R-ARM-BOT
ME395 Final Presentation

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Motivation - A Greener World

- Recycling rate in America is now ***32***%. Comparison was ***72***% in 2019

- Plastics must be sorted before they can be recycled
- Many recyclables become contaminated when placed in the wrong bin.
- Contamination can prevent large batches of material from being recycled. Other materials can't be processed in certain facilities.

SOURCES: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials
https://news.climate.columbia.edu/2020/03/13/fix-recycling-america/

Traditional Recycling Processes

- Recycling process now:
  Materials Recovery Facility (MRF) → conveyor belt → pre-sort removing non-recyclables → sorting area manually sorted by workers
- Sorting is dirty, low-paid, and mind-numbing work. (Usually manually sorted at smaller MRFs)
- Current estimate for sorting labor in the US is *$**5** billion*

Sources:
https://www.cleantech.com/recycling-and-sorting-from-futility-to-efficiency,
https://www.forbes.com/sites/kenrickcai/2020/11/12/rise-of-the-recycling-robots/?sh=3fee204665f9

Robots & Recycling

- Patents for recycling robots first filed in 1990s
- Larger MRFs have automated machines for sorting.
- Autonomous optical and waste sorting systems have been a success story in the recycling industry - key players like ZenRobotics and AMP Robotics
- Uptick in popularity during pandemic too

Robots & Recycling

- Faster computer processing speeds → potential of deep learning to transform existing automotive manufacturing robots for a range of new conveyor belt-based use cases.

- Deep learning to teach the robots how to recognize objects based on colors, shapes, textures and logos.

- Robots far more productive than humans: ability to pick up 80 pieces of material per minute vs 40 → each machine can handle the work of at least two employees → workers free to do other skilled jobs at recycling center

- Robots are more accurate at waste sorting → recycling facilities, which operate on low profit margins, may be able to improve the amount of recycled material they sell

Project Overview

- **xARM UNO Robotic Arm** identifies and picks up different products
  - Products:
    - Plastic water bottles / Aluminum soda cans / Toilet paper roll
  - Products will be on an assembly line
  - Robot arm places them in separate, designated bins

Timeline

Week 1: Introduction to course and choose project groups

Week 2: Refine project topic to Recycling

Week 3: Begin training on FANUC robot

Week 4: Present initial project idea, build xArm UNO robot

Week 5: Finish training on xArm UNO robot

Week 6: Design robot base and conveyor, program robot motion path

Week 7: Build robot base, purchase parts for conveyor, program robot sensors

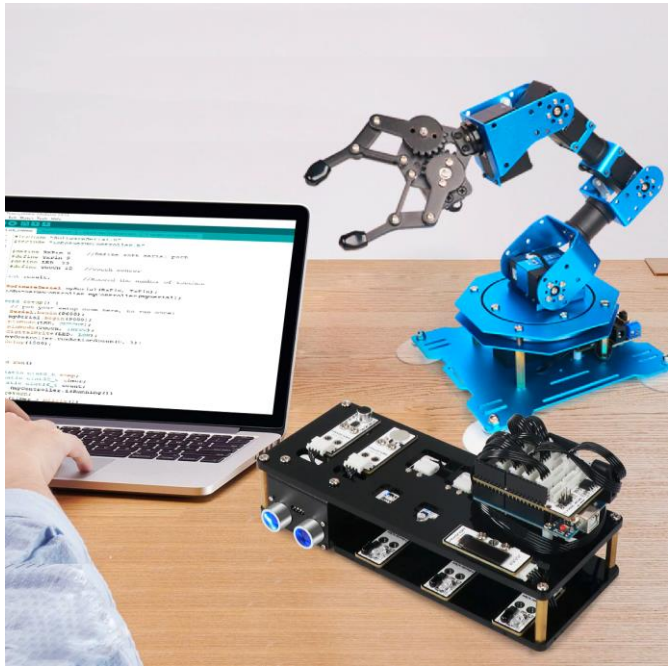
Week 8: Test and iterate motion path + sensor code, build conveyor

