ECE 445 Project Proposal

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Introduction

Problem:

Good2Go (G2G) containers are used all throughout dining halls at U of I for individuals wanting to take their food to go. The program allows you to trade in an old container for a redeemable wooden token, where that token can then be used to trade for a new container. The current process for exchanging containers for tokens and tokens for new containers lacks a unified system across campus, and relies on human supervision and interaction. This proves to be a hassle for both parties that handle the process since it is too simple to have any one person be assigned to it, but occurs often and spontaneously enough to become bothersome. We believe that this entire process can be streamlined and improved with mechanical assistance

Solution:

Our solution involves an automated token and container exchange machine that will serve two key functions:

1. Have a digital token, that upon deposit, returns a clean container.
2. Accept a used container, generating a token or a clean container.

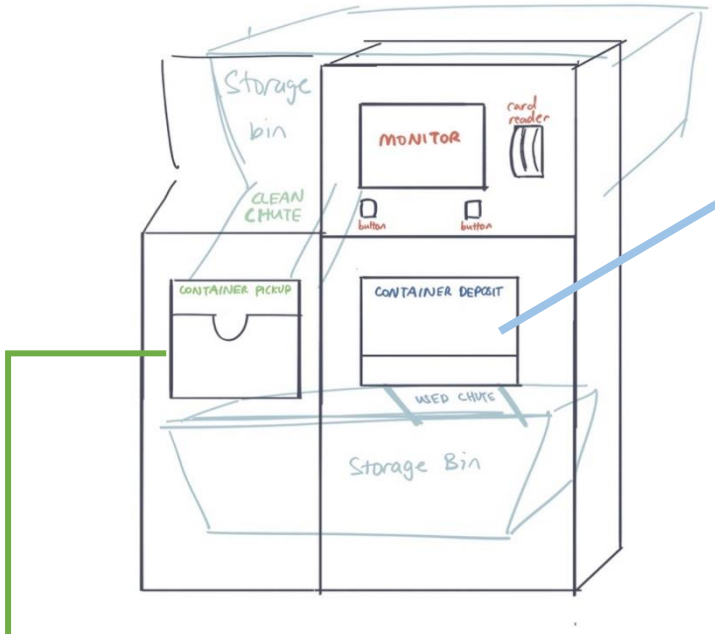
The goal here is to make the process semi-autonomous by removing the human to human interaction and also allow users to directly swap old containers with new ones without the need of exchanging them for tokens. This will improve the efficiency, simplicity, and performance speed of the Good2Go container system.

To do so, the system will require sensors to detect validity of the containers and the tokens. It will also have a screen display and buttons to receive user input. Lastly the microcontroller and motors will be used to process the internal state of the machine and execute the actions necessary to receive old containers, output new ones and generate a token.

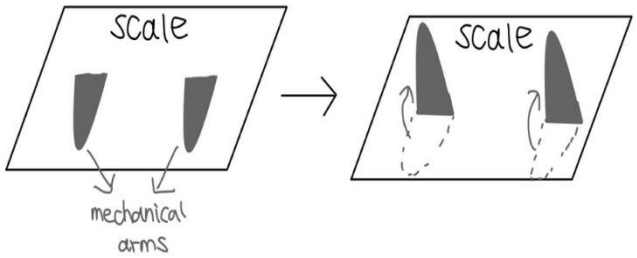
The sensors are the main replacement of human to human interaction, as they are responsible for authenticating valid containers and tokens. Each container has its QR code scanned and weight measured; containers that are overweight or are missing valid QR codes are rejected. Wooden tokens will be replaced with virtualized tokens stored in a magnetic swipe card. A card reader identifies each user. A screen display and a series of buttons are used to inform the machine of the user input. Once a user deposits an old container, they will be able to select to receive a new container or a token. The microcontroller will then take this input from the user and will activate the motors to dispense and receive Good2Go containers. The motors will be placed to allow accurate delivery of only a single container at a time, which is further described in the diagram below as well as under the Subsystem Overview.

