Smart Mirror

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***Abstract*— In the modern world things that were previously "dumb", or in other words not controlled by computers or connected to the internet, are becoming increasingly hard to find. Appliances that we interact with daily are slowly becoming more and more connected to the digital world. Currently widely available and generally financially accessible to the general public are smart speakers, cameras, coffee makers, lights, security systems, alarm clocks, thermostats, air quality monitors, smoke detectors, and even fridges that can tell you when you are low on items. The list of smart home appliances could go on forever, however one item that people use daily that has not been widely brought to market is a mirror.**

Index Terms **— SMART TECHNOLOGY, PIR SENSING, FACIAL RECOGNITION, VOICE RECOGNITION, BUCK CONVERTERS, HISTOGRAM OF ORIENTED GRADIENTS.**

I. INTRODUCTION

Current smart mirror options that are available for purchase can generally be placed into two categories. The first being cheap and simple without much real world use, most in this category are simply mirrors that display the weather in the corner. The second category of options are at the multi thousand-dollar price point and contain great features, however given the cost it would not be worth it or cost feasible for an average person to own one. The third option for a smart mirror is complete DIY. By purchasing all the parts and pieces and setting up a raspberry pi with a UI called Magic Mirror. The user can configure the Magic Mirror software to their liking. They can also make it to any size or shape they want. The issue with the DIY solution is that it isn't accessible to most. In order for a person to DIY they need to be able to construct a frame and 2-way mirror, obtain a display, obtain a raspberry pi, load and configure the raspberry pi with all the required software/ OS, and then take care of any bugs or glitches that they may encounter. Many users don't have the time or skill to do all of these things, leaving it as an option only for the biggest of tech and DIY enthusiasts.

Our team intends to fill the gap in between these two categories and create a smart mirror that provides an experience that aids the user in their daily routines and can be marketed at a mid-three figure price point. We are also hoping to be a superior option to DIY by providing a better and more in-depth user experience than can be reached with a simple garage job. Our Smart Mirror also aims to be a lot easier to setup and use than a DIY option, providing a bug free experience that just works.

The Smart Mirror will feature network connectivity and integration with many existing API's that will make the users life easier. It will also be very power efficient, only using full power when the user is present. The team is hoping to deploy a range of custom and open-source solutions to give the user the best possible experience. We also intend to make the mirror as visually appealing as possible, so the user doesn't have to sacrifice looks for functionality. Hopefully this project will serve as another steppingstone to bringing Smart Mirrors into mainstream use so they can become a standard part of the modern home.

Each invention related to "smart" technology usually brings some sort of convenience to the user. While brainstorming ideas within the group, one of our key motivations was developing a device that would provide convenience within the home. The idea of a "home" usually includes safety, comfort, and convenience. With smart technology, a home expands upon these principles while adding more amenities that are not necessarily required to have but are certainly useful. As smart technology progresses, the home seems to be a focal point to which devices are being used. Most consumers are familiar with some form of smart ecosystem. These smart ecosystems include Google Home, Amazon Alexa, Apple HomeKit, Samsung SmartThings, and more. With these ecosystems already in place, third parties are capable of developing compatible devices.

There are smart lightbulbs which can be turned on/off with voice commands and/or change colors, smart doorbells which allow the user to monitor their front door, and much more. Considering these smart devices are already in place and common within the home, we tried to focus on a device that isn't common but can still be useful when performing daily activities. Our idea is an attempt to bring together multiple smart features into one device. We considered a smart pet bowl which would be a great help for pet owners who either forget to refill or aren't home most of the day to do so. Based on a group vote, we ultimately decided to develop a smart mirror. For our project a smart mirror provides the ability to start small and potentially expand with more intensive features. With smart devices, common features include voice recognition, touchscreen capabilities, and relevant information provided through APIs. Our smart mirror aims to integrate these features into a simple display for the user in the bathroom or any other location in the home a mirror would usually be. With the idea of most people encountering a mirror on a daily basis (usually at the start of the day in a bathroom), our intent is to develop a product that can fit to support daily activities within the home.

