Project Title:

Smart compost bin for measuring home food waste

Abstract

Current approaches to measuring home food waste are burdensome on the consumer and prone to human error. This remains a barrier to wide-spread deployment of such approaches for systemic measurements of consumer food waste. We propose a cyber-enabled technology that automatically and precisely measures food waste designated for compost in the consumer household. We adapt a typical kitchen compost bin to include a weight scale and controller to accurately measure all edible and non-edible food waste discarded in a household kitchen. By adapting technology to users' existing habits, we avoid requiring consumers to change their behavior or perform additional tasks.

We propose a *smart compost bin* to collect and measure food waste in the home consumer kitchen. Our device will weigh the bin each time a user discards waste, creating an accurate and systematic log of waste discarded. Our prototype also contains other tools to enable food waste research, including Wi-Fi for uploading data, microphone for recording descriptions of waste discarded, LiDAR sensors to estimate volume, and stereoscopic cameras to collect images to enable future food waste measurement technologies using computer vision.

By innovating a way to measure food waste at the household-level that does not require undue burden on the user, we expect our system to facilitate large-scale and systematic studies measuring food waste. Additionally, the measurements collected by our system will support future applications and visualization tools that provide data-driven and personalized interventions to empower individuals to reflect upon and change their food waste habits.

Project Description

Introduction. In 2020 the COVID-19 pandemic increased world hunger by 2%, as an additional 100 million people battled chronic hunger. In the same year, approximately 14% of the world's edible food was lost [1]. In affluent countries, rates of food waste are much higher. In the United States, approximately 30% of edible food is wasted and the majority of loss occurs at the consumer level [2]. The problems of food waste and food insecurity are intrinsically linked. And because there is no established way to systematically measure food waste, this gross inefficacy, this gross injustice, continues.

Motivation. In the review *Missing Food, Missing Data?* the authors lament that "more data based on direct measurement are badly needed" [3], finding that only 20% of the studies in the literature are based on direct measures of food waste. The authors concede the high labor and economic cost of such studies, but conclude with calls for more data collection especially among populations not covered by previous studies. Currently, food waste rates among various studies are highly variable [4] and disproportionately sample affluent regions [3]. In this work, we propose an AI-assisted technology that helps close this gap by accurately weighing food waste in the home.

Vision. The current approaches to measure food waste are all costly, time-intensive, and prone to human error. We envision a future in which an AI system can automatically and accurately measure food waste using only sensors and cameras. Given the emerging techniques and novel applications of deep learning over the last decade [5], we see computer vision as the natural, and eventual, solution to estimating measurements of food waste. The long-term goal of the smart compost bin project is to inspire future waste reduction by specifically quantifying, measuring, and tracking the amount of food home consumers send to compost.

Project Objectives. In this work, we propose an AI-enabled device that will automatically and accurately measure food waste in the home kitchen in a design that requires minimal changes to users' current habits when disposing of compost. Additionally, our device will collect images and LiDAR readings of the food waste so we can disseminate an entirely novel dataset to enable and encourage researchers to tackle the problem of food waste measurement with computer vision.

Combining our expertise in artificial intelligence, mechanical engineering, and hospitality management, our team will accomplish the following research objectives:

1. **Compare existing home food waste studies.** We will perform a landscape study of the related food waste measurement approaches to best inform our design and our study.
2. **Design a consumer-friendly smart bin to measure compost in the kitchen.** We will design and iteratively refine hardware and software interfaces for usable, efficient, and flexible technologies to weigh, photograph, and log kitchen compost.
3. **Perform a case study to compare our approach with traditional approaches.** We will perform a small pilot study to rigorously test our device, validate our measurement approach, and assess the potential to scale our approach.
4. **Disseminate novel datasets about home food waste.** We will publish and disseminate novel datasets of food waste measurements, containing associated weights, LiDAR, images, and brief text description of the waste, to enable novel food waste research.

Prior Approaches. In recent years, there have been growing efforts to attempt to quantify food waste measurements. Researchers measuring waste in commercial kitchens have employed a number of indirect and direct measurement approaches. Supermarkets or restaurants may maintain records that facilitate indirect measurement of food waste post hoc. In direct observational approaches, an observer monitors the trash can and records all waste disposed [6] or analyzes the plate waste of each customer [7]. In attempts to directly measure waste, restaurants have sorted trash in different colored trash bins [8] each representing a broad category of waste or they weighed the kitchen scraps before disposal [9]. Unfortunately, these approaches are manual, inaccurate, and not scalable.

