ECE445
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Project #62: Casinova

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1 Introduction

1.1 Problem

During the COVID-19 pandemic, when everyone was stuck indoors, there was an explosion in some of the more common household games involving a deck of cards. Games such as Spoons, BS, Egyptian Ratscrew, and Texas Hold 'em involve dealing a deck of cards to everyone in the game. With the increase in livestream viewers in professional poker, we see the need to try to emulate that professionalism at everyone’s home games. With this experience comes having professionally trained dealers to keep the game progressing and having special-traced cards with compatible cameras to get the casino-like feel of recording your games. With cards having to be dealt in a specific order, it can be frustrating to play a game where the amateur game players are making mistakes often, preventing the entire table of players from enjoying the game at hand. Viewing casino live streams, all the information is given to you on a screen so you can follow along with the players at the table, but to emulate this at a home game, you need an expensive RFID deck of cards and a camera to view them. There is no product out there that is capable of providing statistical analysis to you using a regular deck of cards.

1.2 Solution

To emulate the experience of a live casino game paired with the excitement of viewing a live casino match, we plan to implement an automatic smart card-dealing machine. The machine, placed in the center of a table, will be capable of maneuvering 360 degrees around the table as well as dealing cards at variable distances to place them within arm's reach of the player. The dealer will feature a two-fold camera system, which has one camera facing outwards, detecting player location. Another camera will be pointed towards the underside of the deck, providing a video feed for the machine to detect card values, specifically the rank and suit of the card being dealt. With the card information, the machine will be able to verify the contents of a deck, as well as provide statistical information to players after hands. The cards will be dealt by two motors, one used to queue up cards to be dealt, and one to deal cards at variable speeds to satisfy our requirement for variable distance dealing. Players will be able to connect to the machine through their phones over Wi-Fi to input player action based on what game is being played. The machine will also relay hand analysis to players' phones during the match, with players being able to "sweat" out the table's hands.

1.3 Visual Aid

Starting with the main body of the machine, this component will consist of a housing for the dealer. The housing itself will be made of a transparent material, providing transparency to the inner mechanics of the machine. Within the housing will be a chute for the cards to be placed into, with a rubber finger attached to a motor at the bottom of the chute. The chute itself will have a small opening that is one-card high. The deck camera and LED will act in conjunction to take a picture of the card's top corner, sending that image data to the PCB. The supply motor will then queue up a card when instructed, and then the ejection motor will spit out the card at variable speed depending on how far the player is from the machine. The TOF sensor at the front will provide the distance of the player from the machine, and the player camera provide the PCB with image information, which will be processed by the microcontroller and determine how the swivel motor rotates. The swivel motor rotates only when instructed to, stopping when the microcontroller has detected the presence of the next player. Refer to Figure 1.3.1 for the visual details of the Casinova dealer.

