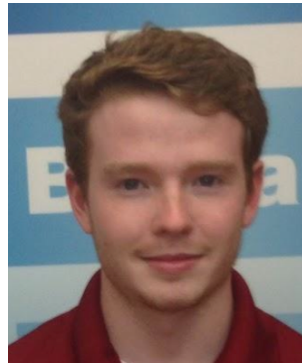


TrackStar:

Motion Tracking Stagelight Mount

Bradley Beady
Michael Bjorge
Ezra Dantowitz
Jason Gurney

Team 13



Bradley Beady, ME



Michael Bjorge, CSE



Ezra Dantowitz, EE



Jason Gurney, ME

Advisor: Tilman Wolf

Problem



Goals

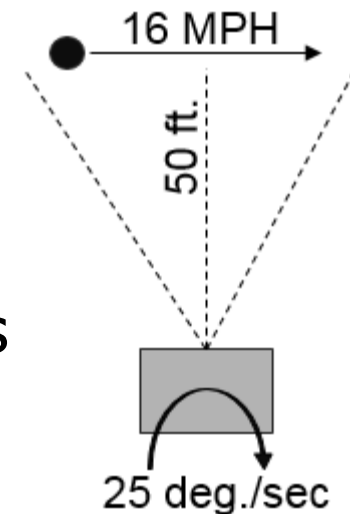
- Current Solutions
 - Manual spotlight operator
 - Pre-programmed, pre-choreographed moving light
- Our Solution
 - Autonomous, real-time tracking
 - Multiple actors

Challenges

- Identify where on the stage to light
- Distinguish between multiple actors to light
- Create robust mechanical design

User Needs & Specifications

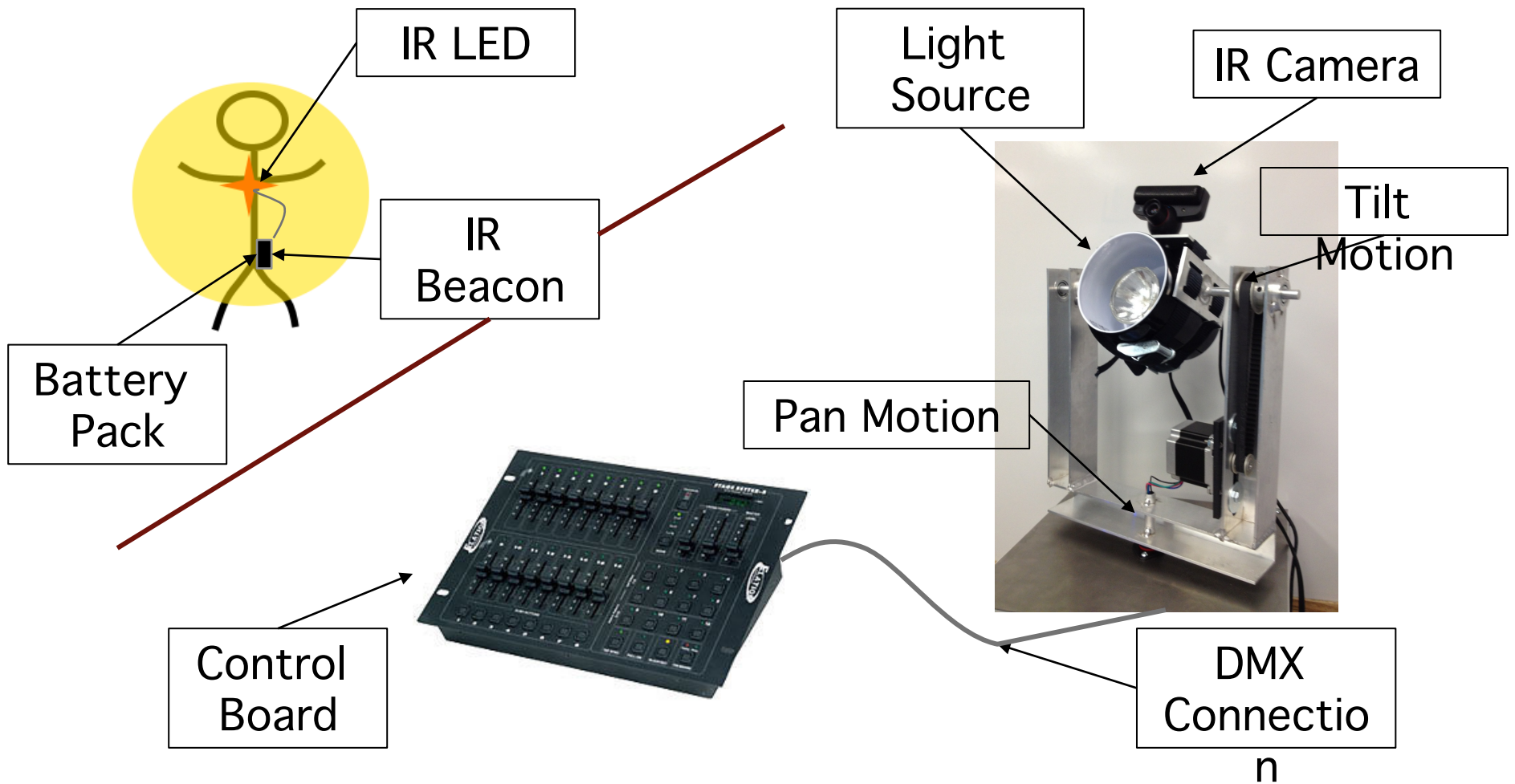
- Track actors moving at full speed
 - 25 degrees/sec (16 MPH at 50 feet)
- Track multiple actors throughout performance
 - Up to 8 simultaneously
- Follow actor anywhere on stage
 - 160 degrees Pan
 - 75 degrees Tilt
- Compatible with current lighting fixtures
 - Fresnels, Ellipsoidals, Floodlights
- Compatible with current control console
 - DMX Communication