Week 9: Implement conveyor with final assembly, code conveyor motor logic

Week 10: Present project

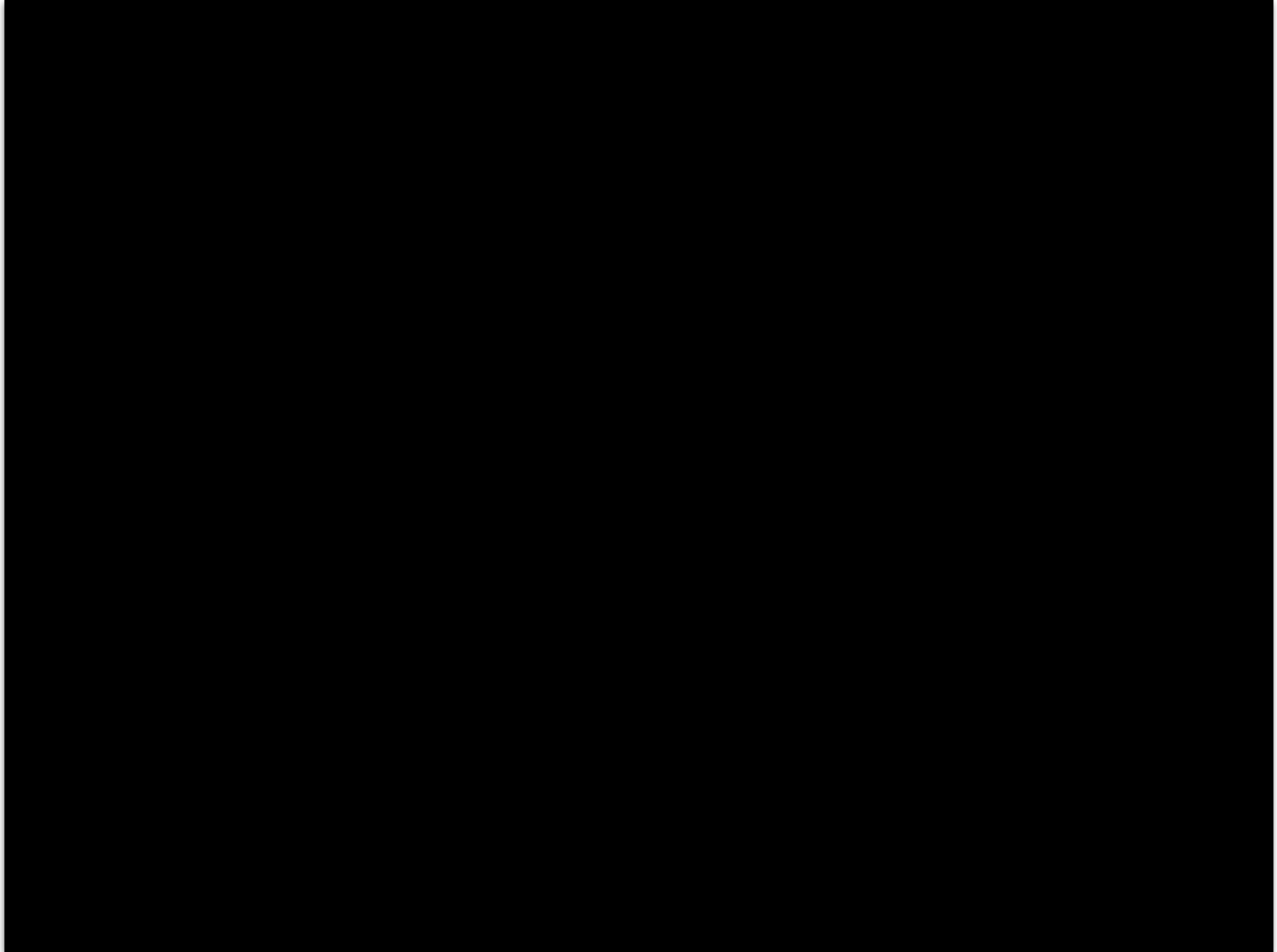
Hiwonder xArm UNO Robotic Arm

- 6 servos (5 dof + gripper)
- Arduino Programming
- Sensor Kit:
  - IR Sensor
  - Color Sensor
  - OLED Screen
  - Touch, Sound, Light, Ultrasonic sensors



How it Works

1. Items randomly arrive on the conveyor belt
2. IR sensor recognizes when an item is in front of the arm and stops the conveyor
3. Color sensor identifies object
4. With this information, robot picks up object and drops it in the designated bin



