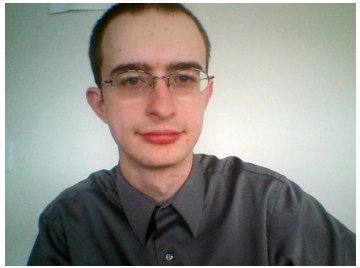
B.R.O.

Basketball Return Optimizer

Team Members



Derek Foster (EE)

Devon O'Rourke (CSE)

Brian Acker (CSE)

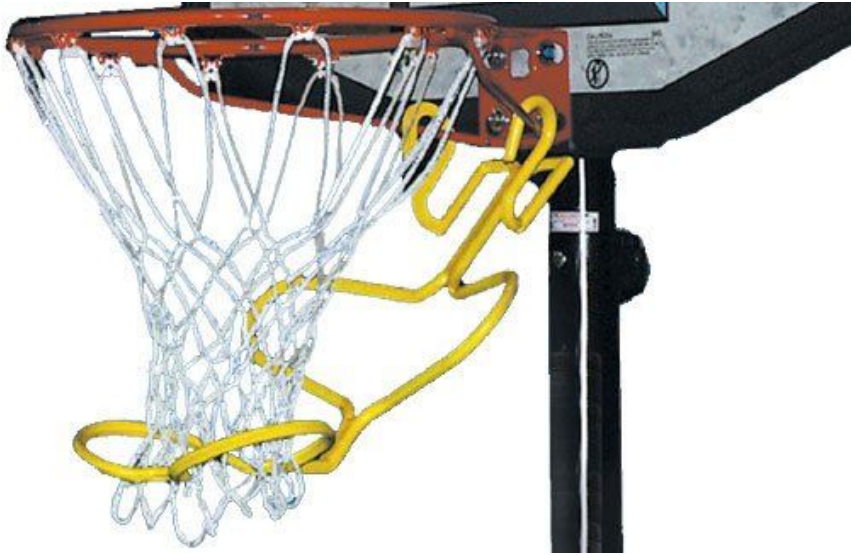
Adam Paranay (EE)

Problem

- 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

Design Alternatives

- Simple ramp (always returns ball to free throw line)
  - Cost: $10-20
- Manually adjustable “funnel”
  - Cost: $30-40
- “Net” return system
  - Cost: $50-350
- Large, expensive systems meant for university and professional teams
  - Long adjustable chutes, “guns”
  - Cost: $1,700-6,500



Ramp

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SKLZ Shoot Around

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iC3 System - Airborne Athletics

