Smart Mirror

High Level Design

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Table of Contents

Introduction

Often it can be difficult to find enough time in the day to complete all the tasks that are a part of life, so multitasking becomes necessary. In the morning it is imperative to prepare for the day in front of a mirror, which often is slow and time consuming. In addition, to make educated decisions about how to prepare for different aspects of the day, time must be spent making oneself aware of current and future weather conditions, which events are currently on a person’s schedule, etc. The problem lies in finding a way to efficiently check all factors that may affect how a person prepares for the day while also performing all necessary tasks in front of the mirror. Our goal is to create a product that fulfills one’s need of getting ready while simultaneously receiving the daily news, weather, time and other useful information. The ability to gather this information during one’s morning preparation will result in a more efficient daily life. If needed, we can expand our product to include multiple methods of control, as well as music and other entertainment options. Overall, we hope that our product is enjoyable and enhances productivity at an affordable cost.

Problem Statement and Proposed Solution

The world we live in today has become a place of the fiercest competition, whether it is in sports, entertainment, or the job market. In order to be the best, one needs to allocate an extraordinary amount of time to their goals with little distraction. However, the advent of information technology tends to act like a dual-edged sword when it comes to work productivity; sometimes one can use the ease of information to help them complete a task, but it can also provide significant distraction. Ultimately one strives to be their best, but the interruption of keeping up with the daily news, or preparing for incoming weather can hinder one’s progress. Taking time throughout the day for these various activities can be extremely distracting and greatly cut into performance.

Along with information, people greatly value their appearance, spending approximately an hour a day in front of the mirror during their morning and night routines. This is a significant amount of time where important things are taking place, but the mind is not working. It would be extremely useful to spend that time on the phone or computer completing any of the tasks mentioned above, but unfortunately it is difficult to do so while preparing for the day. A product is needed that can allow a person to efficiently complete everything they need to do to prepare for the day, all in one place and at the same time.

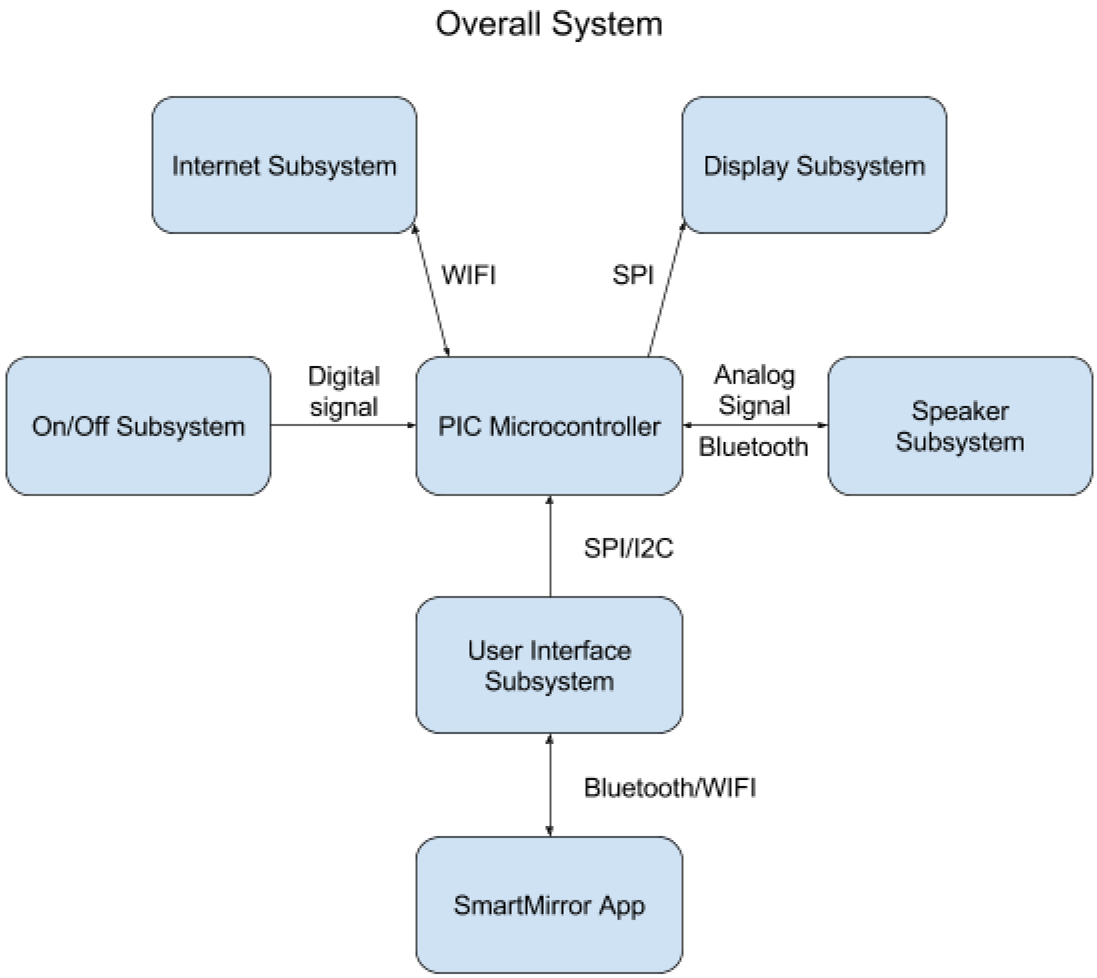
The goal of the SmartMirror is to provide a single easy to access location for a person to receive all the information that could affect how they prepare for the day. Through the use of LCD displays and a two way mirror, weather, time and date, news, and other useful information programmable through the SmartMirror app would be available at a glance. By building these features into a mirror, which most people will already be using in their morning routine, it is possible to present this information in such a way that it will seamlessly blend together with the task of morning grooming.