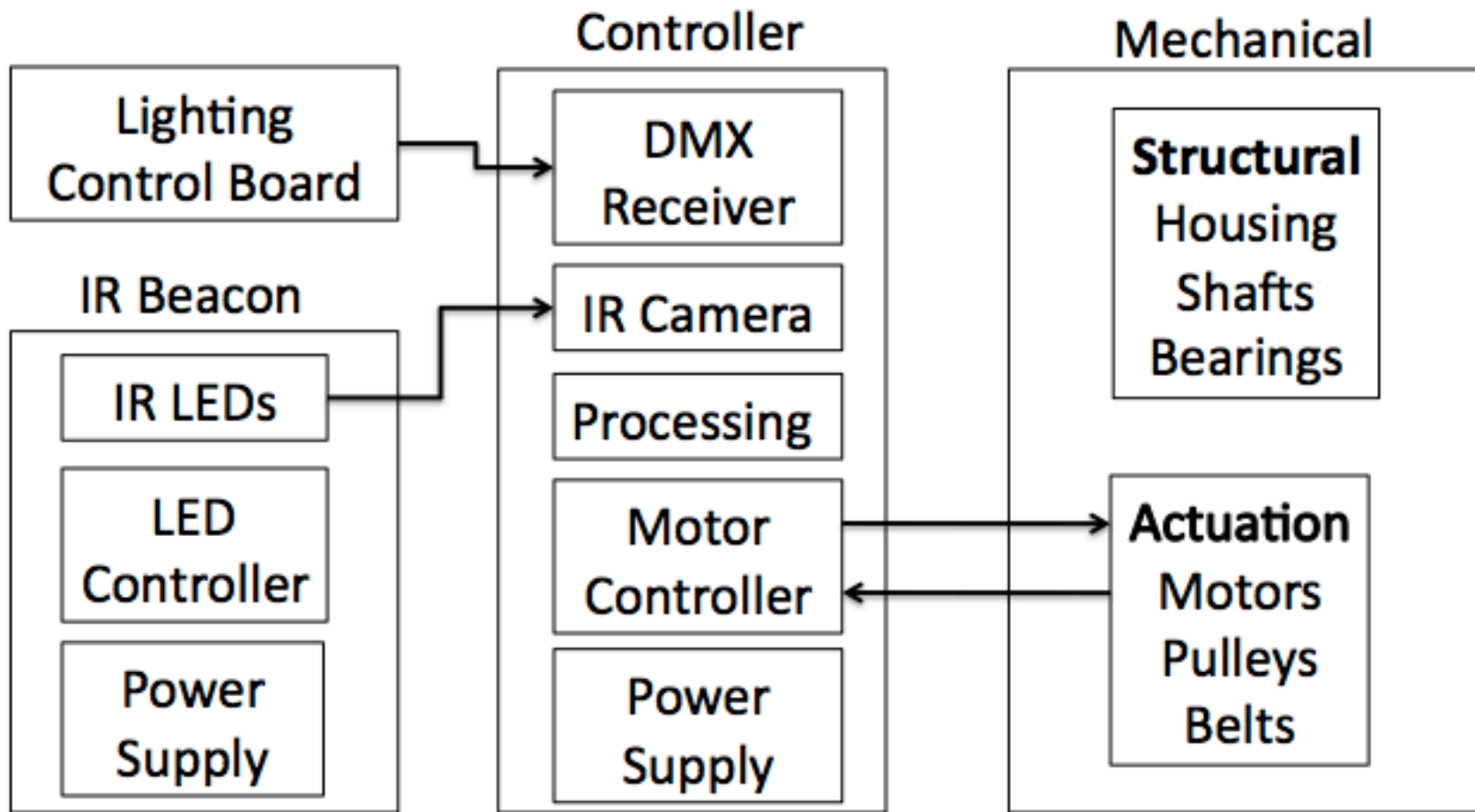
Outline

- Introduction
- **Design & Implementation**
 - IR Tracking
 - Tracking Multiple Actors
 - Mechanical Design
 - Theater Integration
- Videos & Demos
- System Evaluation