II. Project Goals

Our main goal of this project is to improve on the concept of the smart mirror and at the same time Learn about different technologies to gain experience that can help us in our careers. To achieve this goal, we discussed the best way to build on the idea of the smart mirror. We talked about the main features we wanted the mirror to incorporate. Because of the potential and versatile nature of the mirror we are able to look up a wide range of technologies that were of interest to each individual of the team and see how we could apply it to the mirror. Being able to research and apply concepts that interest us allows everyone to enjoy the project and that is an important part of the project. Being able to research and find the best way to build the mirror by comparing and selecting components and building and testing circuits that will be used in the mirror is a good way to develop experience and engineering skills.

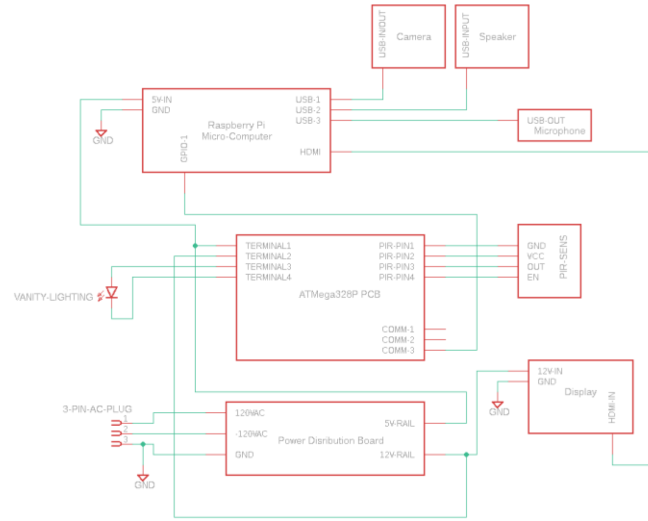
Each member of the team will have their own goals the electrical engineer's goal is to power the device from the wall outlet and distribute the power to the different devices efficiently the Primary goal for the computer engineers is to integrate the most key features into the mirror.

III. Project Requirements

The team has developed a long list of requirements and specifications which should be included to make a successful smart mirror. The full list of those can be found in our project documentation. The core requirements we have chose for this project include speech detection that works accurately within 2 feet, accurate facial recognition within 2 feet, and user proximity detection within 5 feet. Various other none core requirements are things such as the weight of the smart mirror should not exceed 25 pounds. These core requirements were based on how a user generally would want to interact with a mirror. Generally a user stands rather close to a mirror, especially when closely inspecting the face for blemishes or imperfections. This mirror is designed to take advantage of this close distance to enable features such as the speech detection and facial recognition. A mirror of this nature could either be placed on a table or mounted on a wall. The weight requirement is to prevent this mirror from being too cumbersome and inconvenient for the user to mount on a wall or on a high place.

IV. System Components

The Smart Mirror relies on several components that were purchased, as well as designed by team members in order to work together and accomplish the goals of this project. The Mirror consists of 3 main sub-systems. The Raspberry Pi, monitor, speaker, microphone, and camera being one. The ATMega328P, presence sensor, and LED lighting being the second. And lastly the power distribution board and AC/DC power converter. The image below shows the interconnection of these subsystems and gives a view of the project as a whole.



A. *Central Processing Unit*

The smart mirror employs a Raspberry Pi model 4 as the as the main computer. This project is software and hardware intensive, so it was important for us to decide on a computer that can manage these connections between components as well as have the necessary RAM to run our software. The Raspberry Pi 4 was the most affordable and easily accessible option on the market. This computer is compact, and lightweight, which makes it highly suitable for a project of this nature. It comes with 4 GB of RAM and is equipped with a quad core processor, each core running at a clock speed of 1.5Ghz, making it more than a capable component. This particular also comes with 4 USB ports. 2 standard USB ports and 2 USB 3.0 ports. This means we will have enough ports to connect other components. An ethernet port and Wi-Fi connectivity are included on this board. This gives the user 2 options: 1.) If the user wants a faster connection, they may opt to run an ethernet cable to their mirror. 2.) If the user values aesthetic simplicity, and wants as few cables as possible connected to the mirror, they can just connect the mirror to their local network wirelessly, albeit with slower software performance.

Bluetooth 3.0 was one of the reasons our team had selected this particular computer. With Bluetooth capability, this allows us to offer the user more features than without, which will be further explained in the software section of this document.

