Development of 3D-Printed Humanoid Robots

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Introduction

Aashish Singh Alag

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Project Roadmap

1 — 2 — 3 — 4

Background

Review of Koalby (2022, MQP) and Literature Review of Humanoid Robots

Analysis

ANSYS, FBD, Multivariable Calculations, Motor standardization

Redesign

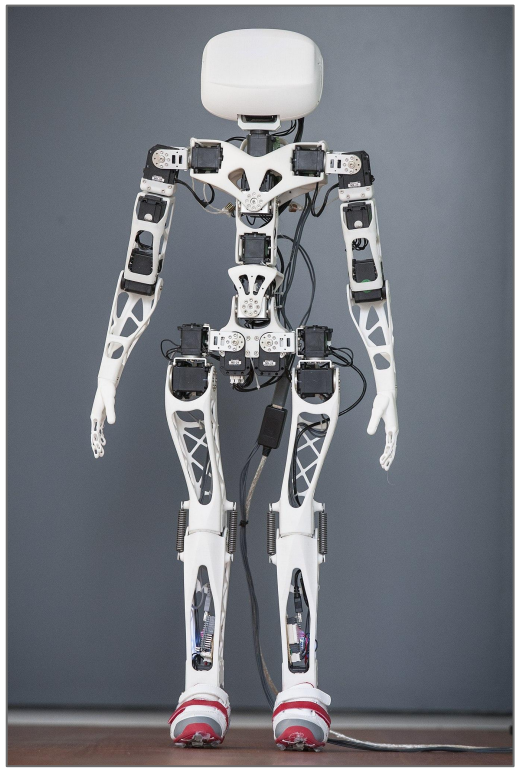
Implementation of design changes to improve overall functionality and strength

Assembly

Testing of Redesigns and Assembling of Ava

Last Year

Poppy



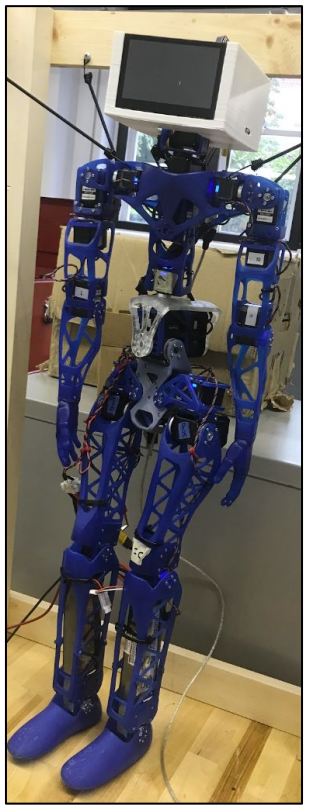
Koalby MQP 2022

Recreated the Poppy Project

Replaced motors to reduce cost

Arm motions like waving and dancing

Koalby

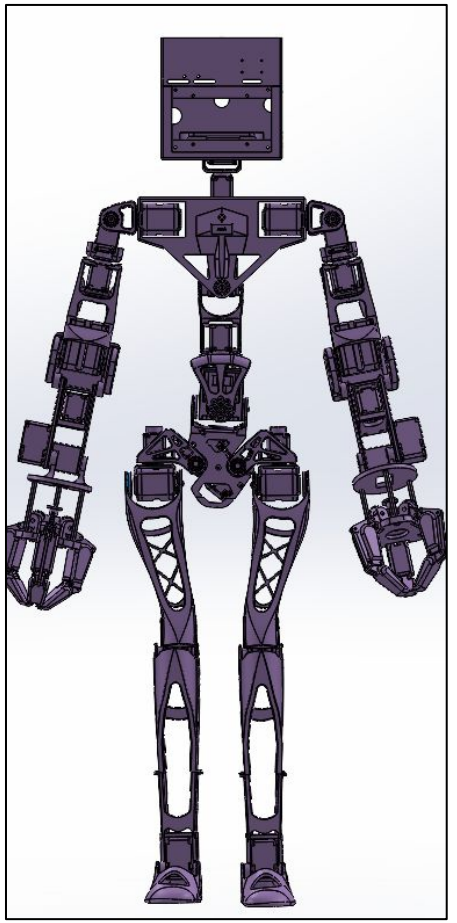


Our Goals

Build a new robot to function as a lab assistant

- Improve Structural Integrity
- Design for Walking
- Gripping Functionality
- Standardized Components