Solution Overview



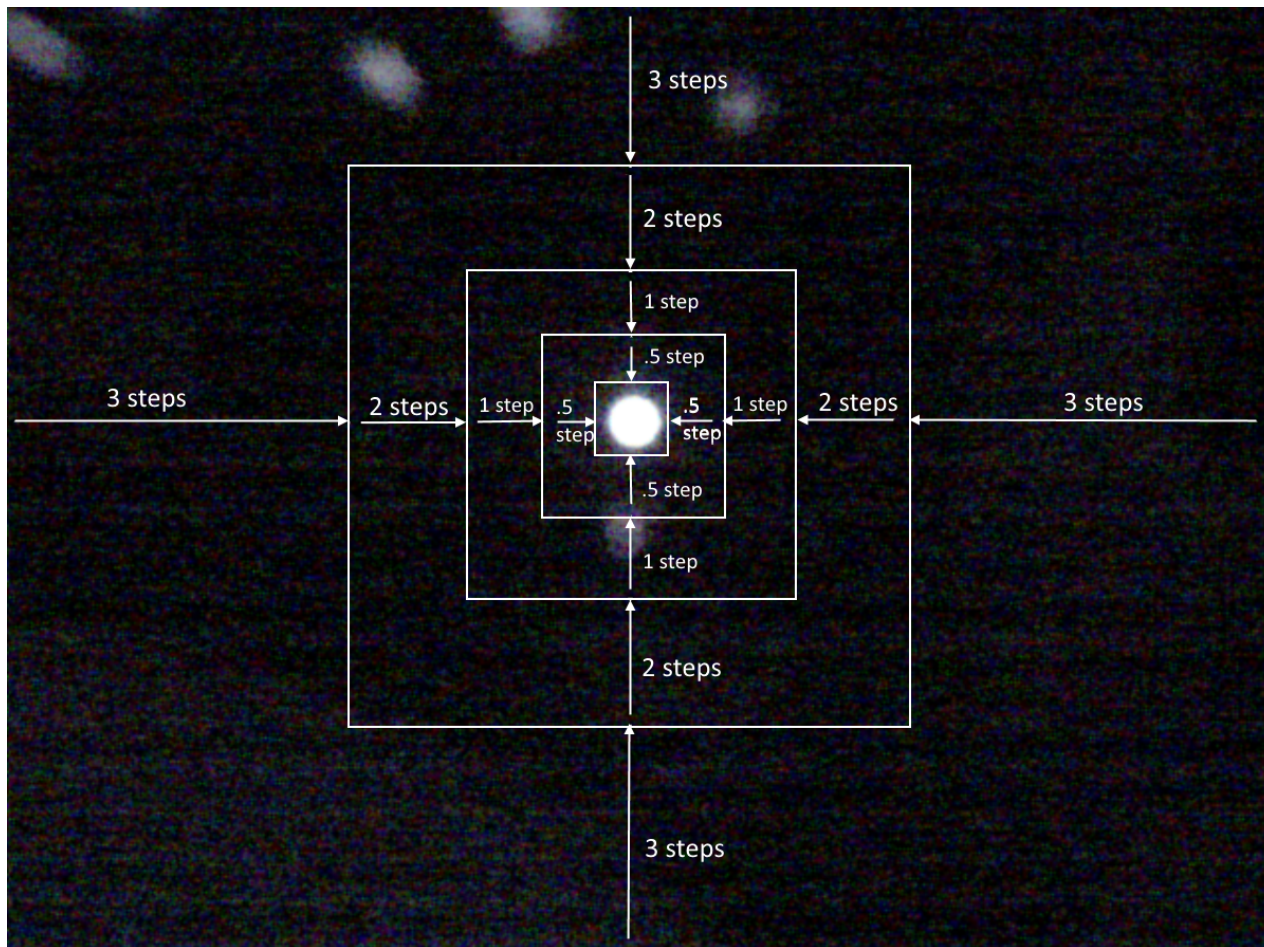
Block Diagram



Camera View of Beacon

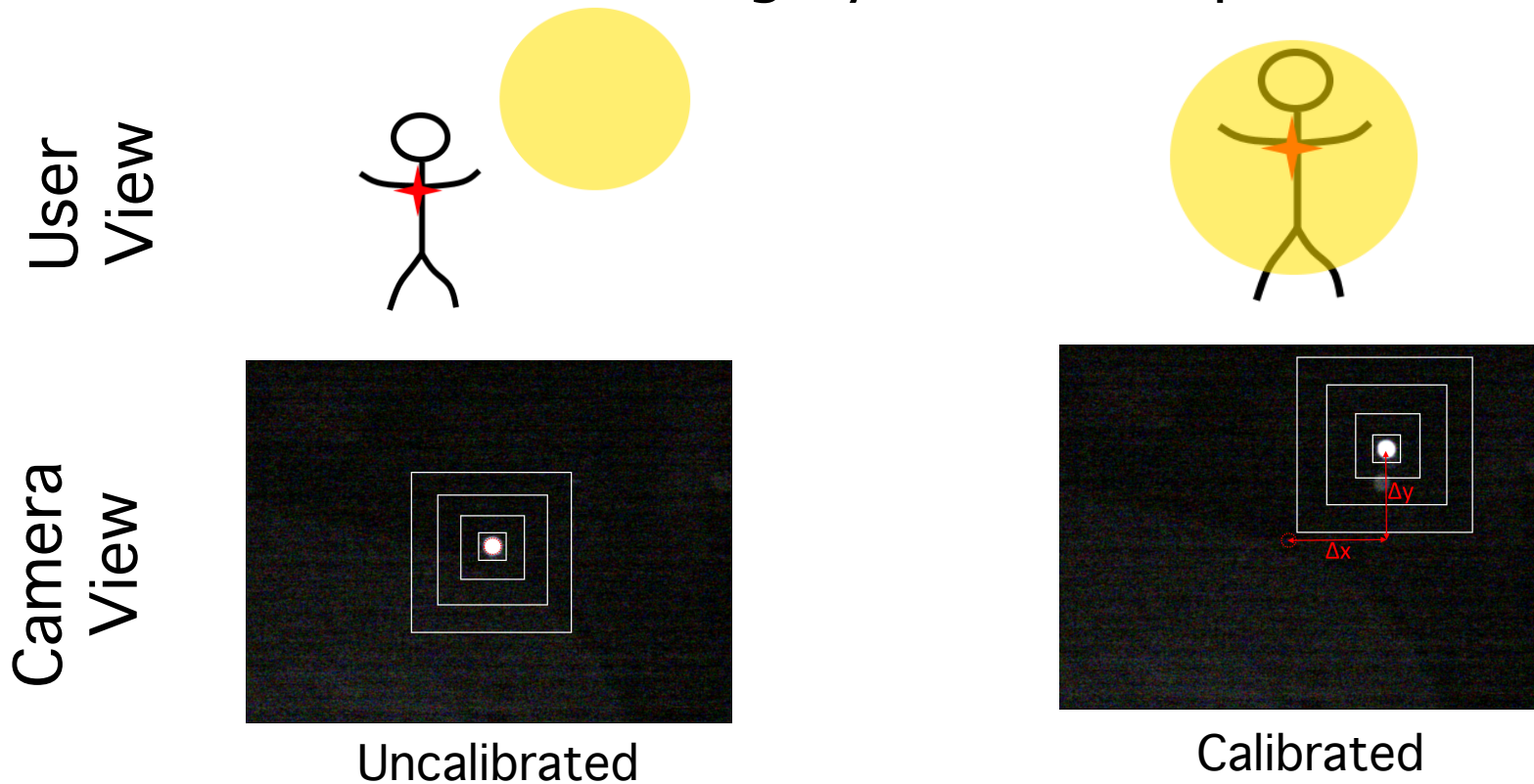


Camera View with Algorithm



Calibration

- User manually calibrate the system
- Done one time during system set up

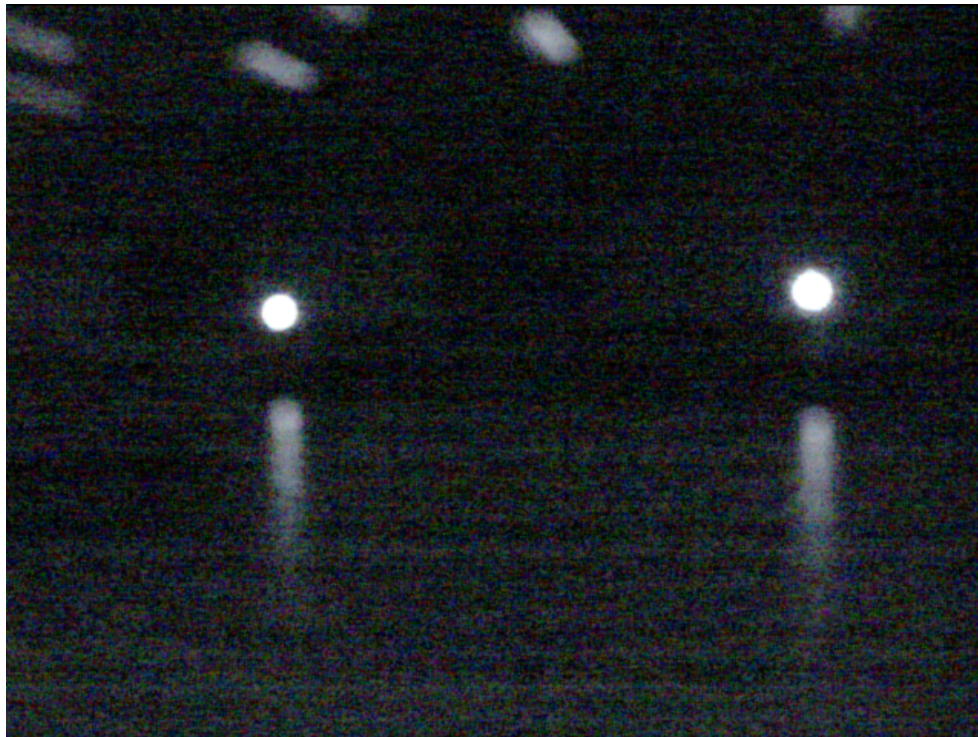


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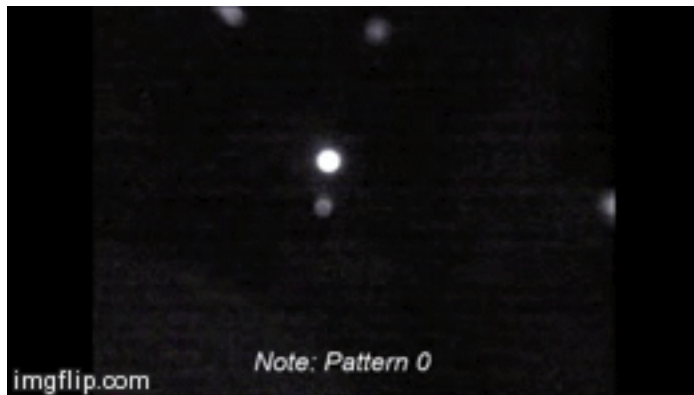
Tracking Multiple Actors

- Two actors on stage
- Track each actor individually



Track Multiple Actors

- To distinguish between actors, beacons blink different patterns



Pattern: 1111110



Pattern: 1010101

Track Multiple Actors

- Camera and Beacons are NOT synchronized
- Beacons sends: 1110111
- Camera might see:
 - 1101111
 - 1011111
 - 0111111
- So all permutations of one pattern must be different from all permutations of all other patterns

