ECE 445 FA23

Team 16: ChipCaddy

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Introduction

Problem

According to a market research study published by Zion Market Research, the demand analysis of Global Trading Card Game Market size & share revenue was valued at $6.39 Bn in 2022 and is estimated to grow about $11.57 Bn by 2030 [3]. As the market for card games increases, so does the need for accurate, secure, and efficient home game systems. Current home games are set up with a simple set of chips, cards, and players, resulting in large amounts of time wasted counting, sorting, and dealing chips. Casinos are well equipped with the endowment to purchase top-end counting mechanisms such as RFID poker chips or table-embedded chip counting mechanisms, but these machines cost thousands of dollars on average and are not suited for the casual home game.

Games such as Omaha are pot-limited, meaning the max bet players can make is the amount of chips currently in the pot. With the current home game system, players must hand count the amount of chips currently in the pot, as well as manually sort and dispense chips after each and every hand. This results in not only a large amount of time wasted, but also makes it easy for players to steal chips and miscount the current value of the pot.

In addition to this, calling players all-in values requires manually counting each stack of chips by hand, which can lead to incorrect values and a lot of wasted time. Online games have an automatic display of each player's stack, resulting in almost 3 times faster gameplay according to Upswing Poker [3].

Solution

Our solution features a combination of sensors, motors, and internal logic to sort, dispense, and identify the current value of the pot. After a hand, the chips will be pushed into a hopper which will straighten the chips into a stack. This hopper will have a color sensor at the base, as well as a rotating disk that uses a servo motor to rotate the disk and place each chip in its own separate tubular container based on its color value. The color sensor will relay the color of the chip to the microcontroller, which will handle the logic and display the current pot value on an LCD display based on the respective colors. When the winner of a pot is determined, the chips will be dispensed out of their individual containers in their respective organized stacks with a number of servo motors. In the rare case of a split pot, the user will be able to press a button that dispenses the pot in halves or thirds. The microcontroller will be responsible for the logic portion and will sit on a PCB that is also used to power our contraption. The device will also use a series of buttons to take in user information regarding big blind, small blind, and buy in values and will need to reset the LCD display to zero when all chips are ejected.

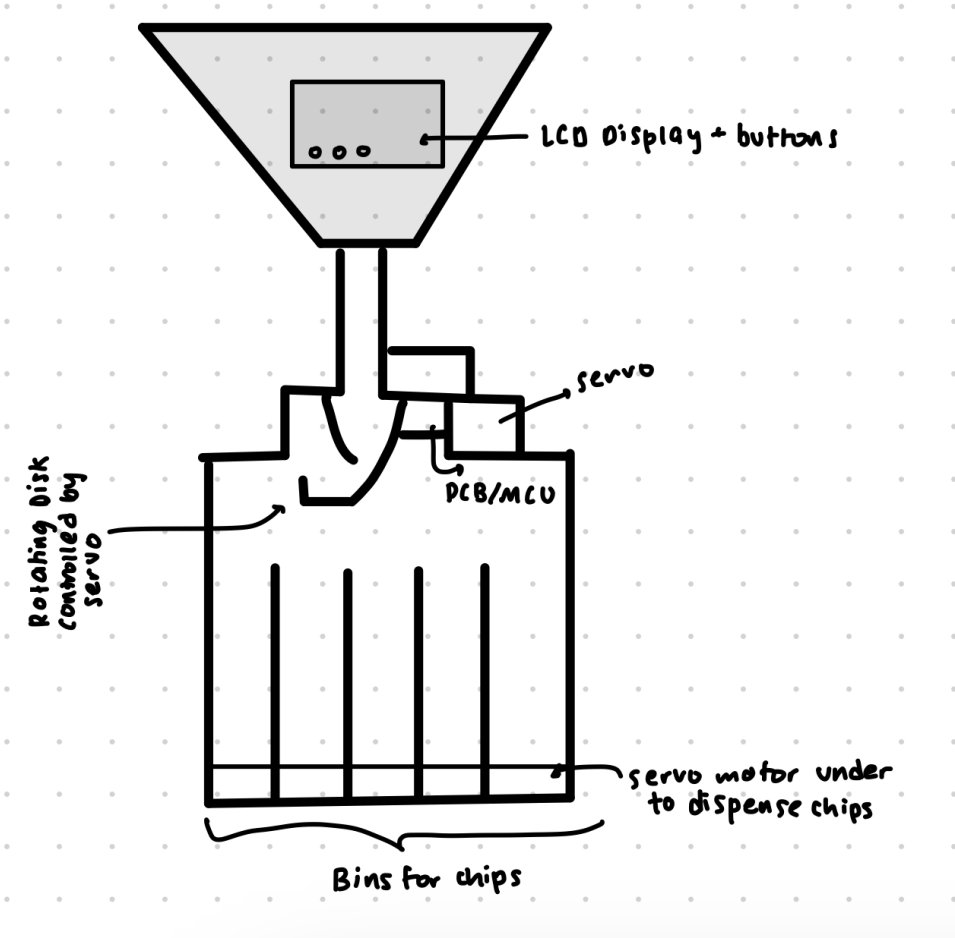
Our solution will greatly increase the efficiency and enjoyment of a regular home poker game. Rather than wasting valuable time counting pots, distributing plastic chips, and arranging chips in neat color coordinated towers, players can focus on having fun and playing.