Ava

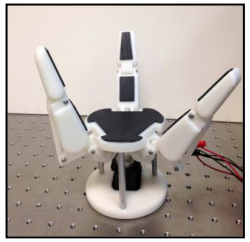


Research

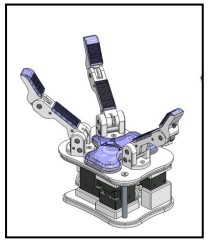
Literature Review

- *Grips*
  - 3-point grip
  - Encompassing grip
- *Walking*
  - Feet
  - Spine
- *Applications*
  - Medicine
  - Industry
  - Service

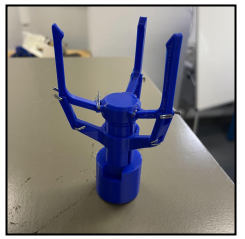
Underactuated Robotic Grip



Model O



The Claw



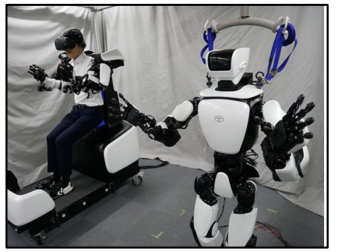
Humanoid Robot Lola

ASIMO

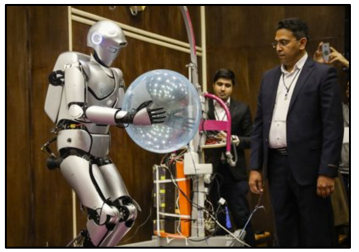
HUBO (KHR-3)

Digit

T-HR3



Surena Robot



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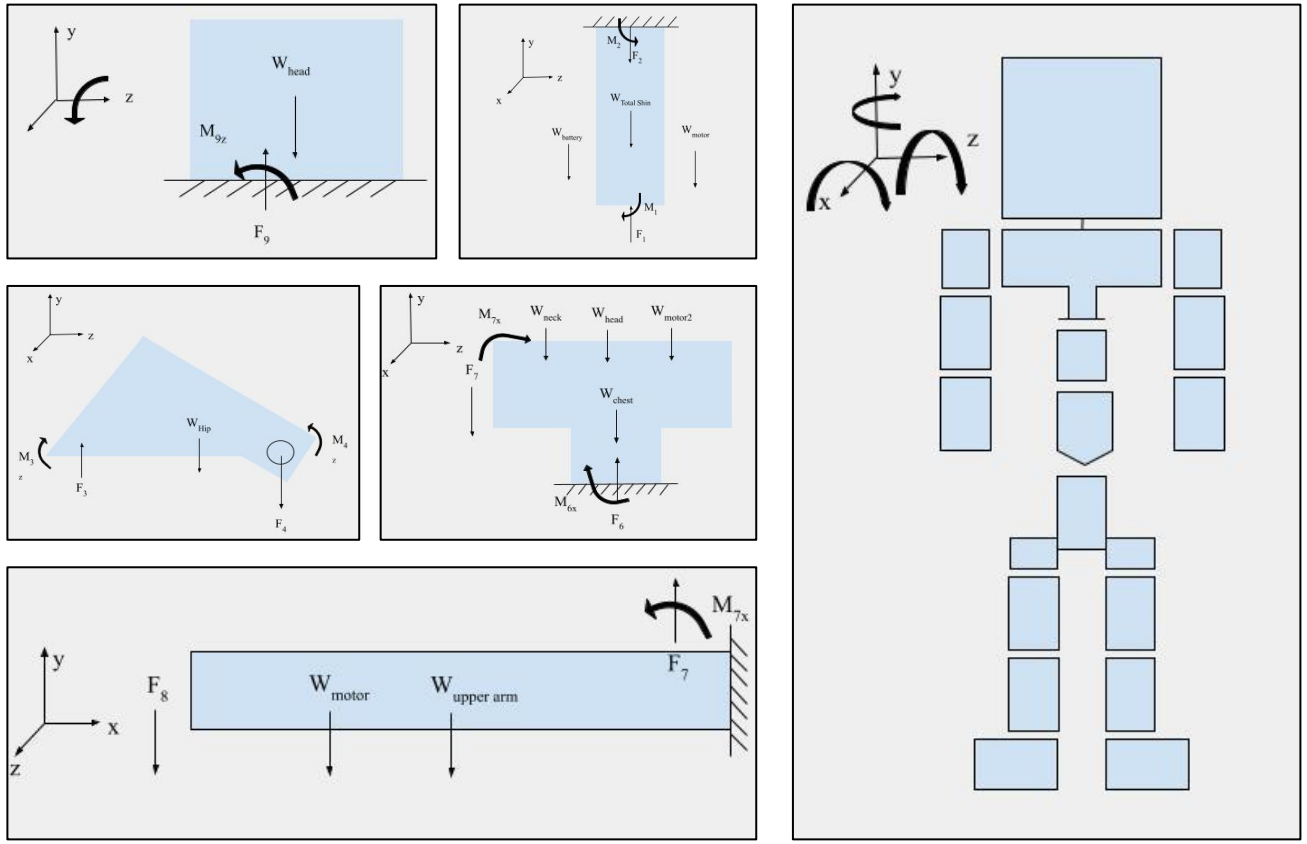
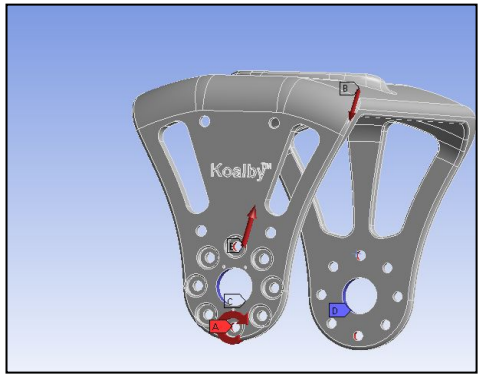
Improve Structural Integrity

