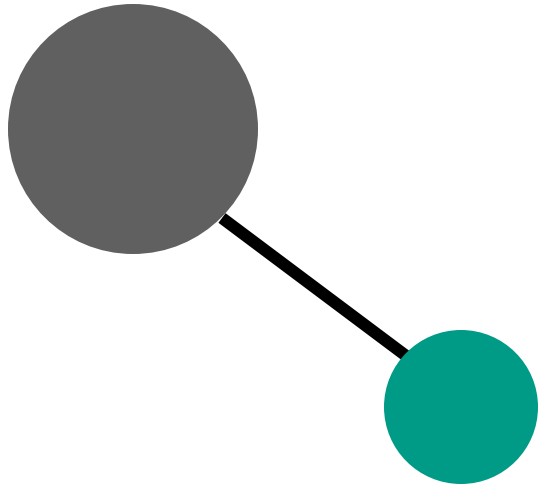
RHex

Two Phases - Slight

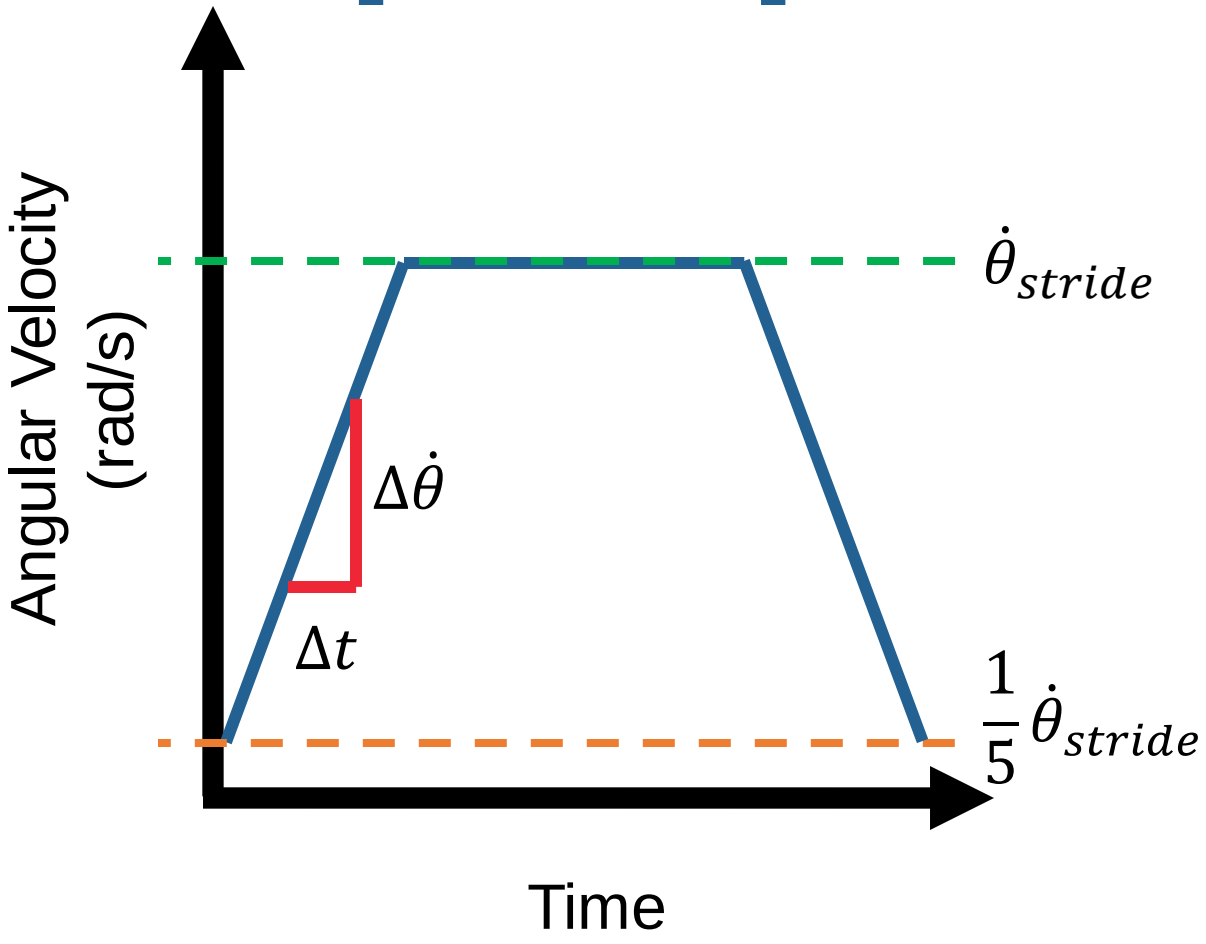


Velocity Profile

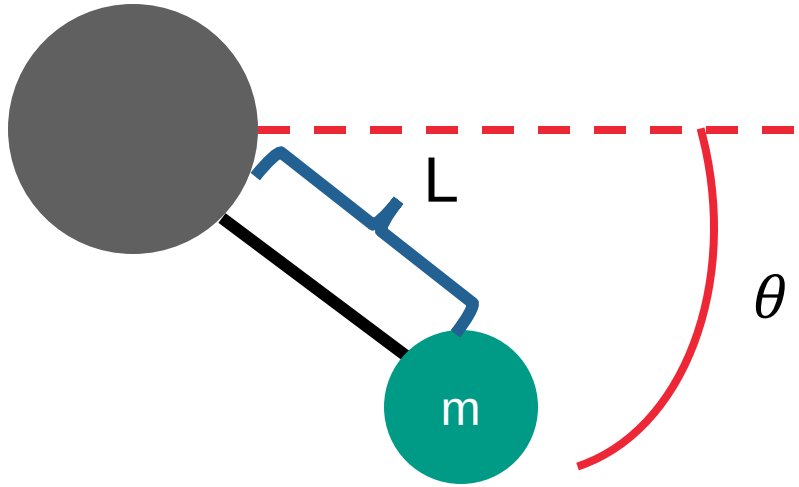




