SPLASH

DESIGN REVIEW EDITION

Team A2
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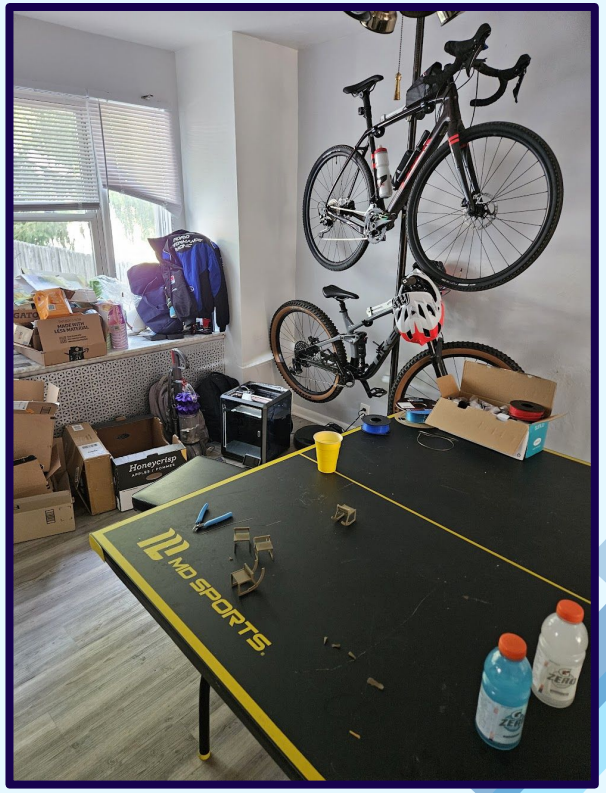
Use Case / Application

Splash is a computer vision-assisted robot that will aid individuals practicing their cup pong shots

- Tracks thrown ping pong balls and moves the target cup to the ball's projected landing location
    - Reduces time spent chasing stray shots
- Provides helpful performance metrics!



Quantitative Design Requirements (Updates)

Project Goal: Catch the pong ball ~80% of the time

- Standard solo cup with 9.2cm diameter
- Move system accurately within ~10 cm radius
- Underhand lob shot

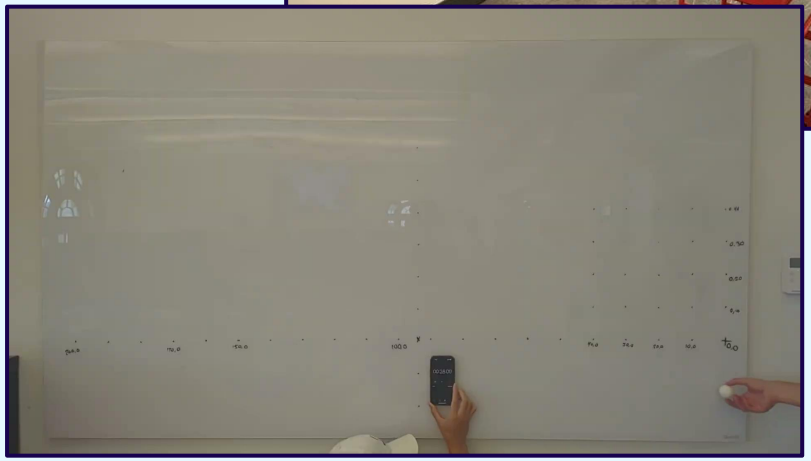
Other requirements:

