Hygieia

Automated Waste Collector and Segregator

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Abstract

Garbage and waste are an ever growing problem for humans environmentally and economically. It is a common problem in countries like India to see garbage strewn across places. In addition to this problem, even when there is garbage collection, it is rare to see it segregated correctly for easy recycling.

Another problem addressed with this project is that of object recognition. Most intelligent systems rely on visual and image processing for recognizing objects. There are many other untapped sensory inputs that can be used to recognize objects, yet there is not much research on it. In this project new sensors will be designed that will measure the magnetic permeability, electric permittivity and transparency. These measured properties will then be used to identify the objects.

Hygieia is a smart garbage collector robot. It is designed to search for objects that are considered waste, and then sort them into either metal, organic waste or dry waste. It will wirelessly communicate with a stationary garbage receiver. The garbage receiver will open the correct trash can so that Hygieia can dump the waste item into it.

Introduction

Hygieia is a fully autonomous robot. It uses a camera sensor to detect waste objects. Once it detects a waste object, it hones in on the target. It has a sensor rig attached to its front.The sensor rig comprises of two parallel plates forming a square enclosure with the forward side open. The detailed construction of the sensor rig will be shown in the diagrams. The robot moves towards the target and captures it between the plates. IR sensors will detect if the object is indeed captured between the plates or not. Once the object is captured, the sensors will activate and use classification algorithms to identify the object. Once it classifies the object into metallic, organic or dry waste, it signals the stationary garbage collector the type of garbage collected. The stationary garbage collector will select the correct trash can and move it towards the waste inlet. Meanwhile, the mobile robot will capture the waste object by enclosing the sensor rig using an actuated arm. It will then drag the object towards the stationary garbage collector and drop the waste item. Once it detects the object is gone, it will resume its waste object search.

Fig. 1 shows the general layout of the arena and the structure of the robot.

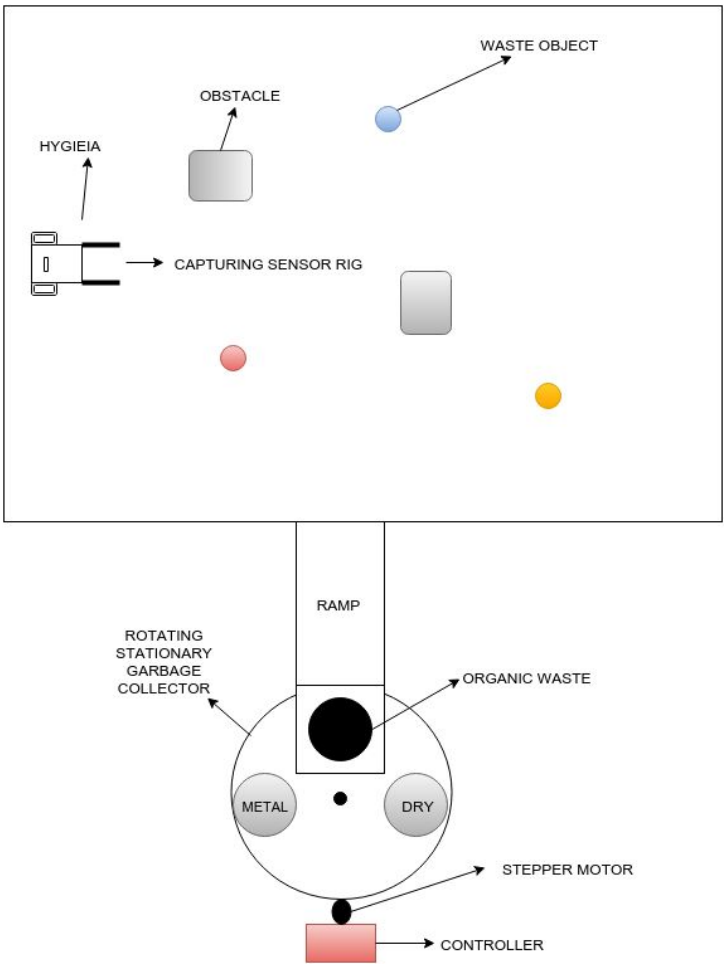

Fig 1. : General layout of the Arena and the robot structure

Integrated Systems

The main robot comprises of a robot chassis, two robot controllers, wheels and sensors. The stationary garbage collector has a stepper motor to control the rotating platform and an arduino to control it. The mobile robot behaves as a master and the stationary garbage collector acts as the slave. They communicate wirelessly using ZigBee.