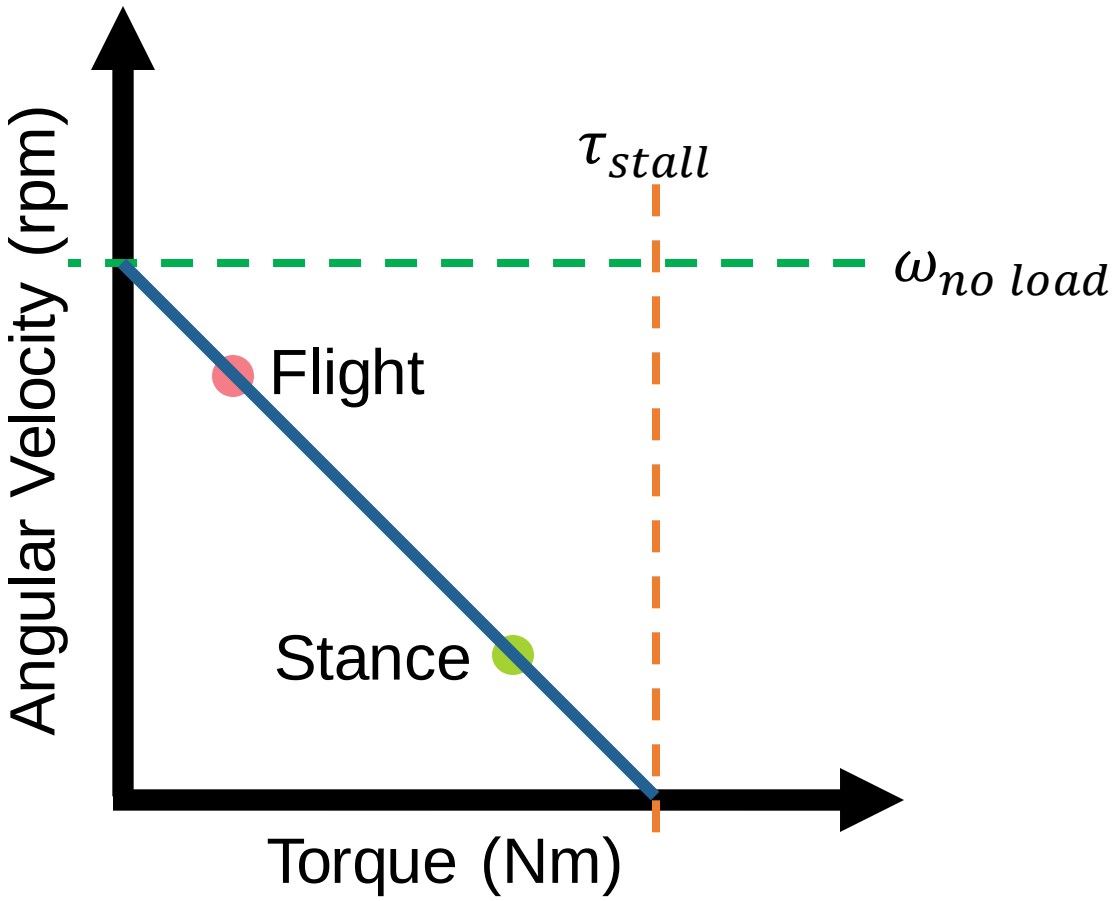
Torque Required

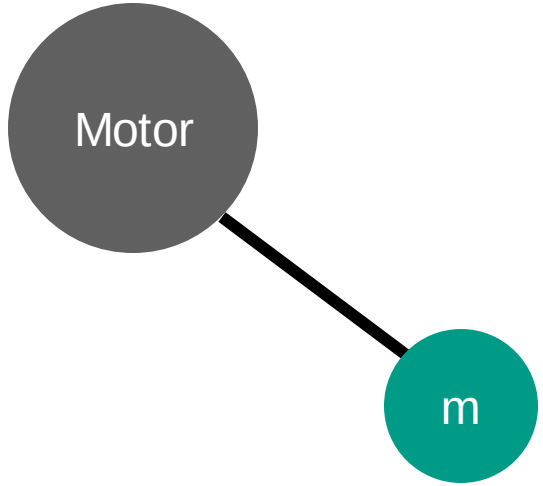


$$\tau_{stance} = m\left(\frac{8\pi f_{stride}}{5\Delta t}\dot{\theta} + g\cos\theta\right)$$