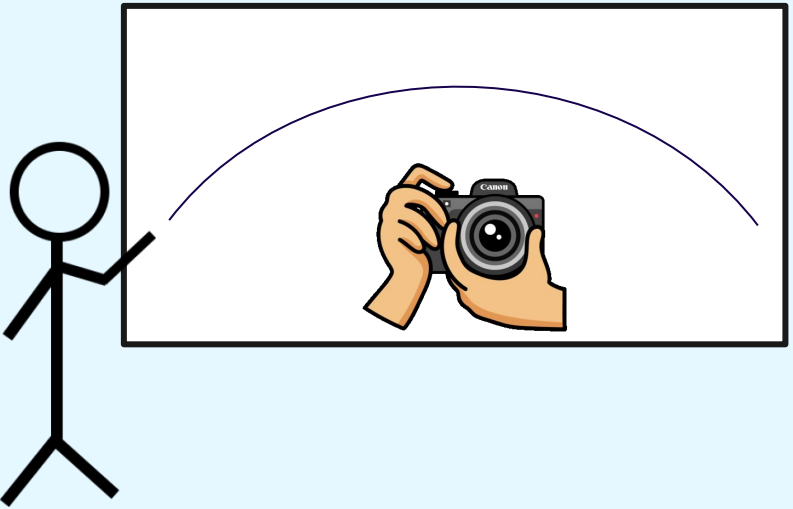
Visual Feedback system

- Webapp to display where your ball landed
- Stats for training session (accuracy, misses, scores)

Trajectory Prediction Testing Setup

- Basic tests to determine whether we can get away with simpler formulas, or if we require more complex algorithms
- Targeted throw distances of ~2m



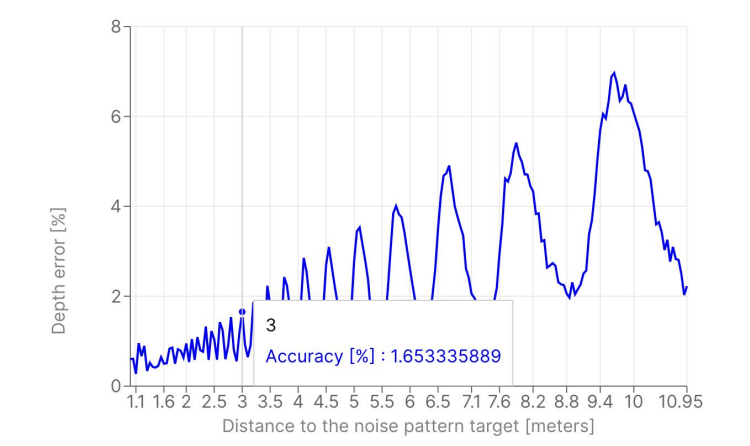


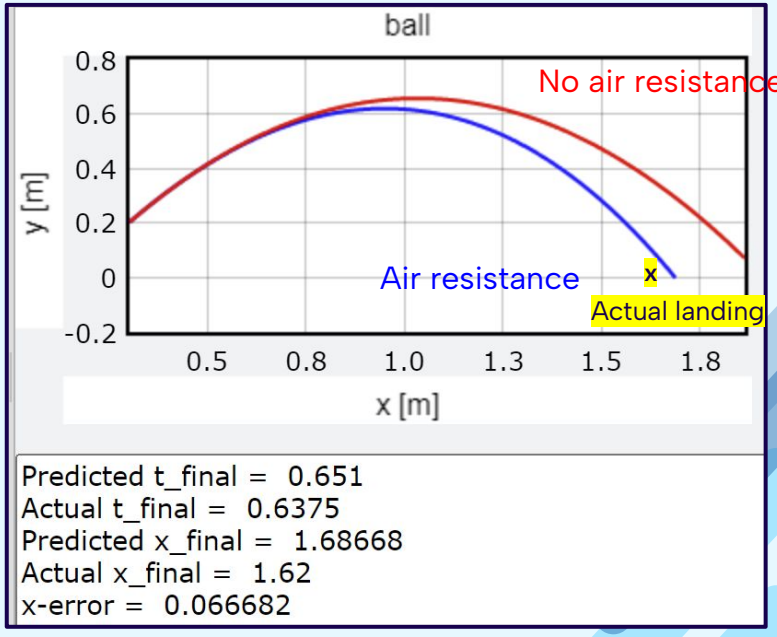
Trajectory Prediction Testing Results

- Determine x_0, y_0, x_1, y_1 @ times t_0 and t_1
- Solve for t_f when $y_f = 0$

