Component Analysis

Year: 2023 Semester: Spring Team: 8 Project: Engineer’s Chess

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Member 1:Jack Gardel Email: jgardel@purdue.edu

Member 2: Tyson Kline Email: kline62@purdue.edu

Member 3: Andy Helton Email: helton4@purdue.edu

Member 4: Bazim Azeem Email: bazeem@purdue.edu

1.0 Component Analysis:

The major components of Engineer’s Chess are an LED matrix, two feedback displays, a single-board computer, an ADC, and a microcontroller. The LED matrix will be the main display of the project. The feedback displays will be used to provide feedback to the user and to display the game timers. The single-board computer will be used to provide the additional processing power necessary to run the voice input. The ADC will be used to process input signal data. Finally, the microcontroller will be the main processor that will run the majority of Engineer’s Chess.

1.1 Analysis of Component 1: LED Matrix

LED Matrix: 32x32 6mm LED Display (Adafruit) [1]

The first LED matrix we considered using for our project was the Adafruit 32x32 6mm LED display. This display module was appealing because we have had experience dealing with the exact same module in the past. This meant that there would be very little learning necessary to properly operate it, and development time would be quicker. This module was by far the cheapest of the displays that we considered, priced at $39.95. The overall module was fairly well sized at 190.5mm by 190.5mm, or about 7.5 inches. This would closely approximate the size of a small chessboard. The biggest problem with this module was that it did not contain enough pixels. If we chose this module, we would only have a four by four area of pixels to display pieces on, which would be nearly impossible to do well. We considered purchasing four of these so that we would have more pixels to work with, but this would have drastically increased both the cost and the programming complexity. For this reason, we decided not to purchase this LED matrix.

LED Matrix: 64x64 2mm LED Display (Adafruit) [2]

The next LED matrix we considered was Adafruit’s 64x64 2mm LED display. Unlike the previously mentioned 32x32 LED matrix, this one had four times the pixels. This meant that instead of the previous four by four tile area, we now had an eight by eight tile area to work with to display individual pieces. This made designing models for pieces very simple. The price was more than that of the 32x32 matrix at a price of $49.95, but this was still very manageable. The biggest problem with this module was its overall size. This LED matrix was 128mm by 128mm, or about five inches by five inches. This was too small for our purposes. A five-inch display would have been too small to view without extra effort. For this reason, we once again decided that this display would not work.

LED Matrix: 64x64 3mm LED Display (Adafruit) [3]

The final LED matrix we considered was Adafruit’s 64x64 3mm LED display. This module accounted for the issues with the previous two modules considered. Unlike the 32x32 LED display, this matrix had 4096 total pixels, meaning we had plenty of space to design pieces. Unlike the 64x64 2mm display, this matrix had extra space between pixels, leading to an overall size of 192mm by 192mm, or about 7.55 inches by 7.55 inches. One drawback of this extra space between pixels was that the display is not as clear. However, we determined that the size of the board was much more important than a small change in resolution, so this was an acceptable sacrifice. Another major drawback of this LED matrix was the price. This module had the highest cost of any of the modules that we looked at with a cost of $59.95. While high costs are definitely something we want to avoid, the price is still within the budget we set for our display. After considering all the options, we eventually decided that the 64x64 3mm LED Display was the best choice for our LED matrix.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **32x32 6mm** | **64x64 2mm** | **64x64 3mm** |
| **Size** | 190.5mm x 190.5mm | 128mm x 128mm | 192mm x 192mm |
| **Pixel Count** | 1024 | 4096 | 4096 |
| **Cost\*** | $39.95 | $49.95 | $59.95 |

**Figure 1:** Comparison Between Potential LED Displays (\*Prices listed are before tax and shipping costs)

1.2 Analysis of Component 2: Feedback Displays

The feedback displays are critical to the design of this product. It allows the users to receive feedback on their inputs. This can be useful because it allows users to know that their input is in fact being registered by the board. Furthermore, we can display any tips on how their input should be formatted. This display will also be used to show the timers of each player.

Two displays were found which fit these requirements: the 1602A-OLED [4] and the 2.2” SPI TFT Module [5].

|  |  |  |
| --- | --- | --- |
|  | **1602A-OLED** | **2.2” SPI TFT Module** |
| **Color** | No | Yes |
| **Module dimensions (mm)** | 80.0 x 36.0 x 10.0 | 68.0 x 40.0 x 11.6 |
| **Previous Experience** | Yes | Yes |

These two candidates were considered because they were already in our possession, meaning that we did not have to spend our budget on obtaining them. Second, we have prior experience using these components, which reduces the engineering effort and time required.

There were two major factors which led us to choose the 1602A OLED display. First, it is longer than it is wide, which would allow it to more easily fit on the sides of our board. Second, it is easier to program. All that is needed to be sent is a buffer containing the characters to be displayed.

1.3 Analysis of Component 3: Single-Board Computer

The single-board computer for this project has to do real-time signal processing operations, which include but are not limited to: Fast-Fourier Transforms, matrix operations, and classification algorithms. The third of which contains lots of machine-learning that certain boards are better at than others. There are two boards with good support that are compared in this section: the Jetson Nano and the Raspberry Pi.

