Georgia State University

Undergraduate Honors Thesis Research Proposal Draft

Title: **Development of Waste Collection Mobile Robot Equipped with Robotic Arm and Trash Sorting Bin using Robotic Algorithms, Computer Vision, and Deep Learning.**

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Note: **This research proposal is subject to change.**

Abstract

Inefficient waste management is a growing concern in environments like college campuses, hospitals, offices, malls, transport stations and etc. This research thesis explores the design, development and test of a smart waste management system comprised of three components: Robotic Arm Mechanism, Autonomous Robot Car, and an Intelligent Waste Sorting Trash Bin. Development of each component is conducted on a separate sub researches. The sub researches are the following: "Design and Development of Autonomous Robot Car using Robotic Algorithms, Computer Vision and Deep Learning", "Design and Development of Robotic Arm Mechanism using Robotic Algorithms, Computer Vision and Deep Learning" and "Design and Development of Intelligent Trash Sorting Bin using Computer Vision and Deep Learning". The robot car will autonomously navigate its environment and identify trash and move toward the trash object, the robot arm will then pick up, and dispose the trash into the bin mounted on the robotic car then the intelligent bin will classify the type of the waste and segregate it into designated compartments for proper recycling and disposal.

Introduction

Traditional waste collection methods are mostly inefficient and labor intensive. Additionally, improper waste sorting remains a significant challenge in today's world. This proposal introduces a solution utilizing robotics and artificial intelligence (AI) to address these challenges.

Research Objectives

- Design and develop a robot car capable of autonomously navigate the environment, identify trash objects, and move towards them.
- Design and develop a robotic arm that can identify and pick up trash objects, rotate towards the trash bin mounted on the robot car and dispose the trash into the bin.
- Design and develop an intelligent trash bin trained with computer vision and deep learning algorithms to categorize waste for proper sorting into designated compartments.
- Integrate the robotic arm mechanism, the autonomous robot car, and the intelligent trash bin systems to enable efficient trash collection, recycling, and disposal.

Research Methods

1. Robotic Arm Mechanism:
   - Design and build grasping arm mechanisms using robotic algorithms, actuators, cameras and sensors.
   - Implement computer vision and deep learning for trash identification.
2. Robot Car Development:
   - Design and build a robot with sensors (LiDAR, …) and cameras for obstacle detection and environment mapping.
   - Implement computer vision and deep learning algorithms for trash recognition.
3. Intelligent Trash Bin Development:
   - Design and build a multi-compartment bin for different types of waste.
   - Implement computer vision and deep learning algorithms to classify waste types.
   - Design and develop sorting mechanism based on the identified waste category.

Expected Outcomes

1. Autonomous Robot Car
2. A Robotic Arm Mechanism
3. An Intelligent Trash Bin
4. A combined system that improves waste management efficiency and reduces human labor requirements.
5. A research paper explaining what, why, how and when this research was done, obstacles faced throughout the research and how the output could be improved and scaled.

Potential Hardware/Software Requirements

1. Hardware:
   A. Arm Movement Mechanisms (Actuators, Joints, Grippers)
   B. Cameras
   C. Control Units (Arduino /Raspberry Pi/Jetson Nano)
   D. Electric Motors
   E. Driver Motors
   F. Robot Car Movement Mechanisms (Wheels, Brakes Actuators)
   G. Sensors (LiDAR)
   H. Waste Segregation Mechanisms (Motors, Rotator)
   I. 3D Printed Body Parts
2. Software:
   A. Programming Languages: Python, C++, C(?), Matlab(?)
   B. Frameworks: TensorFlow/PyTorch, YOLO/OpenCV, Robot Operating System
   C. Tools: Simulators (Gazebo/V-REP…), Design (CAD, Autodesk), Git, GitHub, Dataset for training the AI model

Research Timeline

- **Preparation Phase: May 2024 (1 Month)**
  Literature Review
- **Sub Research 1: Jun 2024 - Sep 2024 (3 Months)**
  Development of Autonomous Robot Car using Robotic Algorithms, Computer Vision and Deep Learning
- **Sub Research 2: Sep 2024 - Dec 2025 (4 Months)**
  Development of Robotic Arm Mechanism using Robotic Algorithms, Computer Vision and Deep Learning
- **Sub Research 3: Jan 2025 - Feb 2025 (2 Month)**
  Development of Intelligent Trash Sorting Bin using Computer Vision and Deep Learning
- **Integration of Sub Researches into a Final Product: Mar 2025 (1 Month)**
  Integration of the Autonomous Robot Car, Robotic Arm Mechanism, and Intelligent Trash Bin Systems
- **Final Phase: Apr 2025 (1 Month)**
  Analyze Final Results and Write Thesis

Conclusion

This proposed smart trash collection, recycling and disposal system, by combining robotic automation with AI-powered waste sorting, has the potential to create a better and efficient waste management system and clean environment.