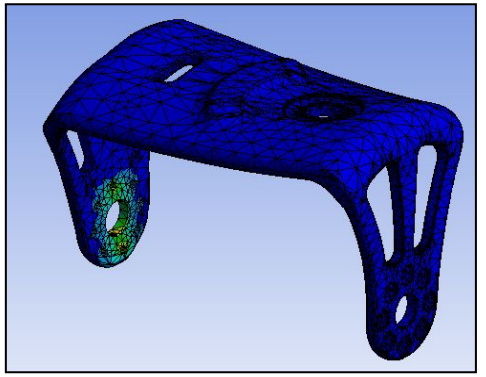
Force Analysis

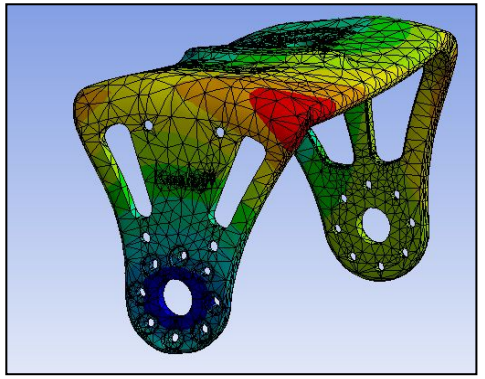
Free Body Diagrams were used to understand where the various forces and moments were being applied to on the parts to then calculate resulting reactions



ANSYS was helpful in highlighting the areas that experienced the greatest stress and deformation

