UMassAmherst

X - Bot

Badminton Shuttlecock Collector

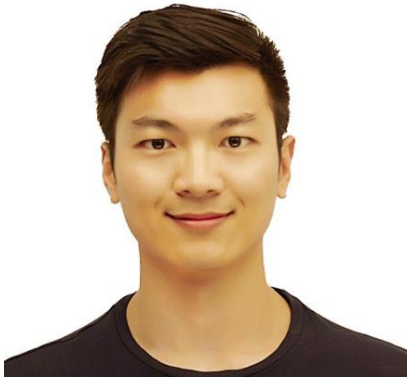
Dec 14, 2018

Department of Electrical and Computer Engineering

Advisor: Professor Tessier

Team Members

Advisor
Prof. Tessier



Daniel Wang

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

Charlotte Wang

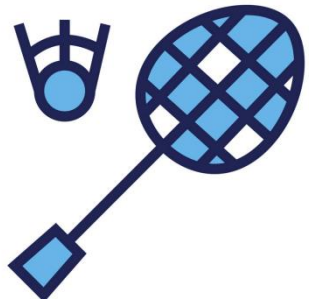
- Hardware structure design
- Website design
- Battery optimization
- 3D printing design for pulley
- Image dataset preparation
- Object detection (CNN)

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**

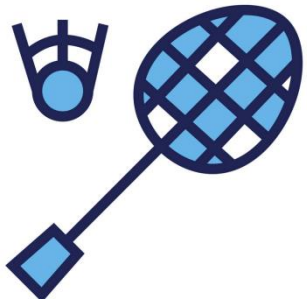
- Pick up & Transmit & Sort in order shuttlecocks to collection centers

- 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



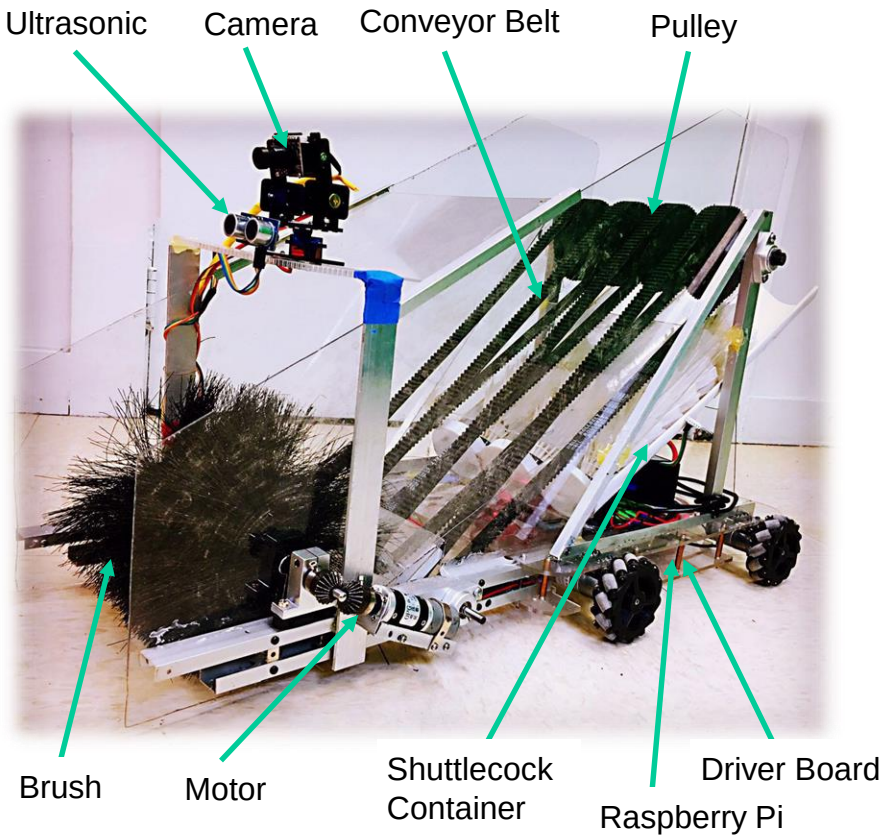
Specifications

Components:

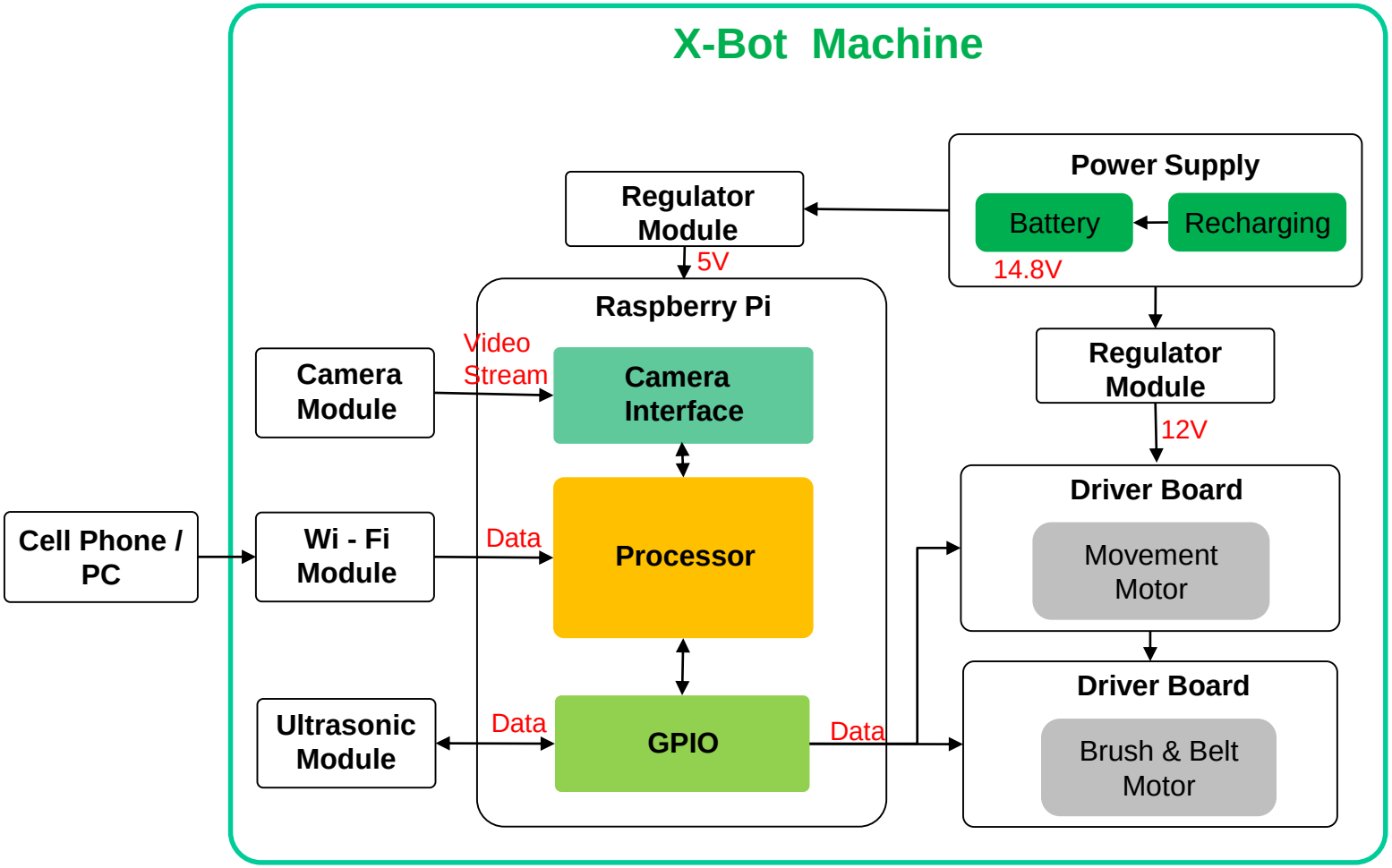
- 1 Main Board (Raspberry PI 3 B+)
- 2 Development Boards
- 1 Chassis + 4 Pulleys
- 4 Synchronous Pulleys + 4 Conveyor Belts
- 6 Motors
- 1 Mechanical Set + 3 containers
- 1 Brush
- 1 Battery
- 1 Camera (480P)
- 1 Ultrasonic module

