Using Artificial Intelligence to Remove Recyclable Materials from Landfills

Jayne Srinivas Audrey Wang Mairah Hashmi Subha Azrin

Abstract: *It is known that the phenomena of climate change, the mechanism behind global warming, is created primarily by the production of greenhouse gases. Greenhouse gases include various gases such as methane, carbon dioxide, and nitrous oxide, which are trapped in the atmosphere. According to the United States Environmental Protection Agency, greenhouse gases are generated from energy consumption caused by the manufacturing of products [6]. Stanford Recycling demonstrates that energy consumption can be decreased by manufacturing products through recycled materials [4]. However, much of the recyclable waste ends up in landfills. We have established a proposal to implement bots in landfill settings, in an attempt to provide a solution for reducing greenhouse gases. These bots that are trained using artificial intelligence will scavenge the landfill for materials that the system has identified to be recyclable within their area (to be assigned using coordinates). They will collect these items and transport them to a separate bin, which will then be collected by a recycling facility. Through this methodology, we seek to provide a feasible solution to this problem that contributes greatly to climate change.*

I. Introduction

Earth's climate has changed over time. But, in the past forty years, we have seen Earth's temperature rise to unprecedented high levels. The global warming trend is particularly significant because it is clearly caused by human activities. Besides temperatures rising, there is compelling evidence that climate change has warmed oceans, melted parts of glaciers, increased ocean acidification, risen sea levels, and caused extreme weather to occur. Some of the major contributors to climate change are greenhouse gases.

According to the City of Irving, TX, 80% of waste in landfills can be recycled. Recycling helps to reduce greenhouse gas emission by avoiding the need to extract raw materials to produce the product [3]. In addition, the emissions generated from manufacturing the product from raw materials can be reduced through manufacturing with recycled materials. Greenhouse gases are not only harmful to the environment; they trap heat in the atmosphere, which leads to various respiratory diseases from smog and air pollution. The purpose is to provide a feasible solution to waste reduction in landfills in order to reduce greenhouse gas emissions. Although various methods of waste sorting processes exist already, many are inefficient and cannot perform the degree of material separation that manufacturers require to recycle items [1]. Through this study, we aim to propose an improved waste sorting process, using artificial intelligence and robotics, so that more material is processed and less recyclable waste is sent to landfills.

Key Words: Artificial Intelligence; Greenhouse Gases; Robotics; Landfills

II. Research Question

We aim to test the application of bots and artificial intelligence in a landfill setting to identify whether the system can correctly navigate through the landfill and identify particular materials as recyclable. Due to the presence of various objects in the landfill, we hypothesize that the bots will need to be trained by a machine learning algorithm, and will need to establish a neural network through the use of a Raspberry Pi microprocessor and programming with C or Python languages.

III. Methodology

Each bot will be trained to identify between recyclable and non-recyclable materials and will be able to distinguish between the different recyclable material types: plastics, tins, and textiles. Within the main container, there will be separate smaller bins, each of which will hold one type of recyclable item. Two to three bots will be allocated to a certain region of the environment, using coordinates. The bots will have a map of their route so that they can navigate easily.

For the purposes of this experiment, we will test the bot on a small scale. We will place a few objects in front of it and observe whether the model can identify a recyclable item between an assortment of materials. A positive result will be demonstrated when the bot correctly identifies a recyclable item and sets it in the proper bin within its container. Conversely, if the bot is unable to identify the item from the group or unable to put the material within the correct bin, then we will have a negative result.

While testing the model, it is a priority to ensure that the model is reliable. We propose to use RDeepSense, a unique deep learning model, to measure the uncertainty for this embedded system through well-calibrated estimations [2]. It is a simple method that allows neural networks to output predictive uncertainty estimations. RDeepSense will allow us to statistically measure the performance of the bot and will enable us to improve the decision accuracy of the bot.

To test the hypothesis, we will need to build the following components:

a) The main body of the bot, which will hold a container for the recyclable waste.
b) The arm of the bot to pick up the waste materials.
c) The software component of the model, using artificial intelligence.

Figure 1 provides a visual for the proposed bot, with all the components listed above.

3.1 Body of the Bot

The body of the bot will be based on the design of Locus warehouse bots. Figure 2 provides a visual for the model. The reason for choosing this particular model for the proposal is due to the configuration for holding the containers and bins. These bots move autonomously throughout their environment and remain in their zones [5]. To create the body of the bot, we will need a chassis to store the electronics and mount the motors, using motor drivers. To the chassis, wheels will be attached for easy movement. Other components include a microcontroller to control the movement of the bot and the arm, sensors for navigation purposes, a camera for machine vision, and power sources such as rechargeable batteries.