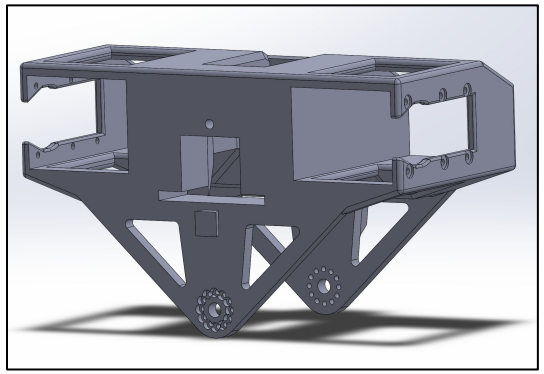






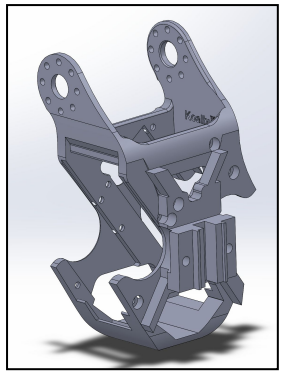
Redesigned Parts

Chest



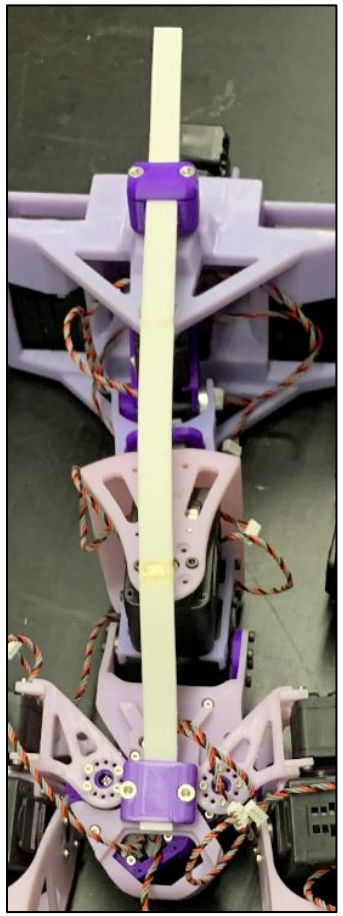
- Increase width to accommodate new motor.
- IMU placement on front.
- Spine attachment on back.

Pelvis



- 5mm thickness increment was made to reinforce the component.
- Attachments were added for the spine.

Spine



- Flexible Rod design.
- Fixed at the Pelvis.
- Limited movement at the chest to support bending motion.

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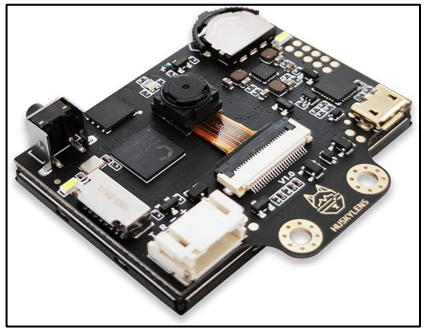
Design for Walking

Sensor Integration

Huskylens Camera

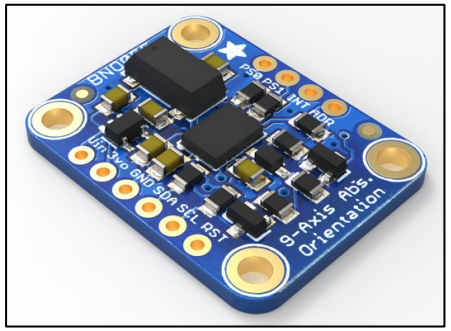


AI Camera used to detect colors and objects. Attached to the head.

LiDAR TF Luna

LiDAR used for obstacle proximity with an accurate range up to 3m. Attached to the chest.

IMU BNO055



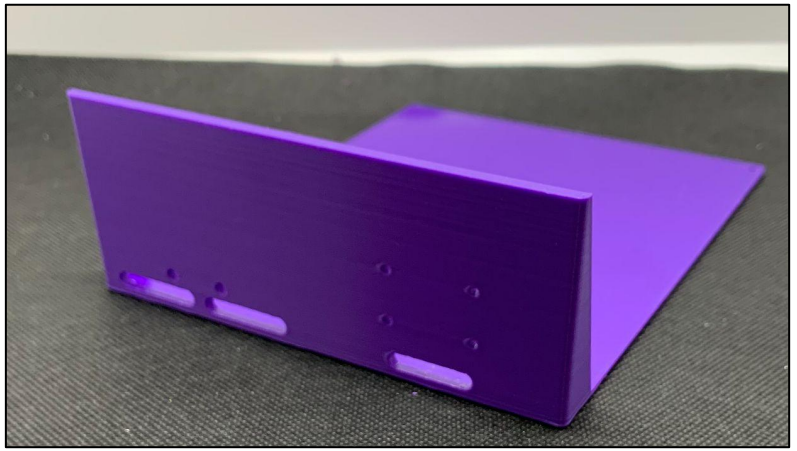
IMU used to record position and balancing data. Attached to the chest.

Walking Redesigns

Feet

Foot was made wider and holes were added for IMU implementation. Polyvinyl Chloride (PVC) was attached to the bottoms to improve traction.

