ZotBins: Technology-Enabled Waste Management for Zero Waste

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BACKGROUND

One of the most significant waste problems faced today is in regards to waste management. Due to the inefficient handling and sorting of trash, **trash has become a major contributor to greenhouse gas emissions**. According to the EPA, **landfills** are the third-largest source of anthropogenic methane emissions. Specifically, landfills contributed approximately 14.1 percent of these emissions in 2017 [1]. Another difficult waste problem is **recycling contamination**. According to the University of Michigan, when a certain percentage of non-recyclables are placed with recyclable materials, the whole batch is considered contaminated and all of the items are sent to the landfill [2]. Both of these problems have led to our country's **low diversion rate of 35%** [3]. In an effort to remedy these problems, we must go back to where trash originates from and revisit the concept of the waste bin.

PROJECT GOAL

The goal of this project is to explore a new socio-technical approach to zero waste that integrates emerging smart internet-of-things (IoT) technologies with waste management to bring transformative improvements in waste diversion and assist communities towards achieving zero waste.

CURRENT STATUS

- Currently 8 deployed ZotBins spread throughout UCI campus: in dining halls and in our computer science building
- Currently collecting ultrasonic distance, weight, and break beam data points
- Currently 18 members strong!
- Stay updated on our progress: https://zotbins.github.io/

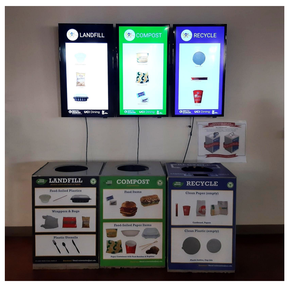

Figure 1. ZotBins Deployed in West Food Court

APPLICATIONS

- Two distinct systems for two separate user bases: (1) waste management and (2) regular end users
  - (1) web app designed to assist waste management in making system decisions (Figure 2). Features include tracking the status and waste metrics of any ZotBin deployed in an area
  - (2) A mobile app for iOS and Android designed to make waste disposal as simple as possible (Figure 3). Features include finding the nearest relevant ZotBin (compost, recycling, landfill, etc.) to the user

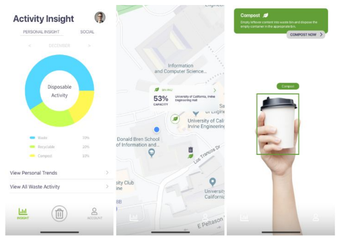

Figure 2. Mobile App Mockup

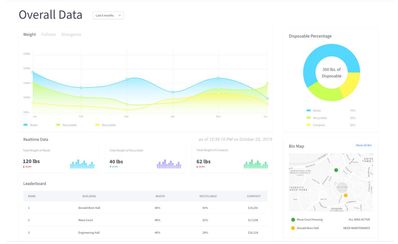

Figure 3. Web App Mockup

FRAMEWORK

- Physical layer consists of smart bins with ultrasonic sensors, load cells, cameras, etc (Figure 4)
- Backend consists of a data management infrastructure called TIPPERS along with a trained convolutional neural network that can process images of trash in order to return disposal instructions (eg. rinse and recycle, compost, etc) (Figure 5)
- TIPPERS provides REST APIs to our ZotBins web and mobile applications for manufacturers (producers), bin users (consumers), and waste management [6]

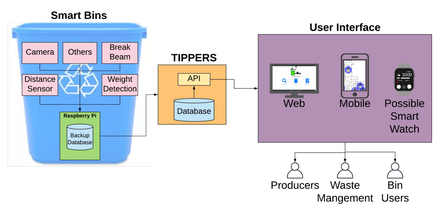

Figure 4. ZotBins Framework

Figure 5. Object Recognition

SMART BIN

- Hardware & Electrical (Raspberry Pi, Arduino) consists of microcontrollers and peripherals that collect data and interact with users (Figure 7)
- Sensors measure bin fullness and waste accumulation through ultrasonic sensors, break beam sensors, and more (Figure 6)
- Stores all waste related data collected from ZotBins into the TIPPERS system via REST API calls [6]
- Total Cost: $214.04

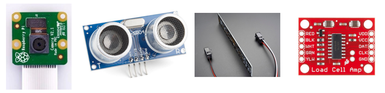

Figure 6. Camera, Ultrasonic Sensor, Break Beam Sensors, and HX711 [4, 7]

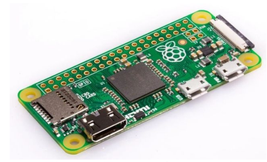

Figure 7. Raspberry Pi Microcontroller [5]

COMMUNITY ENGAGEMENT

- In collaboration with **UCI Dining**, **UCI Housing**, **UCI Sustainability**, and **UCI Physical & Environmental Planning** to collect waste data and further improve the campus' waste management infrastructure
- Endorsed by Sona Coffee and Mike Byrnes representing the **City of Irvine** to implement ZotBins in Irvine
- Partnered with Jennifer Razo with plans use ZotBins data to create a "Journey of Trash" educational simulator for the **Irvine Unified School District**
- Increasing support from other individuals and organizations as well

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