Pocket Pal

Team 70

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1. Introduction

1.1 Objective

Have you ever waited in line at a coffee shop during rush hour, only to have your coins disappear and scatter in your wallet when it's finally your turn to pay? When this happens to me, I frantically search my wallet for the perfect amount of coins while the caffeine-deprived mob waiting in line behind me casts angry glares. Even if this hasn't happened to you, you've most likely been one of those people in the back of the line, agonizing over how long you must wait until you can finally get your coffee fix.

With Pocket Pal, this will be a problem of the past. Instead of frantically fishing around for the perfect amount of coins that may or may not be your wallet, all you need to do is input the coin amount of your purchase into the device and Pocket Pal will dispense it for you. This compact, high-tech wallet keeps track of how many coins it has at any given time, and it will automatically update these values whenever the user inserts more coins into the device. Our solution will use this information to calculate the correct combination of coins needed for a purchase, dispense them straight into the user's hand, and overall make cash purchases quicker.

1.2 Background

Even though credit and debit usage is a solution for some people, cash purchases are still prevalent both in the U.S. and overseas. The 2019 Diary of Consumer Payment Choice found that cash purchases in the U.S. are common for small payments; cash is used for about half of all purchases under $10 and 42% of all payments under $25 [1]. Additionally, the German Association of Money and Bond Services found that 75% of Germany's purchases in 2020 were made through cash, even with the rise in card payments attributed to the pandemic [2]. Cash usage is still relevant, especially in places like coffee shops, fast food restaurants, and other similar businesses that have a large influx of people and lower-priced goods.

Pocket Pal is a solution for those who prefer to use cash for small payments like coffee or fast food. Scrambling for the right coins at a cash register can oftentimes be awkward and time-consuming, but users will be able to hasten this process with Pocket Pal. Our innovative wallet will be capable of determining the exact combination of coins to match the amount input by the user. Pocket Pal will then dispense the coins, sparing the user from having to frantically look through their wallet for change. To reload the device, coins can be inserted into the coin loader, where they will be automatically sorted by coin type and placed in their respective coin compartment slot. The coin compartment will keep track of all the coins in the wallet using motion sensors, as they will detect whenever a coin is inserted into the device. The microcontroller will compute the correct combination of coins to distribute based on the user's input amount, and keep track of the counts of each coin type whenever loading or dispensing processes occur. For this project, we are primarily focusing on tracking and dispensing coins, as this is the most time consuming aspect of cash transactions when compared to bills.