High Level Requirements

1. Disregarding an all-in bet, let's assume the average bet uses at most 10 chips. Ideally we would want our contraption to count the bet in approximately 1 minute. So one high level requirement is that **the device appends the count within 6 seconds of the chip entering the funnel.**

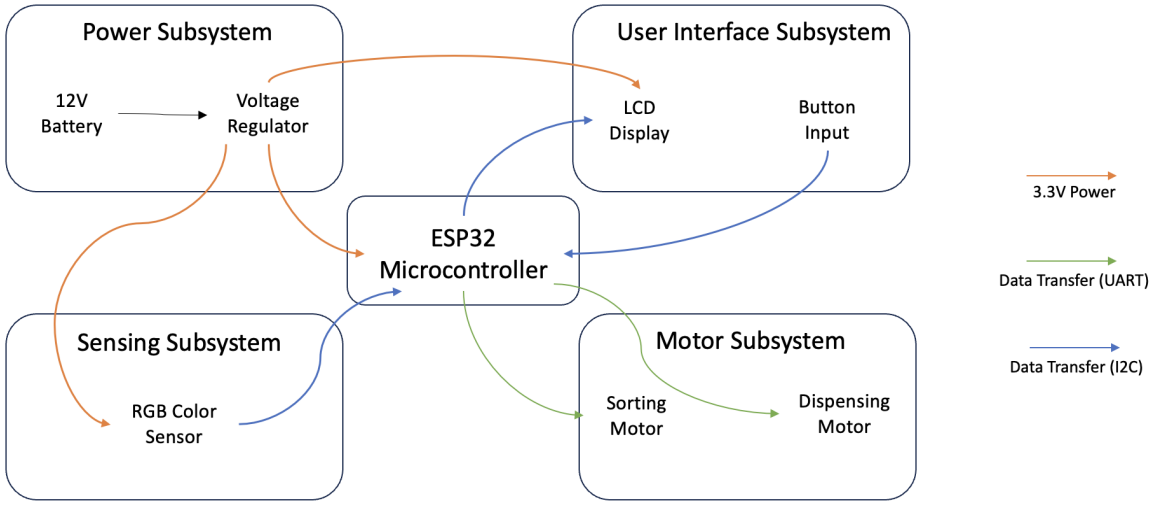
2. Upon ejecting the chips from the enclosure the pot count will **reset to 0**.
3. In the case of split or chop pots the user will be able to manually **choose the number of ways the pot will be split and the contraption will eject those divisions one by one.**

Visual Aid:



Design

Block Diagram



Subsystem Overview

- *Power Subsystem*

Our system will be powered by a 12V battery. This battery will be responsible for providing a stable and appropriately regulated voltage supply to the different subcomponents of our system. This subsystem must be capable of generating and maintaining different voltage levels, meeting the specific voltage requirements of the RGB color sensor, servo motors, LCD display, and our ESP32 Microcontroller.