Dimensions:

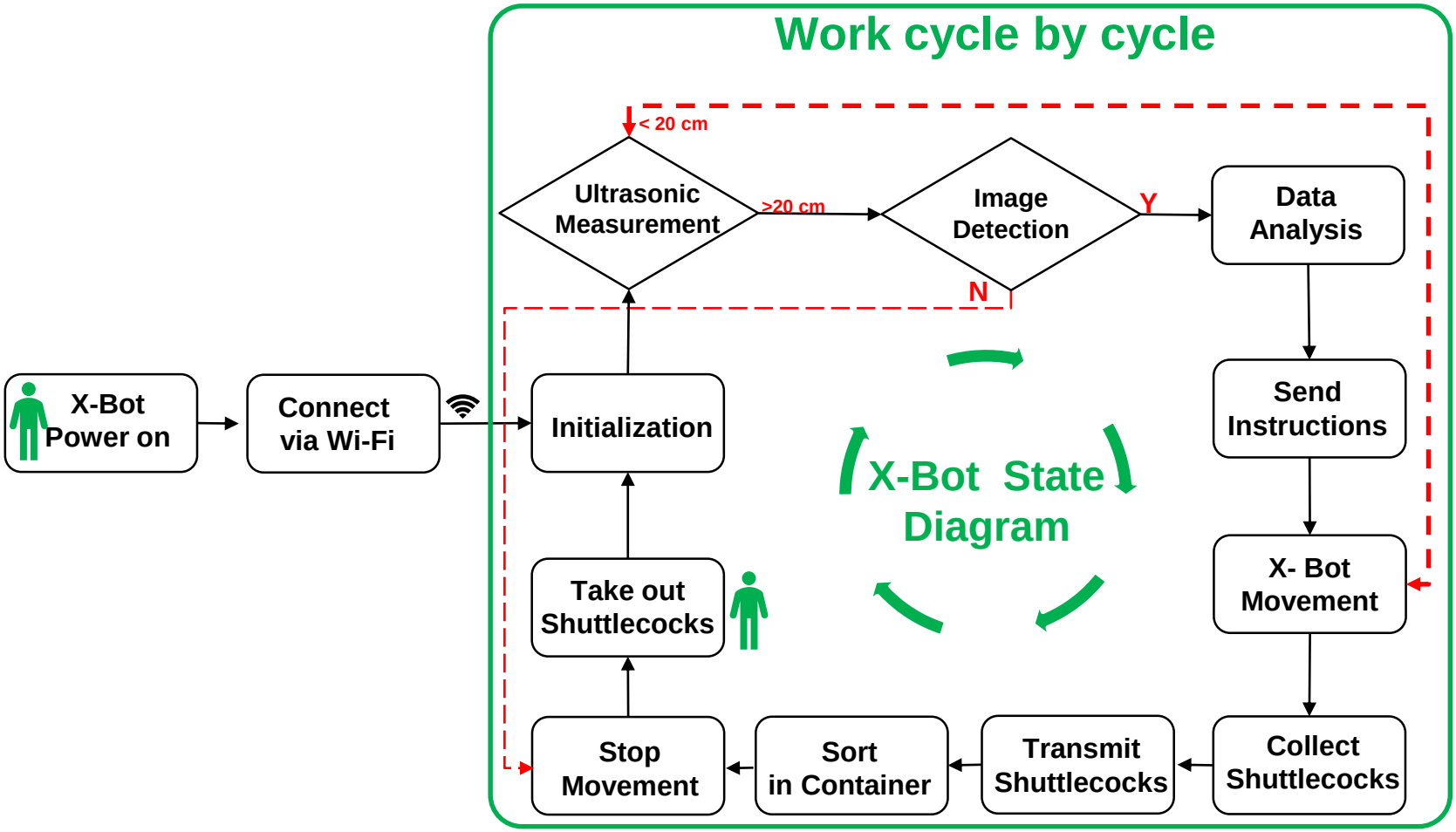
720 * 360 * 390 (L*W*H, mm)