To track food waste at home, researchers have employed a variety of strategies, including tasking participants to record their purchases, consumption, and waste in food journals [10], [11], complete surveys and questionnaires [12]–[14], or log their habits with mobile apps [15]. Unfortunately these methods are all based on human action, and as such are costly, inaccurate, time-consuming, and do not provide an accurate or holistic view of food waste [16]. A meta-analysis of 332 studies of measurements of food waste found that food waste rates were highly variable among studies and by method (see Table 1) [4]. Furthermore, researchers believe studies underestimate FLW by up to 40% [11].

Although researchers in computer vision have given some limited attention to food object detection tasks [17], the problem of identifying food waste has not been well studied (only briefly by [18]). Because datasets of images of food waste do not exist, machine learning researchers cannot attempt to tackle this problem with computer vision. Our proposed AI-enabled device takes first steps to bridge this gap.

Prior Work and Capacity for Success. Our research team is currently working on the problem of estimating individual food waste in cafeterias using computer vision. Cafeterias are a natural starting point for computer vision research of food waste measurement because they serve a fixed menu and different food items are often well separated from other food items. In this work, we collect images of trays of food before and after human consumption with the goal of estimating the quantity of each food item remaining (wasted). With these images, our machine learning team is teaching AI to learn to track the nutritional intake of individuals over time. This will enable our local hospital partner to intervene early upon these subtle indicators of declining health.

In late 2021, we received a small grant ($20k) from the Central Oregon Health Quality Alliance to build an initial prototype of our design. We have manufactured an initial hardware prototype to facilitate data collection (see Figure 1). We aggregated tens of thousands food images from existing dataset sources. We trained initial computer vision object detection models to identify common cafeteria food items, using the limited options of food items available in existing datasets. In preliminary results, we are able to detect 18 common American cafeteria food items with 91% accuracy (0.917 mAP@0.5). Extending this to 32 cafeteria items, including cutlery and glassware, we have achieved 72% correct item detection (0.723 mAP@0.5). We will improve our object detection model with additional data that we will collect in a large data collection study in Fall 2022 in our university's dining hall.

We will accomplish our proposed vision building on this foundation of expertise and artifacts from our ongoing exploratory work in computer vision and food waste.

Approach and Activities. Our goal is to design a device that is as simple to use as possible to minimize any changes to a user's natural behavior when disposing of their food waste they intend as compost. We divide our research activities along four major objectives.

Objective 1: Compare existing home food waste studies. We will perform a landscape study of the related food waste measurement approaches to best inform our design and our pilot study.

<u>Motivation</u>. To test our system that measures kitchen compost waste, we will compare our design for direct measurement in a pilot study against the common food waste journal approach. Previous studies have found up to 40% underestimation of self-reported FLW [11]. In order to design this study, we will first systematically survey the literature to compare and contrast different food waste measurement approaches, with a specific focus on the studies that use either the direct measurement or the journal approaches.

<u>Approach</u>. We will begin by aligning past systematic literature reviews of studies measuring food loss and waste (FLW) [3], [4], [19], [20] to produce a comprehensive list of studies using the weight or journal methods. We will search the literature to update this list to include recent studies not included by these past reviews. To objectively compare results between studies, we will use the cross-study normalization strategy given by [4].

In our landscape study we will pay specific attention to several important dimensions of FLW that will guide our hardware design and our pilot study. These include the challenges of food waste accounting [21], understanding user behavior towards FLW [22], and the efficacy of interventions to inspire changes in consumer behavior towards FLW [23].

Although there have been some attempts to analyze behavior attitudes towards FLW by demographics and socio-economic factors [19], there has been very little attention to the demographic breakdown of participants in waste measure studies, apart from differences between countries or household income [4]. The majority of such studies have taken place in the United States and Europe and there have been far fewer studies analyzing food waste in counties with developing and emerging economies. We will perform our landscape study with specific attention to the demographic makeup of participants in each prior study. To do so, we will contact authors of past studies to seek demographic breakdowns of the participants. Informed by this systematic review, we will design our device to have the broadest reach, enabling data collection across regions and within different demographic subpopulations within these regions.