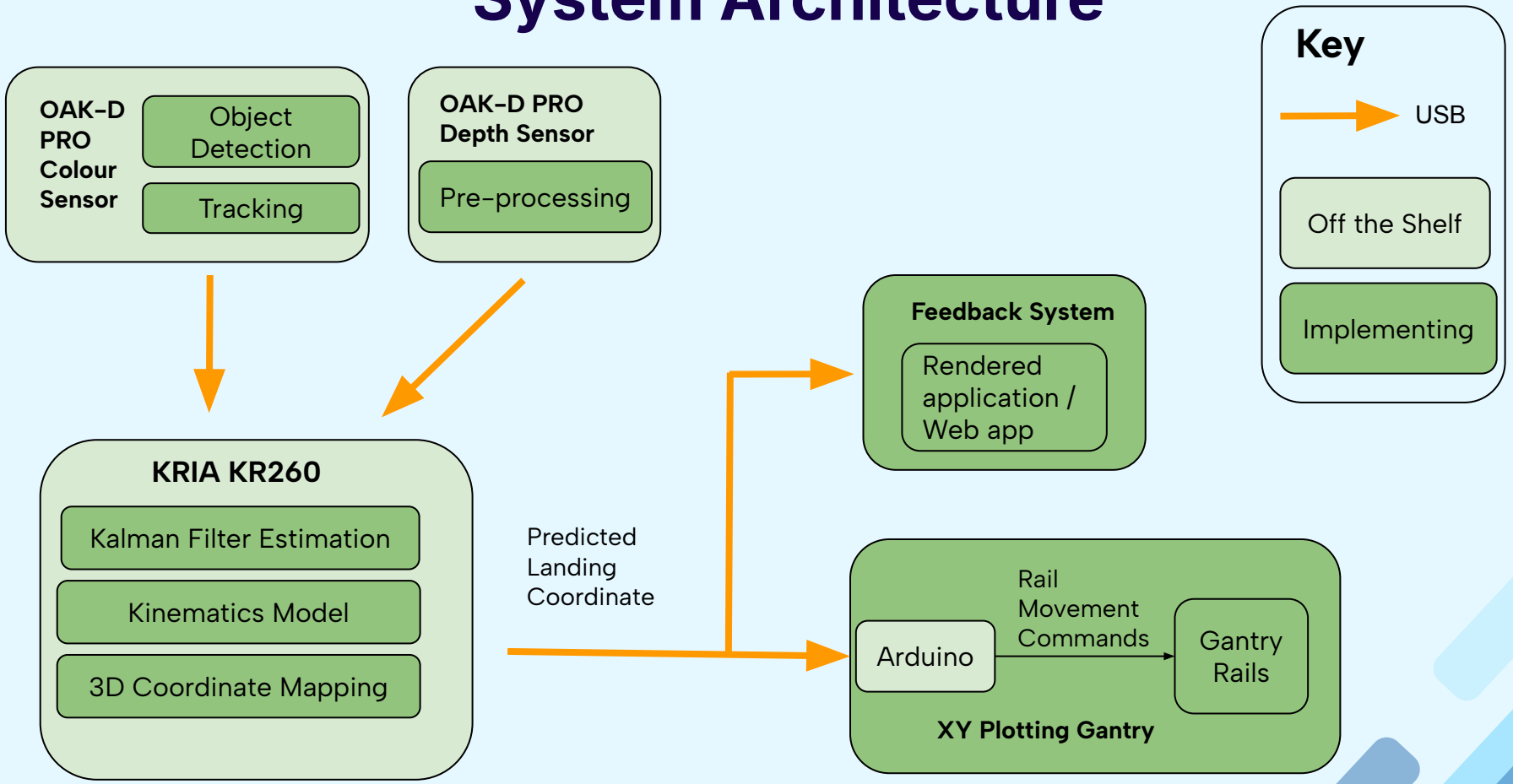
Result: Overestimated. By a lot!