Block Diagram

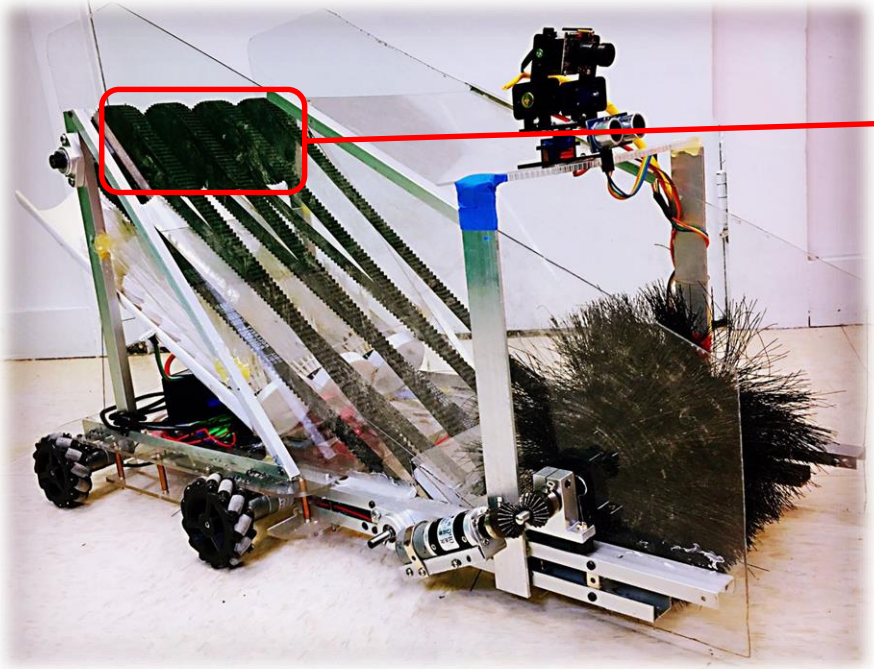


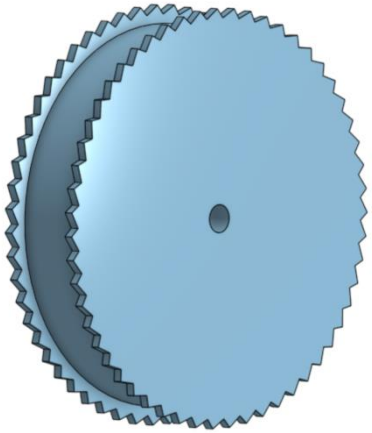
State Diagram



Optimization – Pulley Wheels

Pulley Wheels





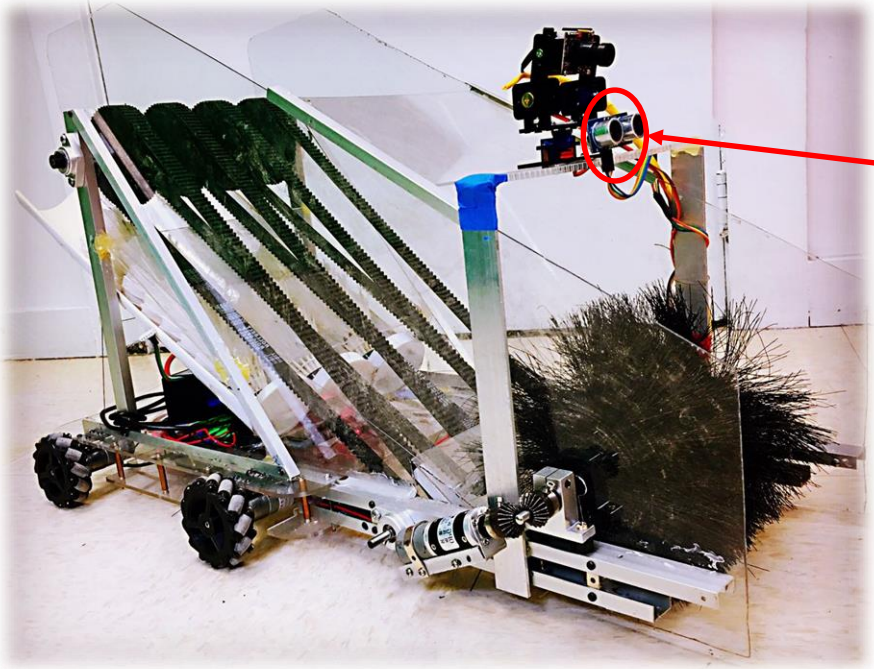
3D Printing

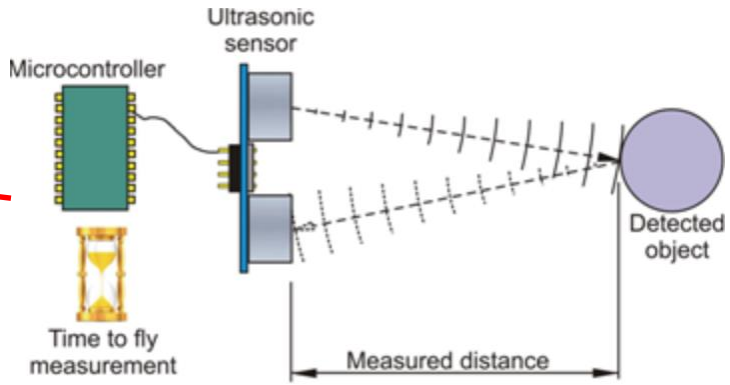
Improvements:

- Effectively transmit shuttlecocks into containers
- Conveyor belts are fixed in a stable position

Avoid obstacles

Calculate distance by using ultrasonic?