Color Detection

- Averaged 50 color readings to get a single value
  - A single reading was found to be unreliable
- Located optimal position from sensor to object
- For any color to be read, max[r,g,b] > 80
  - Needed to add blue tape to the water bottle to make it “blue” enough

```
105 int newColorDetect() //from Discriminate_color.IDO
106 {
107
108   uint16_t r, g, b, c;
109   int rTotal = 0;
110   int gTotal = 0;
111   int bTotal = 0;
112   int t;
113
114   for (int k = 0; k<50; k++){
115
116     //wait for color data to be ready
117     while(!apds.colorDataReady()){
118       delay(5);
119     }
120
121
122     apds.getColorData(&r, &g, &b, &c);
123     rTotal = rTotal + map(r, r_f, R_F, 0, 255);
124     gTotal = gTotal + map(g, g_f, G_F, 0, 255);
125     bTotal = bTotal + map(b, b_f, B_F, 0, 255);
126   }
127
```

Motion Planning

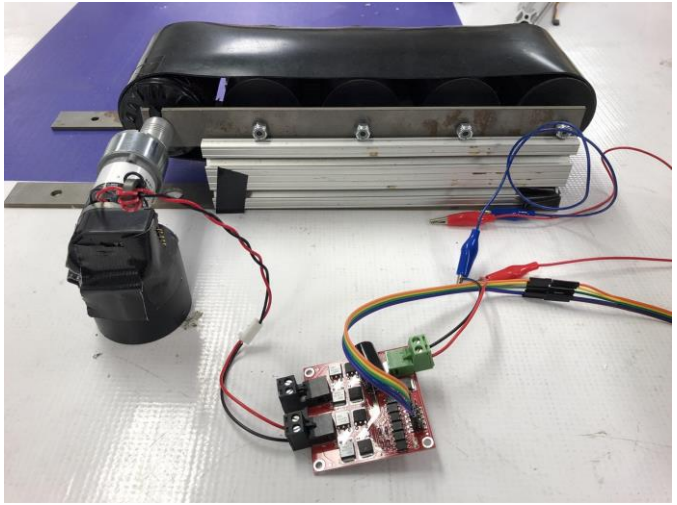
- Four discrete positions: where the motor picks up the object and the three bins
- Robot arm has six servos
  - Documented the position of each using trial and error
- Found the positions to be reliable over many consecutive trials

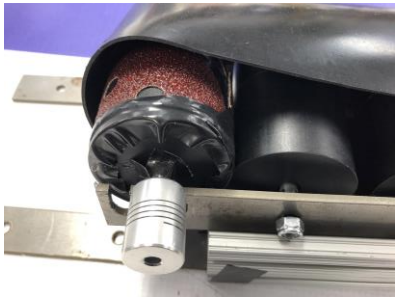
```
void goToObject(){
  // Servo 1: Open gripper
  myController.moveServo(1,0,1000);
  // Servo 2
  myController.moveServo(2,500,1000);
  // Servo 3
  myController.moveServo(3,500,1000);
  // Servo 5
  myController.moveServo(5, 300,1000);
  // Servo 6
  myController.moveServo(6,850,1500);
  delay(2000);
  // Servo 4
  myController.moveServo(4,700,1000);
}

void gripCan(){
  myController.moveServo(1,500,1000);
}

void gripBottle(){
  myController.moveServo(1,600,1000);
}

void gripRoll(){
   myController.moveServo(1,500,1000);
}

void dropCanOff(){
  myController.moveServo(1, 500, 1000);
  myController.moveServo(2, 500, 1000);
  myController.moveServo(3, 500, 1000);
  myController.moveServo(4, 600, 1000);
  myController.moveServo(5, 445, 1000);
  myController.moveServo(6, 270, 2000);
  delay(3000);
  // open gripper
  myController.moveServo(4, 750, 1000);
  delay(1000);
  myController.moveServo(1, 0, 1000);
  delay(1000);
  myController.moveServo(4, 600, 1000);
}
```

Conveyor Belt

- Motor: High torque with low speed
  - With high torque, it has the ability to move items with high mass
- Motor Driver: L298N
  - Uses 9V battery as a power source
  - Signal given by the same Arduino Uno as robot arm
- Conveyor Prototype:
  - Add sand paper on the roll to increase friction

```
176 void conveyorForward(){
177   digitalWrite(10,HIGH);
178   digitalWrite(11, LOW);
179 }
180
181 void conveyorStop(){
182   digitalWrite(10,LOW);
183   digitalWrite(11, LOW);
184 }
```





Potential Future Developments

- Implement computer vision for object detection
  - Color sensor works for this scenario, but is unreliable at times and doesn't scale to other objects easily
- Design more robust gripper for larger objects
  - Needed small objects to grip with this robot
- Speed up entire system
  - Cycle time is very slow, won't scale well

Q&A

The average attention span during a presentation is 10 minutes.