Speed-Torque Curve





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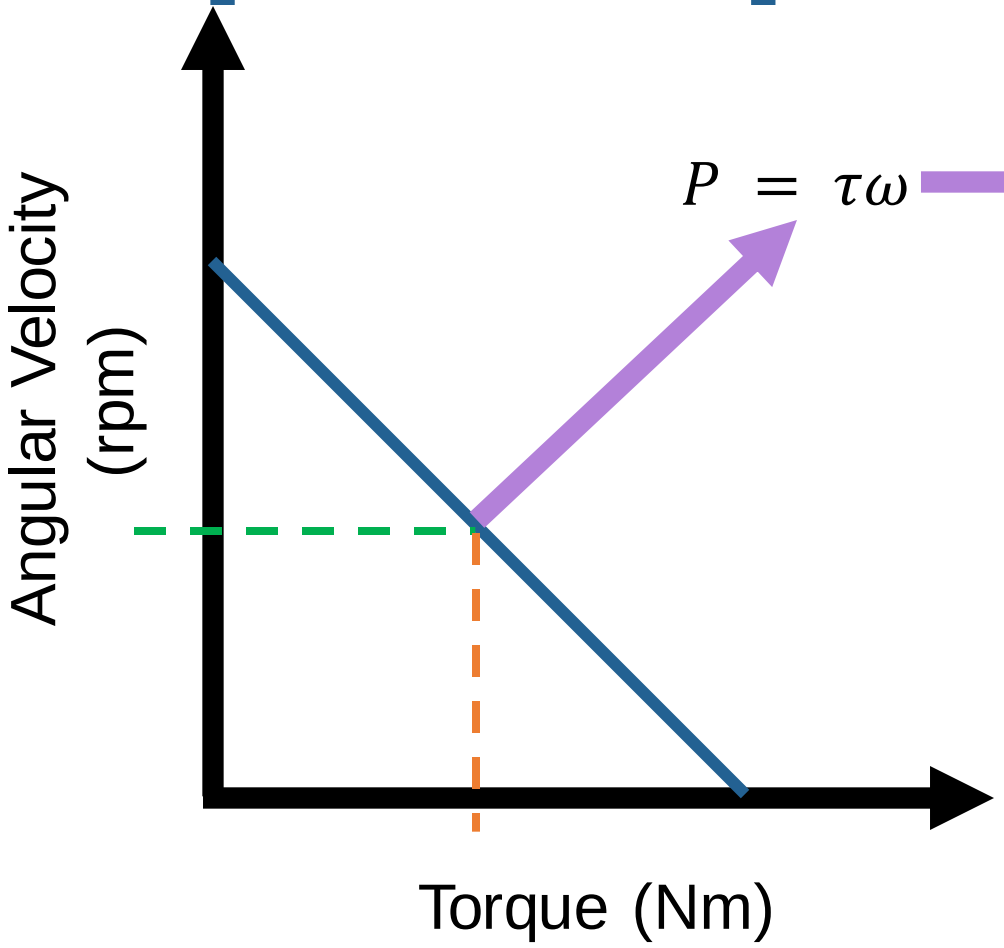
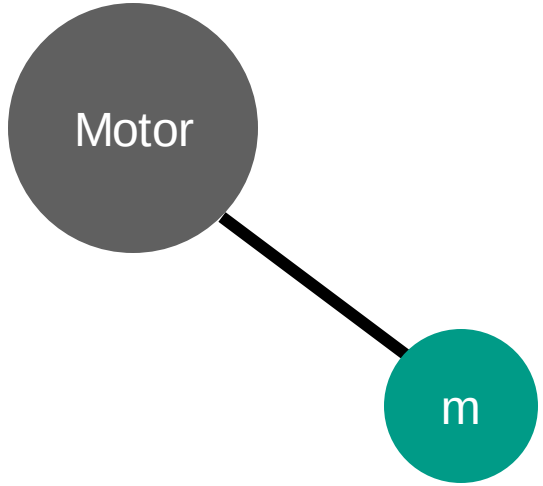
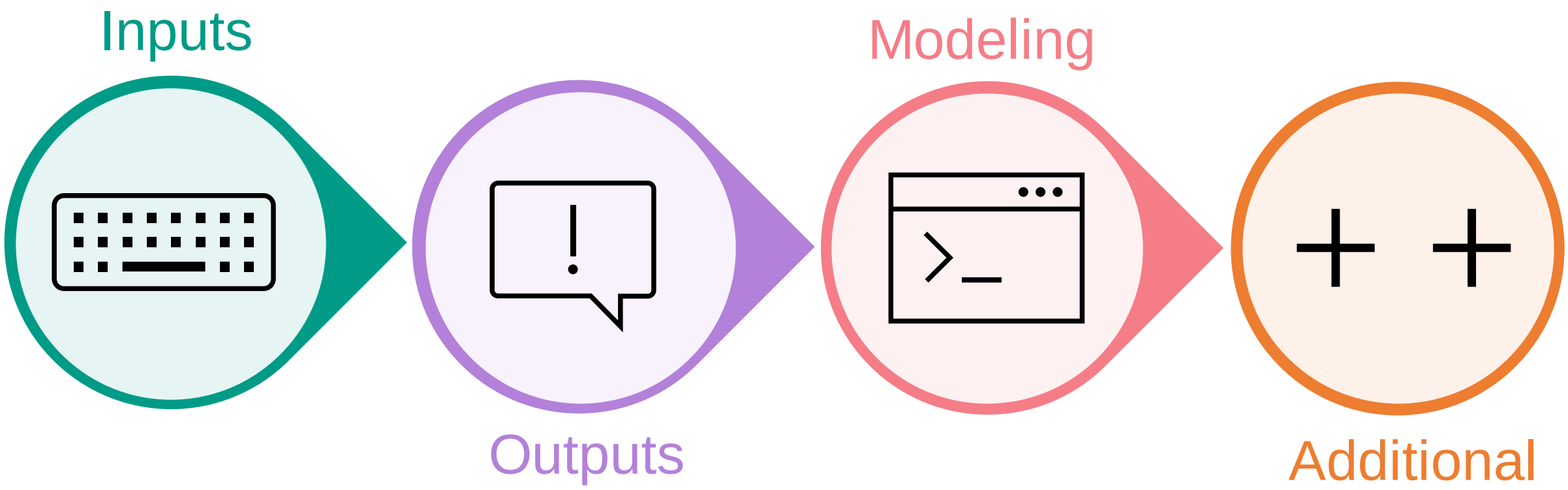


$$P = \tau\omega \rightarrow P \propto m \rightarrow m_{motor} \cong 0.2m_{total}$$



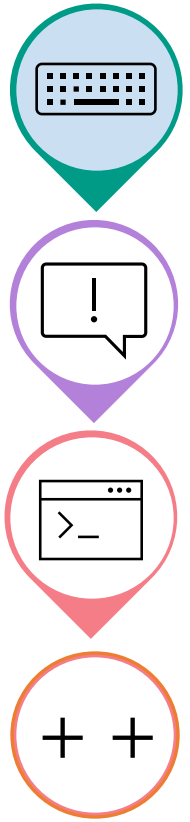
Targets and Metrics



Targets and Metrics

Inputs

Accepts general robot characteristics	1	Binary
Accepts performance specifications	1	Binary

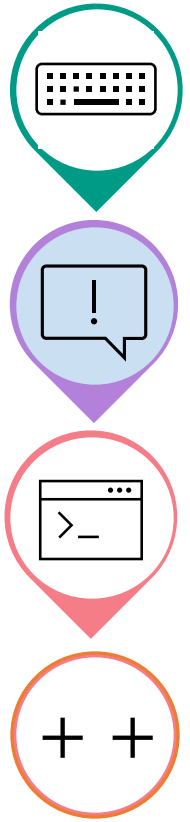


Targets and Metrics

Outputs

Produces and stores critical targets catalog	1	Binary
Calculate critical targets based on user input	1	Binary

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

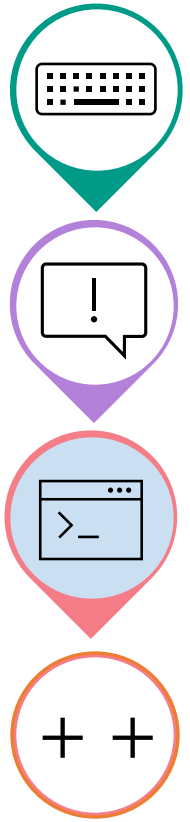


Targets and Metrics

Modeling

Calculate critical targets based on user input	1	Binary

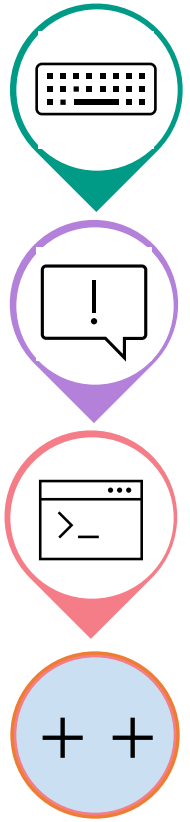
$$\tau_{stance} = m\left(\frac{8\pi f_{stride}}{5\Delta t} + g\cos\theta\right)$$