Trig: Transmit signal
ECHO: Receive signal

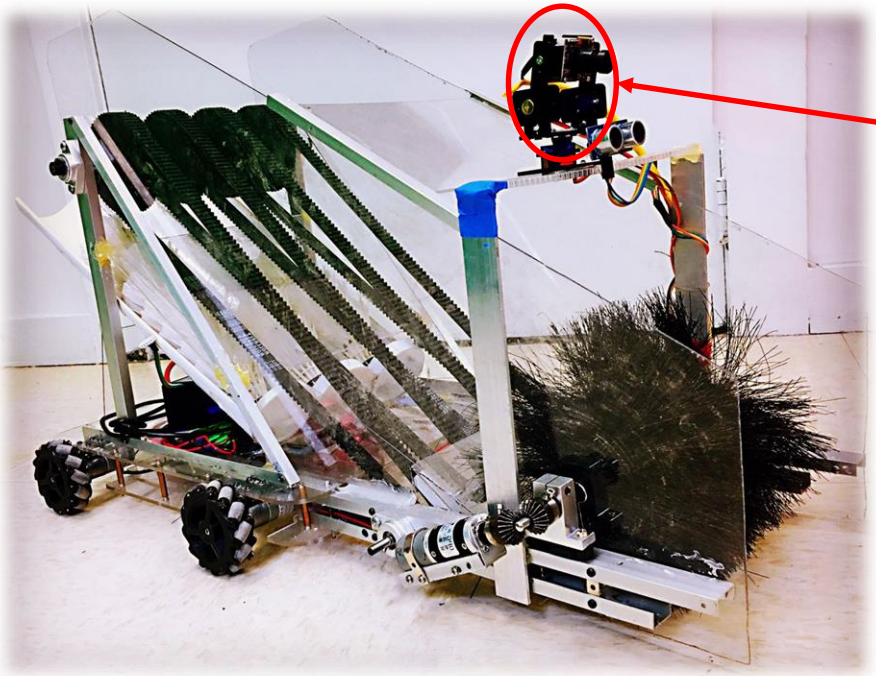
Travel time = ECHO – TRIG

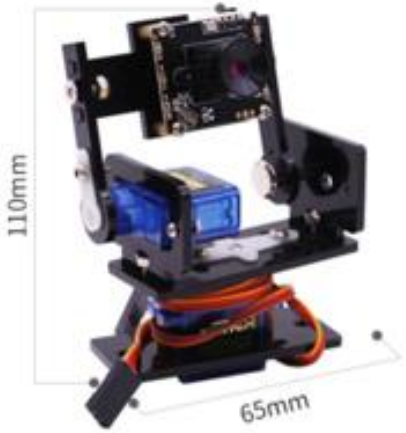
Speed = 340 m/s

Distance= T * S / 2

Camera

Camera Detection





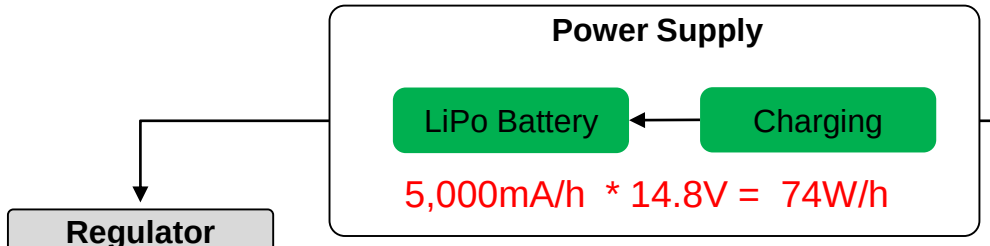
Features of camera:

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

- Horizontally and vertically rotate(Future)

Battery Analysis

How to select the battery ?



Regulator Module

OUT : 12V

Movement system

Components	Q'ty	Current per unit	Voltage	W/h