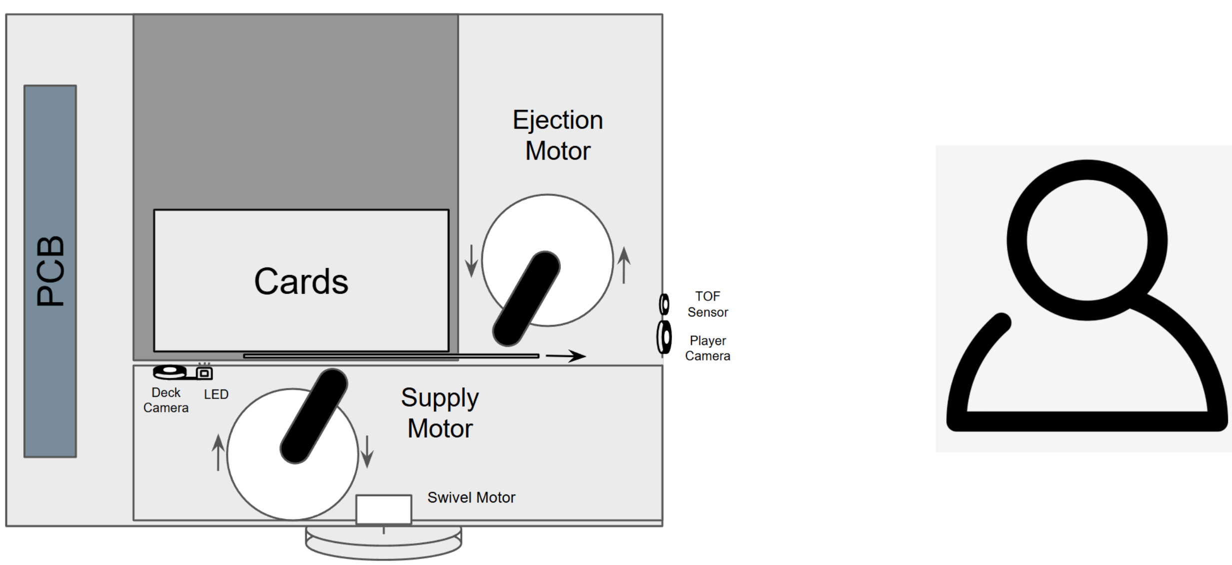


Figure 1.3.1: Casanova Visual Aid

1.4 High-Level Requirements

1. The dealer must distribute two cards to eight players in under 45 seconds with at least 99% accuracy to minimize misdeals.
2. The machine must identify all 52 unique cards in a standard deck to ensure deck integrity, prevent outside manipulation, and ensure fair gameplay.
3. The dealer must recognize player actions and respond accordingly, mimicking the function of human dealers, including the actions of dealing additional cards and advancing gameplay.
4. The dealer should provide statistical insights (odds, sweats, outs) to the player's external feed to enhance the viewing experience and provide strategic analysis to improve player skills.

