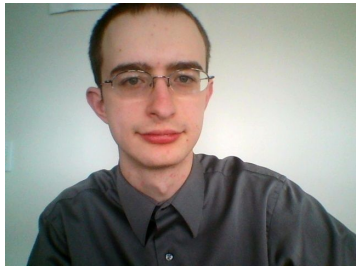
B.R.O.

Basketball Return Optimizer

MDR

Team Members



Derek Foster (EE)

Devon O'Rourke (CSE)

Brian Acker (CSE)

Adam Paranay (EE)

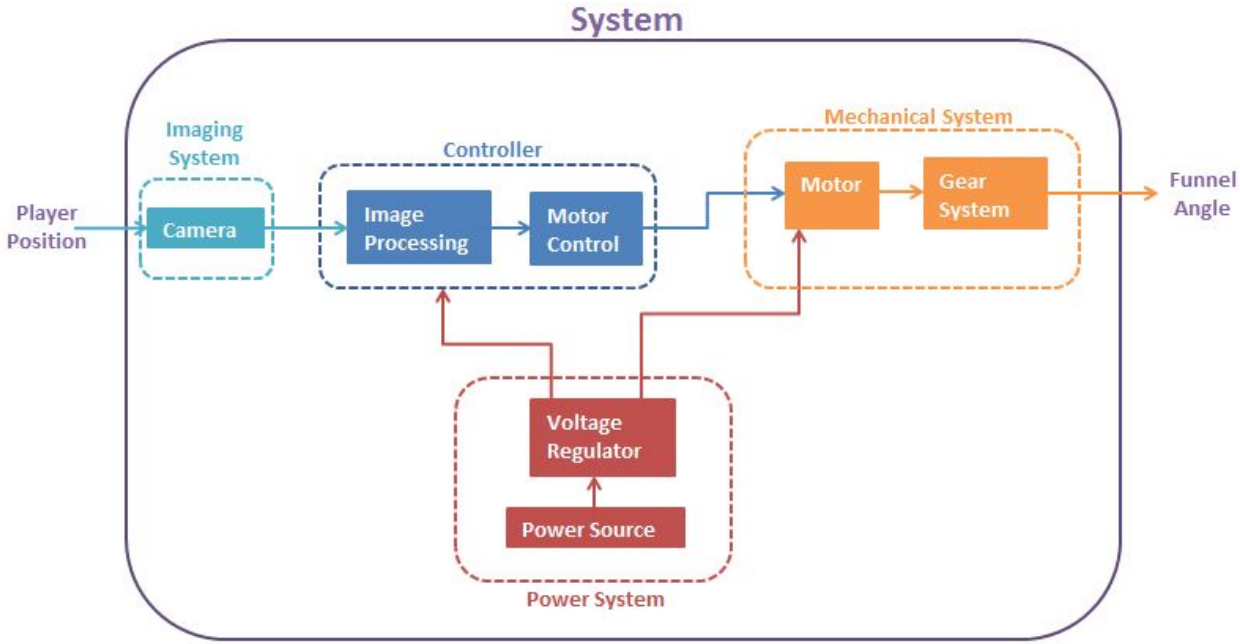
Project Overview

- Practicing basketball alone is inefficient without someone to return the ball to you
- Even if you make all of your shots, still have to retrieve ball
- Inefficient use of practice time
  - Energy/time lost chasing rebounds
- **Current return systems require manual adjustment**