System Requirements

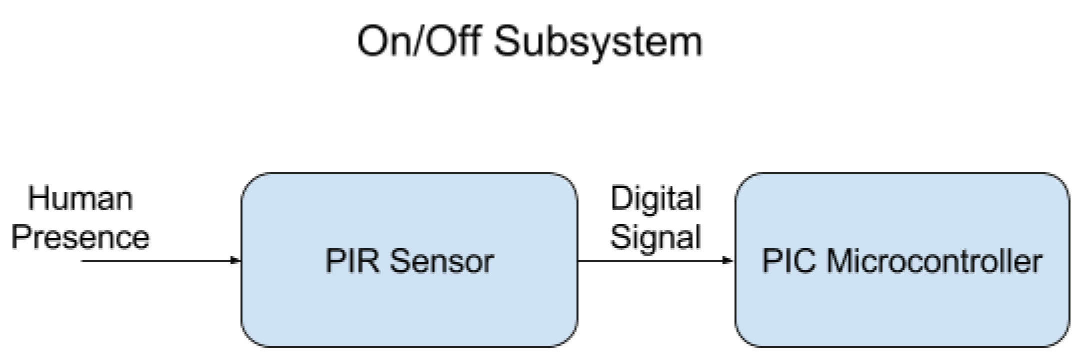
The microcontroller used to control the mirror and the LCD displays will need to be powered by a 5V power supply. This will not need to be a portable as the mirror will be stationary after its initial installation. The embedded system used in the mirror will need to be able to interface with a WiFi interface as well as multiple LCD displays. The WiFi will need to be able to work within a home, so it should be sensitive enough to pick up the signal from a home WiFi router. The system will need to be able to take user input to program the user's location and switch what data is being displayed on the auxiliary screen. There will need to be communication from a motion sensor, which will need to sense motion up to ~10 feet in front of the mirror, to determine if a person is present and the system needs to be woken from its sleep state. The mirror will be around 2’ by 1.5’, so all the hardware will need to fit within this profile. The entire system will also need to be mounted on a wall, so there will need to be a frame built that can support this weight.