1.3 Physical Design

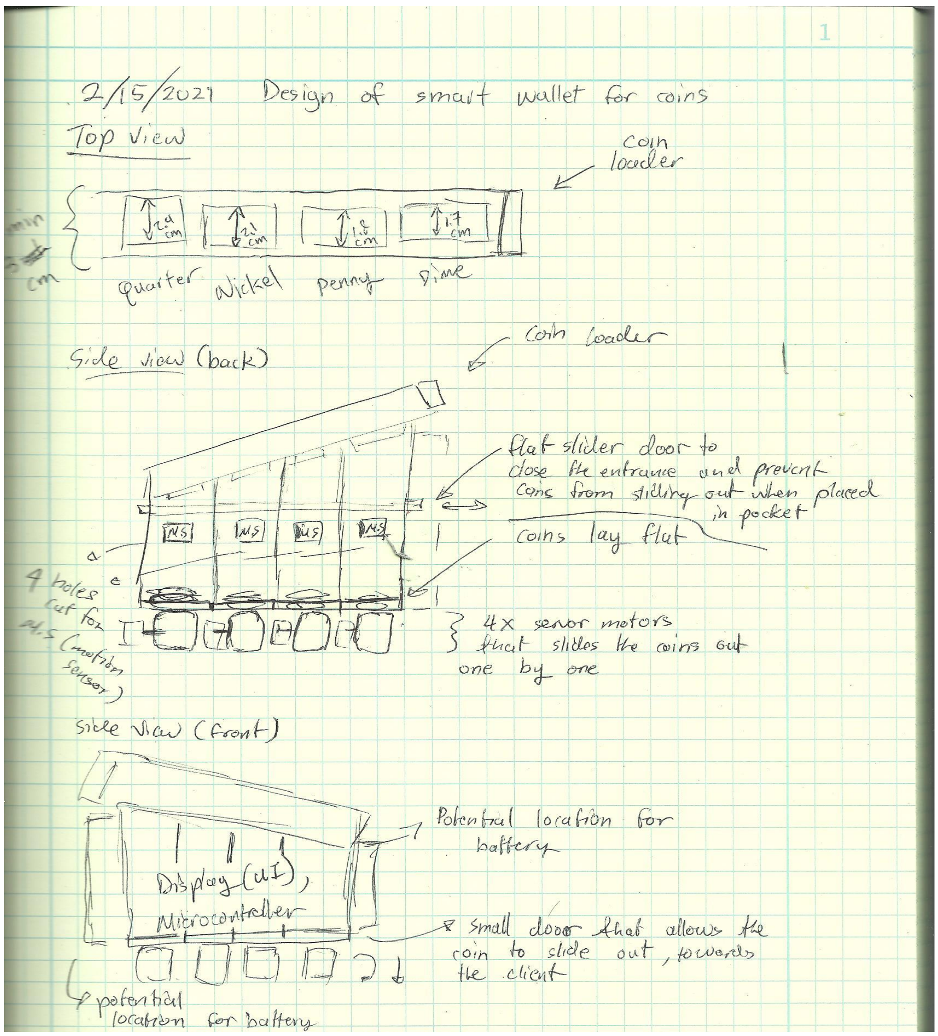

Figure 1. Proposed Pocket Pal Physical Design

1.4 High-level Requirements List

- The coin loader must sort pennies, nickels, dimes, and quarters into their proper compartments with 95% accuracy.
- The coin dispenser must dispense the correct coin amount in a maximum of 15 seconds.
- The overall design of Pocket Pal must be compact, with a maximum size of 6"x4"x1.5".

2. Design

Figure 2 shows the Pocket Pal's Block Diagram. The design will consist of 3 distinct subsystems: a power supply, a control unit, and a coin module. The power supply for Pocket Pal is a portable 5-volt battery. It will power the microcontroller, user input, motion sensors, coin dispenser, and conveyor belts. The control unit handles the user's input whenever they want to make a purchase and sends this information to the microcontroller. The microcontroller uses this data to calculate the correct combination of coins that must be dispensed, decrements all relevant coin counts, and signals to the coin dispenser to power the conveyor belts corresponding to the necessary coin types. When the user inserts coins into the coin loader, the motion sensors detect this change, and the microcontroller increments the coin counts accordingly.

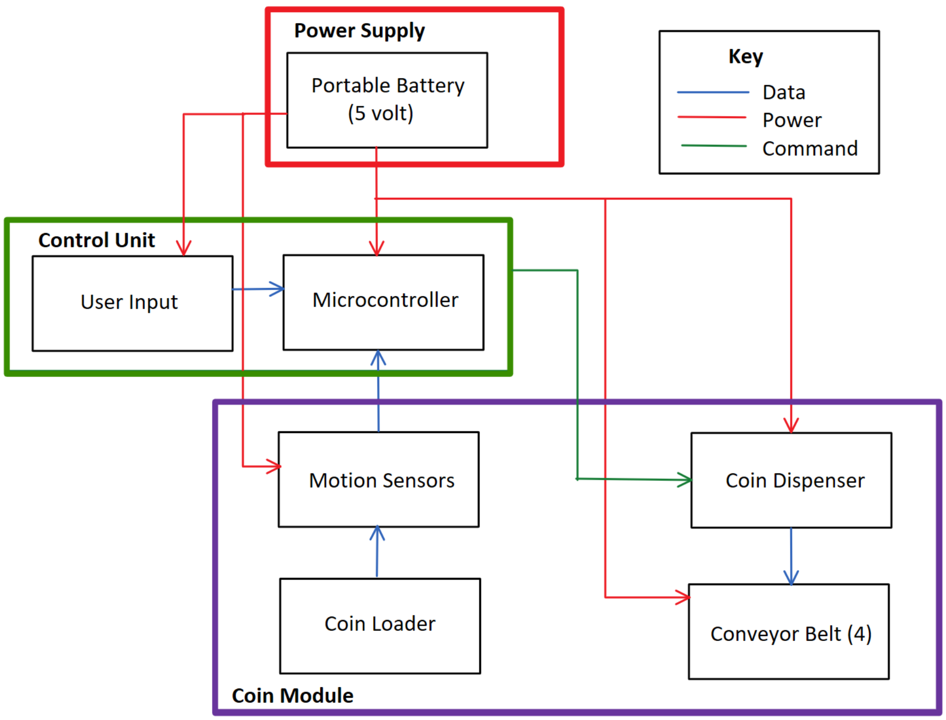

Figure 2. Block Diagram

2.1 Power Supply

The power supply (portable battery) should be able to power the microcontroller, motion sensors, conveyor belts, dispenser, and user input.

2.1.1 Portable Battery

- Requirement 1: The power supply should be able to provide 5V at 1A at all times.

- Requirement 2: The battery's temperature should not rise above 85 degrees Celsius to mitigate the risk of damaging other components.

2.2 Control Unit

The control unit handles all of the computation that occurs when a user inputs a cash amount, tells the coin dispenser how long to run each of the coin dispenser motors, and updates coin counts accordingly. The control unit also increases coin counts when the motion sensors detect a change in the coin compartments.