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Shoot A Way Gun 8000

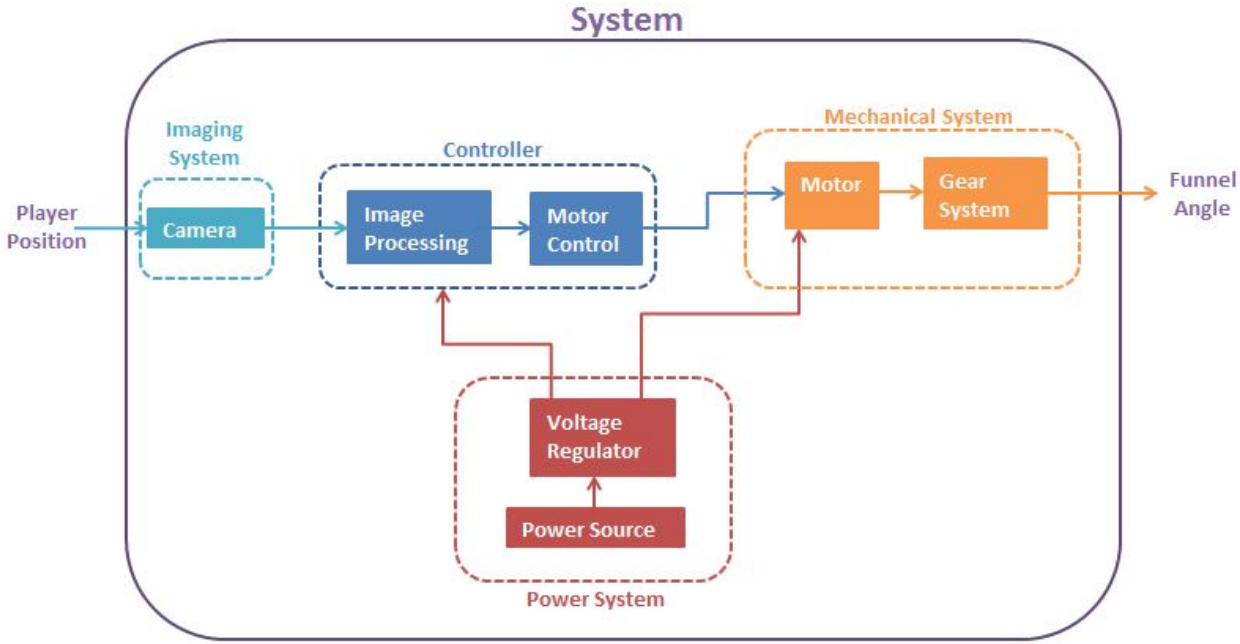
Our Solution

- Based on current return system by SKLZ ($30 system)
- Track the movement of player via camera
- Translate player position to motor that automatically rotates funnel

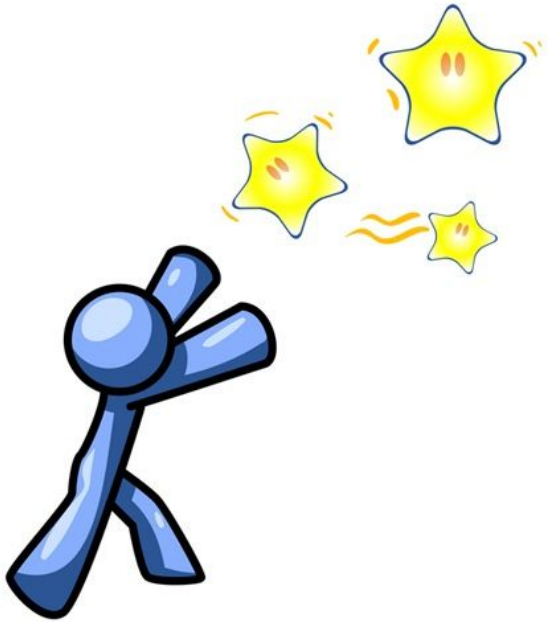
General Requirements

- 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



Features

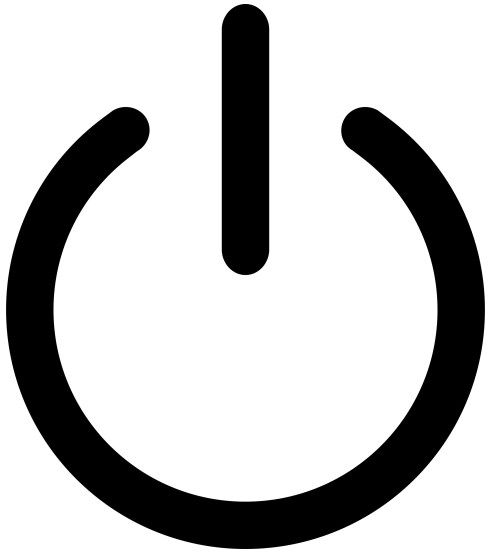


- System returns ball to player, regardless of his/her location on the court
- Quickly navigate court w/out manual adjustment of funnel
- Flexibility in shooting location
- **Innovation: Automatic Player Tracking**

Benefits

- Become a better shooter through repetition
- Increase shots/hour
- Shoot from anywhere, anytime
- Energy spent on shooting, not adjusting return system