2 Design

2.1 Physical Design

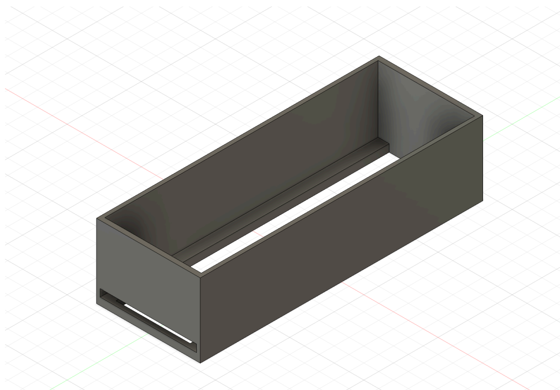


Figure 1: Ejection Arm Layout

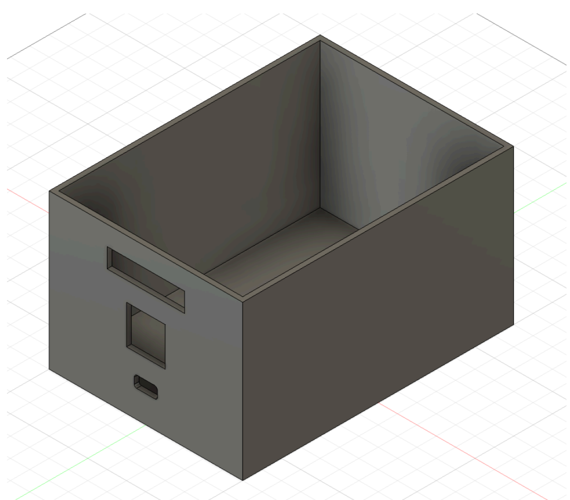
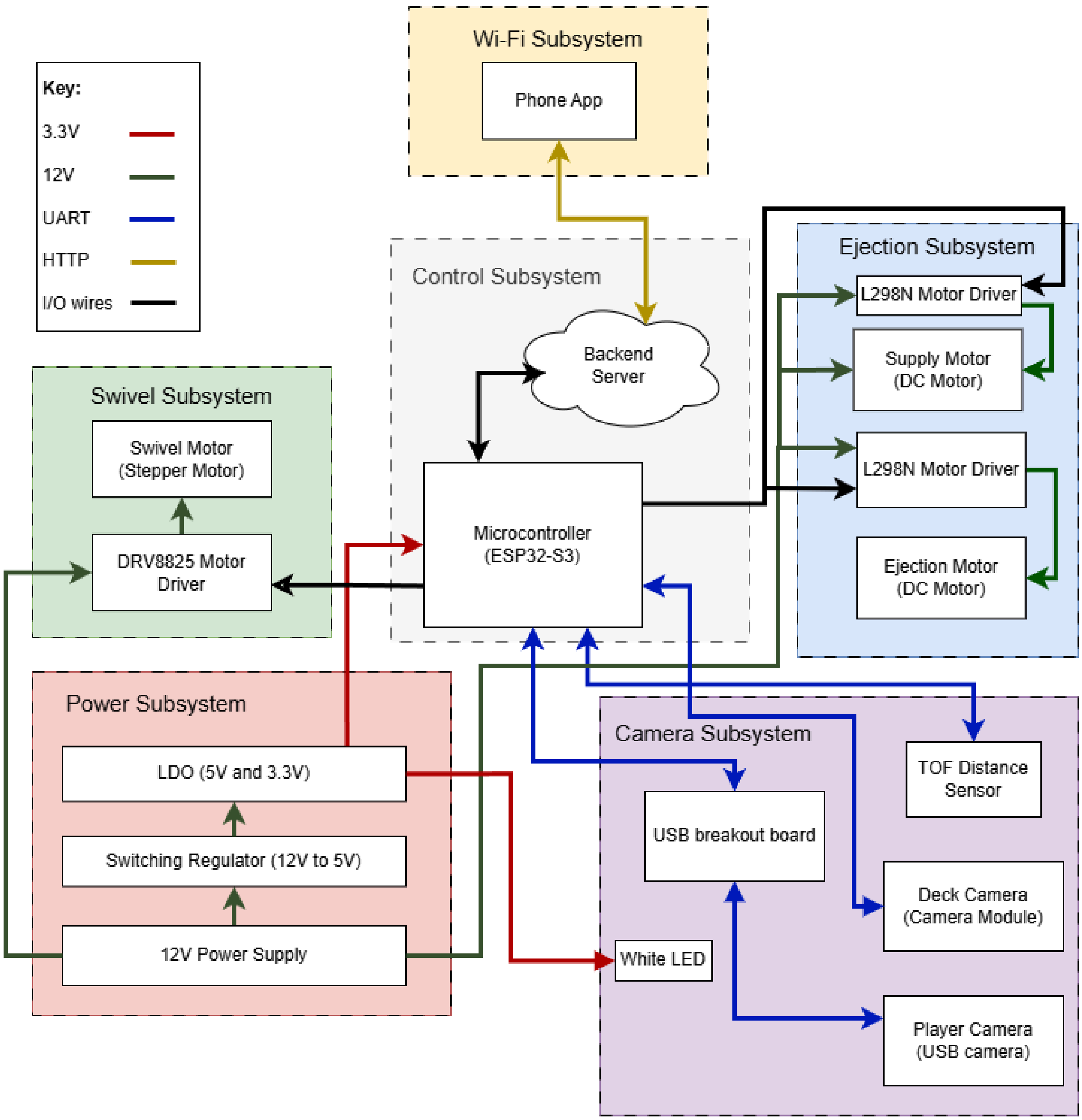


Figure 2: External Box Layout

2.2 Block Diagram



2.3 Functional Overview & Block Diagram Requirements

2.3.1 Control Subsystem

The control subsystem is responsible for three main processes. The first process that the control subsystem is responsible for is the cameras. It is responsible for receiving image data from the cameras and processing the image data to determine player location and card values. Using the results computed from the cameras, its second process is to compute analysis for the players as well as receive player I/O through the backend server hosted on the ESP-32 microcontroller. Player I/O refers to player action, such as a player asking to deal another card, or to stop dealing to a player and to move on to the next player. The third process for the control subsystem is to manage the ejection mechanisms by directing variable levels of power to the ejection motor, as well as direct power to the queue motor and the swivel motor when necessary.