- *Control Subsystem*

The ESP32 Microcontroller serves as our control subsystem for the whole chip counter system. It must be capable of performing critical functions such as analyzing the color sensing data, calculations for the pot counter, interacting with the button, and controlling the LCD

display and the sorting and dispensing motors. Everything in the device will run through the microcontroller.

- *Motor Subsystem*

This subsystem will handle the physical movement of the chips being sorted and dispensed. The servo motors will communicate serially with the control unit and accept instructions on how to place and organize each chip, as well as how many chips need to be dispensed.

- *Sensing Subsystem*

The sensing subsystem in our design will consist of the RGB color sensor placed at the bottom of our hopper. The RGB color sensor shoots light at the surface of the chips and measures the reflected wavelength of each color. With this information the sensor is able to determine what value chip is being sorted, and will communicate this serially with the control unit. The control unit will then instruct the motors to move the chip to its designated area.

- *User Interface Subsystem*

The user interface subsystem will consist of an LCD display for showing the current value of the pot, as well as a number of buttons to inform the microcontroller of split pots. The display will receive data from the microcontroller, and - based on what value of chip is placed in the hopper - will append the count of the pot in real time onto the display. The button inputs will be programmed to communicate with the control subsystem - when a button is pressed the pot will be distributed in halves or thirds.

Subsystem Requirements

- *Power Subsystem*
    - Must be able to maintain consistent and regulated voltage levels for each subsystem
    - Supplies 3.3 V to the ESP32 Microcontroller, LCD Display, and the RGB Color Sensor. Able to supply ~5V for the servo motors
- *Control Subsystem*
    - Must be able to accurately fully analyze the color sensing data from the Sensing Subsystem
    - Performs the necessary calculations for the pot and displays it on the LCD Display
    - Controls the sorting motors to direct the chips based on their colors. The dispensing motors are controlled based on the results of the pot calculations, and the button input from the User Interface Subsystem.
- *Motor Subsystem*
    - Sorting and Dispensing motors possess an operating voltage in the range of 4.8 - 6.0 V
    - Both motors have a minimum of 180 degrees of freedom for rotations in order to successfully dispense and sort the chips
- *Sensing Subsystem*
    - Operating voltage is 3.3 V
    - Needs a light source to illuminate the chips that pass through the sensor
    - Has a high color sensitivity and wide dynamic range

- *User Interface Subsystem*
    - Must accurately display the value of the pot in real time (within 5 seconds of the chip being placed into its value bin)

Tolerance Analysis:

It is imperative that we ensure that our voltage regulators do not overheat due to a high power drain from the components of our project. We will have three total voltage regulators, one for a 3.3 V output, and two with 6 V outputs. We have two separate 6 V outputs because the actuator and motor are capable of drawing a substantial amount of current and the power draw would be too much for one 6 V voltage regulator to handle without overheating. The calculations for all components are in the tables below.

Part (Operating at 3.3V)	**Max Current Draw at 3.3V**	**Comments**
STM32F103C8T6 (MCU)	50.3 mA	External clock(2), all peripherals enabled @72 MHz, Ta = 105 ° C
TCS3200 (Color Sensor)	2 mA	Power-on mode
NHD-0216HZ-FSW-FBW-33 V3C (LCD Display)	3 mA	Max Supply Current
Total Max Current Drawn	55.3 mA < 800 mA (Max Supply Current for LT1117-3.3V)	

Variable	**Value**	**Comment**
Tj	150 ° C	Maximum Junction

		Temperature for LT1117 Voltage Regulators
Iout	55.3 mA	Max Current Draw of Components @3.3V
Vin	9 V	9 V battery voltage
Vout	3.3 V	3.3 V to power above components
Θjc	15° C/W	Thermal Resistance, Junction to Case, for LT1117-3.3V
Θca	45° C/W	59 °C/W is the max Junction to Ambient thermal resistance listed on Data Sheet
Ta	30° C	Assuming warm board

Calculating Tj = 48.9126 ° C < 150 ° C. LT1117-3.3V Regulator will suffice.