Figure 1:

Raspberry Pi Model 4 Specifications

Clock Speed	Quad@1.5Ghz
RAM	4GB
Operating Voltage	3.3/5.0V
Memory	Expandable

B. *Microcontroller*

For this project we have chosen to go with the ATMega328P micro-controller, a low-power Arduino based chip that has all the capability we could possibly need. For prototyping purposes, we have chosen to go with the Arduino Uno Revision 3. The uno is one of the most popular and widely used development boards in the Arduino space. It has many libraries available and can be hooked up to just about anything in the micro-controller space due to its popularity. The board features 14 digital GPIO pins that can be setup for input or output for HIGH or LOW communication. It also features 6 pins that can be used for analog input, 4 of which can be configured to be 4 more digital GPIO pins.

Featured on the Uno development board is the ATMega328P in its 28-Pin Narrow Dual In-line package format, identified as the ATMega328P-PU. For our project in the event, we moved from prototype and chose to develop a board the ATMega328P could be moved onto a custom PCB by simply including a standardized DIP-28N connector, with soldering required.

ATMEGA328P SPECIFICATIONS

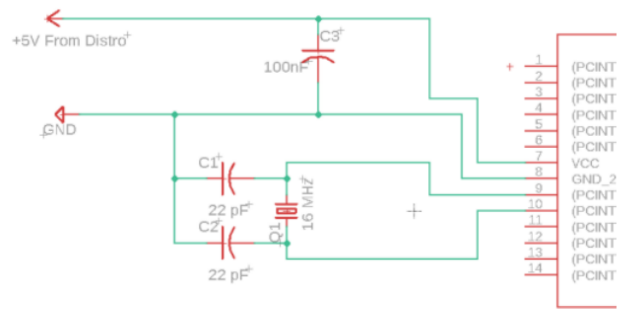
Clock Speed	16MHz
RAM	32Kb
Operating Voltage	5.0V
GPIO Pins	23

To run the ATMega328P on its own board, which was done for this project due to the design required as well as the large advantage in power savings, it will need to be bootloader and some external parts will need to be added.

Adding an external clock to the ATMega328P a 16 Mega-Hertz crystal and 2 capacitors are used. It is recommended by Arduino to use an 18 picofarad to 22 picofarad ceramic capacitor. The crystal and capacitors are connected across pins 9 and 10 on the ATMega328P, pins 9 and 10 are also labeled as XTAL1 and XTAL2 when used this way. Once the external clock has been connected the only other things necessary for the Micro-Controller to function standalone without the development board is the power and ground. The ground will be connected to ground and pin 7, the VCC pin gets connected to the 5V source. A 100 nano-farad de-coupling capacitor was added to make sure clean power gets to the micro-controller from the 5V railing coming from the power distro.

The AVCC pin, pin 20, is used to power the analog components of the microcontroller, for this project it is not necessary but will be powered from the 5V source with another 100 nano-farad de-coupling capacitor. Generally, an inductor would be used before the source voltage gets to the AVCC pin, however this is just for ADC accuracy and noise prevention. The ADC is not necessary for our application and is only being powered to prevent the parasitic power draw on the digital side that can occur when leaving the analog side unpowered.

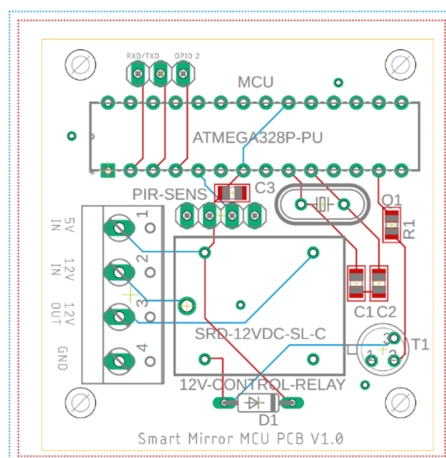
ATMEGA328P CIRCUIT



The above design was implemented on the final PCB design for the micro-controller.

The PCB for the micro-controller was designed with 2 functions in mind, control the vanity lighting, and control the presence sensing. Along with that the presence status will be communicated to the micro-computer via a single bit signal wire. The Raspberry Pi operates on a 3.3V logic vs the 5V logic from the ATMega328P, so a step down will take place on the way.

ATMEGA328P PCB



The PCB was manufactured in Hong Kong and then assembled by the team. The image below shows the final product. A 28-pin dual inline package was used in place of soldiering in the MCU to the board. This decision was made to make boot loading the chip easier, as well as make future programming changes as easy as possible.