Targets and Metrics

Additional

Time to order	15 min	Time
Force required at the foot	±10%	Margin of Error
Torque required at joint	±10%	Margin of Error

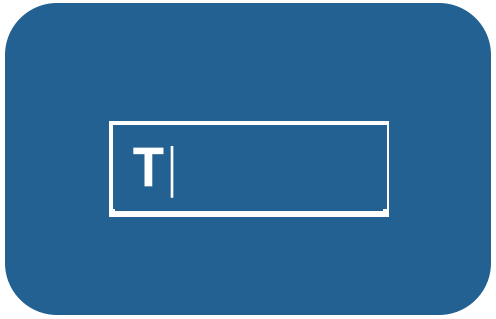


Concept Generation

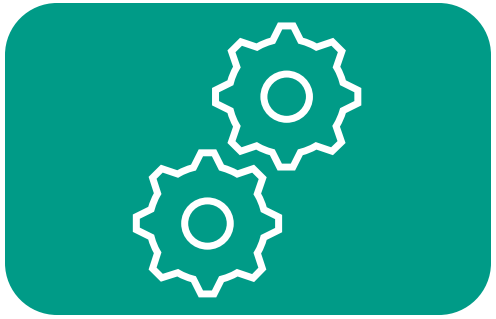
Brainstorming

Forced Analogy

Medium Fidelity



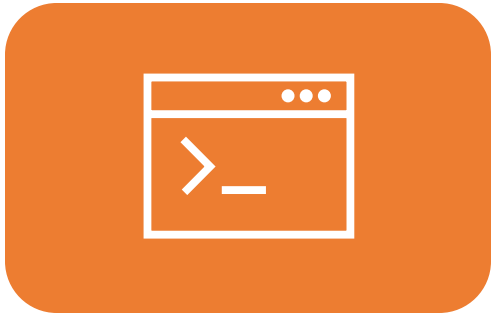
MATLAB Textbox



Simscape Model

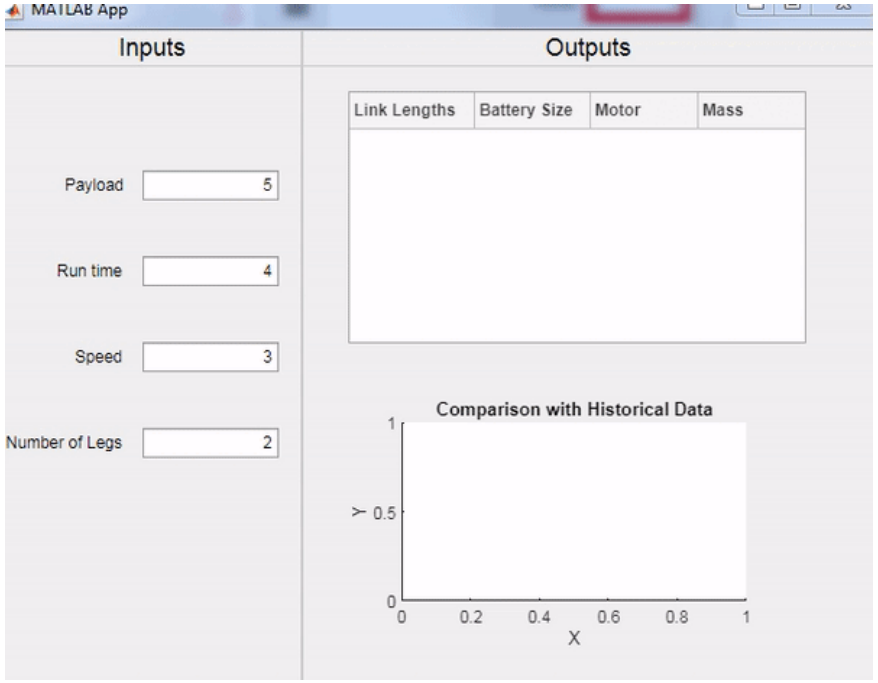
MATLAB GUI with information Dashboard

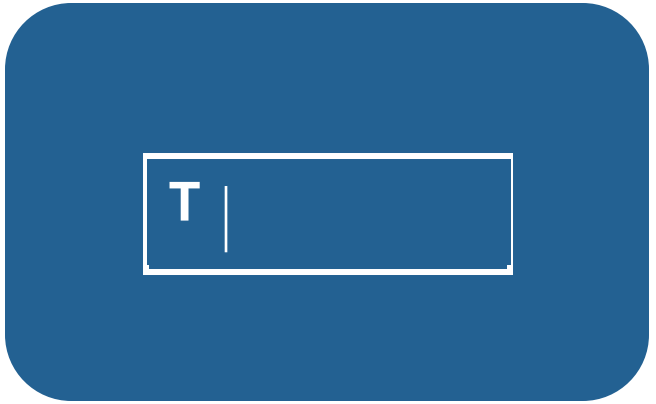
Racing Car Game Selection



MATLAB command line

Medium Fidelity – MATLAB Textbox

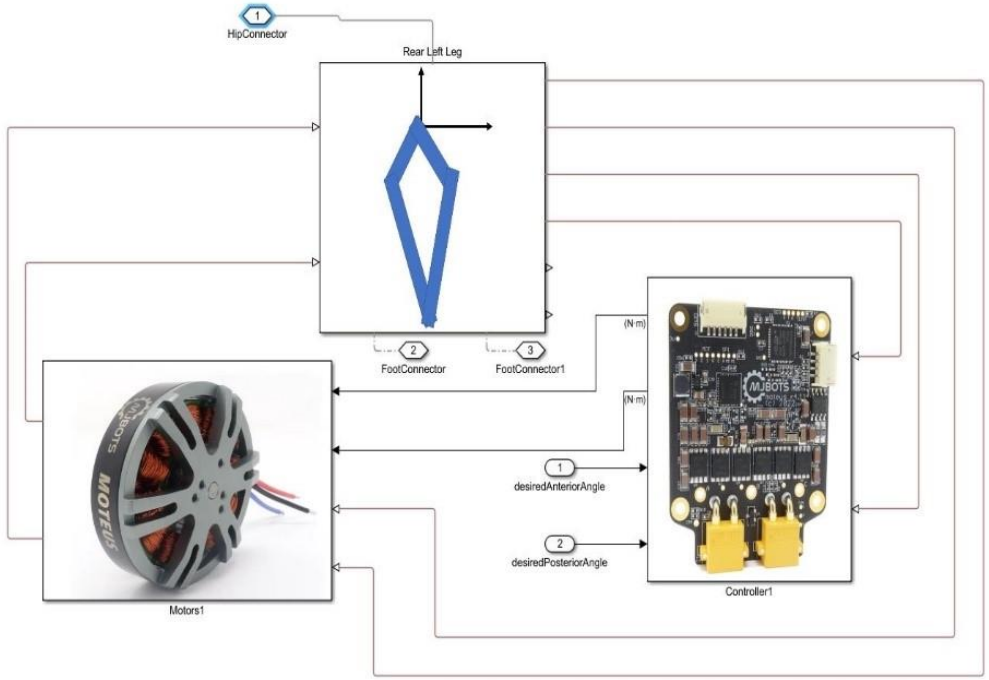