Motor for wheel	4	400mA/h	12V	19.2W/h
Motor for brush / Pully system	2	600mA/h	12V	14.4W/h
TTL	6	1,000mA/h	12V	**33.6W/h**

Regulator Module

OUT : 6V

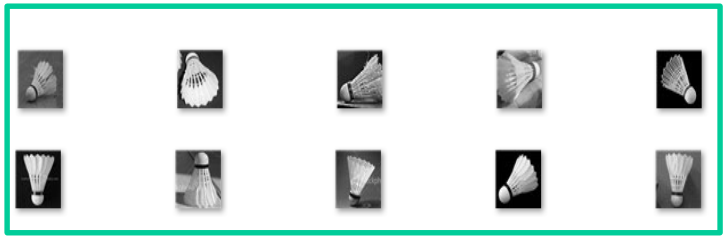
Control system

Components	Q'ty	Current per unit	Voltage	W/h
Raspberry Pi	1	500mA/h	6V	3W/h
Camera	1	160mA/h	6V	0.96W/h
Ultrasonic	1	15mA/h	6V	0.09W/h
TTL	3	675mA/h	6V	**4.05W/h**

74W/h / 37.65W/h ≈ 1.96h

Object Detection

Datasets

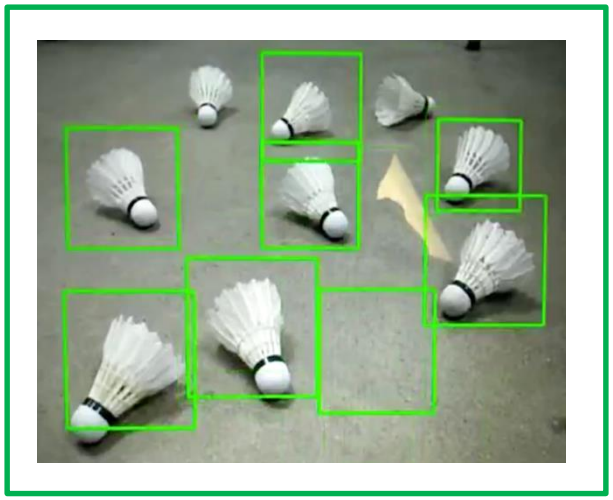


Sample Positive images
(307 Q'ty, 40 * 40 pixel)