ATMEGA328P PCB ASSEMBLED

C. Proximity Sensor

This sensor used is a simple IR motion detector only it has a large 180-degree field of detection, making it a perfect option for our smart mirror. It can detect movement up to 30 feet away, which is plenty enough for any normal sized room. The sensor also boasts a night-time-mode for use in low light conditions. Unlike the previous option this sensor also won't be an eyesore and could easily be flush mounted to the mirror frame. It requires an operating voltage of 3VDC to 6VDC and outputs a single-bit high or low signal to indicate motion.

PROXIMITY SENSOR SPECIFICATIONS

Angle	180 Deg
Range	30ft
Voltage	5.0V
Communication	1/Bit

Although it was the most expensive at almost 13 dollars, the wide angle PIR sensor was the best option for this project. It has very low power consumption, performs the exact task we need to it for this project, and is no more complicated than it needs to be. The Doppler Radar Sensor was a fantastic option, but the power consumption and complexity are not worth the small cost savings and elimination of any visual sensors on the front of the mirror. The Ultrasonic sensor on the other hand is just not at all what we are looking for in a sensor. This sensor is much more focused on overall detection, not range. So, the higher power consumption and low detection range/ angle mean that it did not make the cut. The best and most reliable option by far is the PIR sensor.

D. Display

The display is one of the most important components when it comes to the user experience. The display provides the user interface on a 1080p LED panel which is placed in the mirror housing behind the reflective acrylic panel. This 1080p LED panel was removed from a standard 24-inch monitor and modified appropriately to fit into the smart mirror's frame.

The mirrored effect of the display is achieved by a reflective acrylic panel. This acrylic panel provides an appropriate level of visual transmittance at 40%. This helps to reflect light and create a mirrored surface to which the user is able to see their reflected image. The level of light allowed to pass through the acrylic panel allows for the LED display to pass light through from behind to deliver the smart mirror user interface.

E. Speaker

A speaker is necessary to provide audio feedback when using certain features. Although the monitor used for the display included built-in speakers, they did not provide adequate sound for delivery to the user. Instead, an external USB speaker is used to provide decent sound to which the user can clearly receive feedback from the smart mirror. The chosen USB speaker includes two 3W and one 2W driver for a total output of 8W. This speaker is connected to and powered by the Raspberry Pi via USB 2.0.

F. Camera

A high-quality camera is required in this project, as one of the core requirements is accurate facial recognition. The camera the team settled on using for this project is the Arducam Pi Camera. This particular camera is capable of taking 1080p HD images. This is level of detail is necessary because the facial recognition software works best with high quality input images. What really makes this a worthwhile camera is that this camera is equipped with an autofocusing lens. This is important because the user might not always be standing still in front of the mirror when using it. This autofocusing gives us a better chance of taking a high quality image for the software to detect who is currently using the mirror.

G. Microphone

The user will be standing a distance of 2 feet, which is actually rather close to the mirror. Most microphones are able to pick up audio from this distance without much difficulty. This meant that any generic microphone would be functional for this project. The group settled on a standard lapel mic, this small microphone allows us flexibility on how to mount the mic onto the prototype.

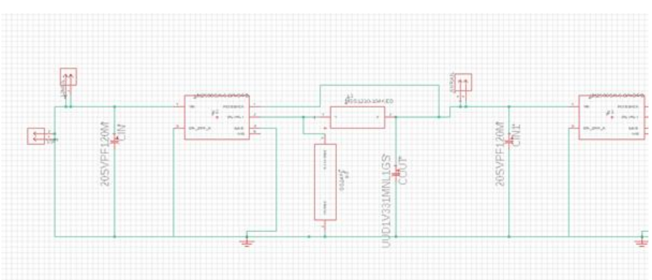
H. Power Distribution Board

Device	**Voltage**	**Current**	**Power**
Raspberry Pi 4 Model B	5V	3A	15W
ATMega328P	2.7/ 5.5V	2mA	0.011 W
Monitor	12V	2.5-3A	36W
Led Lights .	12V	3A	36W
Total Power			87.011W

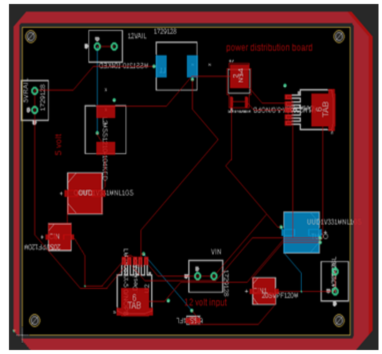
The chart above is of the main components power consumption for the mirror. That will Total 87watts. The purpose of the power distribution board is so the Smart Mirror can be powered by A lone source. A 12-volt 10-amp Ac to DC power supply adapter will be used to power the device. It can output 12V DC stable output. Automatic overload cut-off, over voltage cut-off, automatic thermal cut-off, short circuit protection.

