

## Problem Statement

Can an **affordable, safe, and portable** machine be created to **automatically identify** a batter's **strike zone** and **accurately pitch strikes** and **balls** to **designated locations**, regardless of the batter's **height** or **position**?

## Background

In a typical two-hour baseball game, a player only receives two to three at-bats, making off-field training essential for developing batting skills. However, **existing baseball training methods** have **several limitations**, as shown below. To address these limitations, I invented a **Portable, AI-powered Baseball Pitching Machine**.

| COMPARISON OF BATTING TRAINING METHODS       |                  |                              |              |
|----------------------------------------------|------------------|------------------------------|--------------|
| Training Capability                          | Human Front Toss | Traditional Pitching Machine | VisionStrike |
| Automatic personalized strike-zone detection | ✗                | ✗                            | ✓            |
| Automatic nine-section strike zone targeting | ✗                | ✗                            | ✓            |
| Automated strike and ball pitching           | ✗                | ✗                            | ✓            |
| Consistent repetitive pitching               | Limited          | ✓                            | ✓            |
| Safety                                       | Varies           | Varies                       | ✓            |
| Portability                                  | Varies           | Limited                      | ✓            |
| Affordability                                | Varies           | Limited                      | ✓            |
| Accessibility                                | Varies           | Limited                      | ✓            |

Table created by Finalist using google sheets, 2026



**Human Front Toss**

Requires a thrower and has limited consistency.

Photo taken by Finalist, 2026



**Traditional Pitching Machine**

Throws repetitive pitches, but only to a fixed location and is less portable(weight>150lbs).

Photo taken by Finalist's Parent, 2026



**VisionStrike Prototype**

Portable(10 lbs), AI-powered system with personalized and targeted pitch placement.

Photo taken by Finalist, 2026

## Engineering Goal

My goal is to design and build an **affordable, safe, and portable** baseball pitching machine capable of **detecting** the batter's **six key points**, **automatically calculating** the **strike zone**, **accurately delivering pitches** to **any of the nine sections within the strike zone**, and pitching **both strikes and balls accurately**. Therefore, this machine can effectively help improve batting mechanics, pitch recognition abilities, and reaction time by simulating **real-game conditions** for baseball players.