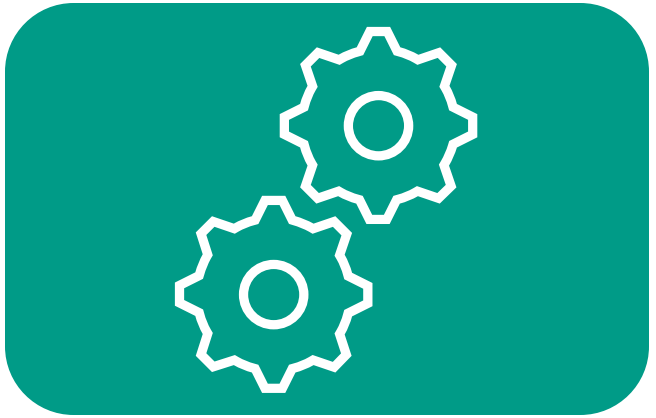


MATLAB Textbox

MATLAB App focused on textbox input with visual results relayed to users

Medium Fidelity – Simscape Model





Simscape Model

Simscape app which allows the user to create dynamic models

Medium Fidelity – Information Dashboard

MATLAB GUI with information Dashboard

Idea to have a similar MATLAB app with a dashboard to display info to the user

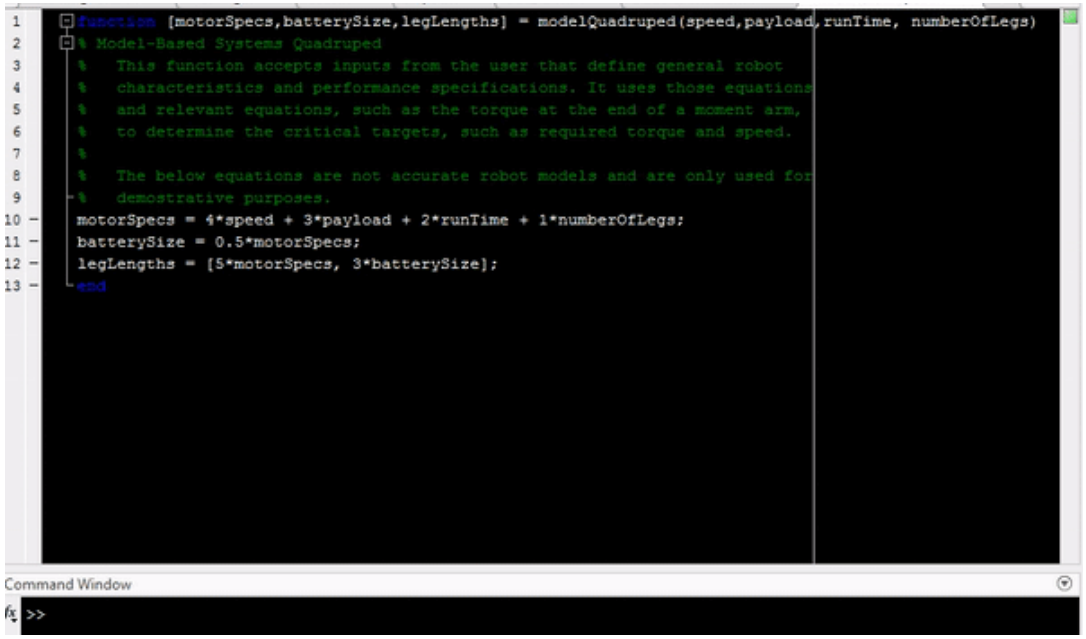
Medium Fidelity – Racing Car Game

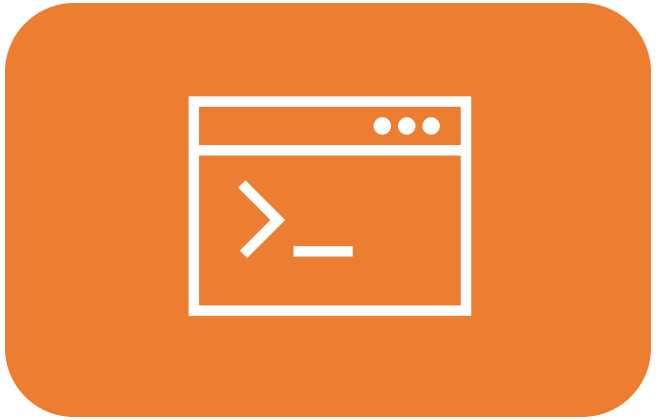
© Nintendo, 2018

Racing Car Game Selection

Robot characteristics selected like Mario Kart components with visual comparisons