Visual Aid:

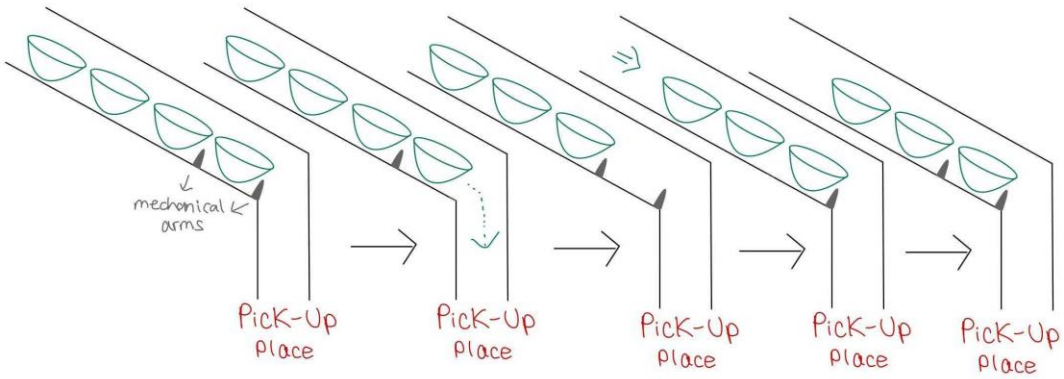
OVERALL DESIGN



USED CONTAINER DEPOSIT MECHANISM



CLEAN CONTAINER DISPENSING MECHANISM

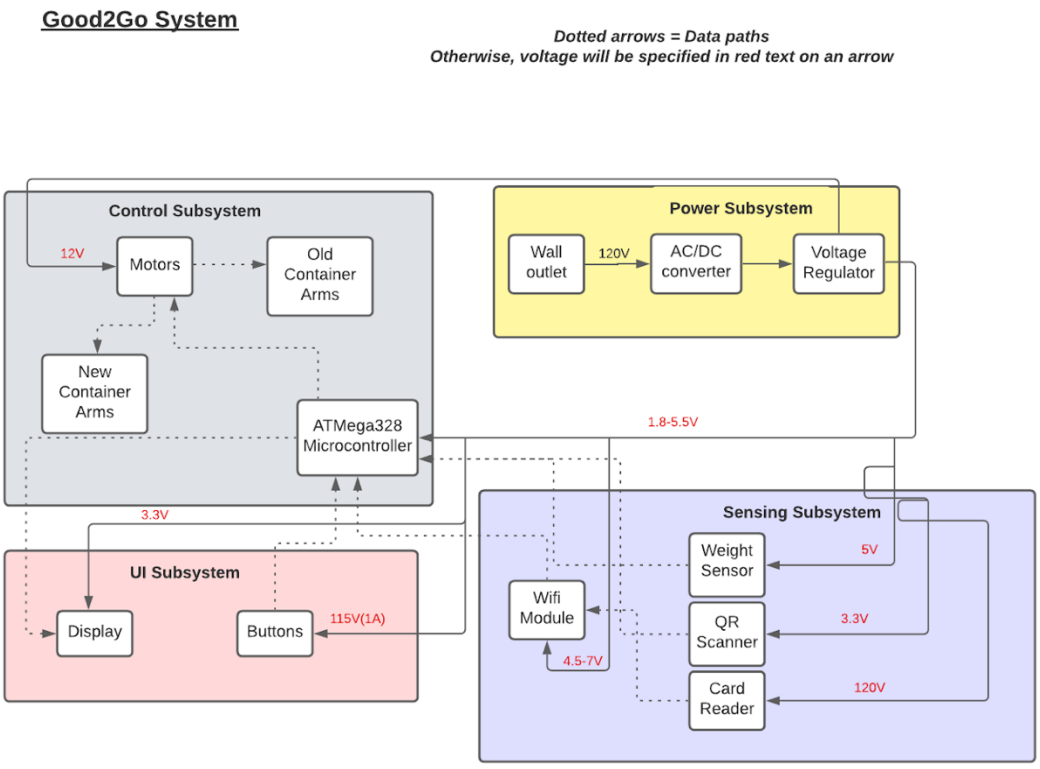


High-level Requirements List:

1. Deliver the entire process (from receiving container/token to dispensing a new one) in less than 15 seconds
2. Dispense exactly one new container at a time indefinitely without any jamming
3. Accurately detect invalid containers that are overweight by more than 30 grams compared to the base weight so that containers holding too much food waste are rejected

Design

Block Diagram:



Subsystem Overview:

Initial State: in its initial state, the machine will be waiting for user input for either an {old container} or a {token}

1. UI Subsystem: display screen and buttons

The display screen along with the button is used to guide the user into selecting one of the two options. The first selection is {old container} and {token} which is used to inform the machine what it's supposed to expect from the user. In the case of the {token}, the machine will read from the card swipe. The next option that will be displayed is {new container} and {token} which occurs in the event the user returns an old container. Based on the input, the machine will return either a new container or update the token info from the swiped card.

2. Sensing Subsystem: scale, card reader, camera

QR scanner to identify valid containers by reading the food container ID and a wifi module to send it over to the microcontroller. If it is an invalid ID, the machine returns to its initial state. Otherwise, the machine will dispense either a {new container} or generate a {token}

Scale to measure weight so that once it exceeds {container weight + constant}, the machine will not accept the container and will return to its initial state. If the weight is within the threshold, the machine will dispense either a {new container} or generate a {token}

Card Swipe is used to process digital coins instead of physical ones. Each card will hold information of the number of tokens and will get updated for every swipe. If a card swipe is read from the initial state, the machine will dispense a new container

3. Control: motors and microcontroller

An ATMega328 microcontroller will keep track of the state transitions and will also be responsible for activating different motors and reading data from the scale, token as well as the food container ID. From the initial state (old container, token), if the user inputs an old container, the microcontroller will take input from the scale and activate the motor to receive the returned old container, and then wait for further user input for {new container} or a {token}. Otherwise if the user selects a token, the microcontroller will process the token and activate the motors to dispense a new container.

Motors will be wired to a pair of arms near the opening of where the user can place an old container. It will be placed on the same surface as the scale (on the bottom of the old container) so that once the motors are activated, it lifts up and acts as the pushing mechanism to deposit the old containers.

A different set of motors wired to two arms (spaced for a single container) will also be used to dispense new containers. Only a single container will be preloaded in between the arms, with the rest being loaded behind this single container at an angle. Upon the activation of the motors, the first arm closest to the drop chute will open first, dispensing the container. That arm will then close, followed by the second arm opening, allowing one container through. That barrier will then close, completing the process of preloading another container that's ready to dispense.

4. Power Subsystem: AC/DC converter and voltage regulator

Takes in power from a conventional wall outlet and outputs regulated voltage specified in our design to properly power all components.

Subsystem Requirements:

1. UI Subsystem:

The UI subsystem includes a display screen with a 10 inch display size using a power supply of 3.3V. The only input the display screen takes is from the power supply and from the microcontroller so as to give the user an option to select a specific action the machine needs to perform. This includes a selection between an {old container} and {token} to inform the machine what it should expect to read from the user. The next selection is between two outputs including {new container} and {token} for returning an old container. 10mm wide push buttons with switch functions (ON and OFF) are used to read the user choice, which is then fed back to the microcontroller to carry out the next course of action.

Requirements:

- Clear and readable text output to screen with specific message defined by microcontroller
- The microcontroller must detect the ON and OFF switch functions of the buttons

2. Sensing Subsystem:

The sensing subsystem includes three main components with inputs from the power supply. The first one is a 5V weight sensor used to identify valid containers by checking the amount of food waste left. Along with this, the 3.3V QR scan will be sent to the microcontroller to check for the final validity of the old container from the user. The third component is a 3.15 x 1.1 x 2.64 inches 120V card reader that reads in a magnetic stripe card of a standard credit card size. After reading the swipe, it will be sent to the microcontroller via a WLAN Wireless module so as to update the token information for the user.