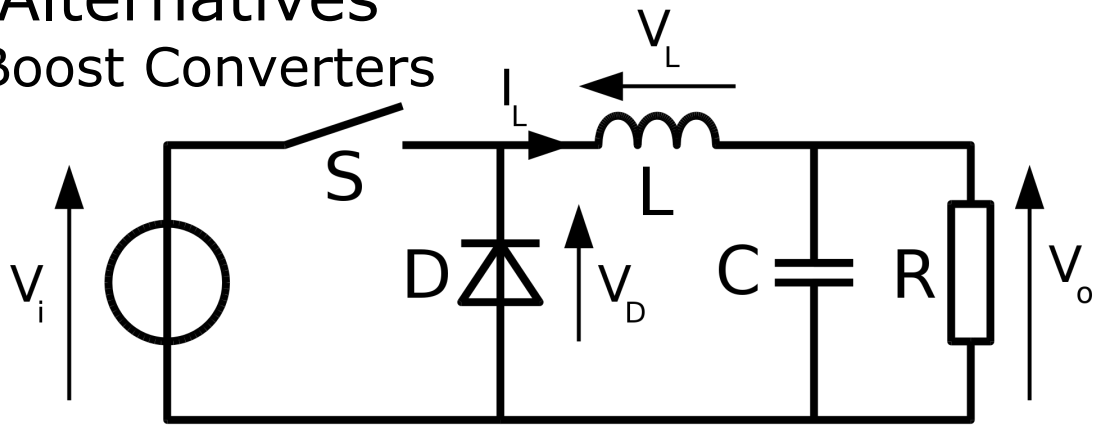
Power System Requirements



- Supply battery power for >= 1 hour at a time
  - Limited by motor size (TBD)
- Lightweight (cannot weigh rim down)
- Power both controller (3-5V) and motor (>5V)

Power System Design Alternatives

- Power Source Alternatives
  - Wall Outlet
  - Rechargeable Battery
- Voltage Regulation Alternatives
  - Buck, Boost, Buck-Boost Converters

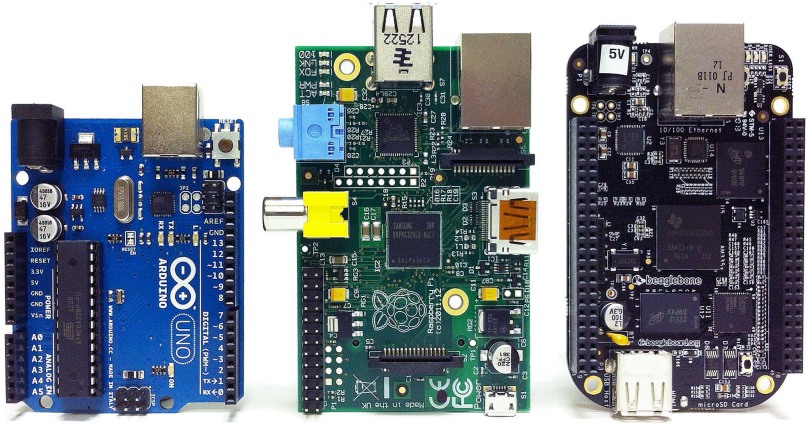


Power System Implementation

- Efficient voltage regulation circuits
  - Depends on motor size, amps required
  - 2 separate circuits for motor and controller
- Battery and circuitry mounted on mechanical part of system

Controller Options

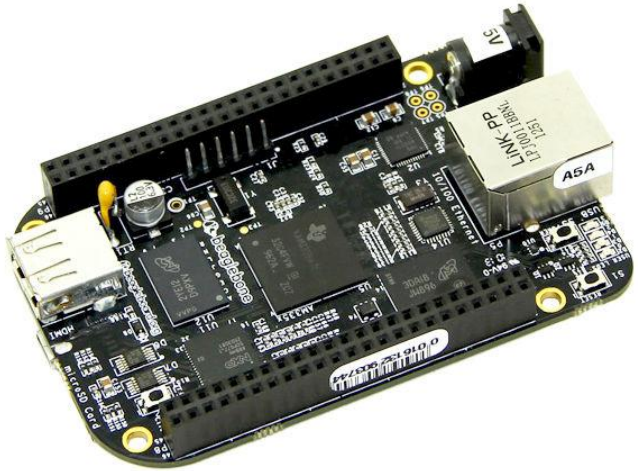
- Beaglebone Black $45
  - 1GHz ARM Cortex-A8
  - 512MB DDR3
  - 4GB 8-bit eMMC flash
  - 2x PRU 32-bit 200MHz µcontrollers
- Raspberry Pi2 Model B $35
  - 900MHz quad-core ARM Cortex A7
  - 1GB RAM
  - uSDHC slot
- Arduino Uno $26
  - 20MHz ATmega328
  - 2KB RAM
  - 14 i/o pins



Controller Considerations

- Need a system that can:
  - function as a motor controller
  - process large quantities of image data quickly
  - interface with the hardware easily (camera, motor)
  - lightweight and compact system

For similar costs, the BeagleBone Black is the most robust system.