The power distribution circuit will have three rails at voltages of 3 volts, 12 volts, and 5 volts. The circuit below will be used to make the 5 volts rail and 3 volts rail using LM2596(5/3.3volt) SIMPLE SWITCHER Power Converter. The LM2596 is a buck converter; this IC was chosen because it can handle an input voltage of 40 volts and outputs the 5volt, and 3.3 volts and 3 amps needed to power devices in the mirror. The switching regulator was chosen instead of a linear regulator because switching regulators have a higher efficiency ,as the switching regulator is continually switching on and off it creates less heat than a linear regulator based on the data sheet this device requires only four external components to function the 120 µF capacitor to smooth out the input voltage signal and the output of the IC will contain a flywheel circuit consisting of a 33µH inductor, 680 µF capacitor, and a 950mV diode. The flywheel circuit consists of an inductor and a capacitor to store energy and a diode when the transistor is on the inductor is being charged with the current and the capacitor is also being charged also the load is being supplied power. The diode will not be in use at this point because of the positive voltage acting on it the diode will be reverse biased. When the transistor is on its off state the e.m.f field of the inductor starts collapsing and reverses the polarity of the voltage across the diode is now forward biased completes the circuit and allows current to flow and prevents voltage spikes caused by the inductor. The capacitor and inductor supply current to the load while the transistor is off.

like a mechanical flywheel using regularly spaced pulses of energy outputting energy smoothly at a steady rate.



Pictured below the power distribution board is a 2-layer copper board. The area of the board is 8000mm2 and is1.57mm (about 0.06 in) thick. There are 28 components on the board the trace is .2mm (about 0.05 in) to hold the 3-amp current for the rails of the power distribution board we are using 2 Position Wire to Board Terminal Block these terminal blocks are rated to withstand 300 volts and 10 amps they also can contain a wire Gauge of 14-30 a 5.5x2.5mm Barrel Tip connector is placed on the board to connect to the power supply



V. Software details

The smart mirror is a software intensive project with many moving parts that together, form a useful product. Using open-source software for the user interface made development a more streamlined process as it provided a base with which to begin customization and addition of features. The magic mirror consists of a module-based interface. Individual user profiles can be distinguished by the particular modules present on the screen when a user is logged in. General modules that are available for all users include:

- ***News***
  News headlines will fade in and out of the interface giving the use a basic idea of world current world events
- ***Weather***
  Weather information will be displayed, showing information such as the temperature, humidity, and what kind of conditions to expect during the day.
- ***Events Calendar***
  A list of approaching events will be shown to the user on the interface. This list can be changed from profile to profile, meaning events relevant to a particular user can be shown to them, and them alone.
- ***Digital Clock***
  A clock displaying the current time will be included in the interface.
- ***YouTube Simulcast***
  Any user will be able to connect their phone to the smart mirror via Bluetooth, and stream YouTube video so long as both devices are connected to same internet access point.

Every user, whether registered on the mirror or not, will have access to these basic features. An account is not necessary to use this mirror. Account merely add some minor customization on what kinds of modules appear and where.

A. *Speech Recognition*

Speech recognition is a flagship feature of this project. The vision was to create a smart device that could be used without touching the mirror. It is generally a bad idea to touch a mirror as many are and prone to smudges/scratches. The decision to include speech recognition is a consequence of this commitment to hands-free design philosophy. A clear distinction must be made between speech recognition and voice recognition. Voice recognition a software's ability to identify the voice of a particular human being out of a set of voices. Speech recognition is merely the ability to recognize any human speech. The smart mirror does not have the ability to identify a user by voice alone. The team decided that the best way to integrate speech recognition was to integrate a smart assistant into the smart mirror itself. Using the freely available Google Assistant SDK, we were able to include a smart helper that is capable of answering most questions the user asks. Using Google's own smart assistant in this project allows us to offer more features to this mirror. For example, a user could ask for the best route from point A to point B, and the assistant will automatically open google maps and show the user the best route. Or if the user has a general question, the assistant will display a Wikipedia article to the user. This would not be possible without inclusion of this software.