Requirements:

- The weighing scale should always be on and always initialized to 0
- The QR will need stickers with white backing to allow scan on transparent containers
- The QR scanner should be able to scan regardless of the orientation of the container
- The token data for each user should only be updated once per card swipe

3. Control Subsystem:

The control subsystem will include two sets of 12V motors, each used for the mechanical arms that control the retrieval and dispensing of the containers. The first set of mechanical arms used for retrieving old containers will be placed on the same surface as the weighing scale. The motors will take input from the microcontroller to be activated, and the arms will be lifted up to push back the container into the storage bin. The second set of motors are used to power two mechanical arms for dispensing. These two arms will be spaced so as to allow exactly one container in between. The rest of the new containers will be placed behind these arms on a slanted chute so that once a new container is dispensed, the rest will slide in. To allow exactly one new container to be loaded in between the arms, the first arm closest to the dispenser will fall to allow the container to be dropped at the pick-up place. The first arm will then come back up and the second arm will fall for the rest of the containers to slide in. Finally the second arm will come up to allow continuous repetition of the cycle to dispense one new container at a time.

Requirements:

- Sequential timing (in order) of the mechanical arms to allow one dispensing at a time
- The arms should not cause any mechanical faults such as jamming

4. Power Subsystem:

The power subsystem for our machine will mainly rely on a typical 120V wall outlet. The power from the outlet will then go through an AC/DC converter to ensure no components get damaged or burnt. Finally, it will go through a voltage regulator so as to maintain a constant voltage to supply to other subsystems with specific voltage specified in the block diagram.

Requirements:

- The power supply should be able to output constant voltage within the range specified by each component

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Tolerance Analysis:

The sequence of which a container is dispensed is a concern. Our system should not be too quick, otherwise we may exceed the motor's throughput, which can cause damage to the mechanical arms that dispense the container. We also do not want it to be too slow, as we want users to be able to retrieve containers relatively quickly. For a 5cm arm attached to a traditional stepper motor (https://www.sparkfun.com/products/9238) with a 1.8 degree step angle and 200 steps per revolutions, we need a total of

$$5 * 200 = 1000 \text{ step or } 5 \text{ revolutions}$$

to safely rotate the arms without any damage to the system. Additionally, between both motors for the two dispensing arms, we will incorporate a 1 second delay between when both actuate so that the first arm can allow a container to be dispensed, which will then allow for the next container to preload itself via the second arm dropping.

Another aspect that poses a risk to a successful project completion is the processing of digital coins. In replacement of the physical G2G coins, the digital coin allows greater security and convenience for users. However since the human to human interaction is eliminated, no further security check is made beyond the card reader system. If it malfunctions in updating the number of tokens, the users may end up with unlimited exchange for new containers. This can be checked through simulation of card swipes and reading the number of tokens for every update and checking against the expected output.

Ethics and Safety

This project has potential pitfalls with ethics and safety issues that can conflict with the IEEE Code of Ethics, with safety and privacy of the user being two of the particular issues [1]. Namely, the user could get their finger stuck in the motor area with the chutes for dispensing and accepting containers, which is a safety concern. Additionally, with our database of user info associated with each RFID card, the user could be prone to a data leak, which is a big concern for privacy, especially in current times where data is extremely valuable. It is our utmost priority to ensure that people's privacy is protected and they are aware of safety concerns. As noted in the IEEE Code of Ethics, we will treat all persons fairly and not discriminate against people based on race, age, disability, gender, national origin, gender identity, or gender expression [1]. We will also not engage in harassment of any form, including sexual harassment or bullying behavior [1]. Additionally, we will also accept honest criticism of our project as well as properly credit contributions by others [1].

References:

[1] https://www.ieee.org/about/corporate/governance/p7-8.html