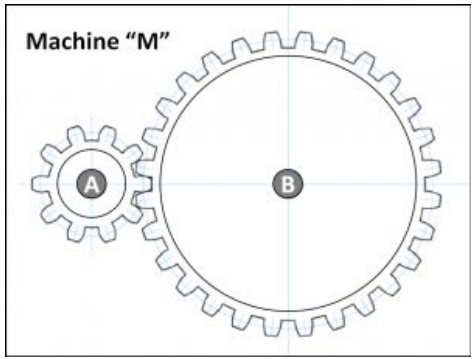


Mechanical System Requirements

- Unit has to withstand impact from ball while maintaining the integrity of the system.
- Unit must rotate at a pace that will match that of the shooter's movement.

Motor and Gear Requirements

- Motor must have enough torque to turn two gears in series.
- Gear A must have enough force to turn Gear B.
- Force to turn Gear B based off of weight of system and of the basketball shot.
- Force and speed of gears are directly proportional to their size relationship.



Motor and Gear Requirements cont.

- 1 HP = 745.69 W
- Torque = HP * 5252 / RPM
- RPM calculated based on max speed the user can be tracked.
- HP determined on motor selection and power requirements.

Image Processing Requirements

- Must be able to identify the shooter at any spot within range on the court and communicate with the motor controller based off of his/her location
- Must not be interfered with by changing background conditions
- Must be able to complete all image processing and controller actions within a small fraction of a second in order to allow for continuous sampling and real time tracking

Image Processing Techniques Considered

- Background Subtraction
  - Find default background before target object enters frame, subtract background from every frame thereafter and the leftover image includes any changes in the image
- Semi-Global Matching (SGM)
  - Track changes in image based on age of pixels rather than pixel value
- Kernel Density Estimation (KDE)
  - Use the first frame to initialize the camera and then continuously update the background by controlling the learning rate; use background subtraction with varying background

Our Image Processing Approach (Color Filtering)

- Have camera move with return funnel
- Separate shooter from all other objects by having them wear a jersey with a unique color and/or pattern on it
- Analyze pixel values every frame looking for the jersey color range
- Determine shooter's location based off of pixel coordinates
- Communicate with the motor controller based on location relative to middle of image

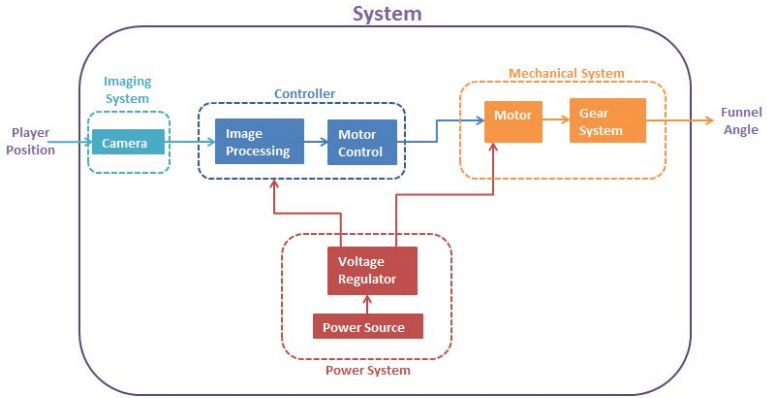
Other Possible Approaches

- Use stationary, wide angle lense camera; sample background before shooter enters court; use background subtraction to detect shooter's position

- Mount camera on funnel and have it move with motor; sample panoramic image of background before shooter enters court; use background subtraction by comparing each frame to specific section of the panoramic image

MDR Deliverables

- Demo of motor rotating funnel system
  - Lead: Devon & Adam
- Decision on power system
  - Lead: Derek & Adam
- Image Processing for target detection
  - Lead: Brian
- Webcam/Controller Setup & Integration
  - Lead: Derek
- Gantt Chart



Cost Estimate

- SKLZ Shoot Around - $30
- Beaglebone Black - $45
- Webcam - $20 - $30
- Motor - $40 - $100
- Gears - $20-$40
- Battery - $30-$100
- Power supply - $30

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

Questions?