3.2 Arm of the Bot

The design of the arm will be based on Bünger, Chan, Cotto, and Sun's research for robotic waste sorting [1]. The proposed model calls for the arm to be placed on the same shaft as the camera. Figure 3 provides a visual for the arm. The design consists of a closed-loop, five-link mechanism, which is powered by two motors. The five-link mechanism allows for linear motion of the arm in a three-dimensional area. This allows the bot to lift items. The arm's gripper is designed to be able to hold both wet and dry objects, a feature that will be helpful in a landfill environment. It consists of three two-pronged arms, which are connected to a vertical rail. The gripper is powered by a motor that is attached to the end of the arm.

3.3 Software for Navigation and Operation of the Bot

The hardware and software components of the model that control the bots include a Raspberry Pi microcontroller and a desktop computer. The Raspberry Pi controller directly controls the movement of the bot itself and combines with vision processing and sensors to control those features as well. The desktop computer is connected to the bot primarily to coordinate parts of the bot, to perform calculations relating to the kinematics of the bot and vision processing, and control the arm of the bot [1]. The vision of the bot is achieved by connecting a camera, which will classify the data (objects and materials) based

on the clusters formed during the training of the bot. Code can be written in the Python or C programming languages as they will be compatible with the microprocessor.

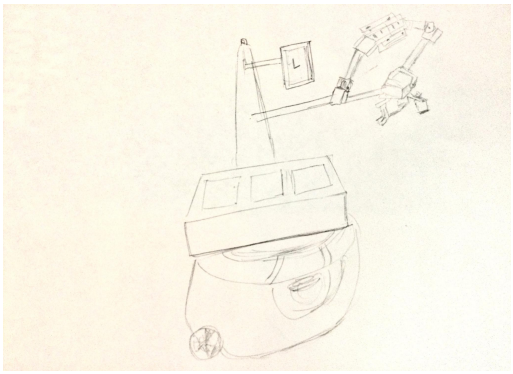

Figure 1 shows the model for the proposed bot.

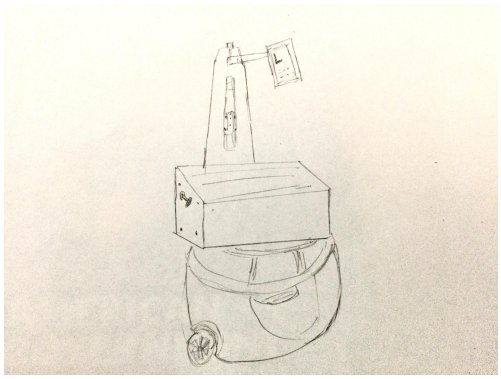

Figure 2 shows the model for the Locus warehouse bots.

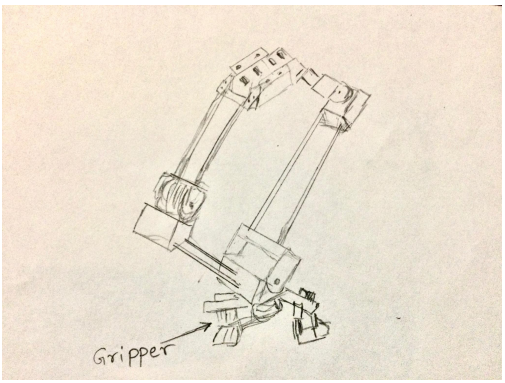

Figure 3 shows the model for the arm and grabber of the bot based on Bünger et al. research.

IV. Relevant Application

Using artificial intelligence and machine learning to remove recyclable waste from a landfill (on a large scale) will surely direct the reduction of greenhouse gases. Countries that are at a severe risk of the damaging impacts of climate change will greatly benefit from the technology. For example, in 2019, Mozambique faced extreme weather conditions as an effect of global warming [7]. By reducing the emission of greenhouse gases, through proposals such as this, the frequency of such erratic weather can be greatly reduced.

It is likely for this proposal to be adopted by first-world countries as research, training, and materials are all various factors that need to be considered in order to create and implement the bots in the landfill environment. Additionally, numerous trials of the proposal must be conducted to measure reliability, by using the RDeepSense, so that decision accuracy can be improved [2]. Considering all of these factors, it is evident that vast funding is needed to execute and implement this methodology in real-world settings.

V. References

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