Head Lid



New attachment points made for TF Luna Sensor and HuskyLens were added to the lid

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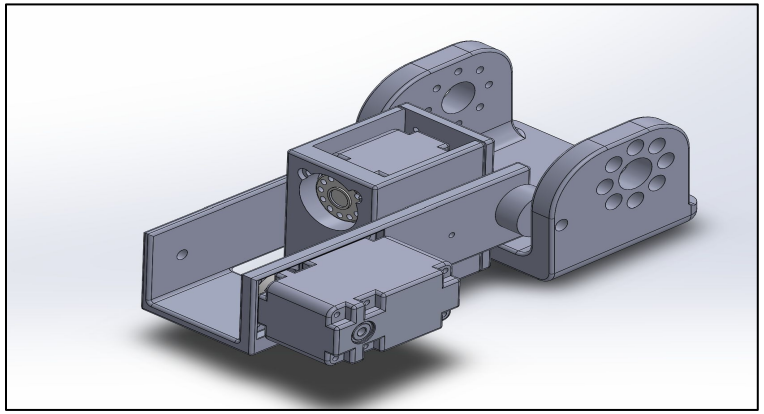
Gripping Functionality

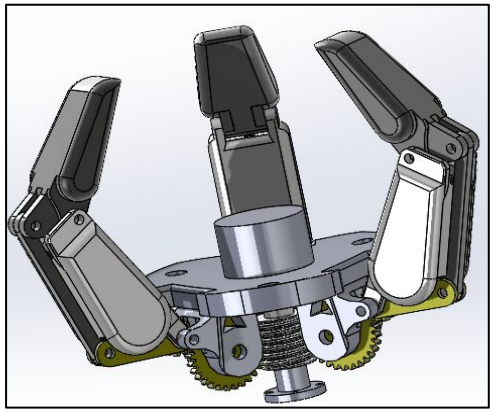
Forearm and Grip Redesigns

Forearm



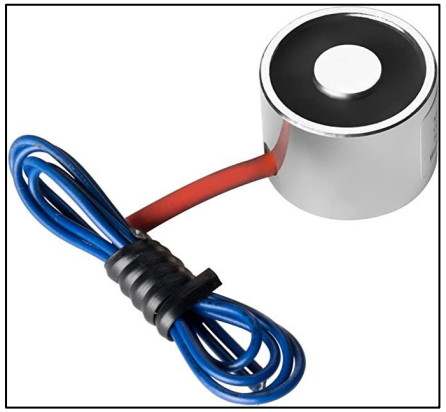
Forearms were made wider and a motor connection point was created at the wrist for the grip

Grip



Underactuated Grip was modified and scaled down to fit Ava

25N Electromagnet



Electromagnet was used to improve the handling and manipulation of objects

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Standardize Components

Motor Standardization

Key Considerations

- Stall Torque
  - Multivariable Torque Analysis
- Weight
- Cost

Key Functionality Considerations

- One motor brand
- Feedback and control capabilities
- Communication speed and resolution

