ECE445 Design Document
Fingerprint Protected Voting Machine

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1. Introduction

1.1 Objective

As the 2020 election brought upon many questions with regards to voter fraud [9], we felt our project would be best served to attempt to help or fix this problem. We believe the best way to uniquely identify voters and prevent voters from revoting is to use each voter's fingerprint. Since each fingerprint is unique to a person, there will not be the ability to fake your eligibility or your name when voting.

Our plan is to utilize fingerprint identification to confirm that a voter has not voted previously to keep the voting fair. We will design and create a scrolling device that allows the voter to scroll through the options and select the candidate they decide on. After this, they will receive a receipt to confirm that they had voted.

1.2 Background

To further give context on the need for this system, our group did research with regards to the 2020 presidential election and the claims about potential voter fraud, many which came via Donald Trump's tweets as well as his campaign. This is something we feel can be completely fixed with voter identification through fingerprints. According to the BBC, the Trump campaign mentioned "voter turnout in some areas was higher than 100%, an
outcome known as an 'overvote'" [9]. Along with voter fraud, this new method for voting can help reduce voter suppression, as eligibility of voters is scanned with the fingerprint. By utilizing the fingerprint as a method of identification, this eliminates any further voter identification needed in order to officially register and vote.

An overvote would not be possible if after a uniquely identified fingerprint has a boolean true saying that the person has in fact voted. It is understood that this election was unique because mail-in votes were more prominent due to COVID-19, but we feel this would be a safe alternative to the current system for voting.

1.3 High-Level Requirements

- Voter can scan their fingerprint and successfully make a vote. If the fingerprint did not have a match after three tries, then the voter is rejected.
- Interface and controller are easy to use and understand in order to cast a vote on a candidate as well as being able to print out a receipt with proof of voting. This will allow for a fast and efficient voting process.

- Voter will be able to receive feedback through the LEDs, speaker, and receipt printer as to whether their vote went through as well as to confirm which candidate they voted for.