- Huge fluctuations even with tiny data variance





System Architecture



Camera + Trajectory Design

Real-Time Stereo / IR Depth & Camera Data

Object Tracking
Object Detection
Hough Circle
YOLO

Generate Bounding box w/ Depth info

Real World Coord Mapping
Based on depth data of tracked ball

3D Real world coordinates

Trajectory Estimation
Kinematic Models
Kalman Filter

Projectile path predictions

Image Source: https://www.mdpi.com/1424-8220/23/3/1726

Hardware Accelerator (KRIA) Design

Software

- Ubuntu Linux on SOC (Feedback App)
- HLS Programs (VITIS / VIVADO)

Display Port for monitor

USB Keyboard + Mouse for using the board

Power Supply

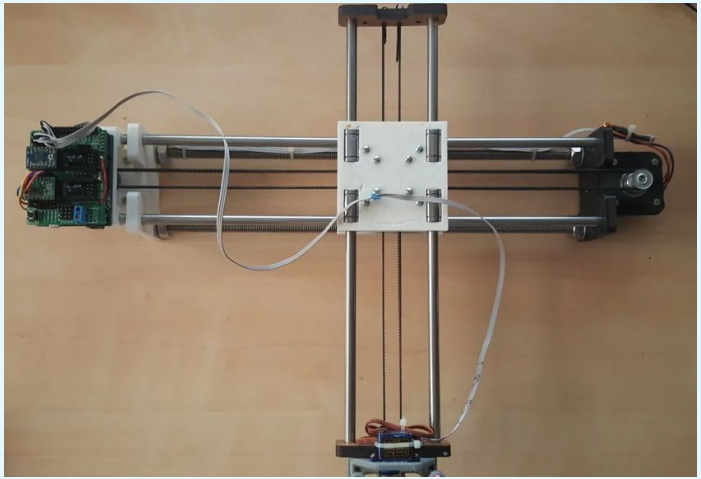
MicroUSB for Data Transfer

MicroSD Card for memory

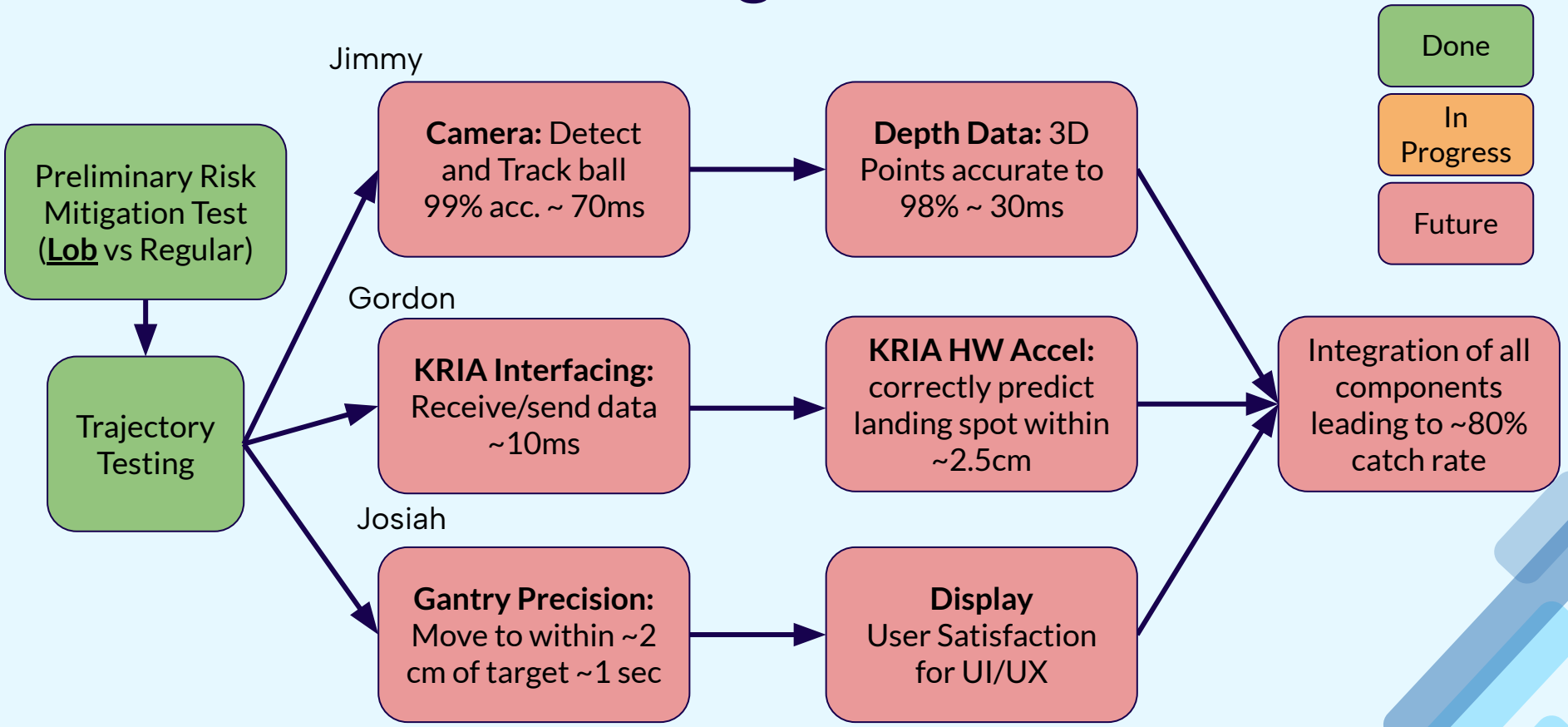
Ethernet for internet access

Robotics Design

- Belt-driven with Stepper Motors
- Cup mounted on X-Y cartesian system