Using 2x LM350 for each 6 V output. This will give us a 3 A max current output for each motor.

Part (Operating at 6V)	**Max Current Draw**	**Comments**
1x Servo Motor (Base)	600 mA	Claims to draw a maximum of 200mA (but we are going to allocate 600 mA just to be safe) current for a 6V

		Continuous Rotation Servo (#900-00008)
1x Linear Actuator (Pusher)	550 mA @6V	550 mA max current draw at a 6 V input for the PQ12-63-6-S Linear Actuator.
Total	600mA < 3 A (Base Motor) 550 mA < 3 A (Linear Actuator)	Max Current draw for both 6 V components are under the 3A threshold that the LM350 can output.

Variable	**Value**	**Comments**
Tj	125 ° C	Maximum Junction Temperature for LM350 Voltage Regulators
Iout	600 mA , 550mA	Max Current Draw of each Component (one for each regulator) @6V
Vin	9 V	9 V battery input voltage
Vout	6 V	6 V to power the above components.
Θjc	1.5° C/W	Thermal Resistance, Junction to Case, for LM350.

Θca	33.5 ° C/W	35 °C/W is the max Junction to Ambient thermal resistance listed on Data Sheet (NDS)
Ta	30° C	Assuming warm board

Calculating Tj = 87.75 ° C (Regulator for Linear Actuator), 93° C (Regulator for Motor) < 125 ° C. 2x LM350 Regulator will suffice.

Ethics and Safety:

Ethically, as a project that relates to money and the distribution of monetary equivalent chips, it is very important that we maintain an accurate count of chip value. Any error in the logic and sorting of the chips could result in an unfair financial loss to a player, which can compromise the entire game. The premise of our solution is to eliminate intentional and unintentional errors in home poker games, while increasing the efficiency of the game itself which adheres to Section I.1 of the IEEE code of ethics: “to hold paramount the safety, health, and welfare of the public”[1]. Since, our solution also attempts to eliminate manipulating pots, it also supports Section I.4 of the IEEE code of ethics being “to avoid unlawful conduct in professional activities”[1]. This also means it is of the utmost importance that our microcontroller unit is not compromised to ensure the security of the game. Although it may not seem immediately relevant, our project will collect user data and data about the value of the pot.

Even this seemingly harmless data can raise privacy concerns, so it is essential to adhere to IEEE and ACM guidelines concerning data privacy. As students, it would be difficult to code our microcontroller in a way that makes it immune to hacking or interference. The best we can do to combat interference is by making our logic as simple as possible. Since our solution targets the home-game setting, we can say almost definitely that we will be able to provide a solution that is "usably secure" per ACM ethics guideline 2.9.

From a safety standpoint, any mechanism that uses motors and electrical components presents a safety hazard. Our device will feature a solid enclosure around the motors and moving parts in order to prevent any hair, jewelry, or loose clothing items from getting stuck in the motors and causing harm. In addition to this, our design will feature insulation around any wires and loose electrical components to prevent any harmful contact.

It is also important to abide by the strict IEEE and ACM guidelines against plagiarism [3]. Although there are a number of chip sorting mechanisms available on the market today, none of them are directly targeted for home games. This is reflected in the cost of the device. As our product features proprietary hardware and software - targeting a brand new demographic - we can safely avoid any plagiarism.

Finally, any product that supplements gambling is subject to review from a number of gambling governing bodies. The Illinois Gaming Board is the governing body in the state of Illinois, and controls a regulatory and tax collection for gaming in the state. Although regulations will be less stringent due to the home game target demographic, any gambling product will be subject to review before being commercially available to the public.

Citations

[1] “IEEE code of Ethics,” IEEE, https://www.ieee.org/about/corporate/governance/p7-8.html (accessed Sep. 14, 2023).

[2] R. Fee, “6 reasons why live poker is easier than online poker,” Upswing Poker, https://upswingpoker.com/live-poker-vs-online-poker-easier/ (accessed Sep. 14, 2023).

[3] Zion Market Research, “Trading card game market size, share and demand 2030,” Zion Market Research, https://www.zionmarketresearch.com/report/trading-card-game-market (accessed Sep. 14, 2023).