2. Design

Block Diagram

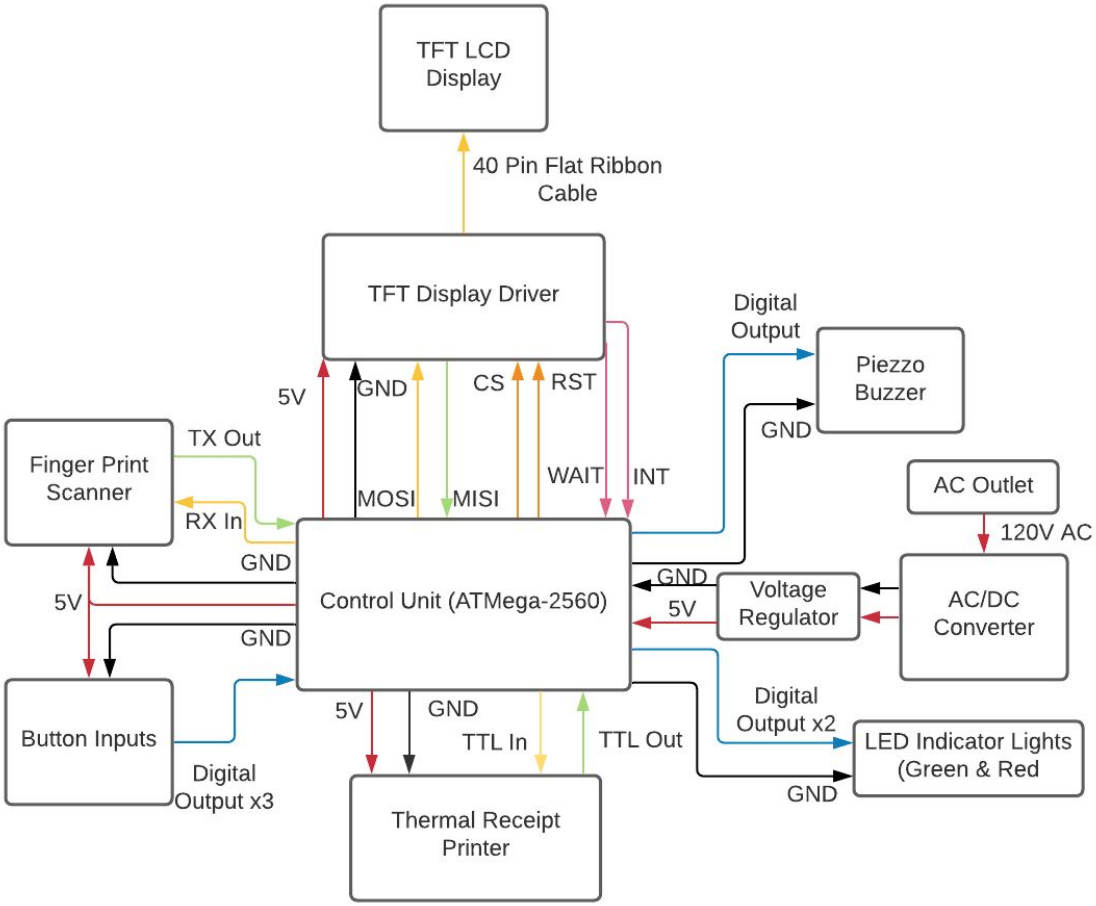

Fig. 1 Block Diagram

Physical Design

Our project will have a fingerprint scanner that is attached to a control panel that allows for scrolling up, down, and a select button to choose the vote. This will connect to a monitor screen to allow for the voter to see who they can select from and then click on the option. The monitor will also tell them if they are eligible to vote after scanning their fingerprint. Above the monitors will be holes for two LEDs, to indicate whether the voter has gained access to the system by verifying their fingerprint.

The physical envisioning of this system will look like a flat box, constructed out of wood. The buttons and fingerprint scanner will be mounted to a piece of wood parallel to a table, with the screen mounted directly above these hardware devices, as the centerpiece of the design. All electronics will be housed on the interior side of the wooden panels, out of sight from the user. Pictured below is a conceptual drawing of what the physical design of this project will look like:

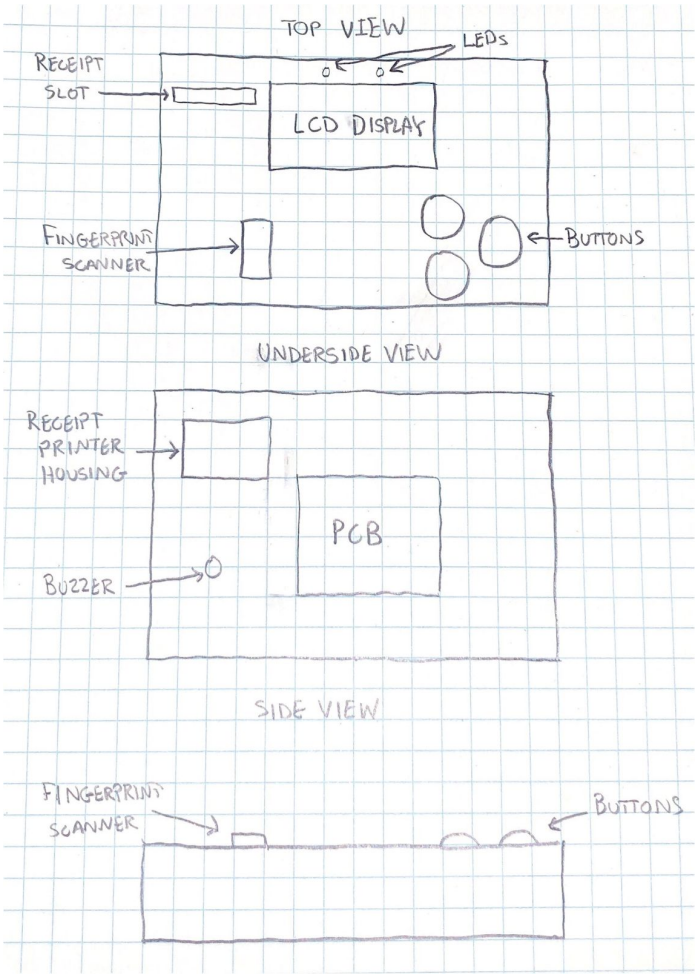

Fig. 2 Physical Design of Solution

Requirements and Verification

2.1 Power Supply

A power supply is required to keep the voting machine and all hardware peripherals running during use.

2.1.1 AC to DC converter

An AC to DC power supply converter is needed in order to allow the system to be plugged into a 120V AC standard wall plug, and convert the power to DC voltage so the hardware in this project can be powered correctly. The AC to DC converter will also need to step down the voltage to 12V so it can be handled by the voltage regulators.

