ECE 445 Spring 2025

Senior Design Laboratory

Project Proposal

Automatic Card Deck Sorter

Team 37

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1 Introduction

1.1 Problem

For centuries, card games have been a staple of entertainment. With just the same standard 52 card deck, hundreds of different card games have been produced over this time. However, in some of these games, there may be distinct and precise rules about setting up and managing the deck. For example, Euchre only uses the 9s, 10s, Jacks, Queens, Kings, and Aces, meaning players must manually sift through the deck before playing. Organizing the deck before playing games of this nature can be extremely tedious and time consuming. Players want to spend their time playing the game, not on the preparation of the game.

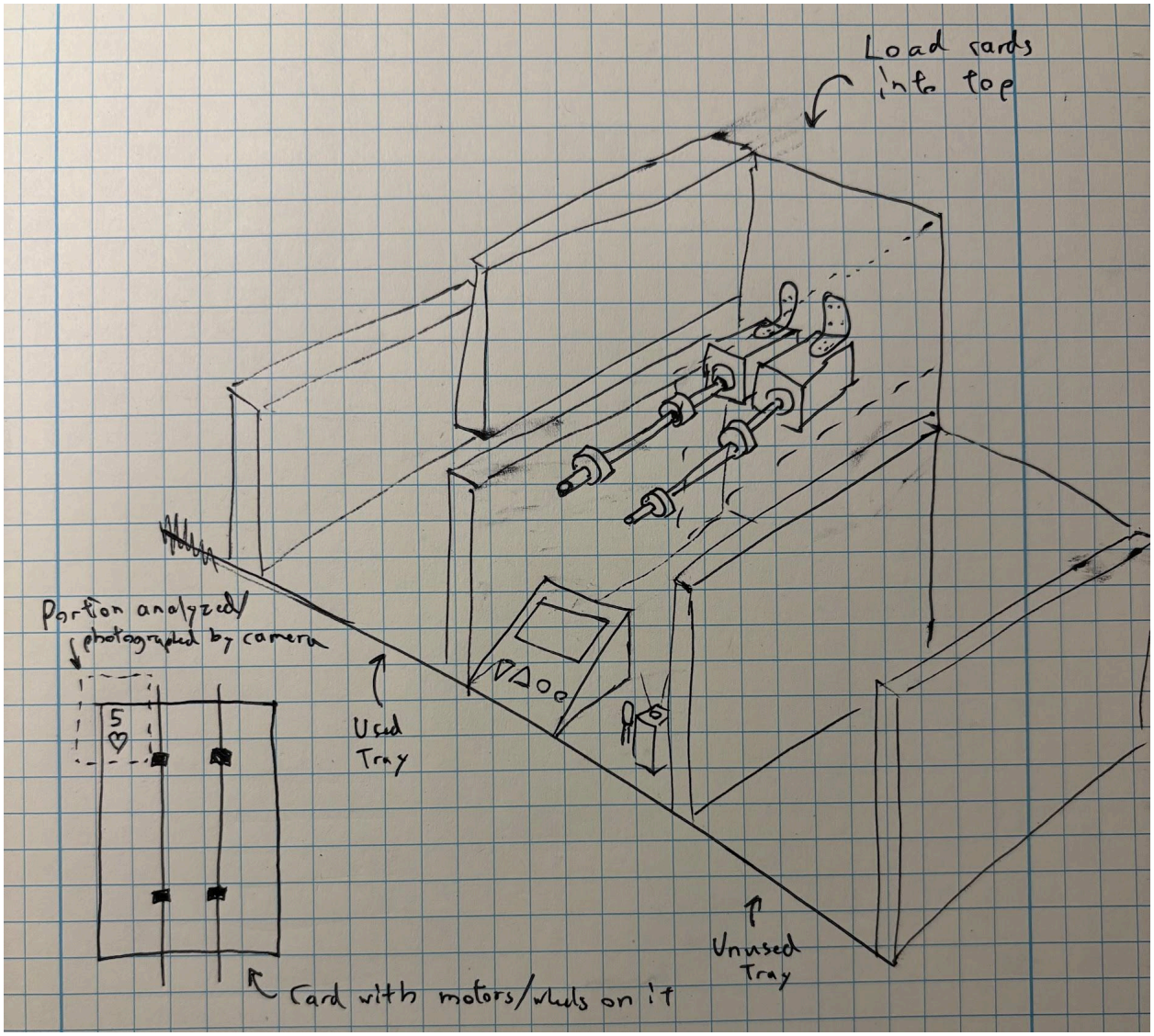
Beyond game-specific needs, many households, casinos, and clubs face the issue of reorganizing mixed or shuffled decks. Again, rearranging the cards back into a sorted order can take a long time and is by no means an exciting task. In a competitive setting, it may be essential to maintain a sorted deck before play to ensure fairness. At places with the need for a large number of decks to be sorted, the need for this process to be automated scales up drastically.

