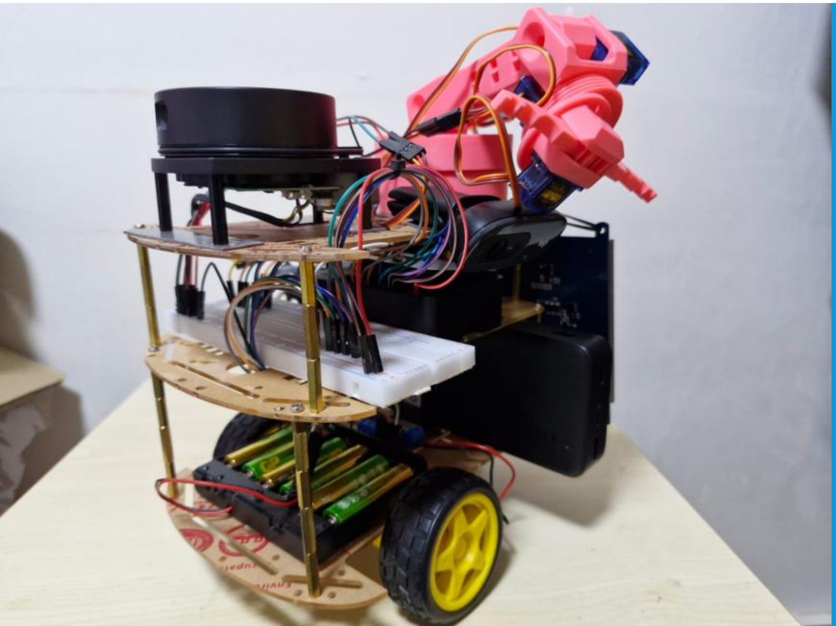
6FTC2062 BEng Individual Major Project

Project Defence

DESIGN A WASTE SORTING ROBOT WITH AI CAPABILITY



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INTRODUCTION

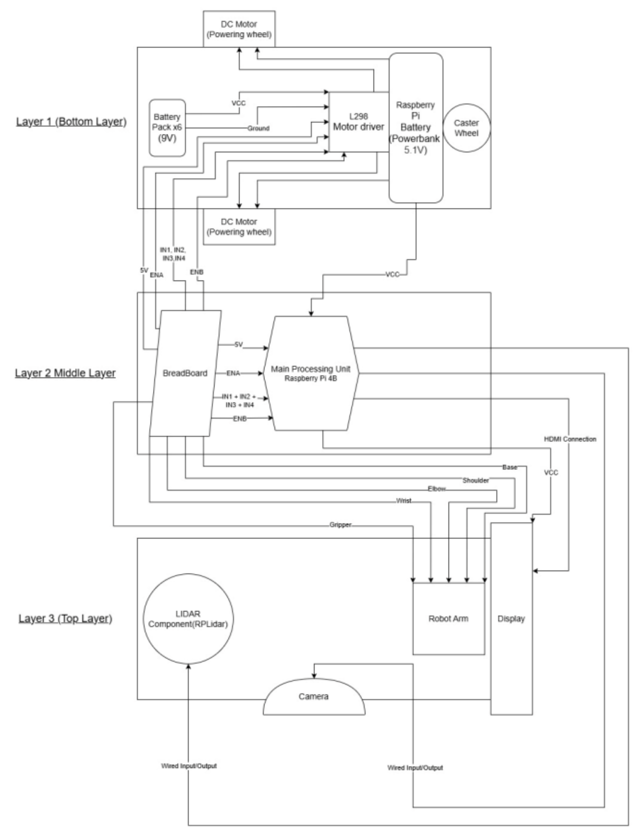
- Approximately 2.01 billion metric tons of waste are produced each year and is projected to grow by 70% by 2050 without significant intervention as of 2023
- Automation of waste sorting would reduce reliance on human labour and encourage recycling
- Waste classification systems built on AI, specifically Convolutional Neural Networks (CNNs), showcase high accuracy in identifying and categorizing materials like plastic, paper, metal and more

AIMS AND OBJECTIVES

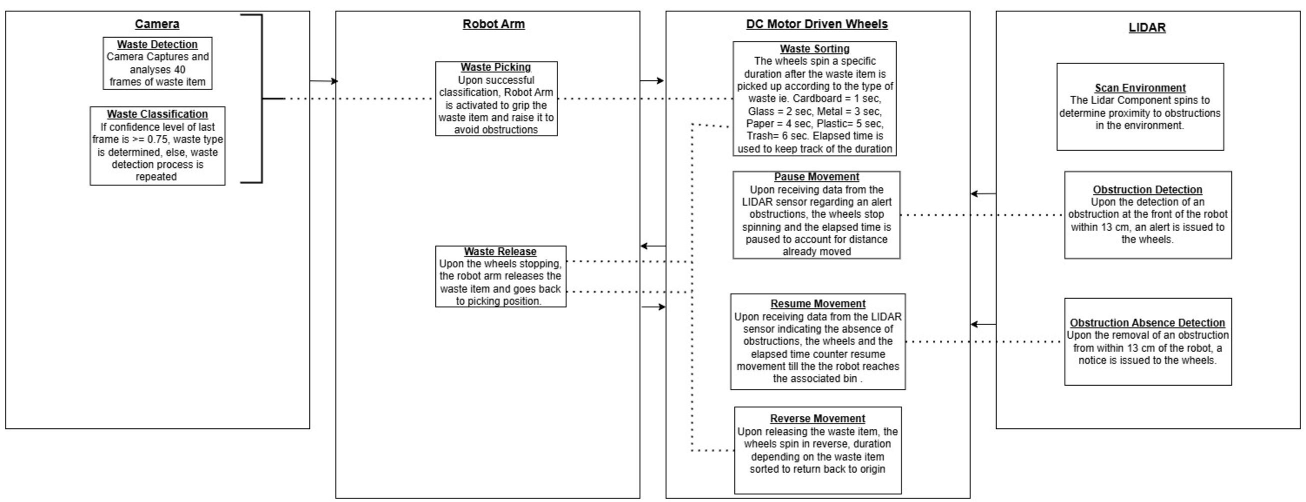
- Develop an autonomous waste-sorting robot for efficient recycling
- Utilize AI-based waste classification using CNNs
- Utilize a modular robot design for hardware and software integration