Dynamixel MX-64AT

Stall torque: 7.3 at 14.8V
Weight: 135g
Cost: $370

HerkuleX DRS-0601

Stall torque: 7.6 at 14.8V
Weight: 123g
Cost: $320

Dynamixel AX-12

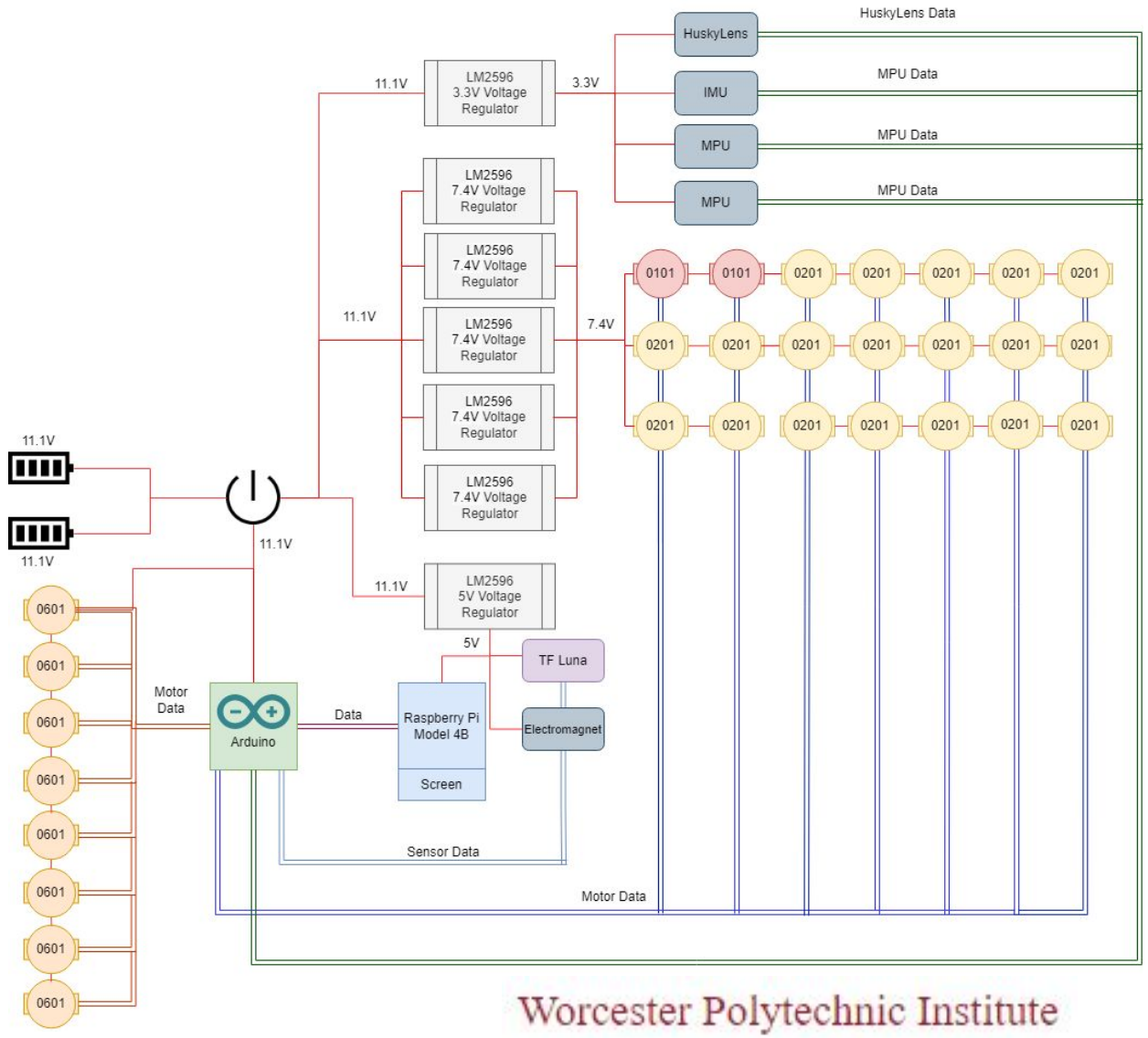
Stall torque: 1.5 at 12V
Weight: 55g
Cost: $50

HerkuleX DRS-0101

Stall torque: 1.18 at 7.4V
Weight: 45g
Cost: $40

Electrical Redesign

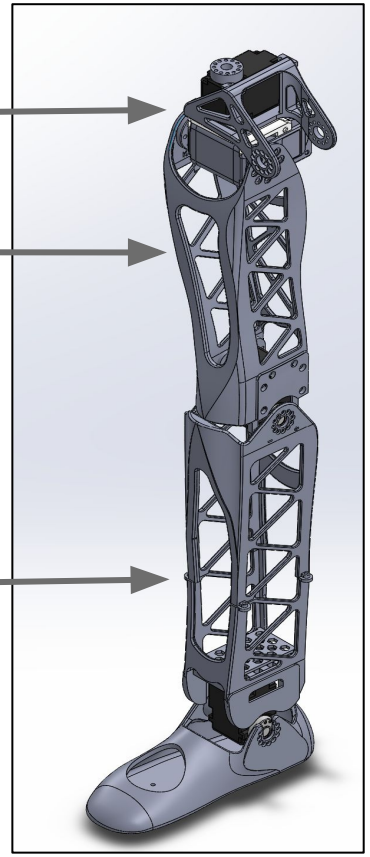
- Increased available power for new motors and sensors
  - 7.4V to 11.1V Batteries
  - Voltage Regulators
- Improved durability & reliability
  - Replaced worn components
  - Used higher-quality wires



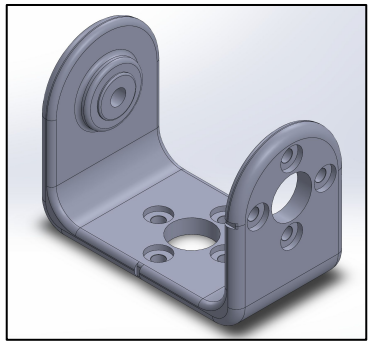
Standardization of Parts

Standardization *of parts include: adjusting motor sizes and removing motor mounts*