Patterns

0111111

0011111

0001111

0101111

0100111

0101011

0110110

0110111

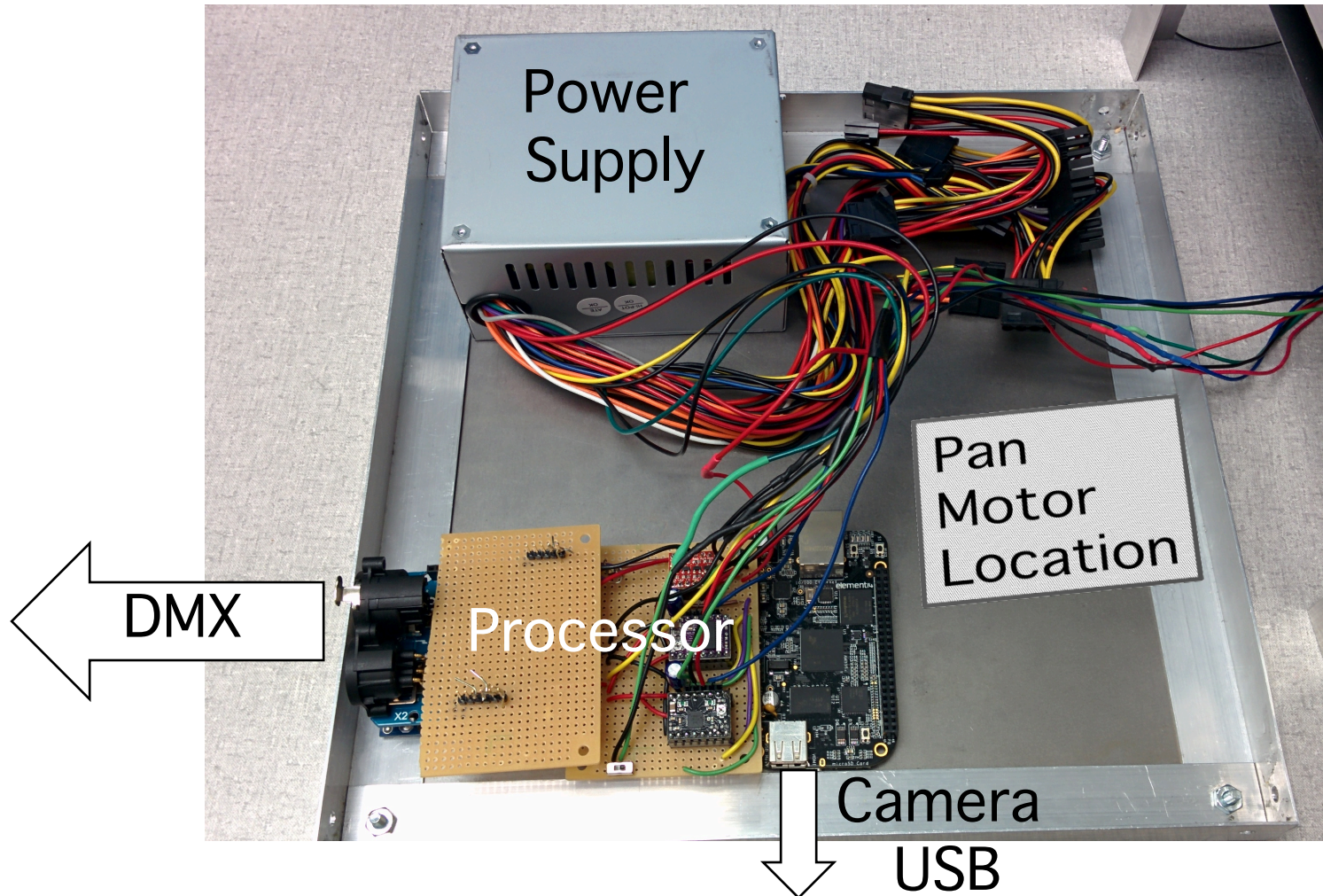
Patterns

- Limiting factor: Camera frame rate
- 1 bit = 3 camera frames
 - 25 frames/sec
 - 7 bit pattern = 945 ms
- Trade off between accuracy and delay