The Jetson Nano is an AI-focused board from NVIDIA. It has a 128 core Maxwell GPU @ 921 MHz and a quad-core Arm Cortex A57 CPU @ 1.43 GHz. The Jetson has 4 GB of 64-bit LPDDR4 RAM [12]. The Jetson has no on-board storage, but requires a micro-SD card which makes storage easily modified. In terms of protocols, it has everything we need, SPI and UART, as well as ethernet [12] to connect to the internet and create an SSH server for remote testing. The Jetson Nano was a main contender for its market availability and great support/ documentation from a well-known supplier (NVIDIA). It also has more than enough computational power for our needs, and can easily accomplish our task. The only downside is the extra heat-sink attached to the board, adding an extra inch of height and complicating our case design. The cost of the Jetson Nano is $150.

The Raspberry Pi 4B is a development board from a smaller UK-based manufacturer. It has a Broadcom BCM2711 quad-core Arm Cortex A72 SoC @ 1.5 GHz with built-in graphics. It has 4 options for RAM; 1 GB, 2 GB, 4GB or 8 GB of LPDDR4 RAM [13]. It also has all of the serial communication we need (including ethernet). Like the nano, the Raspberry Pi also requires a micro-SD card for storage. The 8 GB model is $75. However, it is hard to find this board anywhere in stock because it is so popular with lots of community support.

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| --- | --- | --- |
|  | **Jetson Nano** | **Raspberry Pi** |
| **CPU** | 4xA57 @ 1.43 GHz | 4xA72 @ 1.5 GHz |
| **GPU** | 128xMaxwell @ 921 MHz | Broadcom |
| **RAM** | 4 GB | 1 GB, 2 GB, 4 GB, 8 GB |
| **Storage** | N/A - micro SD | N/A - micro SD |
| **Heatsink** | Yes | Small, flushed with the board |
| **Ports** | USB, SPI, UART, Ethernet | USB, SPI, UART, Ethernet |
| **Support** | High - from manufacturer | High - from community |
| **Availability** | High | Practically Nothing |
| **Price** | $150 | $35, $45, $55, $75 |

Ultimately, we have settled on the Jetson Nano. Having this much computational power may be overkill, but it is much better than having not enough computational power. Additionally, python libraries may take full-use of the Nano’s GPU for ML acceleration. This decision also comes down to availability; the Raspberry Pi is simply too sparse to find one in the timeframe of the semester.

1.4 Analysis of Component 4: Analog to Digital Convertors

The analog to digital converter (ADC) is going to be used to convert the analog signals picked up from an input microphone, and converted to a digital signal. When determining what ADC to use, we wanted a device that would be able to interface with SPI to make interfacing with the single board computer a more simple process. Due to this being a part of a PSSC, we were not going to use a module for this component. To fit these requirements, two ADC’s were found that have this capability. The MCP3004/3008[8] and the ADS7038[9] are what were found to fit the necessary requirements.

|  |  |  |
| --- | --- | --- |
|  | **MCP3008** | **ADS7038** |
| **Sampling Rate (ksps)** | * 200 max. at VDD = 5V * 75 max. at VDD = 2.7V | * 1000 max |
| **Bit Resolution** | * 10 bits | * 12 bits |
| **Package Types** | * PDIP, SOIC and TSSOP | * RTE |
| **Price** | * $3.15 | * $7.63 |

In the end, the MCP3008 was chosen for the main reason that it has the package types that allow it to be used on a PCB, which the ADS7038 is unable to do.

1.5 Analysis of Component 5: Microcontrollers

The decision on what microcontroller to choose was very important for the project. The project needed a microcontroller that could run game logic, control two LCD displays, run a LED matrix, and have buttons for a user interface. With these considerations in mind, the options were able to be narrowed down to two microcontrollers that could be used: the STM32F091[10] or the ATmega[11] line of microcontrollers.

|  |  |  |
| --- | --- | --- |
|  | **STM32F091** | **ATmega** |
| **Clock Frequency (MHz)** | 48 max. | 20 max. |
| **Flash Size (KB)** | 32 | 32 |
| **SRAM Size (Bytes)** | 4096 | 2048 |
| **EEPROM Size (Bytes)** | None | 1024 |
| **USART** | 8 | 1 |
| **SPI** | 2 | 2 |
| **I2C** | 2 | 1 |
| **Timers** | 4 x 16-bit | 1 x 16-bit, 2 x 8-bit |
| **ADC** | 10 x 12-bit | 8 x10-bit (TQFP Package) |
| **GPIO** | 26 (shared with other peripherals) | 23 (shared) |
| **Internal ADC Reference** | Yes | Yes |

After analyzing the capabilities and availability of both microcontrollers, our team was able to conclude the STM32F091 was the microcontroller best suited for the project. The largest reason for this choice was that everyone in the team has worked with the STM32 before, making it far easier for everyone to assist in programming the STM32. Not only were all the team members experienced in using the STM32, but it is a microcontroller that is decently available to ECE students at Purdue University, making getting one far easier than other microcontrollers. The fact that two LCD displays will be run off of the microcontroller, having the two SPI interfaces gives more flexibility, seeing as in the ATmega only having one SPI interface would limit additions to the project through the microcontrollers SPI. With all of the above, it became quite clear that the STM32 was the correct choice for the microcontroller in this project.

**1.6 Analysis of Component 6: Passive Component Packages**

For our passive components, we selected the exact package and footprint based on what was readily available and proven to work in boards we have used in prior coursework. We went with the 0805 surface mount package for our resistors and capacitors, as we can find them easily from the electronics shop in our building.

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