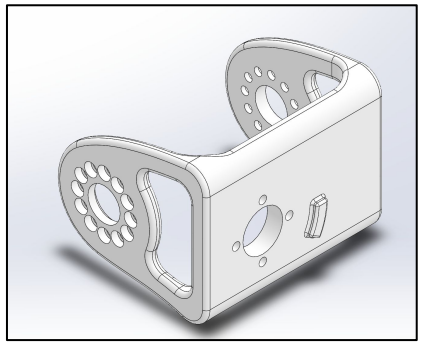
Leg Assembly



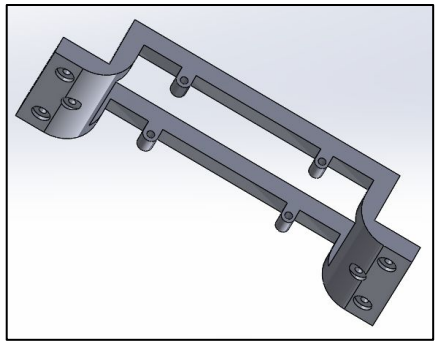
Neck



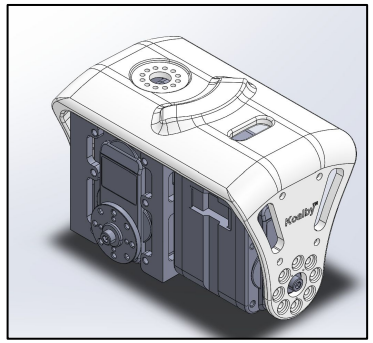
Shoulder



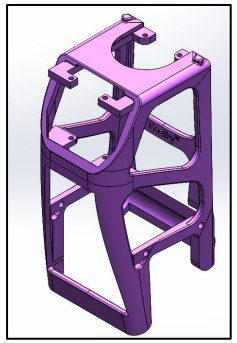
Head Bracket



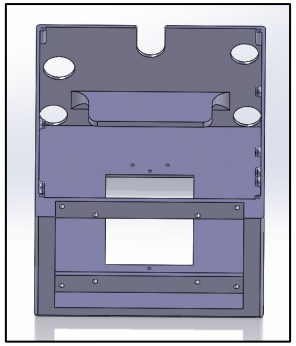
Abdomen



Bicep



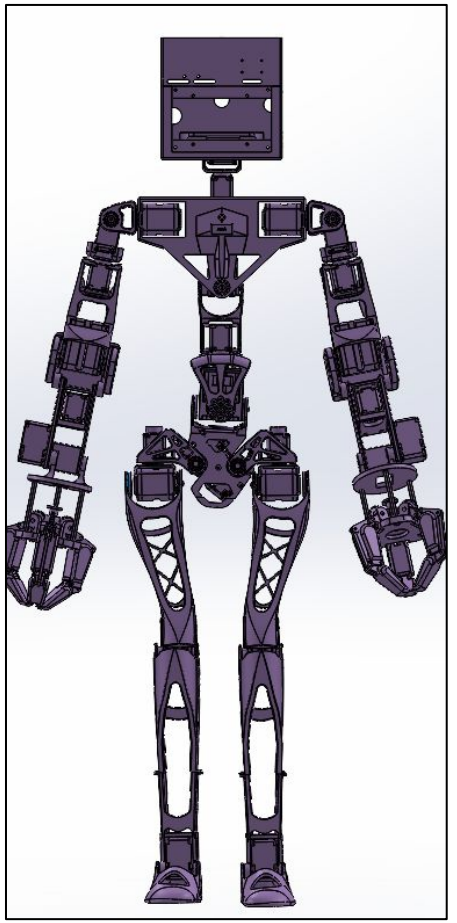
Head



Overall Achievements

- **Improved Structural Integrity**
  - Adjusted the chest and pelvis
  - Added a spine
- **Designed for Walking**
  - Integrated IMUs in the feet
  - Added camera to the head
- **Gripping Functionality**
  - Designed a grip
  - Modified forearm to fit grip motors
- **Standardization of Components**
  - Changed motors
  - Adjusted parts to fit motors

Ava



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Future Work

What’s next?

1

Testing

Furthering testing of the spine and grip

2

Pressure Sensors

Install pressure sensors for feedback during autonomous walking and gripping

3

Hazard Resistance

Develop a temperature and water resistance solution for the robot to explore additional applications

Thank you!
Questions?