METHODOLOGY (HARDWARE AND SOFTWARE DESIGN)

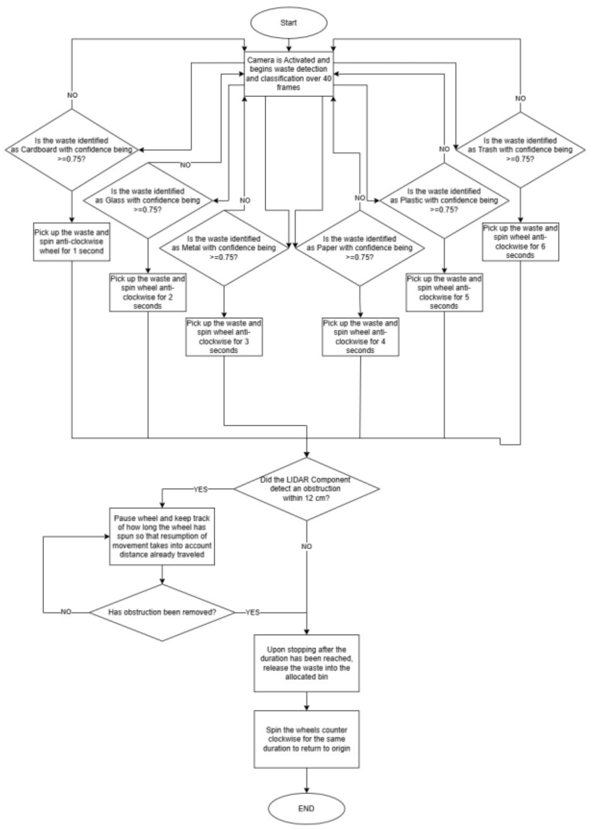
Hardware Architecture Block Diagram



Software Architecture Block Diagram

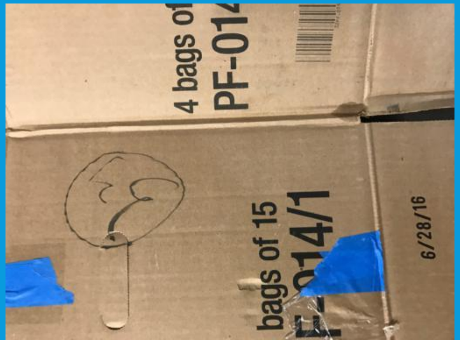


Software Flowchart



METHODOLOGY (IMPLEMENTATION AND TESTING)

- Dataset Preparation
  - Six waste categories: cardboard, glass, metal, paper, plastic, and trash.
  - Dataset balanced with augmentation (rotation, brightness adjustment).
  - Preprocessed images resized to 32 × 32 pixels for consistency.
- Testing Phases
  - Components tested individually (motors, LiDAR, robotic arm).
  - Integrated testing involved waste detection, navigation, and sorting.



RESULTS

- AI Model Performance:
  - Achieved classification accuracy: 92%.
  - Added safeguard: Confidence threshold set at 0.75 to reduce false positives.
  - Classification results for six waste types with confusion matrix analysis.
- Robot Performance:
  - Achieved 85% integration of components (camera, robotic arm, wheels).
  - LiDAR sensor tested independently due to integration challenges.
- Limitations:
  - Power bank unable to sustain load for all components.
  - Occasional misclassification of objects with similar features (e.g., plastic and glass).

CHALLENGES AND PROPOSED IMPROVEMENTS

- **Challenges:**
  - Power bank unable to sustain load for all components.
  - Occasional misclassification of objects with similar features (e.g., plastic and glass).
  - Synchronization issues with the LiDAR and elapsed time tracker.
- **Proposed AI Model Improvements**:
  - Expand the dataset with diverse image conditions for better generalization.
  - Address classification biases for "no object" scenarios.
- **Proposed Hardware Enhancements**:
  - Fully integrate LiDAR with the elapsed time tracker for seamless navigation or replace LiDAR with ultrasonic sensors
  - Upgrade to higher-capacity batteries for sustained operations.
  - Upgrade robot arm both hardware and software wise to ensure waste is picked up smoothly
- **Additional Proposed Features**:
  - Implement facial blurring for privacy compliance.
  - Real-time monitoring and advanced obstacle detection for enhanced functionality.

CONCLUSION & DEMO