<u>Dissemination</u>. We will summarize our findings in a publication that comparatively reviews direct weight and journal measurement techniques of FLW across the literature. We will target journals with established records of FLW literature, such as Waste Management or Sustainability.

Objective 2: Design a consumer-friendly smart bin to measure compost in the kitchen. We will design and iteratively refine hardware and software interfaces for usable, efficient, and flexible technologies to weigh, photograph, and log kitchen compost.

<u>Motivation</u>. We model our design after a kitchen compost bin commonly provided by city municipal waste divisions. In order for such a device to achieve wide-spread adoption and use, it is imperative that this device be intuitive and easy to use. For this reason, we design a device that attempts to capture a consumer's existing and established patterns in handling home kitchen food waste intended for compost.

Proposed Design. The compost tub sits upon a base, which contains the majority of the electronics, such as the microcontroller and a hard-drive for data storage. The base also functions as a high-precision scale, which weighs the entire compost tub. After accounting for the weight of the tub itself, this provides a measurement of the total waste contained in the tub. We will log and track the total weight of the bin each time the user adds waste, allowing our device to calculate the specific weight of food waste items just added. The device contains a microphone and speaker. This enables the user to record an audio note each time they discard compost waste. After converting the audio note with automatic speech recognition, our device will store the weight of the waste alongside the text description of that waste. Figure 2 shows a 3D model of our potential design.

In addition to our primary goal of collecting precise weight measurements, we also collect several additional modalities of data intended to spur future novel research in quantifying FLW. The lid of the plastic tub contains a pair of stereo cameras and a bank of LED lights to serve as a flash. In our pilot study, we will collect images of food waste to release as a dataset to encourage future computer vision approaches to measuring FLW. Together the pair of binocular images will aid computer vision systems with depth perception when estimating the amount of the food waste. Additionally, we include a low-cost LiDAR sensor to aid in determining the total volume of the food waste. The lid also contains a button to release and open the lid, which triggers the actions of weighing, sensing, and photographing the compost.

Use Case: When a user desires to discard kitchen compost, they first press the button to release and open the lids of the bin. When pressed, the device quickly measures the current weight, activates the flash, and takes a picture of the contents of the bin, before the device releases the lid to be opened. The user then adds their compost waste to the bin and closes the lid. The device again weighs the bin and takes a picture. Additionally, the device prompts the user to record a short audio note describing the contents they just added. These notes will be transcribed to text with automatic speech recognition and associated with the other data logging the event.

Objective 3: Perform a case study to compare our approach with traditional approaches. We will perform a small pilot study to rigorously test our device, validate our measurements, and assess the potential to scale this approach.

Motivation. To test our system, we will design and deploy a pilot study in consumer homes. We will simultaneously collect precise weight measurement and self-reported journal entries. By collecting data across two established measurement approaches, we will be better able to validate and interpret our device's measurement.

Study Design. We will inform our study design by our findings in the landscape study (Obj.1) and in adherence to terminology, methods, and protocols of the FLW Protocol. We will follow the protocol's Guidance on FLW Quantification Methods, with focus on the sections: Direct Weighing (1), Counting (2), Assessing Volume (3), Waste Composition Analysis (4), and Diaries (6). Prior studies of the direct measurement of food waste in the home have varied in size from a dozens to thousands. For our validation study, we will use a sample size consistent with other small studies and manufacture a device for each participant. We anticipate building around 50 devices.

We task each participant to carry out their normal process with respect to food waste. Participants may empty their indoor compost bin to their larger outside compost as needed or desired. Because we persistently measure and log the total weight of waste in the bin, we can easily detect and account for this event. In the process of their normal behavior of disposing food waste in their kitchen compost bin, we ask the participant to perform two additional tasks.

First, we task the user to record a short audio note to document what items they just added. We do not intend to overtly direct the participant what to say, other than to generally “describe the food waste discarded”. We make this user-friendly choice while thinking about the practicability and scalability of our approach to subsequent large scale studies. Instead we will leverage automatic speech recognition to interpret their note for inclusion in our dataset.