- Cup slides across two dimensions
- Arduino controlled
- Pros: Autodesk Instructables “4xiDraw”
    - Intended to be a drawing robot



Testing Metrics



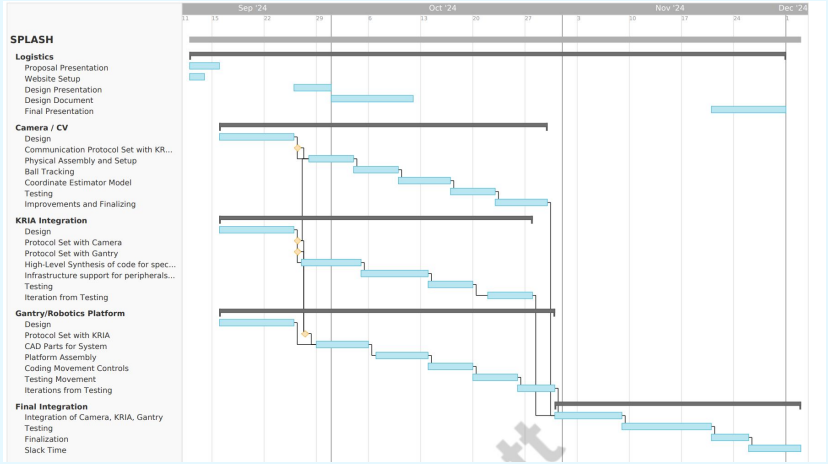
Testing: Method and Mitigations

Subject	Method
Tracking	Time stamps, video / image examples
Depth Data	Distance-marked objects in real world
Trajectory Estimation	Feed sequence of generated coordinates
Gantry Movement	Feed arbitrary points to move to
Feedback System	Feed arbitrary coordinates, test software

Risk Mitigations:

- Use faster motor
- More sophisticated tracking models
- Side-view camera to improve trajectory estimates

Project Management



Robot Rails Assembly	Josiah + Gordon
Rails Movement	Josiah
Visual Feedback System	Josiah + Jimmy
KRIA Porting	Gordon
KRIA HLS / Hardware Acceleration	Gordon + Jimmy
Trajectory Estimation	Jimmy + Gordon
Ball Detection and Tracking	Jimmy