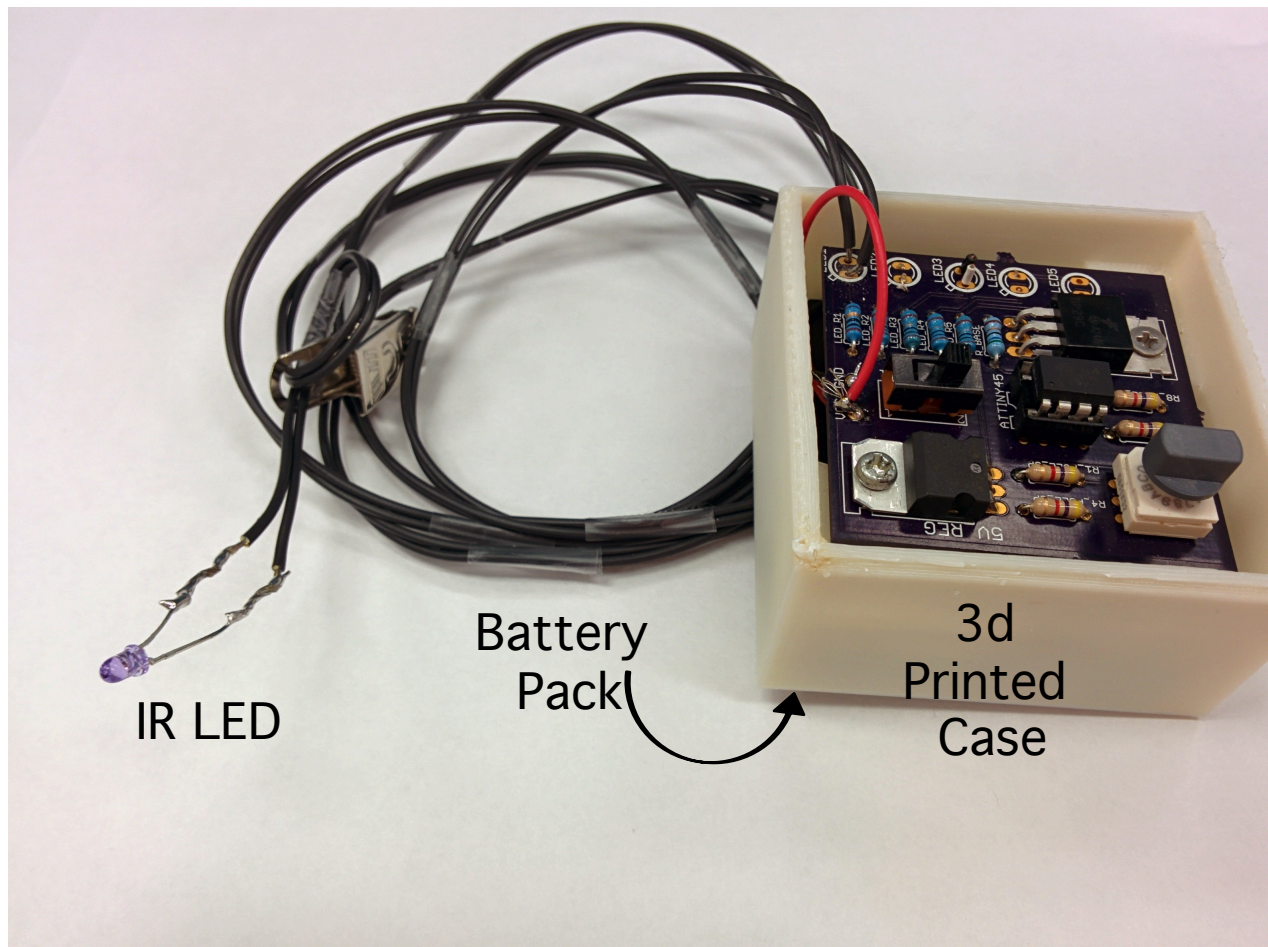
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