General Requirements

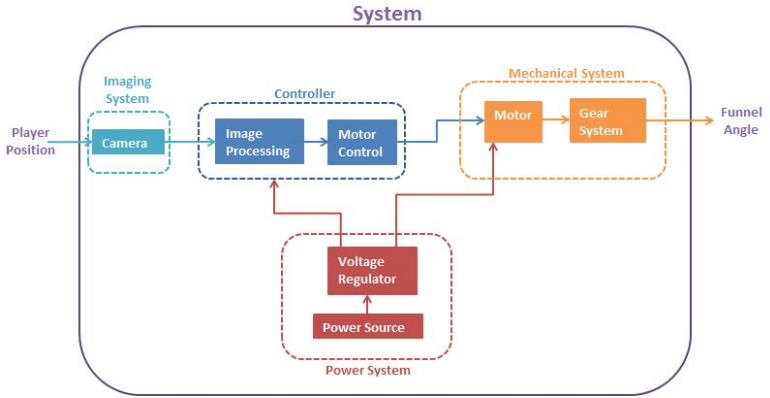
- Track player at distance of 5-25 feet from rim
- Accurately track lateral movement of player in real-time
- Operational for >= 1 hour at a time
- System can withstand direct hit from basketball
- System weight does not pull rim downwards
- Easy setup/teardown of electronic part of system

Block Diagram



MDR Deliverables

- [x] Demo of motor rotating funnel system
  - Lead: Devon & Adam
  - Assist: Derek
- [x] Decision on power system
  - Lead: Derek ~~& Adam~~
- [x] Image Processing for target detection
  - Lead: Brian
- [x] Webcam/Controller Setup & Integration
  - Lead: ~~Derek~~ Brian



Motor Selection Process

- RPM and Torque were our constraints
  - Compiled knowns and unknowns into Excel
- RPM
  - Range set to 45 deg/s - 55 deg/s
- Torque
  - Measured force using pressure gauge from MIE department
  - Used this to determine max load we could handle
  - Translated this to torque

Gear Properties	Diameter (in)	Radius (in)	Teeth	Size Relationship	Estimated Force (lbs)	Speed (RPM)	Estimated Torque (lbs-in)	Estimated Torque (oz-in)
Gear 1	13	6.5	130	6.5	12	10	78	1248
Gear 2 (pinion)	2	1	20	0.153846154	1.846153846	65	12	192

Pinion has to have minimum of 18 teeth

Speed_a * Teeth_a = Speed_b * Teeth_b

Speed_b = (Speed_a) * (Teeth_a)/(Teeth_b)

Torque Ratio = (T_a/T_b) = (Speed_a/Speed_b)

Max Movement Supported = 50 deg/s

Allows for 180deg arc to be covered in 3.6 seconds

50 deg/s = 8.333333 RPM ---> round up to 10RPM = 60 deg/s

Estimated Max Load = 15 lbs

Original Estimated Force was 2lbs but was estimating using two hands

Estimated Force with 5 lbs load = 4lbs

Estimated Force with 15 lbs load = 12lbs

Torque = -(stall torque/max rpm) * rpm required + stall torque

or

Speed = (stall torque - Torque required) * (max rpm/stall torque)

	Stall Torque (oz-in)	Speed w/out Load (RPM)	Speed w/load	Torque w/load	Min Stall Torque Needed
Motor A	**200**	100	**4**	**192**	548.5714286
Motor B	**680.5**	165	**118.4459956**	**192**	316.8
Motor C	**958.2**	118	**94.35566688**	**192**	427.4716981
Motor D	**1347.1**	**84**	**72.02761488**	**192**	848.8421053
Motor E	**1874.8**	**60**	**53.85534457**	**192**	-2304

Motor A	http://www.robotshop.com/en/pololu-12v-100-1-gear-motor-encoder.html
Motor B	https://www.servocity.com/html/165_rpm_hd_precision_planetary.html#.VjlCkCvznMs
Motor C	https://www.servocity.com/html/118_rpm_hd_precision_planetary.html#.VjlCwCvznMs
Motor D	https://www.servocity.com/html/84_rpm_hd_precision_planetary_.html#.VjlC-ivznMs
Motor E	https://www.servocity.com/html/60_rpm_hd_precision_planetary_.html#.VjlDHyvznMs