Table 1: Control Subsystem - Requirements & Verification

Requirements	**Verification**
The Control Subsystem must be able to boot and initialize its backend server when the system is powered on.	● Power on the ESP32-S3 and ensure that the backend server initializes and begins executing its main loop ● Verify through serial debugging that system logs confirm successful initialization.
The Control Subsystem must be able to power on/off the motors of the dealer, as well as keep track of the rotational position of the dealer.	● Connect the motor driver to the ESP32-S3 and control the motors to start and stop using the ESP32's GPIO pins. ● Utilize the distance information from the Camera Subsystem to power on the ejection motor to a certain degree to eject cards the correct distances so they land in front of players ● Keep track of the rotational position of the machine by storing rotational data and updating rotational data as the machine changes direction ● Be able to send output signals

Requirements	Verification
	synchronously so that the actions of the motors do not interfere with each other
The Control System must be able to interpret images of cards to determine the value (suit & rank) of the card.	● Take in the image data from the Camera Subsystem and interpret the rank and suit of the currently queued card ● Store the information of logged cards as reference data for future user actions
The Control System must be able to interpret images of its frontal environment to determine whether there is a person in front of it or not	● Take in image data from the Camera Subsystem of the front-facing camera and interpret if a person is in front of the machine or not ● Signal rotational motors to start when there is no one detected in front of the machine, and to stop and deal out a card when there is someone detected in front of the machine ● Keep track of rotational position, and make sure to reset rotation by spinning in the opposite direction to

Requirements	**Verification**
	reduce torsion load on inner wires

2.3.2 Camera Subsystem

The camera subsystem is responsible for communicating both image and distance data to the control subsystem. The distance sensor we are using is the TOF10120, which uses a laser to detect distances between 5-180cm. The distance that is detected, also known as the player distance, will be communicated to the microcontroller and will be used as a variable when it comes to motor calculations. The two cameras we use are the OV2640 and a generic 1MP USB camera. Both of these cameras will be in charge of providing image data for the microcontroller to interpret. The data will be sent in both DVP (Digital Video Port) and USB (Universal Serial Bus) formats, both of which will be accepted by the ESP32 microcontroller.

Table 2: Camera Subsystem - Requirements & Verification

Requirements	**Verification**
The Camera Subsystem must be able to send a clear image feed of a queued card within the machine.	● Hook up the pins of the OV2640 camera to the ESP32-S3 microcontroller. ● Under normal operating conditions, relay camera data back to the microcontroller with the DVP protocol
The Camera Subsystem must be able to illuminate a queued card when a photo is being taken.	● When an image is requested, send a 3.3V pulse through the LED to illuminate the card. ● Ensure that the LED is lit for at least double the amount of time that the camera requires to capture a photo
The Camera Subsystem must be able to send a clear image feed of players in front of the machine.	● Hook up the pins of the USB Camera to the ESP32-S3 microcontroller ● Relay camera data back to the microcontroller with the UVC protocol
The Camera Subsystem must be able to send a constant information feed regarding the distance of an object in front of the machine (up to 180cm away).	● Hook up the pins of the TOF10120 sensor to the ESP32-S3 microcontroller ● Under normal operating conditions, be able to detect between 5-180 cm distances of players sitting in front of the machine ● Relay that information to the microcontroller as raw data bytes.