System Block Diagram

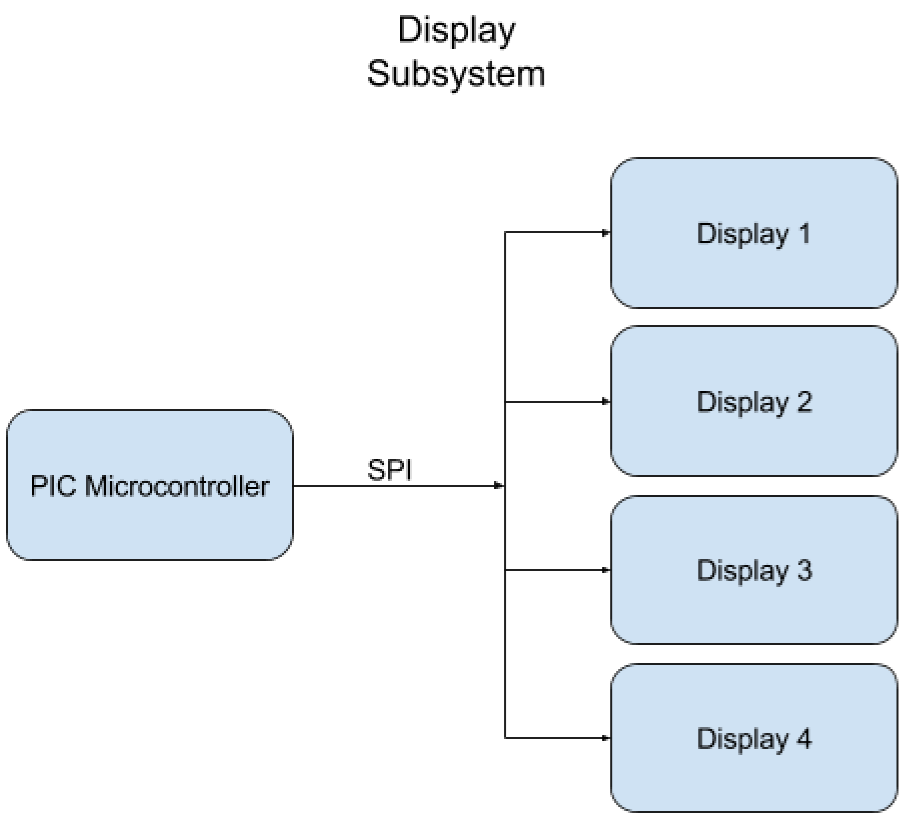
Overall System: The overall system has been broken into five subsystems, which are described below. They are the On/Off Subsystem, Display Subsystem, User Interface Subsystem, Speaker Subsystem, and Internet Subsystem. Connections are shown in the block diagram below.



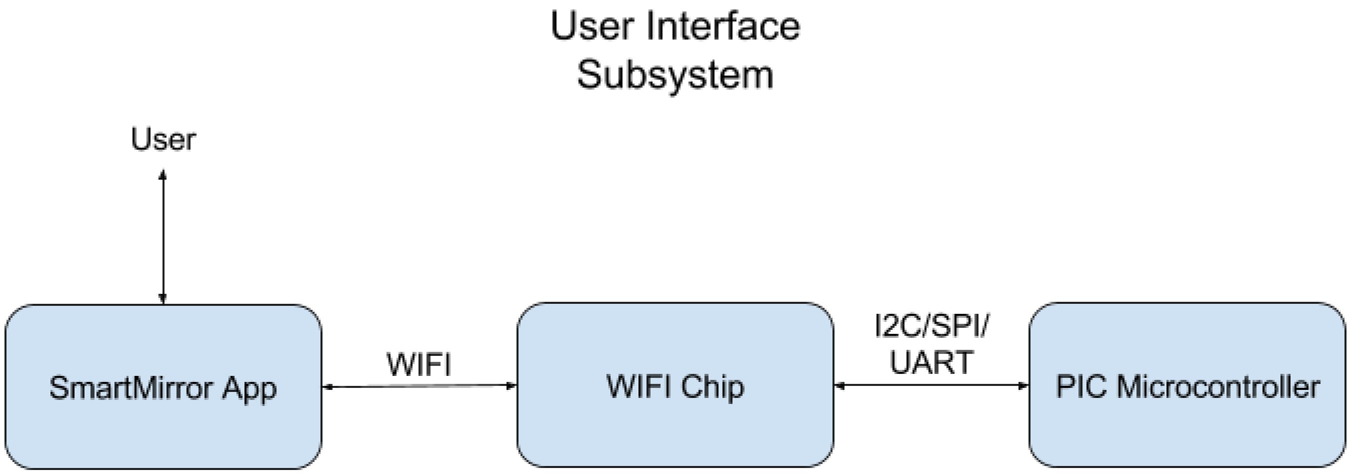
On/Off Subsystem: This subsystem will deal with determining whether someone is in front of the mirror or not. Using a PIR sensor, it will intelligently turn/keep the mirror on or turn/keep the mirror off.