## Design Criteria

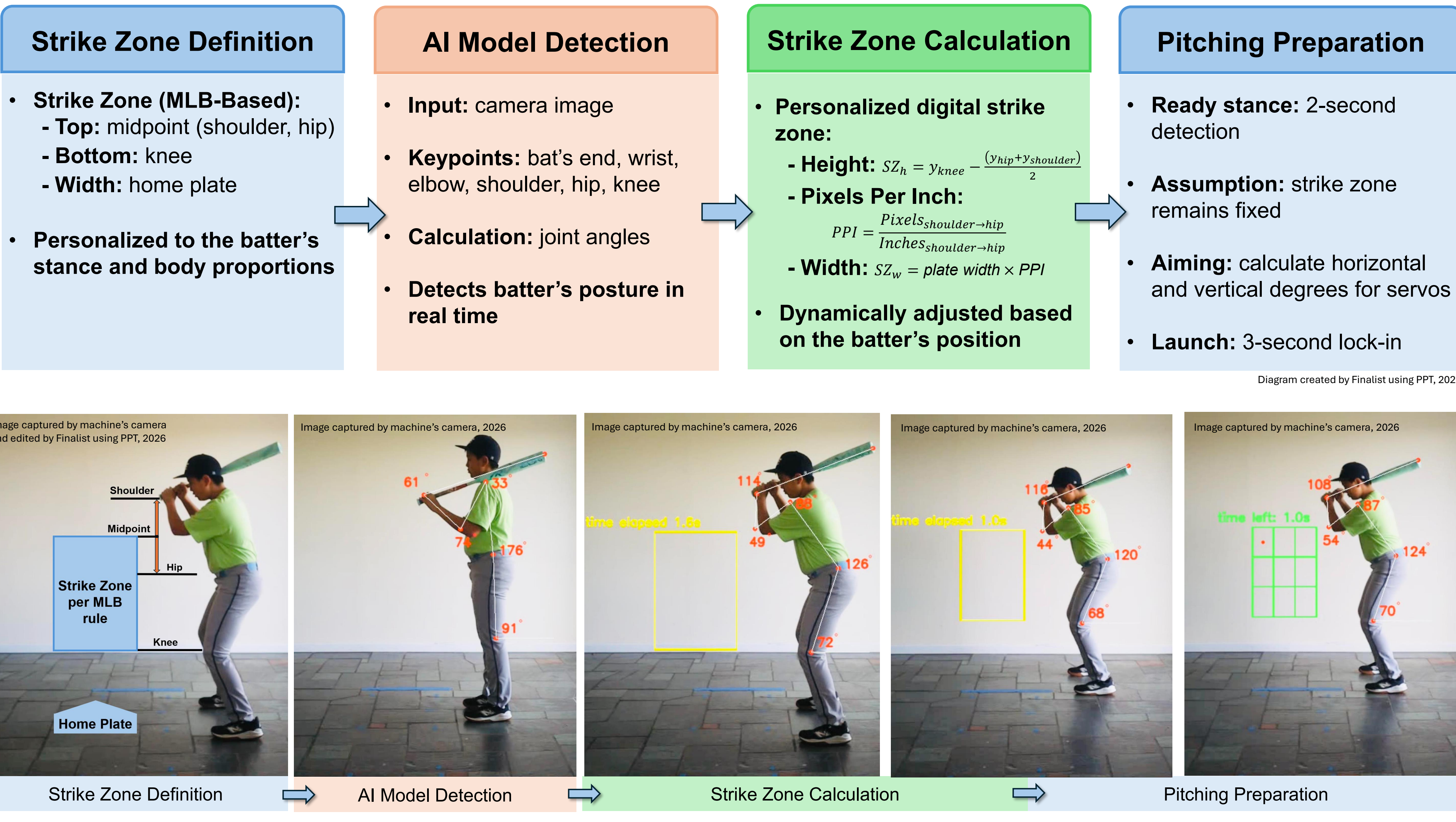
- The ball should be **similar size** as a real baseball but **lighter**.
- The top half of the machine must be **lightweight**.
- The bottom half of the machine must be **sturdy**.
- The custom-trained AI model must **accurately** detect 6 keypoints: the bat end, wrist, elbow, shoulder, hip, and knee.
- The frame rate must be **high enough** to capture the batter's movement.
- Only consider strike zone as **2D dimensional surface**.