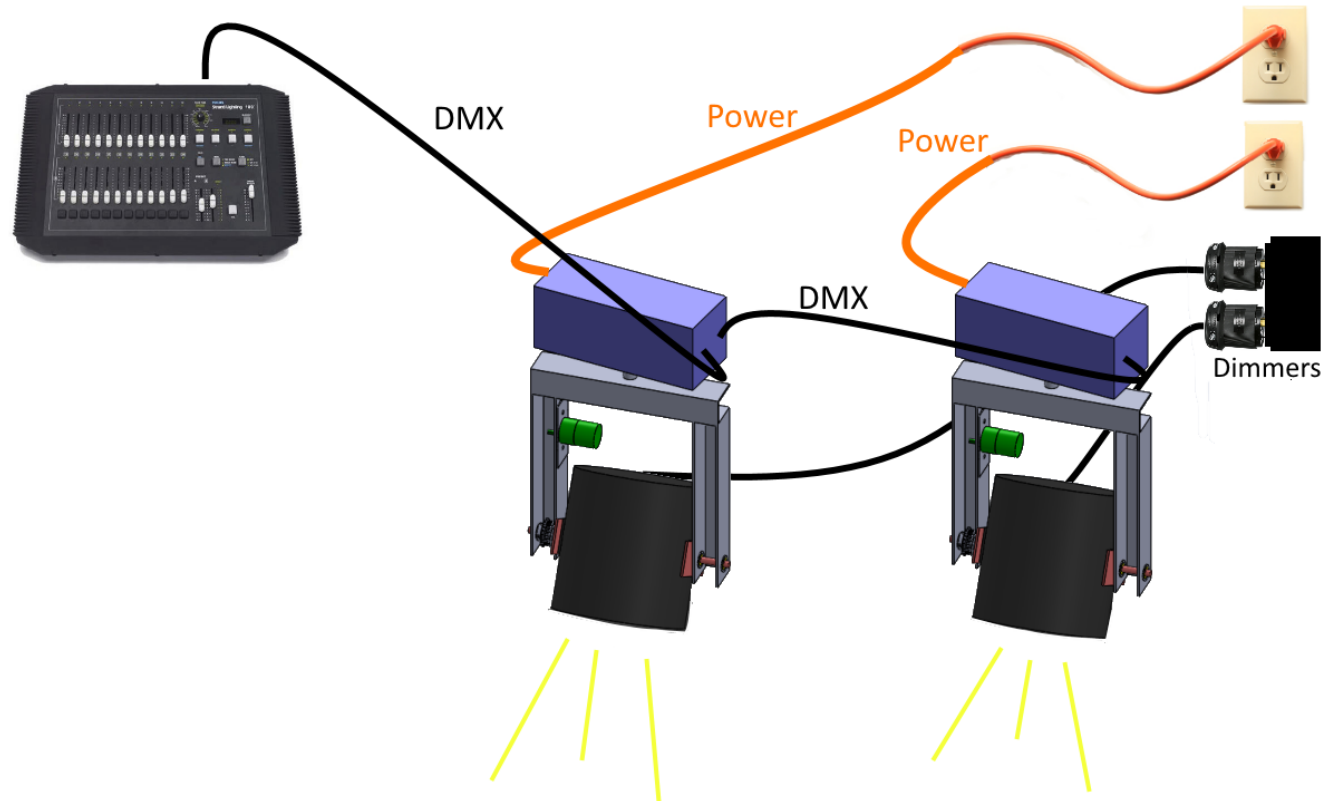
Mechanical Design - Base