The assistant operates in 4 different states: 1.) Idle, Recognizing, Busy, and Expecting.

1. Idle State:

In order for speech recognition to work, the Smart Mirror must always be listening to the user. However, the assistant will not be triggered until a certain "wake word" is detected. This wake word was configured to the name "Jarvis". This is just more convenient than the default "Okay, Google." After the wake word detected, the assistant is "awake" and will transition to the Recognizing state.

2.Recognizing State:

Once in the Recognizing state, the assistant is actively listening for a user prompt. Once the user has completed their prompt, the assistant will decipher what the user wanted, and move on to either the Busy, or expecting state.

3.Busy State:

It is this state where the assistant executes the user's request. If the user requested trivial knowledge, the assistant will search the web and deliver the most relevant result to the user. The assistant will often read out the first paragraph of information returned from the web for the user's convenience. The user, as mentioned earlier, can ask for logistical information, and the assistant will return the user their information via Google Maps. The assistant is even capable of playing certain YouTube videos on the user's request. After completion of this state, the software will return to the Idle state, responding only when the wake word is used once again.

4.Expecting State:

This state exists for when the assistant requires additional information from the user. An example of when the software would enter this state is in the event that the user asks for the assistant to set a timer. In this case the user has not specified how long they would like the timer to last, so the assistant would request that information from the user. After prompting the user for an additional response, the assistant will return to the Recognizing state, after which it will execute the request during the Bus state, and then finally returning to the Idle state to start the process all over again.

The inclusion of smart assistant in this project gives the Smart Mirror much more utility than just simply displaying time and dates. It makes this Mirror much more dynamic and valuable to the user than just another device that tells the time.

B. *Facial Recognition*

Facial recognition as a feature was necessary for us to create individual user profiles. This method of authentication allows the user to identify themselves without touching the mirror or even speaking. Facial recognition generally works by manipulating a particular image, and running feature detection algorithms on the modified picture. These algorithms are able to distinctly identify particular facial features such as the eyebrows, nose, mouth, and jawline. The facial recognition software used in this project relies on a python library that implements an algorithm known as "Histogram of Oriented Gradients" or HOG. This algorithm works by partitioning an image into a grid. Each square in the grid represents an area of about 3x3 pixels. Each grid is then converted into a histogram based on the pixel data in each given grid. When this is done over an entire image, you are left with a unique arrangement of histograms that can be used to personally identify a face. These histograms become in a sense, the password for the user. An example of the HOG algorithm at work is shown in the image below.

When a user stands in front of the smart mirror, the camera will take a photo, and run the algorithm within a few seconds to determine if a known user is present. The vanity lights that are included in the mirror are helpful in this process, because for best results, a user wants to be in a well lit area. However, HOG is an algorithm known to work well from multiple angles and in poor lighting. So the user can expect facial recognition to work reliably. If a known user is detected the smart mirror will then load all the of the user's personal modules, and update existing ones with information relevant to the particular user. Even the location of UI elements may vary from user to user.

It should be noted that this method of authentication is not as secure as something like Apple's Face ID. Face ID takes into account the contours and textures of one's face to authenticate the user. HOG merely runs an algorithm on an image. This means that anyone with an image of a registered user could potentially sign into their account without their consent. However, a device of this nature is not meant to store critical personal details. It is merely meant to supplement the user's daily routine. For more personal tasks, cell phones and conventional computers are much more suitable. So although privacy can easily be compromised, the information that would be stolen would be along the lines of what news sources you prefer to read in the morning. Facial recognition in this project merely serves as a means to personalize the user experience.

VII. Mirror Housing

The frame of our smart mirror was designed to safely house all of our physical components. Our desired dimensions were to be 12x24 inches. Among other considerations, we decided to use wood as the material for our mirror housing. Wood is affordable and does not weigh too much to where we are able to satisfy our weight specification of less than 25 pounds. Precise measurements were made to cut purchased wood to create a sturdy but visually pleasing frame. The visual design of our smart mirror frame can be seen in the figure below.