Second, and only for the purposes of our pilot study, we task the user to record their food waste in a journal. We pair this common and established food waste estimation approach as a baseline to which we can compare our novel measurement approach. We will follow typical practices taken in past waste journal approaches [21]. This has the benefit of allowing participants to also record the reasons for the discarded waste and to differentiate between edible and inedible food waste.

Given a transcription of the user's informal audio note and their more precise journal entry, we use natural language processing and analysis to make conclusions about the reliability, accuracy, and utility of our audio note feature. We believe that those audio notes alone will be sufficient to characterize the disposed food waste, such that future studies need not depend on the costly, time-consuming, and inaccurate method of user journals of food waste.

<u>Deployment</u>. In this study, we will screen for participants already in the practice of saving their kitchen food waste for composting who participate in our existing local composting program. We will provide each participant with a smart compost bin for their kitchen. Participants will use our device to log their food waste for one month while recording their habits in the waste journal.

<u>Data to be collected</u>**.** We model our kitchen compost bucket after those distributed by our waste utility and we will measure all home kitchen waste intended for composting. In our community, customers may compost almost all food waste. This includes edible waste, such as meat, seafood, fruit, vegetables, dairy, baked goods, and plate scrapings, and inedible waste, such as fruit and vegetable peels, coffee grinds, egg shells, and bones. The composting program in Bend, Oregon does not accept seafood shells nor oils and greases, and these inedible food waste items will not be included in our measurement study. During our pilot study, we will ask participants to exclude non-food items that can be composted, such as coffee filters, napkins, or decorative flowers. Yard waste is collected in a larger outside bin and does not factor into our study.

In our pilot study, our compost bin will collect precise measurements in kilograms of the food items added, pair of stereo-images for depth measurement, LiDAR reading for volume estimation, and an audio description of the waste recorded by the participant. In our parallel journal measurement, we task participants to describe the food wasted, give an informal (non-measured) estimate of the amount, and to document the reason for the food waste. We will task study participant to record edible and non-edible food waste separately.

For the purposes of analysis after our study, we will collect basic demographic information about our participants. We will survey participants and record the family size, house-hold income, self-described race and ethnicity, and responses documenting their dining habits and their opinions, attitudes, and practices towards FLW.

Objective 4: Disseminate novel datasets about home food waste. We will disseminate novel datasets of food waste measurements, containing associated weights, LiDAR, images, and brief text description of the compost waste, to enable novel food waste research.

Motivation. Although there exist datasets of images of food items before consumption, these datasets do not provide other associated measurements, such as weight, LiDAR data, or reliable human annotation. Although the company Leanpath has begun examining commercial food waste with computer vision, their focus is limited to commercializable products in industrial kitchens and, as a for-profit entity, their data is not available for non-profit research. For these reasons, there no public research datasets of images of food waste currently exist, a necessary prerequisite to explore this problem with computer vision.

Dataset. The primary goal of this proposed work is to design a high-precision device that consistently measures consumer food waste using a weight scale. As a secondary and forward-thinking objective, we will collect additional multimodal measurements of food waste in the form of images and LiDAR readings. During our pilot study, we will collect a large amount of valuable additional data associated with target weight measurements.

By releasing a novel dataset documenting instances of kitchen compost waste, we hope to encourage other machine learning researchers to join us in tackling the problem of measuring food waste with computer vision. Our dataset will enable researchers to build multimodal deep-learning models using images of the food waste provided by the camera, depth and volume provided by the LiDAR, and weight data measured by the scale. By leveraging these different modalities of measurements together, researchers can learn associations between the data. This is a necessary step to enable a future in which an AI system can just the weight and volume of food waste based on images alone.

We will disseminate this dataset through a publication documenting our design, our study methodology, and a description of the collected data. We will work with Research Data Services at the Oregon State University library system to host and distribute this big dataset.

Expected Outcomes. This project innovate a new tool to produce measurable outcomes that enable consumers to track, measure, and reduce their own FLW. By designing a technological system to provide data-driven estimates of consumer waste, we enable future technologies able to encourage reflection of consumption patterns and motivate changes in consumer behaviors.