For the main mobile robot, the high level processing board used is the ODROID-C1+ and the low level board used is the STM32F407 Discovery board. They both communicate using UART.

The ODROID-C1+ has the following features:

1. Amlogic ARM® Cortex®-A5(ARMv7) 1.5Ghz quad core CPUs
2. Mali™-450 MP2 GPU (OpenGL ES 2.0/1.1 enabled for Linux and Android)
3. 1Gbyte DDR3 SDRAM
4. eMMC4.5 HS200 Flash Storage slot / UHS-1 SDR50 MicroSD Card slot
5. USB 2.0 Host x 4, USB OTG x 1 (power + data capable)
6. Ubuntu or Android OS

The STM32F407 Discovery board has the following features:

1. STM32F407VGT6 microcontroller featuring 32-bit ARM Cortex-M4F core, 1 MB Flash, 192 KB RAM in an LQFP100 package
2. On-board ST-LINK/V2 with selection mode switch to use the kit as a standalone ST-LINK/V2 (with SWD connector for programming and debugging)
3. Board power supply: through USB bus or from an external 5 V supply voltage

For the main mobile robot, here is the list of submodules used:

1. DC geared motors, wheels and motor drivers
2. LiPo battery power system and Battery Elimination Circuit
3. Zigbee Transmitter/Receiver for wireless communication
4. Servo for actuating the capturing arm
5. Sensor rig for object recognition and object capturing, will be discussed in detail
6. Camera for waste object detection
7. IR sensors for obstacle avoidance
8. Display

For the stationary garbage collector, the main robot controller used will be the arduino, for simplicity. Here is the list of submodules:

1. Stepper motor to rotate the platform and place the right garbage can under the garbage inlet
2. IR sensors to detect the arrival of the mobile robot
3. ZigBee Transmitter/Receiver for wireless communication

Fig 2 and 3 show the block diagrams for the robot.

Mobile Platform and Actuation

The main robot is a mobile platform that uses 2 geared DC motors for mobility. The sensor capture rig is a 3 sided square enclosure, shaped like a square sided ‘U’. The side facing towards the front is the open side. Once the object is captured inside the ‘U’, a servo will be used to lower a gate or an arm to complete a four-sided square enclosure so that the object does not leave the enclosure when it is dragged around.
The stationary garbage collector comprises of a rotating disc tray with 3 trash cans laid out on top of it symmetrically. The disc will be controlled by a stepper motor.

Here is a list of the actuation performed:

1. Mobile robot will move around on two wheels using differential drive
2. A servo arm used to capture objects inside the square enclosure
3. Rotating tray that holds the garbage cans. It is rotated using a stepper motor