Motor Selection

60 RPM HD Precision Planetary Gear Motor

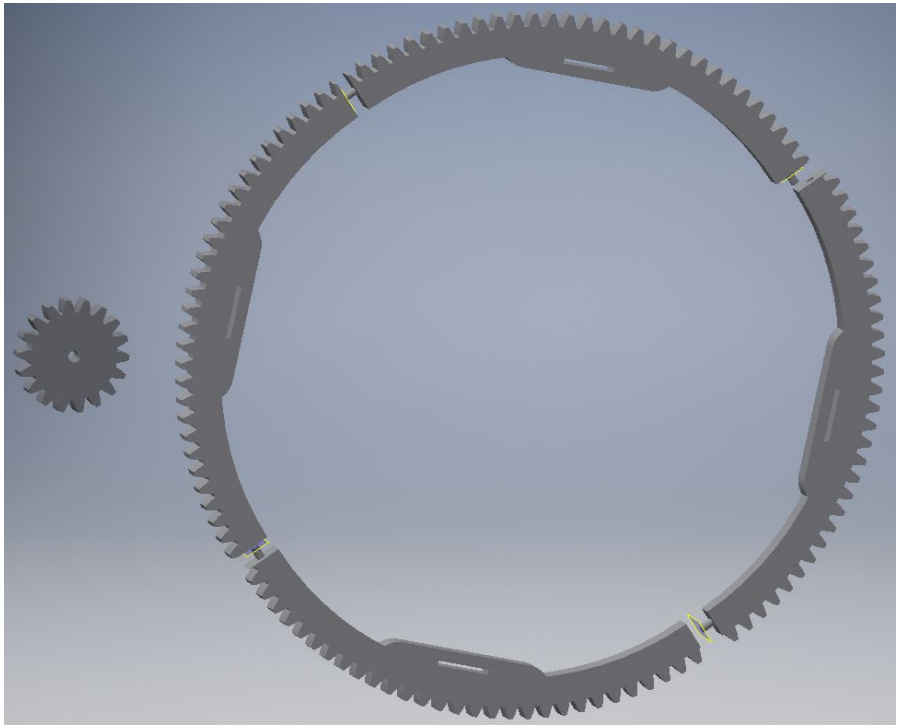
MAXIMUM TORQUE 1,874.8 oz-in. (12VDC)

Operating Specifications:
Operating Voltage Range: 6~12VDC
Rated Voltage: 12VDC
Rated Load: 15 kgf-cm (208.3 oz-in)
Operating Temperature: -10 ~ +60°C
Max No-Load Current: 0.53A
No-Load Speed: **60 RPM**
Min. Stall Torque: 135 kgf-cm (1874.8 oz-in)
Max. Stall Current: 20A @ 12VDC
Dielectric Strength: 250 VAC
Motor Brush Type: Graphite
Output Power at Max. Efficiency: 11W
Gear Type: Planetary
Gear Ratio: **139:1**
Bearing Type: Dual Ball Bearing
Shaft size: 6mm (0.236")
Net Weight: 360g (12.70oz)

Mechanical System

- Achieve rotation via motor and gear system
- Used Autodesk Inventor to design gears
- 3D printed gears and tested result

Gear Design

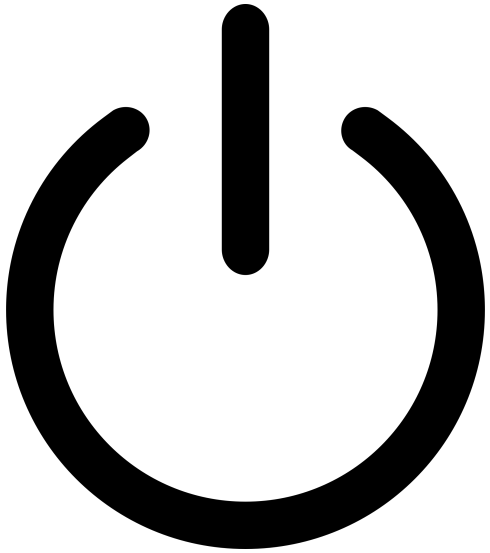


Gear Results

Mounting

Mechanical Demo

Power System Requirements



- Supply battery power for >= 1 hour at a time
  - Limited by motor size (12V, max 1.7A)
- Lightweight (cannot weigh rim down)
- Power both controller (5V) and motor (12V)
- Switch between battery and outlet power
  - Considered Solar Power