2.2.1 User Input

- When the user wants to make a purchase, the user will enter the necessary monetary amount into this subsystem through either buttons or an LCD screen. The user input is required so that it can communicate this value to the microcontroller. The user input consists of the numbers 0-9, as well as "Enter" and "Backspace" buttons.
- Requirement 1: User input must be supplied 20-50 mA in order to send the user's intended monetary amount to the microcontroller.
- Requirement 2: LCD screen must consume less than 5V at 50mA. Possible options include the Adafruit 1.3" display [3].

2.2.2 Microcontroller

- The microcontroller's function is to keep track of how many of each coin are in the system and update these values when necessary. It increments values when the motion sensors detect a specific coin type loaded into the device. It decrements values automatically when it signals to the coin dispenser that it should begin its dispensing process. When the microcontroller receives data from the user input, it calculates each bill's count and coin type that needs to be dispensed to reach the user's input price. Once the microcontroller calculates the number of coins, it tells the coin dispenser which of the four-coin conveyor belts should be turned on and how long each should be on to dispense the correct number of coins. A potential option we are looking to use is the ATMEGA328P Microcontroller [4].
- Requirement 1: The microcontroller should be able to accurately keep track of coins in each compartment and communicate with the servo motors to dispense the coins.

2.3 Coin Module

The coin module communicates with the microcontroller whenever coins are inserted into the coin loader to know when to update the coin counts. The coin module is also signaled by the microcontroller when the coin dispenser needs to start running its conveyor belt.

2.3.1 Coin Dispenser

- The purpose of the coin dispenser is to control the four conveyor belts to dispense the correct number of coins. The coin dispenser receives a signal from the microcontroller giving the amount of time each conveyor belt should run. The coin dispenser is required since it determines which conveyor belts should receive power and controls when the conveyor belts start and stop.
- Requirement 1: Coin dispenser must supply 5 volts to the servo motors corresponding to the conveyor belts that need to dispense coins, and 0.5 volts to those that must remain off so that conveyor belts only run when intended.

2.3.2 Conveyor Belt

- There are four conveyor belts, one for each coin type (quarter, dime, nickel, penny). The conveyor belt is required to drop coins individually into the user's hand physically. Every conveyor belt will begin to dispense if the coin dispenser determines that it must be powered. Otherwise, the conveyor belt will remain off so that no coins of that type will be released from the device.
- Requirement 1: Servo motors must receive 5 volts when they correspond to a coin type that needs to be dispensed. Otherwise, they must receive less than 0.5 volts when communicating to a coin counter that does not need to be dispensed [5].

2.3.3 Coin Loader

- The coin loader is a mechanical roof that will sort coins into their respective compartment when the user inserts a coin into the device. Coins will slide down a ramp with four different sized holes on its floor. Each hole corresponds to the size of a coin type (quarter, dime, nickel, penny), and only coins of matching type will be able to fall into each hole.
- Requirement 1: The coin loader must be able to sort coins based on each coin type's dimensions accurately, so that we can satisfy our 95% high-level requirement.
    - Dime (1.7 cm), Penny (1.8 cm), Nickel (2.1 cm), Quarter (2.4cm)

2.3.1 Motion Sensors

- IR motion or proximity sensors are being used to detect when a coin has been loaded into the compartment. Motion Sensors are being fitted onto the top of each coin compartment, and will detect whenever a coin falls from a hole in the loader.
- Requirement 1: Motion sensors must accurately detect when a coin has been loaded into a specific compartment, with no false alarms.
- Requirement 2: Be compact enough to fit in each compartment and keep the wallet within 6"x 4"x1.5".

2.4 Risk Analysis

The control unit poses the most significant risk to the successful completion of our project. We are unsure of the power consumption our microcontroller with a display would require. We are also unsure how many pins our numerous sensors and motors would take up, as our initial design uses at least four servo motors and four motion sensors.

The control unit must also compute the correct coin combination and quickly send those instructions to the coin module to meet our requirement of dispensing all coins within 15 seconds. This is because every motor must run for a specific amount of time to dispense a single coin. When we have multiple coins of the same type, the motors will need to run multiple times to drop all of the required coins, so we need to optimize our control unit to ensure data is communicated quickly.

To mitigate this risk, we will try using different power sources to determine the most efficient power supply. We plan on using 5V for all the components, which is subject to change depending on the power consumption of motors and microcontroller.

For the second risk, we intend on tuning the necessary cadence and duration for a single coin to drop. These factors will depend on the material we use on the motors to dispense the coin. Rubber wheels and sandpaper are both being considered currently.

3. Ethics and Safety

Being an electronic wallet, there is a slight risk of the power supply malfunctioning and exploding in people's pockets, especially during hot weather when the batteries will be exposed to more heat. To mitigate this risk, we are looking at efficient servo motors and microcontrollers that work accurately and operate with a low power consumption. As stated in the IEEE code of ethics, we have a responsibility to “improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems.” [6]. Through Pocket Pal, we will be able to showcase these capabilities by increasing the flexibility of coin usage for smaller payments.

4. References

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