Requirement	Verification
Must be able to convert AC voltage to DC voltage, and step down the voltage to 12V +/- 5% so it can be processed by voltage regulator ICs.	A. Use a voltmeter to ensure that the DC output is steady at within 5% of 12V

2.1.2 Voltage Regulator

These ICs will supply the necessary 3.3V and 5V to the hardware in this project. These ICs will need to be able to handle incoming DC voltage from the AC to DC converter [2].

Requirement	Verification
1. The voltage regulator ICs must be able to handle incoming 12V DC voltage from the wall. 2. Provides 3.3V, 5V +/- 5% from the 12V source 3. Can operate at currents within 0-1.5A	1. A. The voltage regulator specifications indicate that it may receive a 12V DC input 2. A. Using a multimeter, measure the output voltage(s) and ensure that they are within 5% of the required 3.3V and 5V.

	3. A. Use resistors to scale down the current from 1.5A to lower currents to match peripheral hardware's specifications. Use an ammeter to measure and verify this range of currents.

2.2 Control Unit

A control unit will handle all inputs from people (selection buttons), sensors (fingerprint reader), and process the voter identification and voter selection data to be displayed on a screen, with feedback given to the user through LEDs, a buzzer, and a receipt printer in this system.

2.2.1 Microcontroller

The microcontroller, chosen to be an ATmega2560 [1] will handle all user input and output for the voting machine. These input and output signals sent to the various other devices in the system will be a variety of UART, digital, and PWM signals.

Requirement	Verification
The microcontroller must be able to simultaneously process input data from the fingerprint reader, display voting instructions on the screen, process voter input from the button controller, and send signals to control various outputs to the LEDs, buzzer, and receipt printer	

2.2.2 Input Controller Device

An input controller device will be made up of three buttons: two for scrolling up and down, and one to advance the display/enter a selection. These buttons will communicate with the microcontroller via digital signals.

Requirements	Verification
1. The buttons must be easily pressable, with an operating force of 0.6N 2. The buttons should be prominently displayed and easily accessible. They will be the main forefront of the physical design. 3. The buttons should not have input delay exceeding 50ms	1. A. Press the buttons and ensure that it can be done without strain. 0.6N is the average amount of force needed to press a key on a keyboard, so it is a good metric. 2. A. The buttons will be mounted on the front of the physical design. The housing will be placed at a variety of heights, and ensure that a wide variety of users can easily access them. 3. A. xxxxxxxxxx

2.3 Fingerprint Scanner

The fingerprint scanner [6] will have the ability to read in a user's fingerprint, and send data to the microcontroller via UART to compare with existing fingerprint data.

Requirements	Verification
1. The scanner will have a less than 1 second fingerprint image acquisition time 2. The scanner can match each fingerprint on a 1:1 basis if there is existing fingerprint data 3. The scanner accurately produces a fingerprint image within 3 user attempts. If there is an unsuccessful attempt, the screen will display a message asking the user to wipe or clean their finger, as dirt or sweat may be impeding	1. A.

the scanner from reading the fingerprint.	

2.4 LCD Display

An LCD display will be the main user interface of the machine. It will provide instructions, show messages granting or denying access to the system, and show candidate choices for a voter to make their selection.

2.4.1 4.3” 40-Pin TFT Display

This is the LCD display that has been chosen for use in this project [3]. It will communicate data on the machine’s with the user, and will be the main output source for the overall UI.

Requirement	Verification
The display will need 5-9V and 125-150mA input to maintain its backlight, so it is easy for users to read.	A. Using the voltage regulator, ensure that this steady voltage can be maintained, while using resistors to adjust the current. B. Place the screen mounted in the physical design at a range of distances, and ensure that the screen can still be read.

2.4.2 TFT Display Driver Board

A RA8875 driver board for 40-pin TFT touch displays [4] will be used as the driver for the LCD display. This will allow the display to be refreshed at 60hz, and adjust the power to the display, as the display requires a 5-9V and 125-150mA input. The driver board will maintain the input power to the screen, and handle the screen RAM and timing requirements in the background.

Requirement	Verification
This driver will communicate with the microcontroller via SPI.	A. Connect to the microcontroller and send example images to the screen, ensuring that the data displayed matches the data sent.

2.5 Output Hardware

Output hardware devices will help to improve the overall user experience, as well as enhance the project with audio and visual output.