We will design, manufacture, and test a hardware prototype that weighs food waste intended for compost using a precision scale, depth cameras, and LiDAR (Obj.2). This design provides a technological solution to accurately measure food waste in the home kitchen. Additionally, our design captures additional data to support future computer vision research attempting to quantify food waste. Our design is forward-thinking such that it can readily be updated to support future measurement approaches based on computer vision once such models have been developed.

We will perform a systematic review of FLW studies based on direct measurement (Obj.1) to inform the formal design of our pilot study to validate our approach and demonstrate its potential to scale (Obj.3). We will distribute these smart bins to participants and collect weight measurements, images of waste, and associated entries logged by the user in a journal.

Lastly, we will create and publish novel datasets of precise measurements kitchen compost waste associated with as pictures, LiDAR, and descriptions (Obj.4). Presently no dataset of images of food waste exists. We will create a website to disseminate this data while using social media to increase public engagement on the topic of FLW. These datasets will enable the development of future technologies using computer vision to estimate amounts and quantities of food items.

Potential Limitations and Alternate Approaches. Current approaches to direct measurement typically provide a weight scale and task users to log each entry separately, a time intensive method prone to human error. Although we do not measure food items individually, we justify our approach as having the enormous benefit of eliminating human time cost and error.

Our device measures the weight each time waste is added to be bin. We collect images of commingled food waste, rather than pictures of individual items, because we envision this as the common scenario in which a computer vision system will encounter food waste in real world settings. With enough data, research, and time, future AI-assisted technologies will be able to estimate quantities of individual items from images of commingled waste.

Our device resembles a typical kitchen compost bin and we do not need to differentiate between edible and non-edible food. In our pilot study, however, we task participants to manually *disaggregate* their edible and non-edible food waste, adding each type as a separate transaction. This enables us to disaggregate edible and non-edible food to learn the contributing percentage of each type of FLW. To eliminate the missing data from slip-stream waste, such as food fed to pets, we task our participants to compost all food waste during the study.

Food immediately begins to desiccate or decompose while stored in a compost bin at room temperature. This has been a limitation in the ability to accurately measure FLW at the curb. In our design, we measure immediately before and after a user adds waste. We use this difference to quantify the exact weight of the waste added. This approach has the additional advantage of measuring the amount of weight loss because of desiccation. With such knowledge, researchers can better estimate the original weight of the FLW, given on measurements taken at the curb.

Because we model our device on existing compost bins and we select high-volume consumer electronics and sensors, we are able to manage the costs of each prototype we develop. We anticipate each developmental prototype to cost around $2000, which includes hardware, electronics, raw materials, and 3D printing costs. We anticipate building 50 devices in order to match sample size of other statistically significant studies. Should we encounter difficulty in manufacturing all devices, we will scale back the number of devices built and instead rotate the devices between participants.

We will recruit participants in the OSU-Cascades community with whom have previously engaged on issues of FLW. We acknowledge that this pilot study will have a sample bias of participants already interested in food waste reduction and will not accurately represent the demographics within our community. We view this pilot study as a validation of our technical approach and device itself so that this work can enable future measurement studies of food waste trends scientifically sampled across population demographics. To promote representative samples of community demographics, waste utilities should waive monthly fees when performing studies.

Anticipated Applicability and Impacts

Our novel design to collect food waste intended for kitchen compost provides several important benefits and enables many broader outcomes.

Our design resembles the existing kitchen compost bins distributed by waste management companies and the use of our device requires no deviation in a user's established behavior. By adapting our goal of measuring waste to the established consumer method, we provide a non-invasive approach that collects accurate weight measurements without human intervention or human error. This will enable municipal waste utilities to run long term or ongoing studies that track food waste generated in the home. Presently, the majority of direct measurement studies occur in restaurants, hospitals, and schools [3], but the volume of food waste generated by households is much higher than at the business level [24].

Currently municipalities have no way to approximate what percent of compost waste picked up at the curb steams from food waste as compared to other compostable yard waste. Because our system requires no human action or intervention to measure the weight, this will enable waste management companies to run novel waste measurement studies. For example, a company could run long term studies over the course of many months or years. Currently, the human-labor cost of current measurement approaches preclude the collection of measurements over extended periods. Alternately, the company could collect and redistribute the device to other participants in a rotating study to target a representative sampling of the demographics of the community.