OpenCV
+
Python

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

LBP Feature
Algorithm

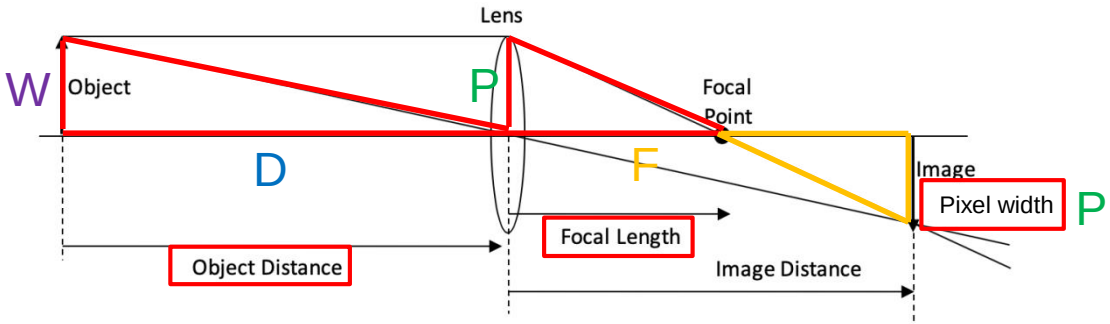


The result of detecting in M5 ground

*** LBP:** Local Binary Pattern

Running time

How far should X-Bot run after every detection?



Formula

$F = (P \times D) / W$

$D' = (W \times F) / P$

$T = D' / S$

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

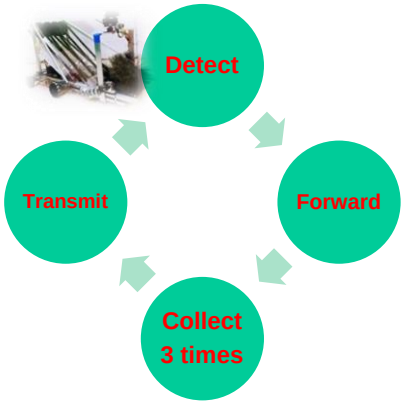
Analysis:

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

We will use the greatest distance.

Logic Control

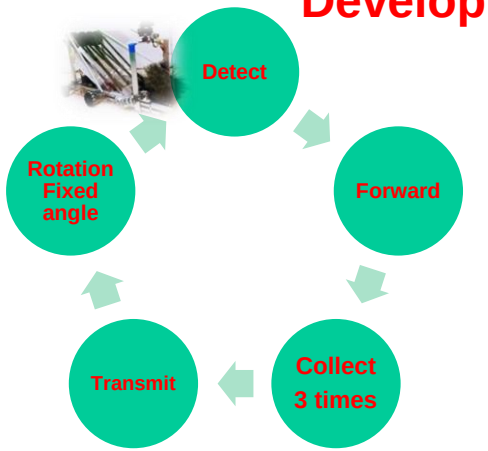
1. Collect straightforward



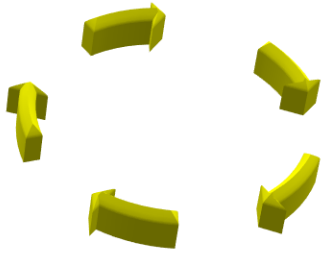
❖ Movement trajectory

2. Collect Turn-Left / Right

Developing



❖ Movement trajectory



Expenses

No.	Item	Q'ty	Cost(¥)	Cost($)
1	Raspberry Pi 3B +	1	269	39.6
2	Driver board	2	100	14.7
3	Infrared Moudle	1	20	2.9
4	Camera + Servo	1	260	38.2
5	Mecanum Wheels	4	200	29.4
6	Chassis	1	300	44.1
7	Motors for Chassis	4	180	26.5
8	Battery + Packs + Charge	3	280	41.2
9	Aluminium alloy matrial	1	300	44.1
10	Motor for brush and pulleys	2	260	38.2
11	Conveyor Belts	4	130	19.1
12	Pulleys	8	150	22.1
13	Nylon Brush	1	80	11.8
14	Badminton Shuttlecocks set	2	80	11.8
15	Bearings + Axles	6	50	7.4
	TTL	**41**	**2,659**	**391.0**

FPR Deliverables

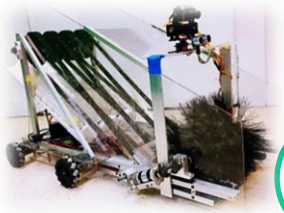
- **Software: Image Identification of Shuttlecocks & Programming**
  - Function
  1) Tell the brush to sweep up a shuttlecock whenever one is observed.

- **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**

In the future

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