X - Bot
Badminton Shuttlecock Collector

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Team Members

Advisor
Prof. Tessier

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➢ Team leader
➢ Object detection (OpenCV)
➢ Main control programming design
➢ X-Bot movement programming
➢ Distance calculation
➢ Ultrasonic sensor programming

Charlotte Wang
➢ Hardware structure design
➢ Website design
➢ Battery optimization
➢ 3D printing design for pulley
➢ Image dataset preparation
➢ Object detection (CNN)
Problem Statement

- Many people choose professional gymnasiums to practice badminton with family, friends, and coworkers.
- Gymnasiums pay salary to staff to collect shuttlecocks.
- The main ways to collect and sort shuttlecocks are manual or mechanical.
- To save human cost and improve sorting efficiency, semi-automatic robots controlled by staff in gyms would be welcome.
- With X Bot, the shuttlecocks on the floor will be sorted with high efficiency and the sorted shuttlecocks will be transported to assigned collection centers.
What can we do with X - Bot?

- Collect and sort shuttlecocks with high efficiency
- Transmit shuttlecocks to assigned places via remote control on Raspberry Pi platform
- Useful for both professional individuals and gymnasiums
Requirements Analysis

- **Requirements**
  
  - **Pick up & Transmit & Sort in order** shuttlecocks to collection centers
  
  - **Image Identification** of shuttlecocks and the courts to pick up the balls with the help of camera
  
  - **Ultrasonic module** avoid obstacles
  
  - **Interfaces**
    - WI-FI
  
  - **Battery**
    1) Rechargeable
    2) Can use at least 1 hour after charging
Specifications

Components:
- 1 Main Board (Raspberry Pi 3 B+)
- 2 Development Boards
- 1 Chassis + 4 Pulleys
- 4 Synchronous Pulleys + 4 Conveyor Belts
- 6 Motors
- 1 Mechanical Set + 3 containers
- 1 Brush
- 1 Battery
- 1 Camera (480P)
- 1 Ultrasonic module

Dimensions:
720 * 360 * 390 (L*W*H, mm)
X-Bot Power on

Connect via Wi-Fi

Initialization

Ultrasonic Measurement

>20 cm

< 20 cm

Image Detection

Data Analysis

Send Instructions

X-Bot Movement

Collect Shuttlecocks

Transmit Shuttlecocks

Sort in Container

Stop Movement

Take out Shuttlecocks

Work cycle by cycle
Optimization – Pulley Wheels

Pulley Wheels

**Improvements:**
- Effectively transmit shuttlecocks into containers
- Conveyor belts are fixed in a stable position
Avoid obstacles

Calculate distance by using ultrasonic?

\[ \text{Distance} = \frac{T \times S}{2} \]

- **Trig**: Transmit signal
- **ECHO**: Receive signal

**Travel time** = ECHO – TRIG

**Speed** = 340 m/s

**Distance** = \( T \times S / 2 \)
Features of camera:

- 300,000 resolution, 480P camera, good for video stream transmission

- Horizontally and vertically rotate (Future)
Battery Analysis

How to select the battery?

Power Supply

LiPo Battery

Charging

5,000mA/h * 14.8V = 74W/h

Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Q'ty</th>
<th>Current per unit</th>
<th>Voltage</th>
<th>W/h</th>
</tr>
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<tbody>
<tr>
<td>Motor for wheel</td>
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<td>1,000mA/h</td>
<td>12V</td>
<td>33.6W/h</td>
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</table>

Movement system

OUT : 12V

Control system

<table>
<thead>
<tr>
<th>Components</th>
<th>Q'ty</th>
<th>Current per unit</th>
<th>Voltage</th>
<th>W/h</th>
</tr>
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<td>Camera</td>
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<td>6V</td>
<td>4.05W/h</td>
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</table>

74W/h / 37.65W/h ≈ 1.96h
Object Detection

Datasets

Sample Positive images (307 Q'ty, 40 * 40 pixel)

Sample Negative images (2,037 Q'ty, 100 * 100 pixel)

OpenCV + Python

LBP Feature Algorithm

The result of detecting in M5 ground

* LBP: Local Binary Pattern
How far should X-Bot run after every detection?

Definition:
- $W =$ Actual object width
- $D =$ Distance from camera to object
- $P =$ Object pixels width in image
- $F =$ Focal length
- $S =$ Car speed per second
- $T =$ Car running time

Formula:
- $F = \frac{(P \times D)}{W}$
- $D' = \frac{(W \times F)}{P}$
- $T = \frac{D'}{S}$

Analysis:
If the camera finds many objects in the video, which distance will be used?

We will use the greatest distance.
1. Collect straightforward

Detect → Forward → Collect 3 times → Transmit

❖ Movement trajectory

2. Collect Turn-Left / Right

Detect → Forward → Collect 3 times → Transmit → Rotation Fixed angle → Collect 3 times

❖ Movement trajectory

Developing
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<th>Item</th>
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<th>Cost(¥)</th>
<th>Cost($)</th>
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<td>Mecanum Wheels</td>
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<td>Chassis</td>
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<td>Motor for brush and pulleys</td>
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<td>Badminton Shuttlecocks set</td>
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<tr>
<td>15</td>
<td>Bearings + Axles</td>
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<td>50</td>
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<td><strong>41</strong></td>
<td><strong>2,659</strong></td>
<td><strong>391.0</strong></td>
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</table>
- **Software: Image Identification of Shuttlecocks & Programming**
  - Function
    1) Tell the brush to sweep up a shuttlecock whenever one is observed.

- **Hardware:**
  - **Alarm Sensor**
    When one of the container is full, tell the brush to stop working.
  - **Ultrasonic avoiding obstacle**
    When the distance between the ultrasonic sensor and an obstacle is less than 20cm, the X – Bot will move away.

- **Website Updated**
A better X – Bot in the future

1. Implement CNN detection model in X-Bot
2. Develop APP using Bluetooth connection
3. Optimize hardware design
4. Optimize software logic design
Q & A
Thank you