Medium Fidelity – Command Line

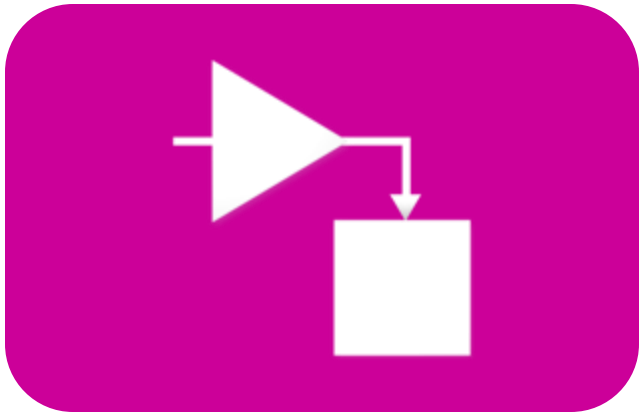




MATLAB command line

MATLAB function called from the command line with results shown as graphs/text

High Fidelity

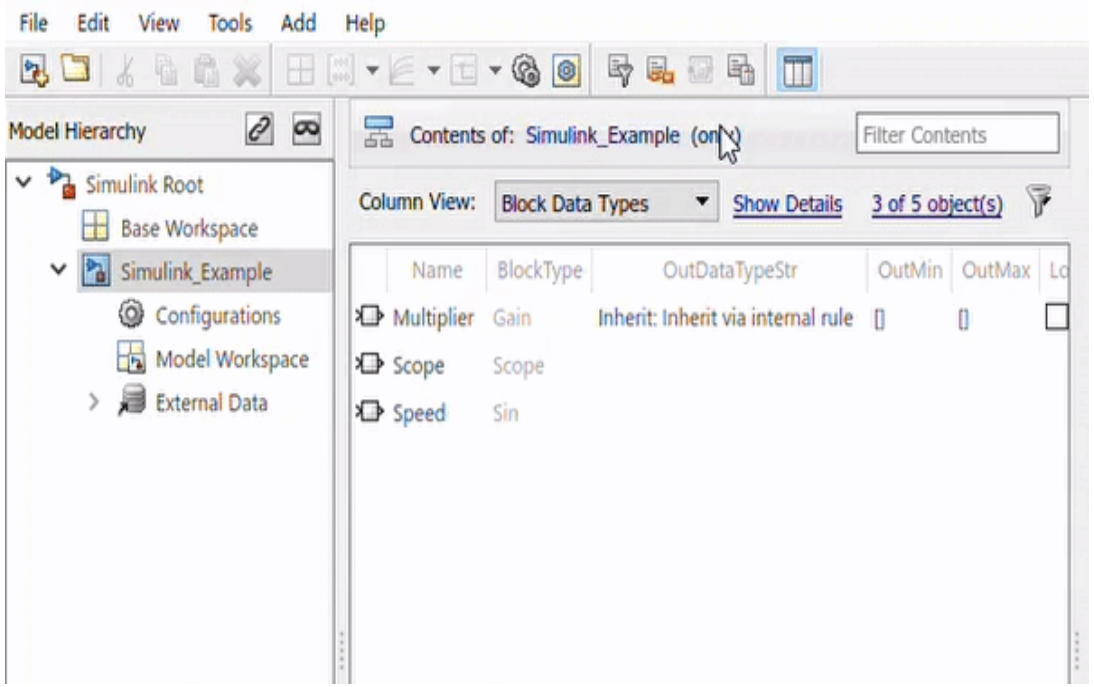


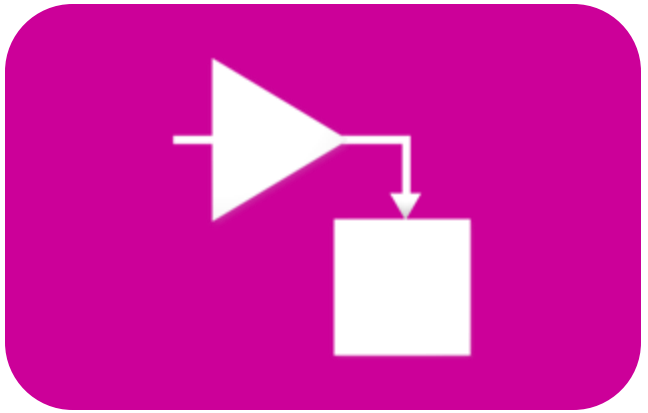
MATLAB to Simulink

MATLAB GUI with Dropdowns

System Composer GUI

High Fidelity – MATLAB to Simulink

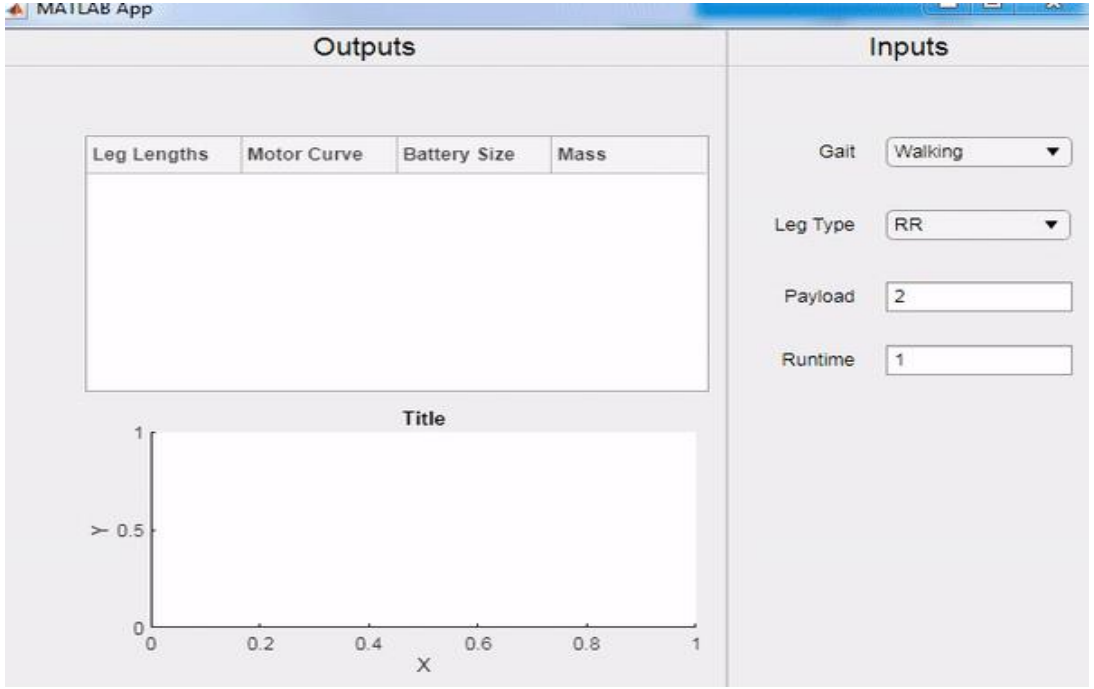




MATLAB to Simulink

Custom MATLAB variables which affect a running Simulink model

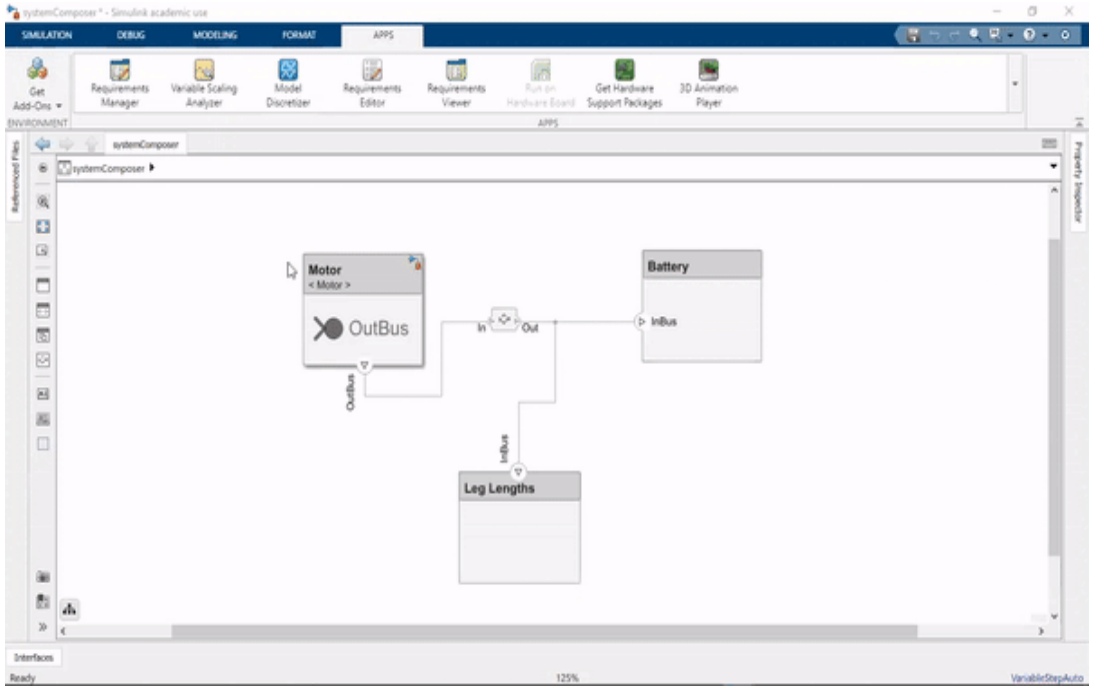
High Fidelity - Dropdowns



MATLAB GUI
with Dropdowns

MATLAB GUI with dropdown inputs with clear, predefined options for robot features

High Fidelity – System Composer

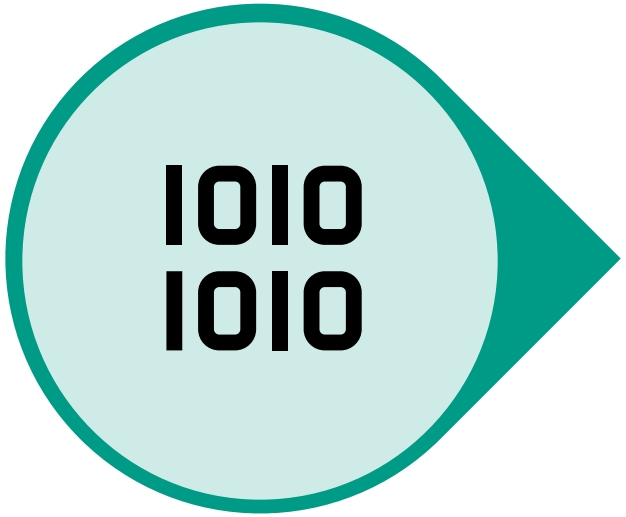


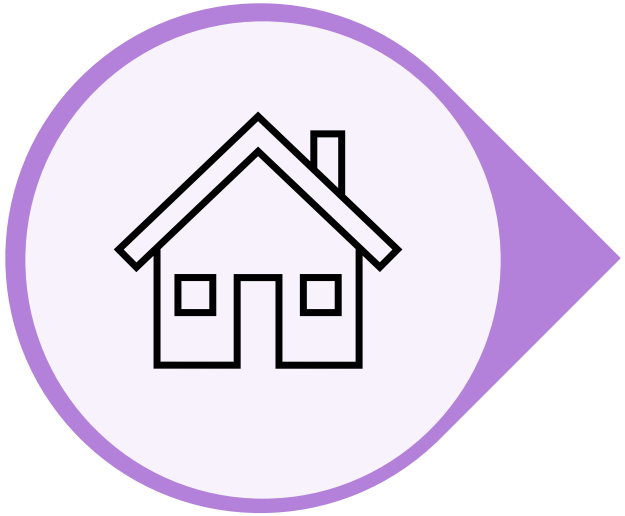