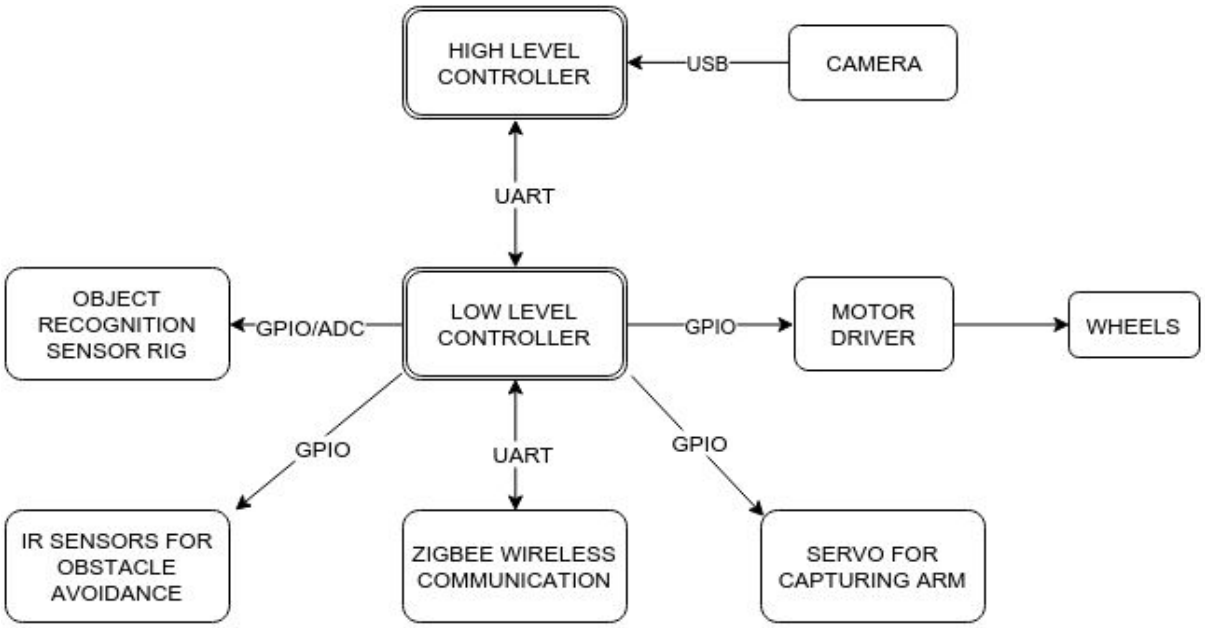

Fig 2. Block Diagram for the Mobile Robot

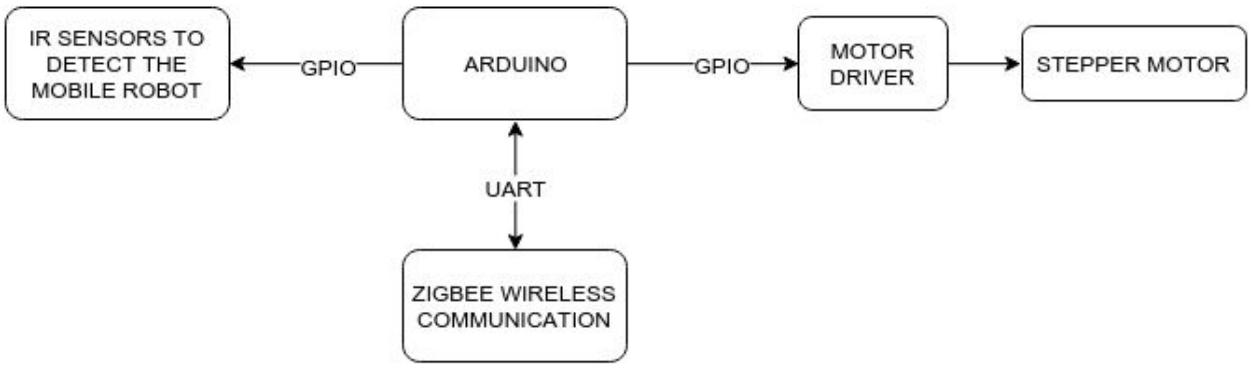

Fig 3. Block Diagram for the Stationary Garbage Collector

Sensors

The main sensor on the robot is the object recognition sensory system. It is described as follows:

1. An inductance sensor that uses an inductive coil and an Inductive-to-digital converter (Texas Instruments LDC1000)
2. A capacitance sensor using capacitive plates and a Capacitance-to-digital converter (Texas Instruments LDC1004)
3. IR sensors to detect object presence and transparency

This sensory system will measure the inductance, capacitance and transparency of the object and classify it accordingly into metal, organic or dry waste.

The other sensors used are:

1. Camera for waste object detection
2. IR sensors for obstacle avoidance
3. IR sensors to detect the presence of the mobile robot approaching the stationary garbage collector

Conclusion

This report proposes the basic design of the robot and the challenges faced during the preliminary design of the robot system. The timeline has been decided and if all goes well, the robot will be completed before the deadline.