1.2 Solution

To address the inefficiencies of manual card sorting, we propose an Automatic 52-Card Deck Sorter. This device will quickly and accurately organize a mixed deck into an order specified by the user. This solution eliminates the need for players to manually separate cards for games like Euchre, where only a subset of the deck is used. The sorter will incorporate a card recognition system to identify each card and a mechanical sorting mechanism to place them in the correct order efficiently. Additionally, a PCB based control system will manage the identification and sorting process, which will ensure accuracy and reliability. By automating this task, the device saves time, reduces human error, and enhances convenience for casual players and competitive tournament organizers alike. Whether preparing for a game, ensuring a properly ordered deck, or simply avoiding the hassle of manual sorting, this system provides a reliable and efficient way to manage playing cards, making it a valuable tool for both home and competitive settings.

1.3 Visual Aid

This is a rough sketch of what we think our final design will look like. A deck of cards is loaded into the top, as is labeled in the image, and there are walls on either side of this container to allow only one card to be moved at a time (note that the wall closest to the viewer is only partially drawn with dotted lines in this sketch).



1.4 High Level Requirements

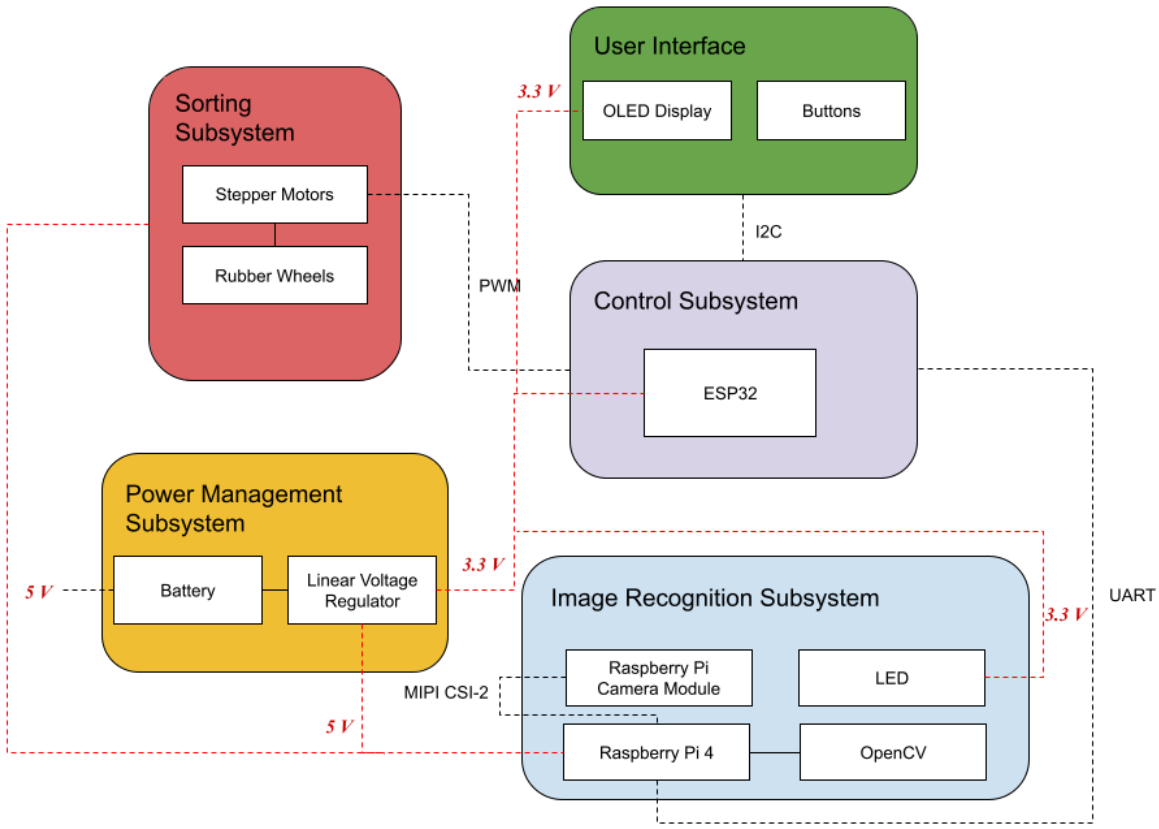
High-level requirements

- The camera can recognize the cards by suit and rank. It can recognize and sort 1 card in **4 seconds**, which translates to **3 minutes** for a 52 card deck
- Cards are successfully sorted into two piles, a ‘Used’ pile and an ‘Unused’ pile. The system goes until all cards are sorted into one of those two piles, and will automatically stop once there are no more cards to be sorted.
- The system can detect and display a warning sign or an error message when something goes wrong. It will do this when the same card is detected twice in a row (indicating a jam), a card is unrecognized by the camera, or the deck is incomplete.