System Composer GUI

Comparative relations formed using user input functions and targets

Concept Selection

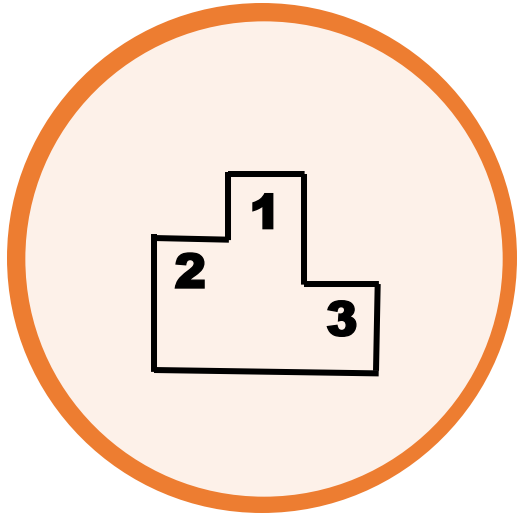
Pairwise Comparison





House of Quality

Pugh Chart



Analytical Hierarchy

Binary Pairwise Comparison

House of Quality

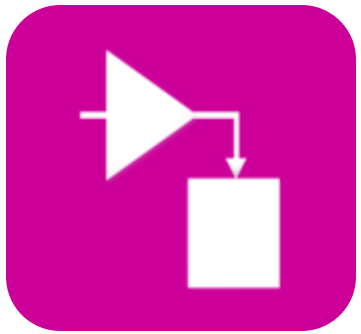
Accepts Performance Specifications	Calculate Critical Targets From Inputs	Accepts General Robot Characteristics	Produces and Stores Critical Target Catalog	Accepts Old Parameters and Data	Generates Simple Block Model
Produces Graphic for Comparisons	Time to Order	Generates Dynamic Model	Populates Parametric CAD Model	Displays Information Dashboard	Generates a Bill of Materials
		Updates Model with New Information	Stores Old Parameters and Data		