As mentioned previously, when it comes to construction, the cut pieces of wood were attached together to form a sturdy housing for our smart mirror. Many regular mirrors include some sort of frame that helps protect the glass and provide a stylish look. With more physical components than a regular mirror, we needed to have enough space within the housing to fit each part. From the back of the housing, the acrylic panel and display panel were "sandwiched" against the thick bezel of the mirror frame. Using another wood piece against the back of the display, a tight fit was achieved to hold the acrylic panel and display in place. The other key components including the microcontroller, Raspberry Pi, and power distribution board are attached to this wooden piece. Creating a custom frame gave us freedom to fit components where appropriate and allowed for any needed customization to occur for functionality and design. With all components securely in place, the inside of the smart mirror is closed in with a wooden back.

VIII. The Engineers

Tyler Newman, a computer engineering student at the University of Central Florida, is primarily interested in circuit and PCB design specifically in the field of embedded systems and IoT devices. Throughout his time at UCF, he has been introduced to embedded systems programming, testing, and design in courses such as embedded systems, digital systems, junior design, and electronics. After this introduction from UCF, he has pursued more knowledge of the subjects and pushed into the world of IoT devices, something that will soon be a massive thriving industry. This interest and experience in embedded computing will be beneficial in the development of the smart mirror and its embedded components. He will be designing many of the schematics present in the project as well as PCB components for certain project elements. He hopes that this project will be another steppingstone to the future and add highlight the skills he's acquired while studying at the University of Central Florida.

Axel Aristud Ortega is a computer engineering student attending the University of Central Florida. Axel has an interest in robotics, robotic vision, and virtual reality. He is also interested in smart devices and the future of the industry. This interest has manifested itself into this smart mirror project. Axel plans to enter the industry and further develop his interests in multiple fields in both hardware and software development before returning to academia as a graduate student.

Jonathan Martin, an electrical engineering student, attending the University of Central Florida. His interest is in in renewable energy when entering the industry Jonathan plans to try to develop new ways to produce renewable and sustainable energy and implement them across the globe Jonathan Currently works at a component testing facility where he is learning skills in test engineering. And Metrology where he learns about Industry standards after graduation Jonathan will be working at UL as an Associate Field engineer

Jacob Williams-Moore, a computer engineering student at the University of Central Florida, developed his love for computers and technology at a young age. Having access to computers and video games consoles since he could remember, it was natural to become a key hobby of his. When starting college, Jacob wasn't too sure of which major to choose but ultimately decided upon Computer Science. Though his interests in computers were more on the hardware side, he progressed through the first two years of his degree and learned basic coding. During year three, Jacob switched majors from Computer Science to Computer Engineering in hopes of learning more about computer hardware instead of software. This decision may be seen as redundant after Jacob getting internships in the software engineering field. He has learned to appreciate computer software while keeping his initial interest in computer hardware as a personal hobby. Jacob's subject related and professional experience mostly consists of front-end development using common frameworks such as Angular and React for web-based applications. This experience helped extend into some of his interests, but he also continued to collect computer parts and build computers to fulfill his initial preference towards hardware

VIX. Conclusion

A The goal of this project was to create a product that is not widely available on the market today. During the fall semester of 2021, group 31 has been able to show a thorough design of a potential smart mirror. This design process by first identifying products of this type that do exist in the market and learning from them. "What kind of features would users want in a product like this?", and "how would it help them become more productive", were necessary questions we had to ask ourselves before implementing any sort of interface or design.

At this point we began researching the technology that would need to be used in order to make our vision come to fruition. Methods of serial communication, face detection algorithms, popular voice recognition software, as well as diverse kinds of hardware options we had available to us. This research allows us to filter for the precise hardware and software development needed for this kind of project. Once proper research has been conducted, at this point testing and development can occur. Experimentation with the ordered hardware and development of the software needed is done to verify the feasibility of our design.

This process has exposed us to a real-world design scenario and allowed us to put our accumulated knowledge we developed over the past 4 to 5 years to use. This project has allowed us to put the theory we learned in university into real practice. In the semester to come, our designs will mature and will be pieced together into one cohesive prototype. The struggles experienced and lessons learned in this semester will help us push forward in rapidly approaching spring 2021 semester and help guide us in our lifelong careers as engineers.

Acknowledgment

The authors wish to acknowledge the assistance, support, and guidance of Dr. Samuel Richie and Dr. Lei Wei. As well as the UCF College of Engineering and Computer Science for giving us the knowledge to pursue this project as well as the tools and labs to complete it.

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