2.3.3 Ejection Subsystem

The ejection subsystem is responsible for shooting out the card from the machine to the players. There are two concerns that we need to address. How can we only eject one card at a time instead of multiple? And how can we variable the distance from which the cards are being ejected? We address both these concerns in two separate steps: a supply step and an ejection step. The supply step is one DC motor right underneath the deck that rotates at a slow and constant RPM that will only activate when the machine is ready to shoot. Since we can control the RPM of the supply DC motor, this will allow us to feed only one card into the ejection motor. Before the card is queued into the next step, we need to make sure that the camera inside the machine can read the card and forward the information to the Wi-Fi subsystem. The ejection motor is a DC motor that will run at a much faster RPM that will shoot out the card to the player. Both of these motors will be connected to an L298N driver that is connected to the microcontroller that provides the PWM to variable the ejection motor RPM. The ejection subsystem will receive data from the camera subsystem to notify when the dealer is ready to shoot out the card to the player. The duty cycle on the PWM is determined by the TOF sensor from the camera subsystem, the farther the player is from the dealer, the lower the duty cycle will be to lower the RPM of the ejection DC motor.

Table 3: Ejection Subsystem - Requirements & Verification

Requirements	Verification
The ejection system must be able to eject a card to a player sitting a variable distance away from the machine.	● Verify that the card is delivered to players at different distances 50cm, 100cm, and 150cm ● Confirm that the duty cycle decreases as player distance increases and that the ejection motor RPM reduces in proportion to the duty cycle changes
The ejection system must be able to communicate with the Wi-Fi subsystem with the card information	● Confirm that the RPM of the supply motor is at a speed that the camera can read the card with 100% accuracy ● Ensure that Wi-Fi communication doesn't delay the ejection process
The ejection system must be able to deal with potential errors (such as jams) and relay the information to the user	● Intentionally create card jams and ensure that the system halts on operation and signals an error ● Relay the error codes to the user with information on which motor is the cause of the jam ● Create an easy-to-reach access point to allow the user to clear the jam without taking the machine apart

2.3.4 Swivel Subsystem

The swivel subsystem is responsible for rotating the center console a full 360 degrees from a point of origin. We will implement this feature using a NEMA-17 Stepper Motor with a DRV8825 chip. To fulfill the requirement of accuracy, we needed a stepper motor with a high angle of precision. The NEMA-17 stepper motor can rotate up to an accuracy of 0.05625 degrees if needed, which is more than enough for the dealer's usage. The DRV8825 chip will be connected to the ESP32 microcontroller that will send pulses when the stepper motor rotates. The microcontroller will send a pulse to rotate the machine when it has received data from our camera subsystem notifying it that there is no longer a person in view and should continue to rotate until it does. When the camera picks up a person in the camera, the microcontroller will stop sending pulses to the DRV8825 chip so that it may eject a card in our Ejection Subsystem.

Table 4: Swivel Subsystem - Requirements & Verification

Requirements	Verification
The swivel system must be able to rotate 360 degrees from its starting orientation in an accurate manner in both a clockwise and counterclockwise manner	● Marking the starting position on the motor shaft and visually confirm it completes a full 360 degrees clockwise and counterclockwise ● Test rotations at different speeds to ensure that accuracy is maintained throughout the entire 360-degree motion
The swivel system must be able to stop the rotation when a person is detected by the camera subsystem	● Sit a person down and see if the system can stop rotating with the front of the machine facing the person ● Verify that the motor will resume rotation when a player has removed themself from the table ● Sit multiple people down and see if the system can stop and continue rotating after each person is detected
The swivel system must be able to accurately track its current position relative to the starting orientation and maintain its position when not actively rotating (even when power is removed)	● The machine can rotate to a specific angle at the table with the front of the ejection subsystem being 0 degrees ● Test the position retention by manually rotating the motor when powered off and verifying that it returns to the original position when powered back on