Additionally, by collecting precise measurements of food compost waste at the level of the individual kitchen, we will enable software developers to build apps and visualization tools to allow a family unit to track their food compost waste over time. This provides the opportunity to provide meaningful data-driven interventions aimed to encourage consumers to reflect upon and potentially change their behaviors with respect to food waste.

Lastly, our approach will provide, as an intentional by-product, a novel dataset of images of food waste. These dataset will enable computer vision researchers to begin exploring the difficult task of estimating volume and weight of food based on images. Associated with each image, our dataset will provide accurate weight measurements and LiDAR data. These measurements will serve as labels when training the machine learning models, ultimately enabling models that predict the weight and volume of food from images alone. Such a computer vision system will have broad and transformational impacts on the world's ability to quantify consumer food waste.

Our interdisciplinary collaborative teams presents an innovative solution to measuring household food waste. Our agile research plan provides a technological solution that rigorously and autonomously measures kitchen compost waste without undue burden on the consumer. The availability of a low cost, AI-enabled compost bin will pave the way for large scale measurement studies. Our audacious and forward-looking device will also collect novel dataset to enable future computer vision research to further pioneer new technologies. The Foundation for Foot & Agriculture should fund this project because your very "commitment to funding bold science".

Objectives by Year

In order to design, manufacture, and validate our device and approach, we require the maximal 18 month period specified in the solicitation. We discuss our four objectives divided over quarters of the year.

Year 1: Quarters 1 and 2

Towards Objective 1, we will identify all direct measurement and journal FLW studies in the literature. We will search the literature, identify relevant studies, and collect and normalize study results following the method of [3].

Towards Objective 2, we will design our prototype for a smart compost bin. This entails developing a design, engaged with the Engineering System Engineering Design Capstone. We will select and order necessary microcontrollers, electronics, sensors, and other hardware. We will model the design in 3D software and build a first prototype.

Year 1: Quarters 3 and 4

Towards Objective 1, we will perform a comparative meta-analysis on the studies identified in the landscape study. We will build upon the work of past comparative papers, updated with the most recent literature. We will include in our review analysis on demographics of the results. We seek to quantify the standard deviation between studies to better understand the fidelity of these studies. We will disseminate our comparative review paper in publication and/or presentation.

Towards Objective 2, we will test our prototype and iteratively refine our design. We will engage our campus Dining Services for advice and help with testing. We will begin manufacturing prototypes for use in our pilot study. These prototypes will be manufactured in the Makespace laboratory on the OSU-Cascades campus.

Towards Objective 3, we will design our pilot study informed by our comparative landscape study. This entails writing and validating our protocols, generating instructional materials, and recruiting participants.

Year 2: Quarters 5 and 6

Towards Objective 3, we will deploy our pilot study targeting n=50 volunteer participants. We plan for each participant to collect waste in their home for one month. Afterwards, we will aggregate results, analyze, and disseminate findings comparing our measurements and our journal logs.

Towards Objective 4, we will organize, aggregate, and process the data collected in our study. We will publish and disseminate novel datasets of FLW weight, image, and LiDAR data. This will be a novel dataset that will inspire machine learning researchers to investigate this important problem with computer vision.

After the Funded Timeline

After this study, we will continue our work on the data collected in the pilot study. We will begin to train computer vision models to quantify the amount of food in the image.

First, we will build **object quantity models** to estimate the amount of food total in the image. We will leverage our high-quality dataset of sequences images of comingled compost, each tagged with weights and LiDAR data. With these trained computer vision models, we can begin to estimate the amount of compost waste with cameras alone.

Second, we will **build object detection models** to attempt to identify and count the individual food items present in the image of comingled waste. This task involves segmenting and labeling a subset of images to facilitate semi-supervised machine learning. We will leverage our transcribed notes documenting the waste to train these models. With these trained computer vision models, we can begin to estimate the composition of compost waste with cameras alone.

Third, we will refine our smart compost bin prototype for a version that can be mass-produced. This version would have only a weight-scale and a low-cost camera and flash. With such a device, we can encourage municipal waste companies to run large-scale studies with the goal of a true demographic sampling of FLW behavior across the community. Furthermore, the device can connect to an app to facilitate personalized tracking of food waste and encourage reflection upon individual FLW practices.

