GVSU First-Year Lab Hardware Sorter & Dispenser

Project Sponsor – Dr. Hittepole

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Introduction

The GVSU Interdisciplinary Engineering first-year lab faces issues with excessive hardware acquisition and inaccurate sorting by students, leading to wasted materials. The current open-bin system allows students to take surplus hardware without effective monitoring and often results in parts being incorrectly sorted upon return. Our project aims to develop a vending and sorting machine with a credit-based system to track hardware dispensed and returned by students. This solution will help regulate hardware usage, reduce waste, ensure accurate sorting, and promote fair distribution of resources.

Key Specifications

- **Dispensing Accuracy:** The device must dispense stocked hardware with a tolerance of ±15%.
- **Jam Frequency:** The device must experience no more than one jam per 100 dispensed pieces.
- **ADA Compliance:** The device must be ADA reach compliant. Therefore any required reach must not exceed 15-48 inches above ground and lateral reach must not exceed 10 inches.
- **Low Stock Alert:** The device must provide an alert when any given hardware is below 20% of its stocked inventory level
- **Inventory:** The device must be able to hold 1,000 units of each piece of hardware
- **Cycle Time:** The device must have a maximum cycle time of 30 seconds from the time the user requests a piece of hardware util it is dispensed
- **Cost:** The device must cost less than $3,000

- **Stocked Hardware:** The device must be compatible with the following hardware:
  - PHP: M3 x 8, M3 x 16, M3 x 30 , M3 x 50
  - M3 Hex Nut, NIL M3 Nut, M3 Flat Washer
  - PHP M2 x 10 and M2 Hex Nut

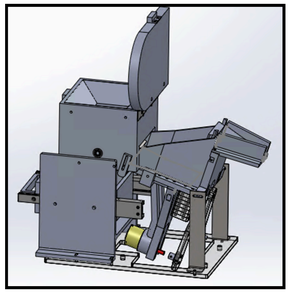
Design Challenges

- **Cost Constraints:** Working within a $3,000 budget was particularly challenging as it limited the materials and resources available for designing a reliable hardware sorting and dispensing machine. For this reason, many components were sourced from the GVSU machine shop and were either 3D printed or laser-cut from acrylic.
- **3D Printing Limitations:** The reliability and time associated with 3D printing posed significant challenges during the build of the machine. The tolerances of 3D printing are not as precise as other fabrication methods, which resulted in multiple iterations of prints before finalizing many component designs.
- **ADA Reach Compliance:** Meeting ADA reach requirements was essential to ensure the device was accessible for current and future students with disabilities. The device needed to be designed within the reach range of 15 inches to 48 inches above the ground, which presented additional design constraints.

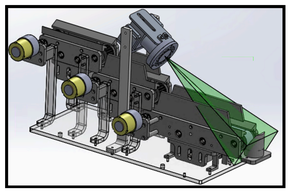
Key Design Features

User interface: The user interface enables students to use credit from their building key cards to retrieve hardware from the machine. Any leftover or unwanted hardware can be returned through the intake, and credit will be added back to their account for the returned materials. Additionally, the user interface includes an admin portal for maintenance of the machine.

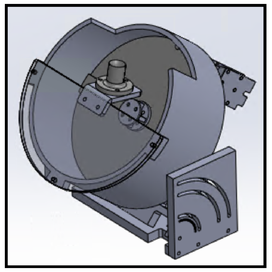
Intake & Singulation: The intake utilizes an electromagnet, which can be activated or deactivated to attract ferromagnetic objects, as an initial method to sort out trash. The ferromagnetic items are then dropped onto an indexer, where a limited number of objects are arranged into a single file line before being moved to the conveyor system.



Conveyor & Vision System: The three-tiered conveyor system separates parts by operating at three different speeds. On the final conveyor, a vision system identifies the hardware and signals the distribution ramp to rotate to the corresponding distribution cup. The vision system utilizes YOLOv8, a Python package of a computer vision model created by Ultralytics, with a custom-trained model based on the hardware to detect various parts. Any unidentifiable objects are directed to a larger cup designated for trash.



Film Reels: The film reels serve as storage and distribution for hardware. Each reel's basin holds 1,000 units, with a disk featuring cutouts matching the hardware shape. When dispensing, the disk rotates to pick up hardware at the bottom of the basin and release hardware through a hole at the top. A proximity infrared sensor on the back side of the fill reel then counts the dispensed units.



Controls: The system uses a Raspberry Pi 5 to communicate with two Arduino MEGAs via UART serial communication. The Raspberry Pi 5 handles the user interface and image recognition, while the Arduino MEGAs manage sensor inputs, outputs, and motor controls, with one focusing on sorting and the other on dispensing. The motor controls for the dispensing reels are split between the two Arduino MEGAs due to limited PWM pins. H-bridges are used to control motor speed independently based on PWM signals from the Arduino MEGAs.

Final Design