2.3.5 Power Subsystem

The power subsystem is responsible for supplying the power at the correct voltage levels and current levels for each of the subsystems. It features a 12 Volt 2A Power Adapter Supply connected by wires to the machine. The various subsystems require voltage levels of 12V, 5V, and 3.3V. To provide these voltages for the subsystems, we plan to use an LM2931AZ-5 Switching Regulator to drop the initial 12V to 5V. We then plan to use an LD1117S33CTR Dropout Regulator to go from 5V to 3.3V. We are using a switching regulator to 5V and then dropping to 3.3V because dropping from 12V to 3.3V may cause some issues. The first of which would be excessive power dissipation since we're using a rather high current, the power dissipated would be (12V - 3.3V) * 2A = 17.4W. In addition to a high power dissipation, using a linear regulator in this scenario would provide a rather lower efficiency. This efficiency would come out to be 3.3V / 12V * 100% = 27.5%. This means that over 70% of our input power would be wasted as heat and could potentially damage the chips. Using a switching regulator to 5V would decrease the power dissipation: (5V - 3.3V) * 2A = 3.4W, and also increase the overall efficiency. Switching from 12V to 5V is ~90% efficiency and dropping to 3.3V is 3.3V / 5V * 100% = 66% which has an overall of 90% * 66% = 59.4% which is about 3x as efficient.

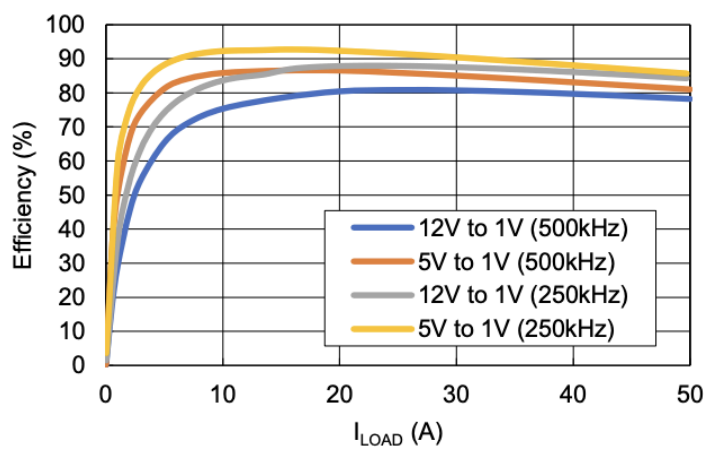


Figure 3: LM2931AZ-5 Efficiency Rating

Table 5: Power Subsystem - Requirements & Verification

Requirements	**Verification**
The power subsystem must be able to regulate and provide the following voltages (12V, 5V, 3.3V)	● Connect the 12V power supply to the Switching Regulator, and confirm 5V is sustained while powered ● Connect the 5V from the Switching Regulator output to the Dropout Regulator, and confirm that 3.3V is sustained while powered

2.3.6 Wi-Fi Subsystem

The Wi-Fi subsystem is responsible for receiving data from the camera subsystem. The ESP32 microcontroller is equipped with a dual-core Xtensa LX7 microprocessor that can run up to 240 MHz with built-in 2.4 GHz Wi-Fi support. With these specifications, we can send and receive data up to 150 Mbps, which is sufficient for transmitting camera data in real-time. Using the included Station mode on the microcontroller, we can connect to an access point. These hardware components will allow us to build an HTTP Server component that will run a lightweight web server station on the ESP32. The HTTP server implementation will use the ESP-IDF (IoT Development Framework) which provides multiple HTTP server components that will help us with this integration. Integrating this with the camera subsystem, we can send data to a remote server that would be able to run calculations to display them to the users. The Wi-Fi subsystem will also implement WPA/2/3 security protocols, ensuring secure data transmission to ensure we keep the integrity of the games from the users.