Mechanical Design - Beacon



Theater Integration



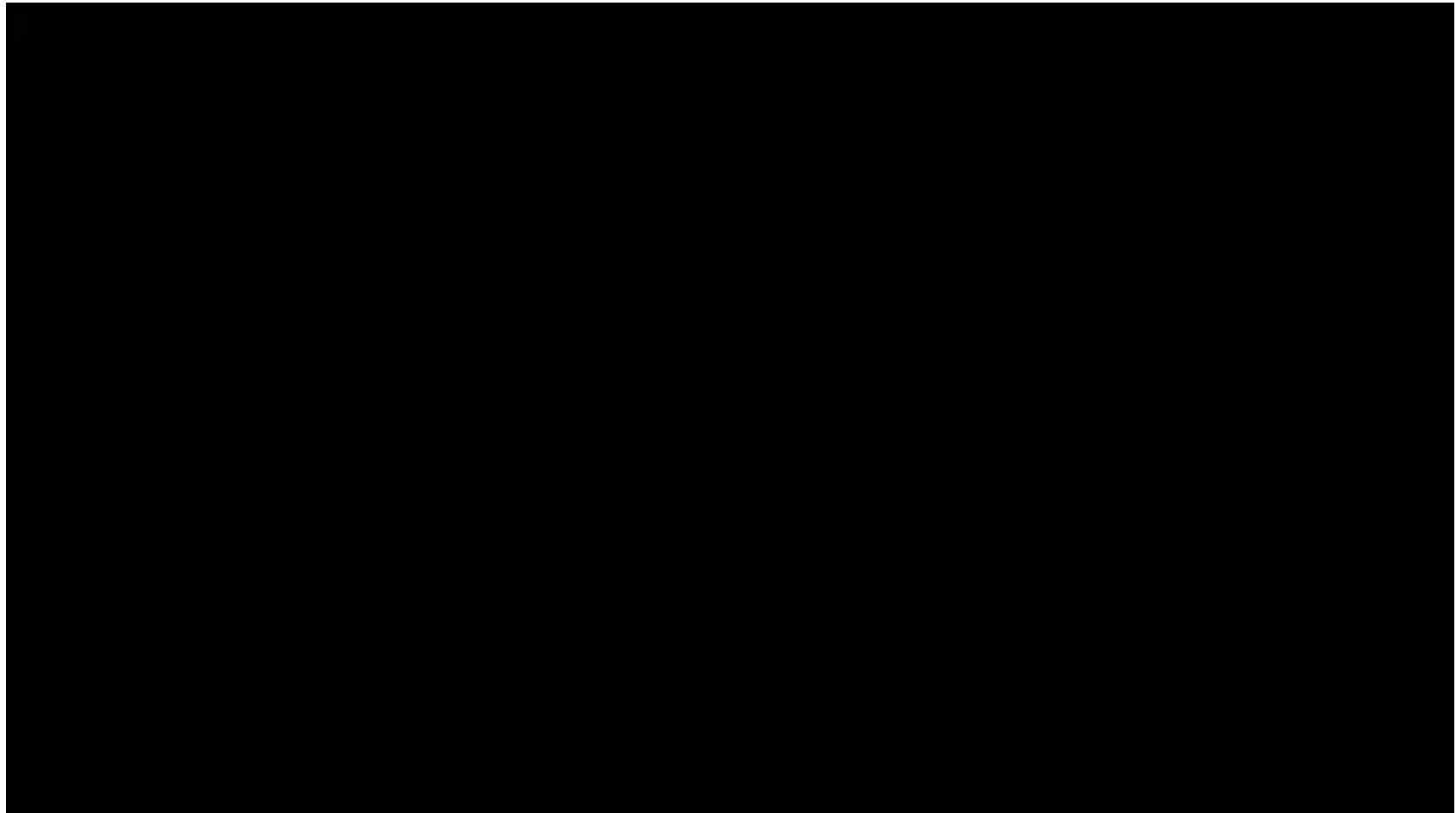
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- **Videos & Demo**
- System Evaluation

Videos

- Videos taken on 30 ft. wide stage from 50 ft.
- Tracking
- Tracking at high speed
- Actors meeting and crossing
- Actors meeting and returning

Videos



Demo

System Evaluation

- Track actors moving at full speed ✓-
 - 25 degrees/sec (16 MPH at 50 feet)
- Track multiple actors throughout performance ✓
 - Up to 8 simultaneously
- Follow actor anywhere on stage ✓+
 - 160 degrees Pan
 - 75 degrees Tilt
- Compatible with current lighting fixtures ✓
 - Fresnels, Ellipsoidals, Floodlights
- Compatible with current control console ✓+
 - DMX Communication

Cost Analysis

MOUNT		
Component	Development Price	Price per 1000
Stepper 1	49.94	44.95
Driver 1	8.99	8.09
Stepper 2	39.95	35.96
Driver 2	10.45	9.405
DMX Shield	16.95	15.26
Arduino Mega	0.00	20.90
BeagleBoneBlack	0.00	50.00
300W PSU	20.00	20.00
PSEye	8.40	4.84
NIR 880nm filter	25.00	25.00
Logic Level Converter	2.95	1.50
Belts & Pulleys	60.89	51.76
U Channel	28.64	17.18
Ball Bearings (4)	18.28	10.97
Roller Bearings (2)	26.64	15.98
Aluminum Tube	7.50	4.50
Aluminum Rod	2.61	1.57
Straps	5.00	3.00
Set Screws (2)	2.64	1.58
Total	334.83	342.43

BEACON		
Component	Development Price (\$)	Price per 1000 (\$)
PCB	6.00	1.84
Wiring (20ft)	2.47	1.34
IR LEDs (5)	1.40	0.65
SPDT switch	0.40	0.15
ATTiny 45	0.00	0.64
Resistors (10)	0.00	0.04
Hex Switch	0.00	1.50
5V Regulator	0.00	0.16
Transistor	0.00	0.02
Total	10.27	6.34

Summary

- Implementation of an automated tracking system
- Able to distinguish up to 8 performers
- Mechanical enclosures for mount and beacons