2 Design

2.1 Block Diagram

This is the high level block diagram for our design.



2.2 Subsystem Overview

Our design is divided into 5 subsystems, which are implemented in both hardware and software.

2.2.1 Camera

The Camera subsystem, upon receiving a signal from the control system that a new card has appeared, will take a picture of the upper right corner of the card. It will then send that image to the control system to be analyzed. This process gets repeated until the camera sends an image of there being no more cards.

2.2.2 User Interface

The User interface will be a small screen with an assortment of buttons; Up, Down, Select, and Start. When the system is powered on, the screen will show a menu with a list of different games which have been preloaded for the system to sort into. Using the buttons, the user can navigate to their game of choice and hit the select button. Then, when the Start button is pressed, the system will begin sorting the cards. While sorting, the screen will display any pertinent information or errors - such as if a card jam is detected, if any cards are unrecognizable, etc.

2.2.3 Sorting System

The sorting system is responsible for moving the cards in a way to ensure they are appropriately sorted. This will be done by placing the deck of cards on the top of two rubber tires, powered by two motors that will slide each card to one pile or another through a slot the size of one card. Some sort of “metal card” will also be placed on top of the deck to add weight to the deck. This will ensure that as the deck thins out weight and friction with the rubber tires is not an issue.

2.2.4 Control System

The control system will do the majority of the heavy lifting on the software side of the device. It will work closely with the camera in order to identify suit and rank of cards, detect potential errors in the movement/sorting of the deck, and determine when the sorting process is over. The control system must also work closely with the sorting system, essentially telling it where each processed card should be moved to. Finally, the control system must communicate with the UI early on in this whole process to store which cards we care about and which we do not.

2.2.5 Power System

The power system will deliver power to all of the other subsystems. It will use linear regulators to ensure that each component gets the voltage that it needs to operate without negatively affecting the performance of the other components/subsystems.

2.3 Subsystem Requirements

The requirements for each of our subsystems.

2.3.1 Camera

- The Camera can take a picture of the card corner and send that card to the Control System.
- The Camera System can turn on a light when it takes a picture and turn it off afterwards.

2.3.2 User Interface

- The user can use the User Interface to select a game to sort the cards for.
- When the user presses Start on the User Interface, a signal communicating what game/sorting has been selected will be sent to the Control System.
- The User Interface can display an error message when given a signal from the Control System.
    - The User Interface can display multiple different error messages when given multiple different signals. These include:
        - A jam (the same card is detected twice)
        - A missing card (no more cards are left and not all 52 cards have been counted)
        - A unrecognized card (the system cannot sort the current card because it does not have a rank/suit)

2.3.3 Sorting System

- The Sorting System can move a card to either side based on an electronic input.
- The Sorting System can move just the top card of a stack of cards without affecting the rest of the stack

2.3.4 Control System

- When given a signal from the User Interface, the Control System will prepare what cards to accept/use and start sorting.
- The Control System will send a signal to the Camera System to take a picture after the Sorting System sorts a card.
- The Control System will analyze images received from the Camera System and give one of two signals to the Sorting System (indicating which direction to move the card).
- The Control System will recognize various errors and send a signal to the User Interface when they occur.
    - The detectable errors include:
        - A jam (the same card is detected twice)
        - A missing card (no more cards are left and not all 52 cards have been counted)
        - An unrecognized card (the system cannot sort the current card because it does not have a rank/suit)

2.3.5 Power System

- The Power System can power everything without overheating or slowing down the system.

2.4 Tolerance Analysis

An aspect of our design that we think poses a notable risk is the Power System. The table below shows some of our components and their typical voltages and currents.

Component Name:	Voltage:	Current:	Comment:
Stepper Motor	5 V	350 mA	Two motors used, 350 mA current per motor. Using continuous voltage. [1]
Raspberry Pi	5 V	7 mA	Only minimum current listed [2]
Screen	3.3 V	60 mA	[3]
ESP32	3.3 V	500 mA	[4]
White LED	3.3 V	30 mA	[5]

From the table we can conclude we need 2 different voltages: 5 volts and 3.3 volts. To achieve this, we can use a 5 volt battery with a linear regulator translating 5 volts to 3.3 volts.

We can determine the temperature of these linear regulators using a modification of an equation from the wiki [6].

$$T_j = i_{out}\Theta_{ja}(V_{in} - V_{out}) + T_a \quad (1)$$

We'll be using an LM 317 Linear Regulator in a KCS (TO-220) package. Based on this device's datasheet, we can get the junction to ambient thermal resistance value of 23.5 $^oC/W$ for both linear regulators [7]. Similarly, both regulators will have a 12 Volt V_{in} value. Our intended use case for this device is inside a house, so we'll estimate a max air temperature of 80^o Fahrenheit or 27^o Celsius (rounded up).