Pugh Chart

Pugh Chart

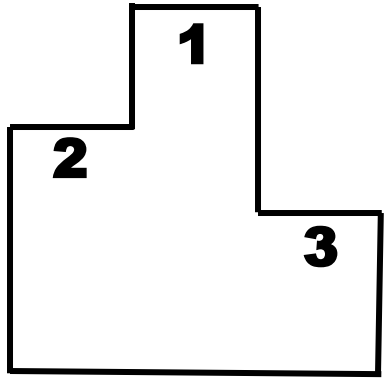
MATLAB
to Simulink

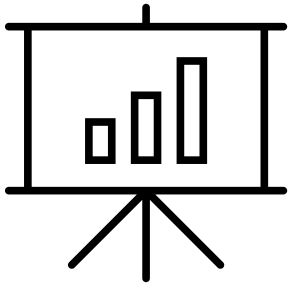
MATLAB GUI with
Information Dashboard

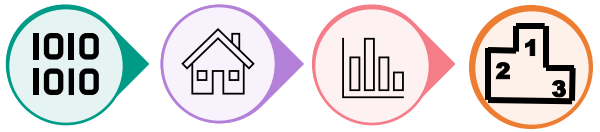


System
Composer

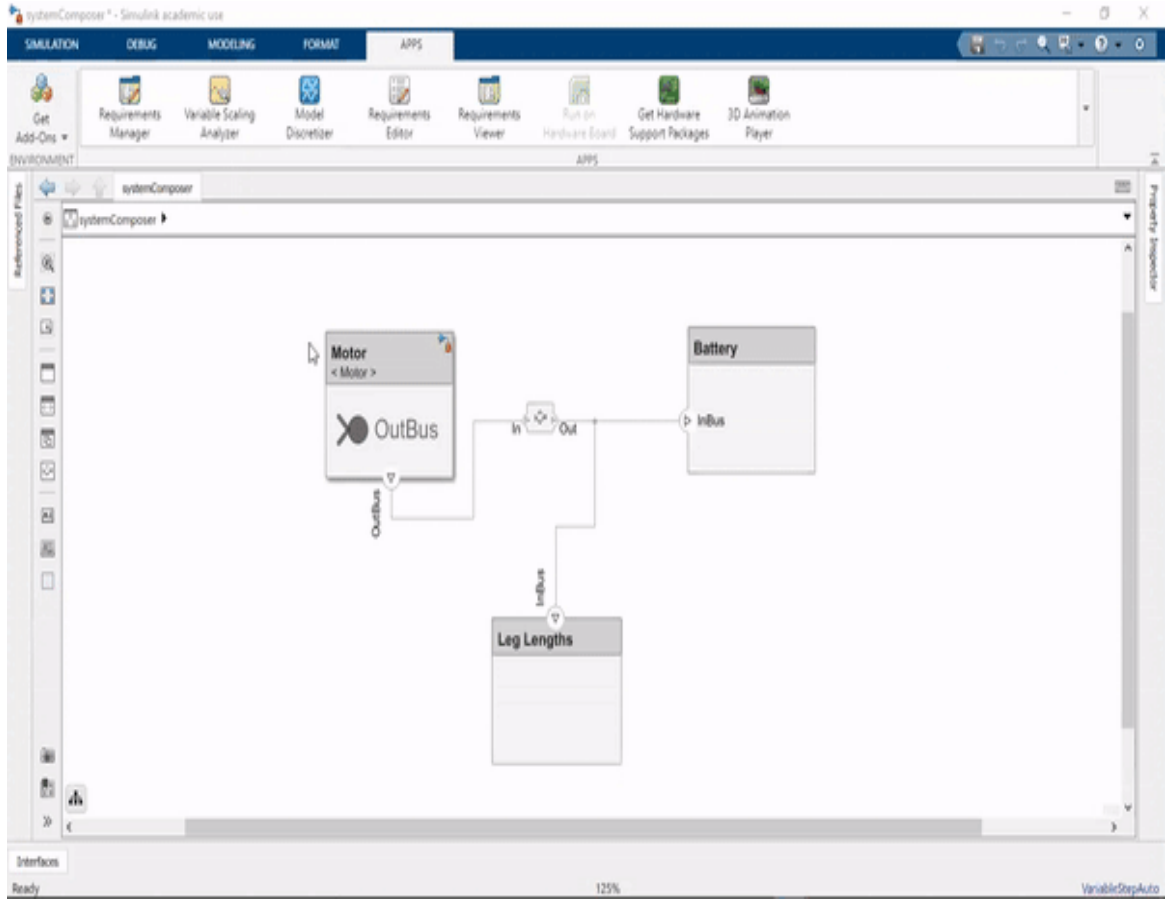
Analytical Hierarchy Process







Final Selection



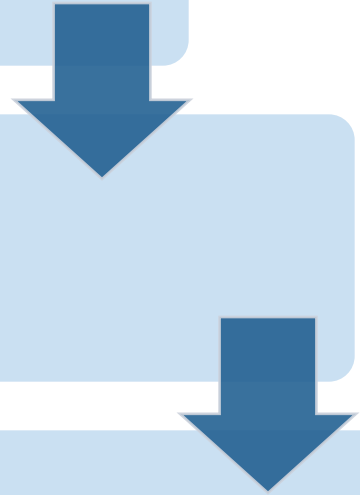
System Composer GUI

Accepts constraints from user in the form of performance characteristics

Attach Simulink models to specific functions

Future Work

Practice System Composer



Future Work

Practice System Composer

Continue user interface prototype

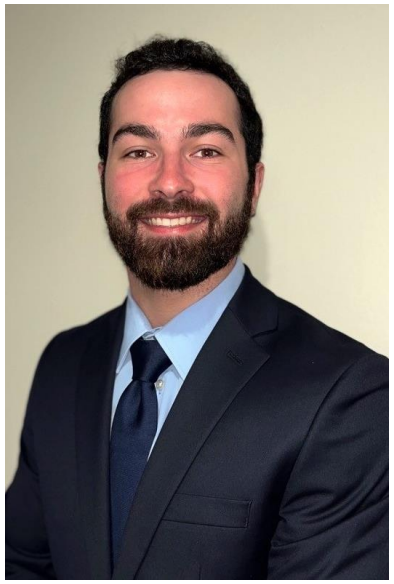
Future Work

Practice System Composer

Continue user interface prototype

Analyze SLIP model

LinkedIn Profiles



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Jackson Raines
Testing Engineer

Zachary Shapiro
Materials Engineer