2.5.1 Buzzer

A Piezo buzzer, model PS1240 [7] will be used to communicate to the user that their access has been denied. This will be communicated from the microcontroller via a digital signal.

Requirement	Verification
Output frequency should be at a minimum 2KHz, and maximum 4KHz	A. Use a frequency spectrum analysis application to measure the frequency produced by the buzzer. B. Ensure that the buzzer's frequency matches the frequency specified by the software.

2.5.2 LEDs

LEDs will communicate "access granted" with a green LED illuminating, and "access denied" with a red LED illuminating.

Requirements	Verification

1. Turn on within 10ms of access denied/granted 2. Remain RED until access is granted, remain GREEN once access has been granted until the user is finished voting. The user is finished voting when their vote has been cast and the receipt printer prints out a record of their vote. 3. Operate on a drive current of 10mA, 1.8-2V	1. A. Xxxxxxxx 2. B. In conjunction with the fingerprint scanner, simulate this process by using a matched fingerprint to turn on the GREEN LED, and using a non-matched fingerprint to turn on the RED LED. This will be done using the microcontroller. 3. A. Adjust resistances from a voltage regulator to deliver 10mA to the load. B. Use a multimeter to verify the input voltage and current.

2.6 Mini Thermal Receipt Printer

A mini thermal receipt printer [5] will print the voter's selection on thermal paper, to be placed in a secure ballot box and counted and tallied at the end of the voting process. It will receive data from the microcontroller via digital signal.

Requirement	Verification
Accurately print a voter's selection onto thermal paper with a resolution of 8 dots per millimeter, 384 dots per line.	A. Using the microcontroller, send a variety of example texts in different fonts and sizes to be printed from the receipt printer, and ensure that it can be read clearly B. Decide on a specific font and size to use based on testing.