## Materials

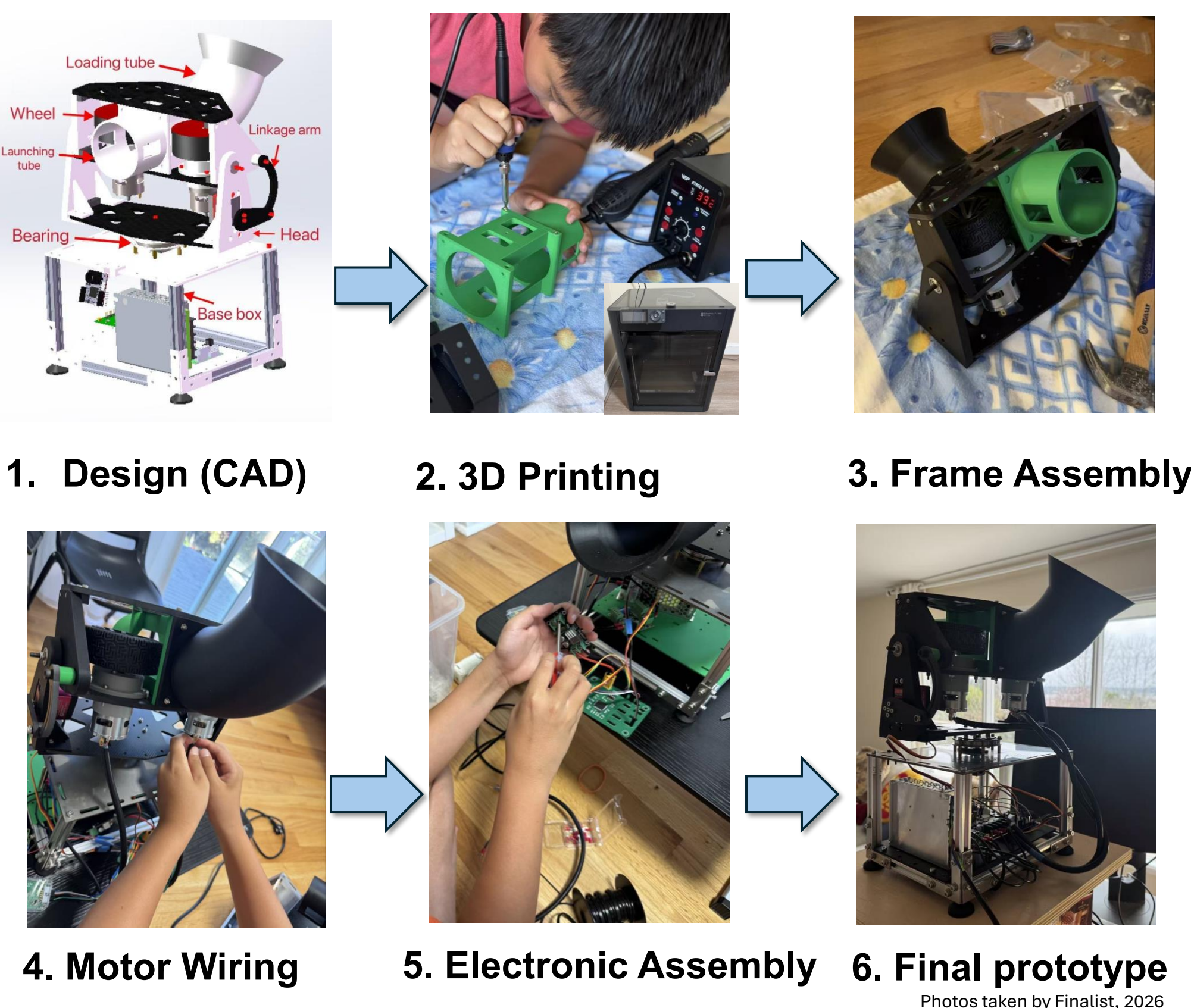
- Raspberry Pi** 4B with a 4GB memory
- Raspberry Pi **Camera** Module 3
- Servo Motors**, 775 **DC Motors**, Rubber **wheels**, **Soft foam balls**
- Cytron 20Amp Bi-Directional 6V-30V DC **Motor Driver**
- ESP32** Dev Board
- Pin Adapter **extension Board**
- Voltage transfer box** 110V to 12V
- Voltage Converter** Module 12V to 5V
- Custom **3D printed parts** and **Carbon Fiber Plate**
- M4 Washer, M3/M4/M5 Lock Nut, M3/M4/M5 Allen Bolts
- M2/M2.5 motherboard standoffs and screws
- Copper Wires, Dupont Wires, and 14 AWG wires
- X-Contact and Flanged **Bearings**
- Aluminum Bar Connector, Corner Bracket, and Custom steel sheet metal for **Base Box**

