

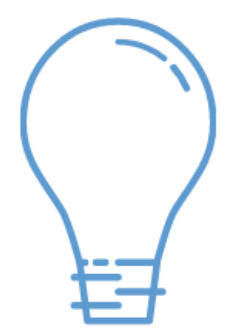
Development of a Reusable Cup Machine

Jehu De la Rosa (ME), Gregory Kashmanian (ME),
 Nicholas Kratovil (ME), Molly O'Connor (ME), Owen Smith (RBE)
 Advisors: Professor Sarah Wodin-Schwartz (ME) and Professor Berk Calli (RBE/CS)

Abstract

This project pursues an autonomous solution for reducing single use cup waste through a reusable cup sharing kiosk. A design concept suitable for this type of program must receive a dirty cup from a consumer and return a clean cup ready-for-use. Such a device must have washing, drying, storing, and dispensing capabilities. The design process consists of three main steps: brainstorming, analyzing, and comparing with a design matrix. The final product prioritizes compactness and simplicity of mechanical systems. It uses a carousel-style design to pre-rinse, deep cleanse, and air-dry cups before dropping them into storage. Cups are dispensed using a two-step rack and pinion mechanism and reoriented for face-up consumer retrieval.

Background & Relevance



REUSABLE CUPS HAVE A LONGER LIFESPAN, MAKING THEM MORE EFFICIENT



APPROXIMATELY 254 MILLION TONS OF GARBAGE IS GENERATED GLOBALLY EACH YEAR



LESS THAN 1% OF DISPOSABLE CUPS ARE RECYCLED

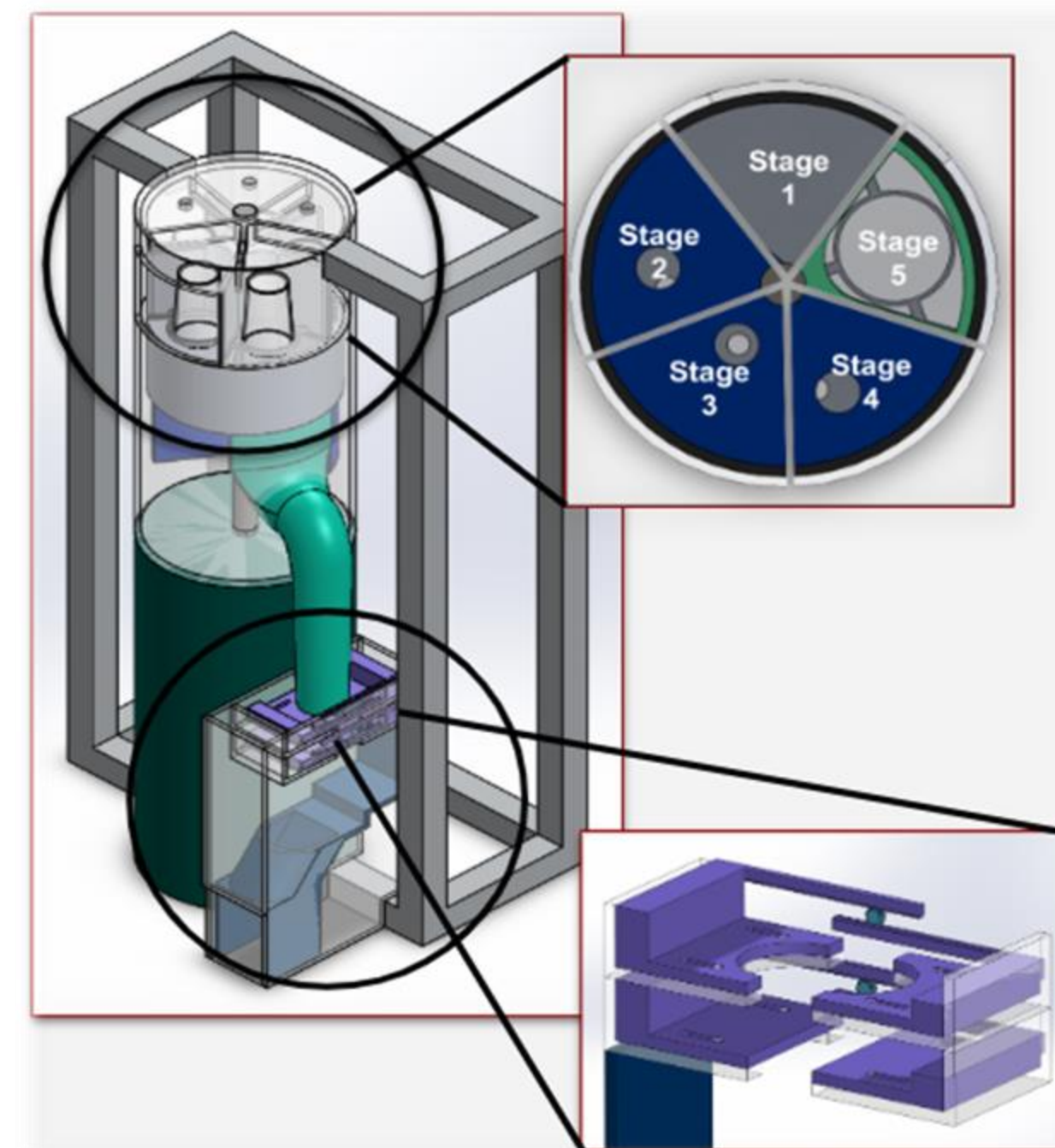


LOCAL BUSINESSES REPORT LESS THAN 2% OF CUSTOMERS CURRENTLY USING REUSABLES

System Function

Machine Steps:

- Stage 1: The user inserts cup into receiving slot of machine.
- Stage 2: The cup is pre rinsed to remove residue.
- Stage 3: The cup is sanitized to remove bacteria.
- Stage 4: The cup is air dried with compressed air.
- Stage 5: The cup drops down the exit chute into the storage tube.