Table 6: Wi-Fi Subsystem - Requirements & Verification

Requirements	Verification
The ESP32 must be able to send data to a specific WiFi network from the dealer	● The ESP32-S3 can establish a connection to a known Wi-Fi network using the IoT Development Framework ● Send a set of predefined sample data packets to the server on the network and repeat this process to ensure consistency
The subsystem should achieve a consistent data transmission rate of at least 1 Mbps which is enough for a video feed	● Set a continuous data stream from the ESP32 server to the network and use a network monitoring tool such as WireShark to measure the data transmission rate ● Repeat this test for an hour to ensure consistency ● Calculate the average transmission rate and verify that it meets the 1 Mbps requirement, +/-5%
Data packets sent from the ESP32 should not exceed 150ms to fulfill a real-time responsiveness	● Implement a ping-pong test between the ESP32-S3 Station and the server to measure the round-trip time of each packet ● Verify that 95% of the packets have a round-trip time of less than 150ms

2.4 Tolerance Analysis

One of the biggest concerns for this project is to make sure that we are following the correct specifications for our motors and their respective drivers. We are using a 12 Volt 2A Power Adapter Supply to power our entire system. This also means that when connected to the motors, we are confident that we providing enough power without damaging the motors. Let's check out the NEMA-17 stepper motor and the DRV8825 driver. Given in the DRV8825 Stepper Motor Controller datasheet, the calculation for the power dissipated is:

$$P_{TOT} = 4 \cdot R_{DS(ON)} \cdot (I_{OUT(RMS)})^2$$

H-BRIDGE FETS					
$R_{DS(ON)}$	HS FET on resistance	$V_{(VMx)}$ = 24 V, I_O = 1 A, T_J = 25°C	0.2		Ω
		$V_{(VMx)}$ = 24 V, I_O = 1 A, T_J = 85°C	0.25	0.32	
	LS FET on resistance	$V_{(VMx)}$ = 24 V, I_O = 1 A, T_J = 25°C	0.2		
		$V_{(VMx)}$ = 24 V, I_O = 1 A, T_J = 85°C	0.25	0.32	

Since we are calculating the maximum possible power being dissipated, we should use the high end of the range which is 0.32 Ohms for the FET resistance. For the root mean square current flow through the load, we should set this value to 2A since that current will be from the power supply. To calculate the output power and output current from the driver to the stepper motor:

$$P_{INPUT} = 12V \cdot 2A = 24W$$

$$P_{DISS} = 4 \cdot 0.32 \cdot (2)^2 = 5.12W$$

$$P_{OUTPUT} = P_{INPUT} - P_{DISS} = 24W - 5.12W = 18.88W$$

$$I_{OUTPUT} = 18.88W / 12V = 1.573A$$

Comparing this output current to the NEMA-17 stepper motor datasheet, we have a peak current per phase of 1.68A. The available current to us is 1.573A from the calculations. This analysis shows that the power supply can provide a sufficient current to meet the motor's requirements without concerns of damaging or underpowering

3 Costs and Schedule

3.1 Costs

We can expect a salary of $40/hr × 40 hr × 16 weeks = $25,600 per team member. We need to multiply this amount by the number of team members, $25,600 × 2 = $51,200 in labor cost.

When it comes to parts, a list of the necessary parts can be found in Figure 3.1.0.