2.7 Schematics

In progress

2.8 PCB Layout

In progress

2.9 Software Algorithm

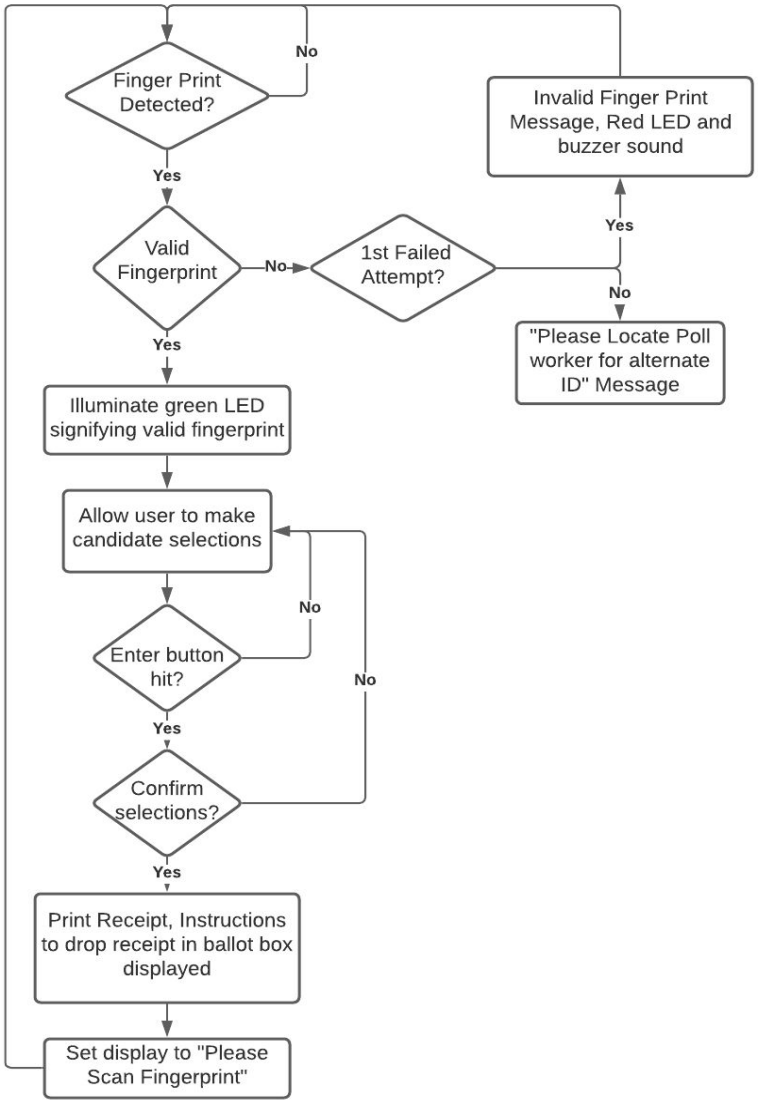

Fig. 3 Software Algorithm

2.10 Tolerance Analysis

Had to ask questions about this with TA, in progress

3. Costs

4. Schedule

5. Ethics and Safety

One of the biggest ethical issues facing this project is the possibility of a person's name being linked to their ballot submission. In person ballots cast in the US have to follow a style of ballot called the "Australian Ballot." The qualifications of an "Australian Ballot" means they must be printed by the government, contain all candidates, distributed at a polling place and marked in secret [10]. Therefore, our system must protect the privacy of voters to abide by state laws in the US. The machine protects against this by not storing the persons votes locally on the machine and only printing out the results on the receipt printer. This is done in order to abide by article 1, section 1 of the IEEE code of ethics which states members of IEEE are to uphold and "protect the privacy of others"[8] and abide by state laws [8]. Once someone has voted, we will not store who they have voted for since this is a privacy concern, but simply print out a receipt with the voting results to be dropped in the "ballot box." People who don't have their fingerprints registered with the government would have the option to register them for free when they register to vote. If they would prefer to use traditional forms of ID (drivers license, state ID, passport, etc) they can choose to do so.

In terms of safety, there is risk of electrical shock when dealing with electrical components. To eliminate this risk, all of the components will be contained in a wooden (or some other kind of material) casing. Another potential safety issue is if the microcontroller overheats and causes a fire. To address this problem, an appropriate sized heat sink will be installed on the microcontroller to dissipate the thermal energy.

References

[1]*ATmega640/V-1280/V-1281/V-2560/V-2561/V*. Microchip, 2021.

[2]"5.0V 250mA Linear Voltage Regulator - L4931-5.0 TO-92", *Adafruit.com*, 2021. [Online]. Available: https://www.adafruit.com/product/2236?gclid=Cj0KCQiAvbiBBhD-ARIsAGM48bwPmOsNJaar1H0GD1zEQbcbxo4e5M9dFng0H0WhFtNMujFfd3P3iAsaAsLREALw_wcB. [Accessed: 18- Feb- 2021].

[3]"7.0" 40-pin TFT Display - 800x480 without Touchscreen", *Adafruit.com*, 2021. [Online]. Available: https://www.adafruit.com/product/2353. [Accessed: 18- Feb- 2021].

[4]"RA8875 Driver Board for 40-pin TFT Touch Displays - 800x480 Max", *Adafruit.com*, 2021. [Online]. Available: https://www.adafruit.com/product/1590. [Accessed: 18- Feb- 2021].

[5]"Mini Thermal Receipt Printer", *Adafruit.com*, 2021. [Online]. Available: https://www.adafruit.com/product/597. [Accessed: 18- Feb- 2021].

[6]"Fingerprint Sensor-DFRobot", *Dfrobot.com*, 2021. [Online]. Available: https://www.dfrobot.com/product-1343.html. [Accessed: 18- Feb- 2021].

[7]"Adafruit Accessories Buzzer 5V", *mouser.com*, 2021. [Online]. Available: https://www.mouser.com/ProductDetail/Adafruit/1536?qs=GURawfaeGuBH8sXw8BXHwg%3D%3D&mgh=1&gclid=CjwKCAiAmrOBBhA0EiwArn3mfC5ZCV1S6u5sI_nAF_xvolSuCzrGVrj3Ezg4_ssEF6eUC5zKGi9L8xoCJQgQAvD_BwE. [Accessed: 18- Feb- 2021].

[8]"IEEE Code of Ethics", *ieee.org*, 2016. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 17- Feb- 2021].

[9]"US election 2020: Fact-checking Trump team's main fraud claims", *BBC News*, 2021. [Online]. Available: https://www.bbc.com/news/election-us-2020-55016029. [Accessed: 18- Feb- 2021].

[10]"Australian ballot | politics", *Encyclopedia Britannica*, 2021. [Online]. Available: https://www.britannica.com/topic/Australian-ballot. [Accessed: 18- Feb- 2021].