Sequential Systems:

Cleaning

- Rinsing
- Sanitizing
- Drying

Dispensing

- Stacking
- Dispensing
- Flipping

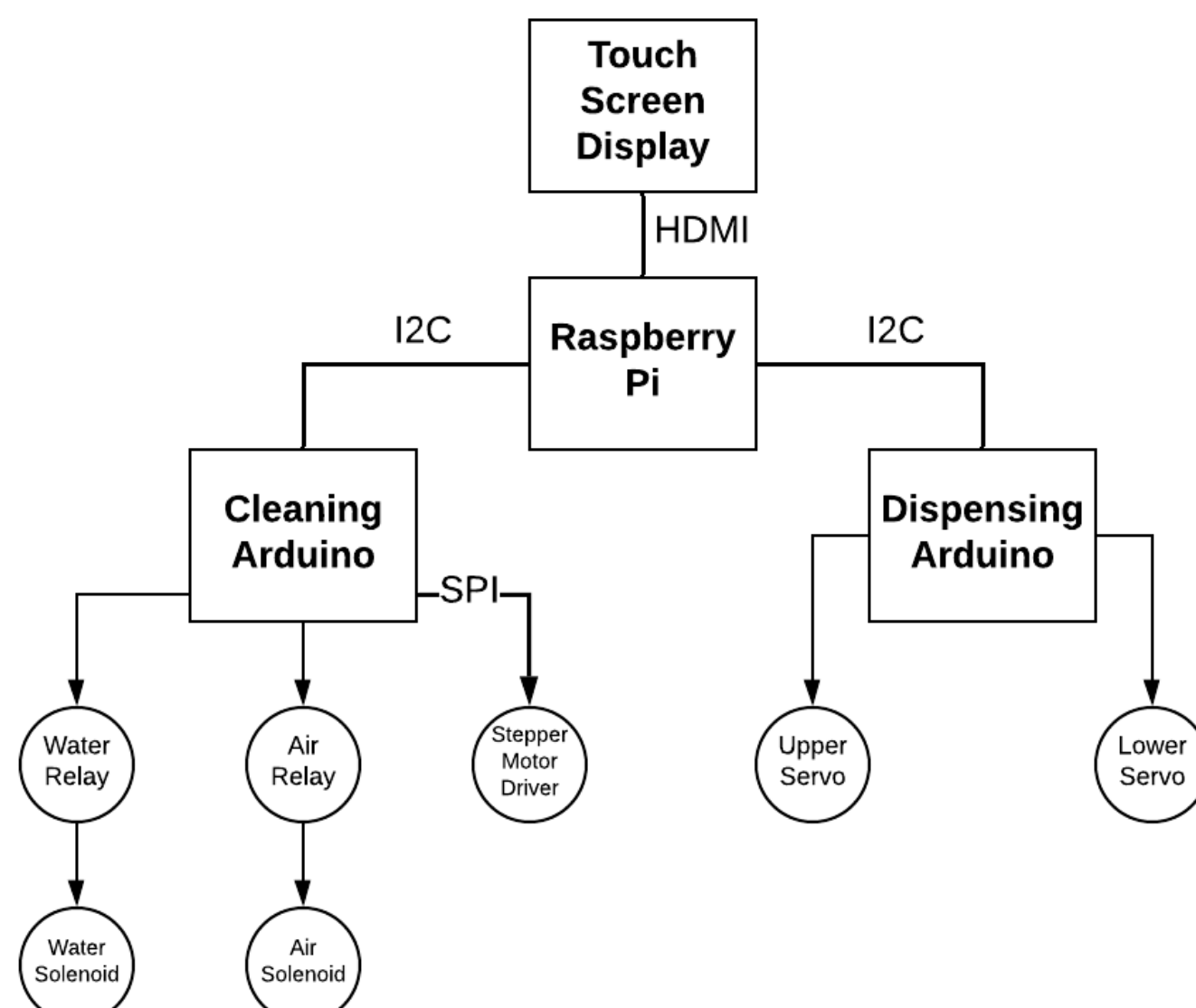
Prototyping

- 22" x 10" x 46" T-slot aluminum frame
- Stepper motor to turn central carousel rod
- Custom 3D-printed parts with acrylic housings
- Flexible PVC tubing for water and air
- Actuation of dispensing systems from servomotors



Communication

- Touch screen GUI run on a Raspberry Pi 3 B+
- Arduinos run controls processes for cleaning and dispensing
- Processes triggered by commands from the Raspberry Pi



Detailed Design

- Required motor torque calculation for the stepper motor

$$Torque = moment\ of\ inertia * angular\ acceleration \approx 1.86\ N * m$$

- Pressure loss of the water flowing through the pipe (depending on which nozzle the water flows to)

$$\Delta P_{Loss} = \rho * g * h \approx 5.24\ to\ 6.53\ psi$$

- Time to reach thermal equilibrium for the deep wash cup compartment

$$T(t) = T_{cup} + (T_{air, initial} - T_{cup})e^{-t/\tau}, \tau = (\rho cV) / (hA), t = 4\tau = 141\ minutes$$

Future Work



Finish water lines, air lines, and assembly



Scale design from 5-ounce to 12-ounce cup



Deploy the system on the WPI campus