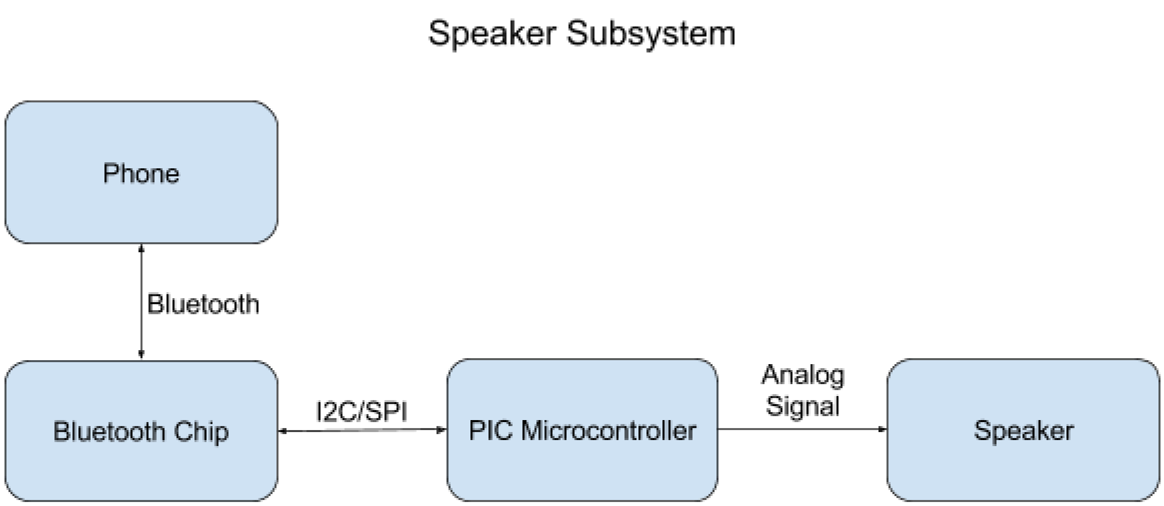
Display Subsystem: This subsystem takes information retrieved by the Internet Subsystem, creates the appropriate outputs, and sends the desired information via SPI to each of the LCD screens. The settings will be based on the user's last inputs with the SmartMirror app, and will change only if settings change as the microcontroller continues to exchange data with the connected device over WiFi.



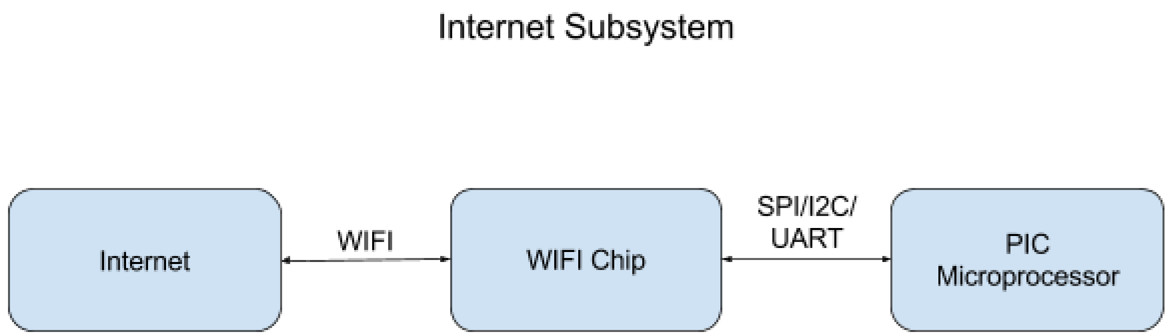
User Interface Subsystem: The user interface will be primarily done through the SmartMirror app. In the initial off-state it should send the last adjusted settings to the mirror's microcontroller. When the user opens the app and makes an adjustment to the SmartMirror's settings, these new settings will be sent to the SmartMirror which will adjust accordingly.



Speaker subsystem: This allows for the user to be able to play music through the mirror via a bluetooth connection. Once the mirror has connected to the bluetooth device (likely a phone), it will continuously receive data from the device and will output music accordingly.



Internet Subsystem: The internet subsystem is in charge of connecting to the internet to retrieve any information to be displayed on the mirror. This includes the time and date, weather, calendar information, and other useful information.