Part Name	Subsystem	Price	Notes
1MP Camera Module Horn Lens W202012HD	Camera	$8.00	Gets here on time
USB-A Breakout Board (Cheaper)	Camera	$5.39	Cheaper option (x10)
FFC FPC Connector Board 24 Pin 0.5mm Socket to 2.54mm	Camera	$9.99	OV2640 Connector (Breadboard Demo)
ESP32-S3-DevKitC-1-N8R8	Control	$19.00	ESP32-S3-WROOM-1
Motor Driver Controller Board x2	Ejection	$6.99	3 drivers, but each board comes with 2
WWZMDiB A4988 Stepper Motor Drive	Swivel	$7.99	Motor Driver for NEMA17 Stepper Motor
OV2640 Camera 160°I2C	Camera	$9.99	Camera Deck Validation
TOF10120 Time-of-Flight Distance Laser Distance Measuring Sensor	Camera	$19.00	TOF needed to have a wider range the commerical use
LM2931AZ-5	Power	$1.11	12v - 5v Conversion (PCB)
LD1117S33CTR	Power	$0.32	5v to 3.3v Conversion (PCB)
ESP32-S3	Control	$3.35	Microcontroller (PCB)
ABM8-24.000MHZ-R60-D1W-T	Camera	$1.00	Crystal Oscillator (24.0MHz) (PCB)
WWZMDiB 3 Pcs Stepper Motor Driver Module	Swivel	$8.99	Stepper Motor Drivers
STEPPERONLINE Nema 17 Stepper Motor Bipolar 2A	Swivel	$13.99	Stepper Motor
Greartisan DC 12V 550RPM Gear Motor High Torque Electric Micro Speed Reduction Geared Motor	Ejection	$14.99	DC Motor with Encoder

Figure 3.1.0: Parts List for the Casinova

The total cost for parts ended up being $130.10

3.2 Schedule

Week	Goals
February 10th - February 17th	• Identify parts required for the project • Work on Project Proposal
February 17th - February 23rd	• Finish and review the Project Proposal • Discuss project timeline
February 24th - March 2nd	• Start on the Design Document • Order breadboard demo parts • Start creating a schematic for the PCB
March 3rd - March 9th	• Finish Design Document • Work on Breadboard Demo • Create prototype dealer housing • Work on PCB routing
March 10th - March 16th	• Present Breadboard Demo • Send PCBWay Order
March 17th - March 23rd	**Spring Break**
March 24th - March 30th	• Verify PCB Works / Revisions • Work on CAD model for final housing • Finish motor / TOF distance sensor integration • Tweak prototype build to a working state

March 31st - April 6th	• Second PCBWay Order (If Needed) • Finish coding camera card identification software • Start work on the backend server • Start work on the I/O website for players
April 7th - April 13th	• Continue work on backend server and website • Verify motor integrations and I/O action • Begin programming card game logic • Verify physical housing and parts are integrated correctly
April 14th - April 20th	• Fix any extraneous errors

Figure __: Schedule for Project Progression

4 Ethics and Safety

Our project has a lot of components, and we need to address every one of the ethics and safety concerns that consumers have. Our project uses a Time-of-Flight Distance Laser Distance Measuring Sensor to determine how fast the card should shoot out of the dealer. We have to be careful about dealing with lasers, as the IEEE Code of Ethics Section I.1 states “to hold paramount the safety, health, and welfare of the public” [5]. A laser mounted onto a moveable object provides an issue with the subjects potentially moving it while in use. One way we could prevent this from happening to our consumers is by ensuring that our product has the necessary documentation that will give accurate information about the laser’s capabilities. From IEEE I.2, we have to “be honest and realistic in stating claims or estimates based on available data” [5], which enforces the responsibility on us, the makers.

For the dealer to “see” where to shoot the next card, we have a front-facing camera for the user. This has some ethical concerns as our product will be recording the public. From ACM Code of Ethics 1.6, the machine should “the minimum amount of personal information necessary should be collected in a system” [6], which means that our dealer should not store and upload any kind of information from the camera to the cloud. In addition, IEEE I.1 states that “to protect the privacy of others and to disclose promptly factors that might endanger the public or the environment” [5], the addition of a camera should be visible to the consumer and marked with documentation that a camera will be in use when the user operates our machine.

With our product shooting cards out at some high speed, there is some danger that we need to take with some concern. The ACM Code of Ethics, section 1.1 states that any product is to “minimize negative consequences of computing, including threats to health, safety, personal security, and privacy” [6]. With further testing with launch angle and safety protocols to stop the motors from spinning too fast, we can mitigate the risk of having any kind of threats to the consumer’s health.

5 Citations

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