We'll use these values to calculate the linear regulator's heat. The following table fills in all of the values for this equation.

Variable:	Value:	Comment:
i_{out}	590 mA	ESP32, White LED, and Screen in parallel.
V_{in}	5 V	

V_{out}	3.3 V	
θ_{ja}	23.5 ^{o}C/W	[7]
T_a	27 ^{o}C	

Plugging these into our equation we get:

$$T_j = 0.590(23.5)(5 - 3.3) + 27 = 50.571 \quad (2)$$

This gets us a temperature value of just under 51 ^{o}C. This is an acceptable temperature for our product as these temperatures are well below the maximum operating temperature of the LM 317 Linear Regulator (150 ^{o}C) [7]. Additionally, we can move this equation to get our maximum ambient temperature.

$$T_{a\,(max)} = 150 - 0.590(23.5)(5 - 3.3) = 126.43 \quad (3)$$

This indicates that our design should be able to withstand ambient temperatures of up to 126.43 ^{0}C or 259.57 ^{0}F, which is well above any reasonable temperature for our user to be in.

3 Ethics and Safety

3.1 Ethical Concerns

In designing the Automatic Card Deck Sorter, we recognize the responsibility to uphold ethical standards as outlined in the IEEE Code of Ethics. While our device is intended to improve efficiency and convenience in card games, it is important to acknowledge potential misuse and mitigate risk, particularly in gambling or competitive play settings.

A major ethical concern is the possibility of our device being misused to gain an unfair advantage in gambling or competitive card games. To align with the IEEE Code of Ethics [8], we must ensure that our design does not facilitate deception or unlawful conduct. Specifically, Section I.4 emphasizes the importance of maintaining ethical behavior in professional activities and rejecting any form of corruption, including actions that could enable cheating. To uphold these principles, our system will be designed with transparency in mind, ensuring that it functions solely as a fair and unbiased card-sorting tool.

Moreover, Section II.9 of the IEEE Code highlights the responsibility to avoid causing harm to others, whether through direct actions or by enabling unethical behavior. Our project should not be used in a way that compromises the integrity of games, damages reputations, or results in financial harm.

However, since our card sorter is designed for convenience, it will prove difficult to use for other purposes. There are no extreme size restrictions or intentional hidden mechanisms that would be ideal for the unethical rigging of a card game, so unlawful use of the device is naturally discouraged. We will clearly communicate that the sorter is intended only for *legitimate, fair gameplay purposes*. By addressing these ethical concerns, we ensure that our technology aligns with professional integrity and responsible engineering practices.

3.2 Safety

Ensuring safety in the design, development, and use of the Automatic Card Deck Sorter is a priority. Our project involves low voltage electrical components and mechanical moving parts, both of which present potential risks. To address electrical safety, we will use proper insulation, secure wiring, and fuse protection to prevent short circuits, overheating, or other hazards. We are not working with high voltage, but we still will follow standard lab electrical safety protocols. Mechanical safety concerns will be mitigated by using low torque motors to minimize the risk of pinching hazards. The device is also not designed to use any sharp objects.

In compliance with ECE lab safety guidelines, we will always work in a group of at least two. Proper handling of soldering stations, power tools, and electronic testing equipment will be

observed. For end-user safety, we will ensure a stable structure, low-voltage power supply, and no exposed sharp parts. While the overall safety risks are relatively low, our plan includes adherence to lab protocols and a low risk design to ensure a safe and reliable automatic card sorter.

4 References

[1] Adafruit, “1.8º 42MM Torque Hybrid Stepping Motor”, XY42STH34-035A datasheet

[2] Raspberry Pi, “Raspberry Pi 4 Model B”, June 2019 [Revised March. 2024]

[3] Display Visions, “DOGM 132 Graphic” 132x32 INCL. CONTROLLER ST7565 datasheet

[4] Espressif, “ESP32 Series Datasheet Version 4.8”, Aug. 2016 [Revised Jan. 2025]

[5] Vishay, “Ultrabright White LED 5mm Untinted Non-Diffused Package”, VLHW5100 datasheet [Revised May 2019]

[6] Engineering IT Shared Services, “:: ECE 445 - Senior Design Laboratory,” *Illinois.edu*, 2025. https://courses.grainger.illinois.edu/ece445/wiki/#/regulators/index (accessed Feb. 13, 2025).

[7] Texas Instruments, “LM317 3-Terminal Adjustable Regulator”, SLVS044Y datasheet, Sept. 1997 [Revised Apr. 2020]

[8] IEEE. “”IEEE Code of Ethics”.” (2016), [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html (visited on 02/08/2020).