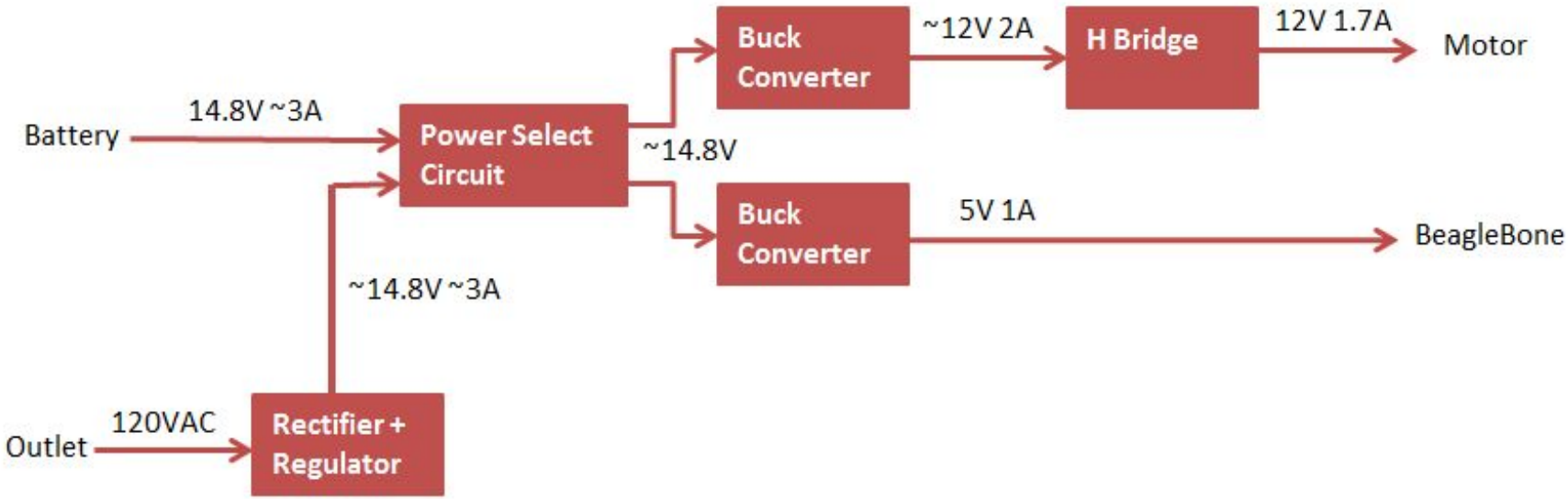
Battery Selection

- Total Current Draw Estimate: 2.7A
- Requirements
  - Lightweight < 1lb.
  - Power for >= 1 hour