Data management plan

We will collect datasets of measurements of food waste consisting of weight, LiDAR, and images of items added to a bin for composting. We will assign each device a unique and random identifier such that the data is not associated with any collection location (participant). Because we do not associate the images of food waste with any individual person or household, we do not anticipate any issues of privacy or confidentiality associated with the collection of measurements and images of food waste.

During development, we will store our data on dedicated storage devices owned by the College of Engineering at Oregon State University. Data stored on this cluster are secured, maintained, and backed up by dedicated IT staff. Throughout the project period, we will maintain the storage of miscellaneous interim data and documents using our university's secure cloud storage platform. At the conclusion of the project, we will publish and disseminate our final image data as a series of publicly available datasets. We will work with the Research Data Services program at the Oregon State University library to host and distribute our dataset.

Project economic feasibility

Our project design models current kitchen compost bins to facilitate data collection without requiring people to change their current practices. We identify the human time cost to measuring food waste as a principle barrier to wide-spread and accurate measurement of food waste. We specifically design our device to enable automatic and accurate measurement of food waste in order to facilitate future wide spread use.

We design our prototype with the goal of manufacturing an affordable final design. In addition to the weight scale, our design requires only electronics and sensors currently found on the most recent cell phones, such as a camera, light array, and LiDAR sensor. As these parts continue to be mass produced, the prices of these parts will continue to decline in the future. Furthermore, our design can be produced in a low cost version that contains only the weight scale and omits the camera and other sensors. Such a version could be produced in mass quantities such that a municipal waste utility provides such a bin to each of their compost customers.

Importantly, our device also enables the large-scale collection of images of home compost waste. Currently no such dataset exists and the publication of our novel dataset will enable machine learning researchers to begin to investigate the difficult task of estimating amounts of food wasted using computer vision.

Possible barriers to adoption

Our proposed device is intended to seamlessly replace existing bins for kitchen compost, with potential to reach consumers that otherwise would not volunteer in a measurement study. We do not anticipate major barriers to wide-spread adoption.

In addition to the weight scale, our data collection device contains a camera, LiDAR sensor, microphone, and the ability to connect to Wi-Fi. It is possible that some privacy-minded users might be reluctant to use a smart device. The camera and LiDAR are intended to help facilitate the data collection for future computer vision solutions. The Wi-Fi enables the device to periodically upload the data to the cloud for analytics. Our device is designed to also be built in a low-cost version that omits these additional sensors and Wi-Fi. This low-cost version contains only a weight scale and records data on the local hard drive, bypassing potential user concerns about privacy. A waste utility would instead periodically swap out their customer's bins in order to retrieve the data.

Because we adapt our technology to the existing product people use to store their kitchen compost, we have prioritized accessibility and usability. Waste management companies have a vested interest in understanding the makeup of their compost intake, as to best inform their composting strategy. We provide a genre of technology that gives such companies an opportunity to provide such a device to each and every compost customer. This would enable, for the very first, a complete and holistic picture of food waste trends within a community.

Project Timeline

In order to design, manufacture, and validate our device and approach, we require the maximal 18 month period specified in the solicitation. We detail our four objectives divided over quarters of the year.

	Quarter					
Objective 1: *Perform comparative analysis of home food waste*	Q1	Q2	Q3	Q4	Q5	Q6
Identify direct measurement and journal FLW studies	•	•				
Perform comparative meta-analysis		•	•			
Disseminate review paper				•		

Objective 2: *Design and build smart bin to measure kitchen compost.*	Q1	Q2	Q3	Q4	Q5	Q6
Design prototype	•	•	•			
Iteratively test and refine prototype			•	•		
Manufacture prototypes for study				•	•	
Objective 3: *Perform a pilot study to collect waste measurement*	Q1	Q2	Q3	Q4	Q5	Q6
Design pilot study informed by landscape study			•	•		
Perform pilot study					•	•
Analyze results and disseminate findings						•
Objective 4: *Prepare and disseminate novel datasets*	Q1	Q2	Q3	Q4	Q5	Q6
Organize, aggregate, and process data					•	•
Disseminate dataset of FLW weights, images, and LiDAR						•

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