# VisionStrike: Portable AI-Powered Baseball Pitching Machine

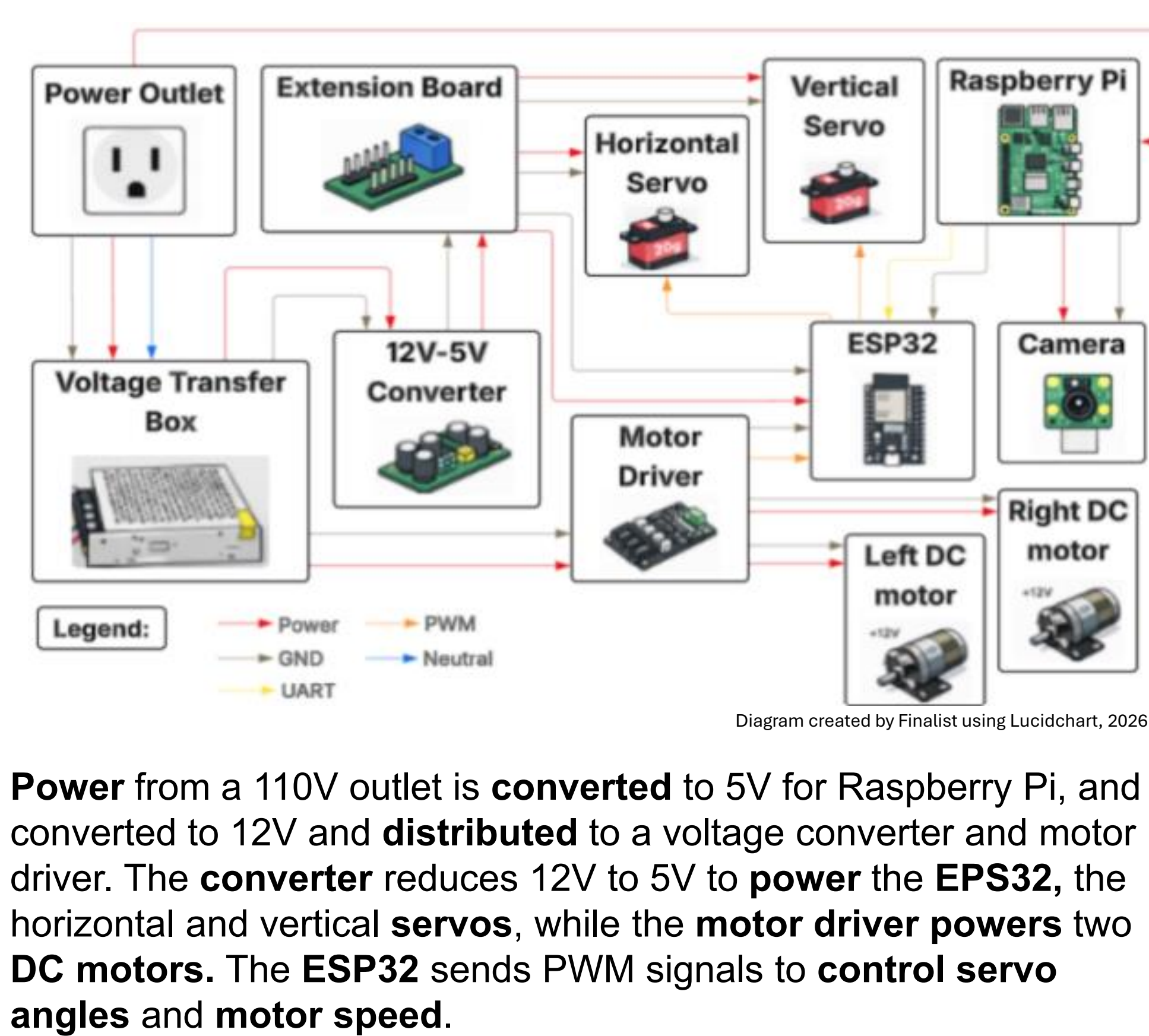
## AI-Powered Pitching System



## Design and Build Process



## Electronical Components

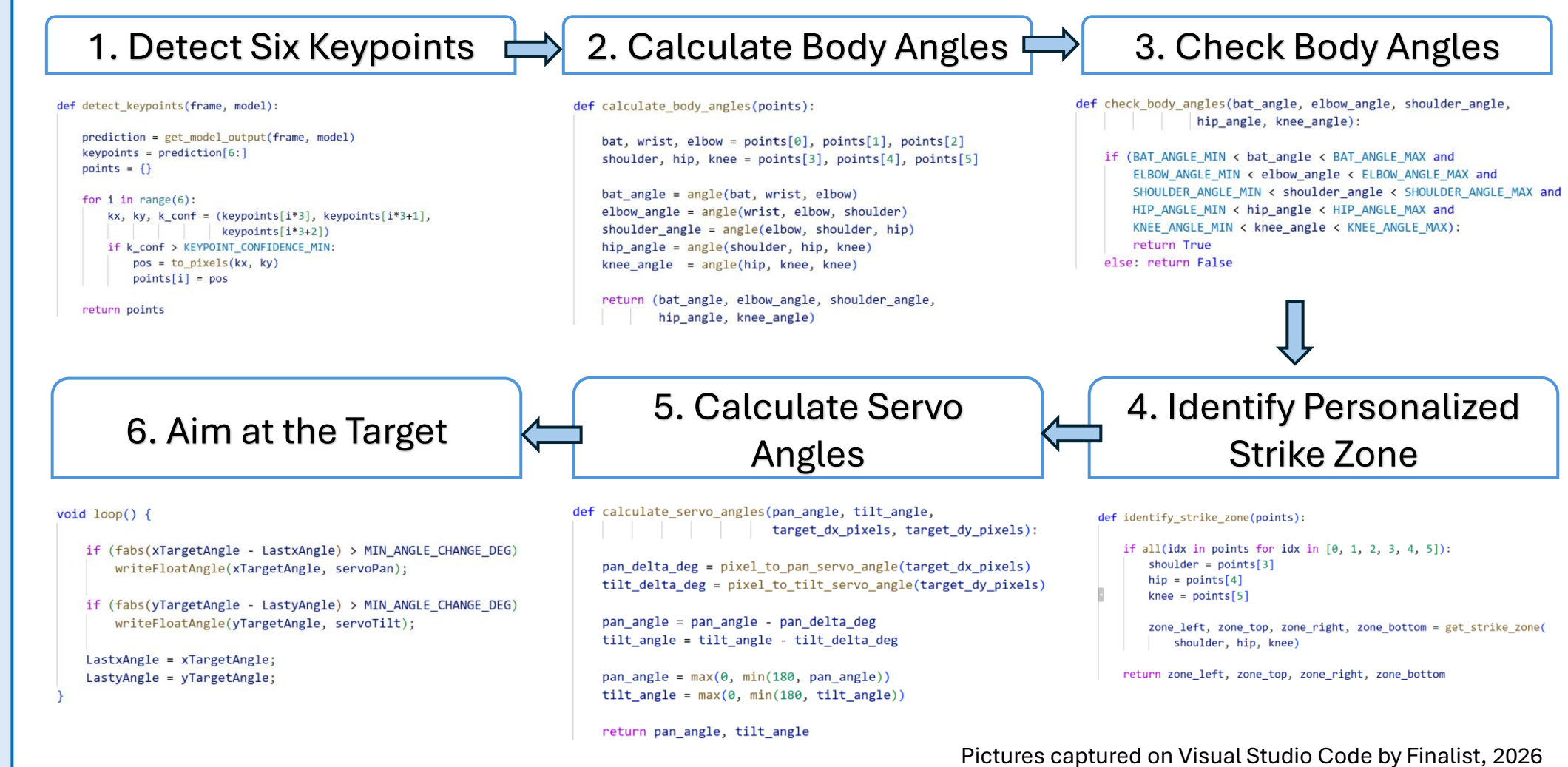


### Main References

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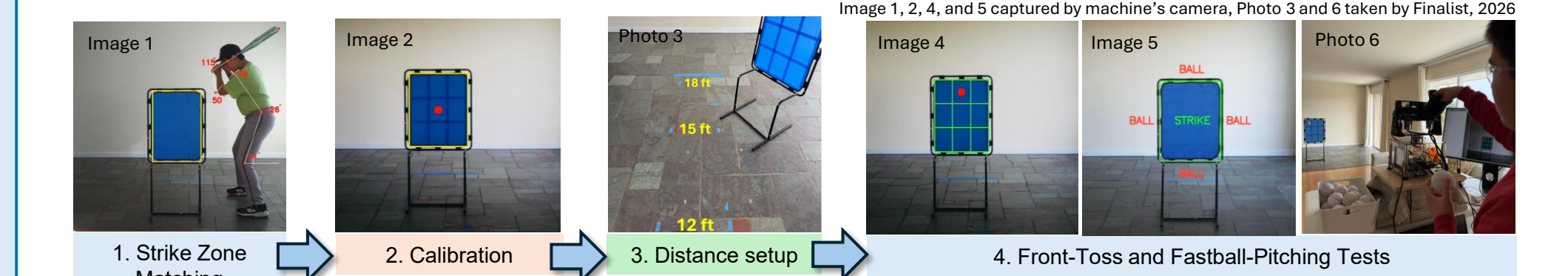
## Software Design Process

- Collected and annotated 200 images of me as the batter to create a dataset for training the AI model, and then trained a custom AI model.
- Programmed the Raspberry Pi to run the model to **detect six keypoints**, **calculate body angles**, **check body angles**, **identify personalized strike zone**, and **calculate servo angles**.
- Programmed ESP32 to control servos to **aim at the target** and DC motors to shoot the ball.