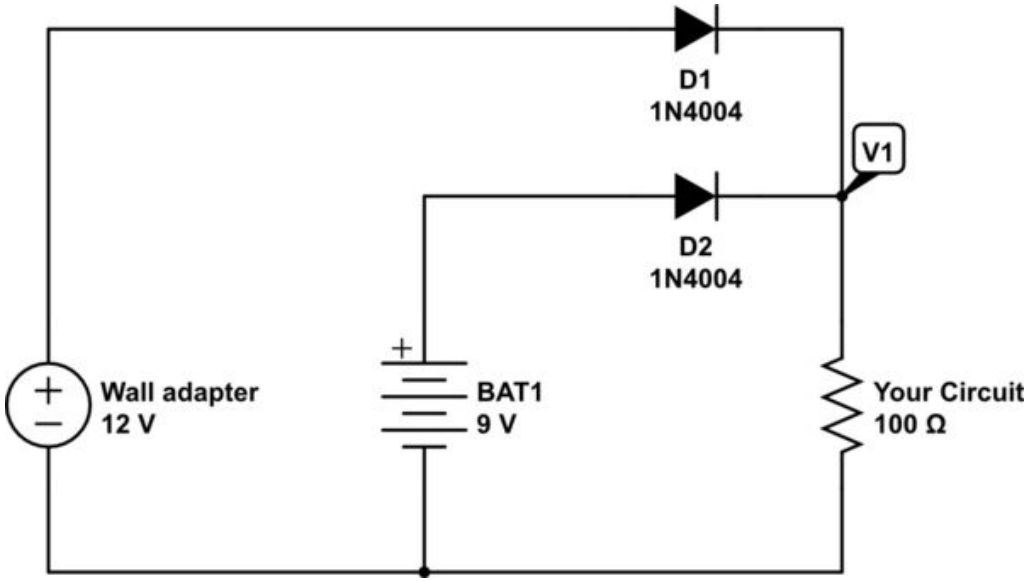
} Tradeoff!

- LIPO battery for high energy density
  - 11.1V (3 cell) vs. 14.8V (4 cell)
  - Requires special charger
- Picture: 5000mAh, 15.2oz

Power System Implementation



Power Select Circuit



OR

Design from electronics stack exchange user CarpetPython (http://electronics.stackexchange.com/questions/130986/automatically-switching-from-9v-battery-to-dc-wall-adapter-on-insertion)

Image Processing-Setup

- Logitech c270 720p HD Webcam
- Beaglebone Black Microcontroller with Debian Linux Operating System
- C++ Image Processing Code written and run from Cloud9 IDE using Beaglebone Bash Command Line

Image Processing-Code

- Uses OpenCV and V4L2 libraries to access camera and process images
- Uses 24-bit BGR pixel format in OpenCV Mat
- Determines target color by analyzing image of centered target initially
- Compares pixel values to target color to find target pixel coordinates
- Determines whether target is left, right, or centered

Color Detection Demo

Image Processing-Moving Forward

- Timing
  - current processing takes 20-40 ms per frame
  - well under 200ms required time
  - could increase with code complexity
- Illumination
  - illumination makes it hard to detect some obscure colors at different distances/lighting
  - distinct colors are seemingly unaffected by illumination
  - Using distinct colors in patterns on jersey should minimize effects of illumination

Gantt Chart


7-Dec
14-Dec
Winter Break
18-Jan
25-Jan
1-Feb
8-Feb
15-Feb
22-Feb
Feb-29
7-Mar
14-Mar
21-Mar
28-Mar
4-Apr
11-Apr
18-Apr
CDR?
CDR?
FDR
FDR
Demo
Image Processing System
Stationary Target Detection
uController/Webcam Setup
Code Optimization/Refinement
Mechanical System
Mounting/Packaging
Power System
Implementation Plan/Schematic
Breadboard Design
PCB Design
System Integration & Test
Controller/Motor
Power
Final System Test

CDR Deliverables

- Camera/BBB/Motor Integration
  - Lead: Brian & Devon
- Completed power system breadboard design
  - Lead: Derek & Adam
- Mounting considerations for hardware
  - Lead: Adam & Devon

Cost Estimate

- SKLZ Shoot Around - $30
- Beaglebone Black - ~~$45~~ $55
- Webcam - ~~$20 – $30~~ $26
- Motor - ~~$40 – $100~~ $40
- Gears/Mounting HW - $20-$40
- Battery/Charger - $70-$100
- Power supply - $30

- **Worst-Case Estimated Total: ~~$375~~ $321**

Questions?