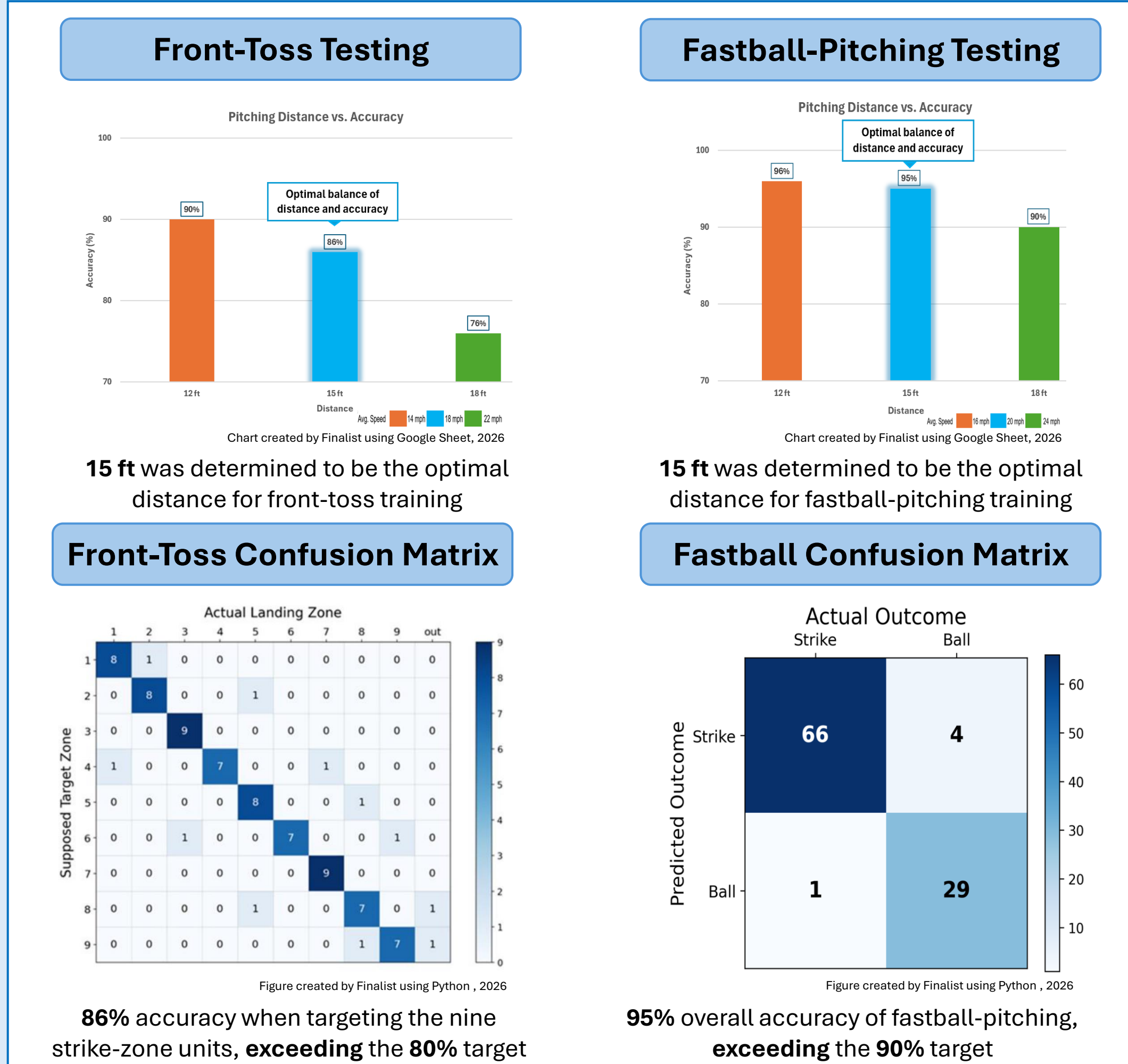


## Methodology

- Strike Zone Matching:** Align a physical strike zone target with the machine-identified strike zone
- Calibration:** Use the physical target to set the initial pitching location
- Distance Setup:** Set the target at 12 ft, 15 ft, and 18 ft with different pitching speeds
- Front-Toss Test:** Pitch to 9-unit strike zone (Goal: **≥80% accuracy**)
- Fastball-Pitching Test:** Pitch strikes and balls (Goal: **≥90% accuracy**)



## Results



## Conclusion

- I **successfully** designed and constructed an AI-powered baseball pitching machine that met **all my engineering goals**.
- The system **accurately detects** the batter's six keypoints and **calculates** a personalized strike zone.
- The machine **consistently** delivers targeted pitches in front-toss mode and **reliably "throws"** both strikes and balls in fastball-pitching mode, enabling **realistic game simulation**.
- The machine is **affordable, safe, and portable**, so it can be used anywhere to help baseball players effectively improve their batting skills.