Subsystem and Interface Requirements

On/Off subsystem: The PIR needs to communicate to microcontroller through a digital pin acting as a switch. When it is idle, it will generate a 0V to said pin, but when triggered the PIR will generate a 3V output to the pin, letting the microcontroller know there is someone in the area.

Display subsystem: The microcontroller needs to be able to communicate to each display what do using SPI, while also communicating with the WiFi chip which is extracting data from the SmartMirror app.

Wireless interface: The WiFi chip that we will be using is the Sparkfun ESP32, which uses the TCP/IP protocol stack and 802.11 WiFi protocol to retrieve information from the internet. It can use SPI, I2C, or UART to communicate with microcontroller..

Bluetooth interface: The bluetooth chip on the microcontroller needs to be able to communicate with smartphone quickly over a short distance (<15 m). It will relay this data to the microcontroller via either SPI, I2C, or UART.

User Interface: Our goal for the user interface in our SmartMirror app is to allow the user to be able to adjust his SmartMirror settings in a simple yet effective graphical user interface (GUI). This could consist of a drop down menu for each setting, or a blank field to type in information. Once the settings are selected, the app will need to communicate with the ESP32 chip over WiFi as quickly as possible, so the WiFi chip can relay the data using either I2C or SPI to the microcontroller, which will in turn relay the data using SPI to the LCD displays.

Internet Subsystem: This subsystem's goal is to enable the WiFi chip on the microcontroller to pull data from the Internet, whether it be news or the forecast, and relay the data to the microcontroller over SPI or I2C.

Future Enhancement Requirements

Voice activation: A problem with a PIR sensor is an animal or unwanted human could get in front of the mirror, causing it to turn on. In lieu of a PIR sensor, a voice activated system to turn on the SmartMirror would be a way to fix this problem. To get this done, we would need a microphone to record the voices then a software package to process the audio and decipher the words spoken.

Multiple languages: This feature would allow the user to view the information posted on each LCD screen in a small number of languages. Choosing a language would most likely be done in the SmartMirror app, and would require some sort of translator. To do this, a software package would need to be included that would be able to translate between languages, or use different web sources already in that language, as well as a library of characters to display for the different languages.

Dictation: This function would allow the SmartMirror to dictate news or the weather to the user over a speaker. The feature could be activated using the potential voice activation aspect of the speaker or could be a setting on the SmartMirror app. We would need to be able to get software that can process text to audio.

High Level Design Decisions

On/Off Subsystem: A Passive Infrared (PIR) sensor will be used as a motion sensor. We chose the one listed in the Major Components Costs section of this document, because of its switch-like nature as well as its flexibility with its operating voltage. For instance, when the sensor is idle by not sensing a change in infrared radiation it outputs 0 V, but when human passes by the two slots inside the sensor, this difference causes the sensor to output a high output of 3 V. All it needs for connection is power, ground, and a signal out to the microcontroller makes the PIR sensor simple. The PIR sensor also allows an operating voltage of 5-12V, but can be dropped down to 3V as long as the voltage regulator is bypassed. This flexibility and simpleness made the PIR sensor desirable to be a part of the SmartMirror.

Display Subsystem: For the display subsystem, we will be using Kuman SC06-3.5TFT-US touch screen monitors. These displays are 3.5” 320 by 480 pixel screens that run on low power and are controlled via SPI. We chose these specific screens for several reasons, the first being their size/price ratio. They are among the larger of the screens we found that will interface with the PIC microcontroller, but because they are designed for use with the raspberry pi (which has become very popular), the price is significantly lower than the other options. For only $15-$20 apiece, it is well within our price range to purchase several. The touch screen feature of the displays will not be used, but unfortunately a cheaper model without this capability does not exist. The second main reason we went with these specific displays is because they are controlled via SPI. Most screens above about 3” or so are controlled via HDMI, DVI, VGA, or another standard video protocol. It would be difficult for us to use any of these with our microcontroller, as extra hardware would be required, so I2C or SPI is extremely convenient. In addition, because SPI supports multiple devices connected at a time, we can run all of our displays on one SPI bus.

User Interface Subsystem: We are using an application to be connected to the SmartMirror with a WiFi chip to optimize the user experience. Another choice we were considering for the user to adjust the SmartMirror’s settings with buttons on the SmartMirror itself. This could make changing the SmartMirror’s settings difficult, so we opted to move toward a SmartMirror app with dropdown menus to allow the user to adjust the SmartMirror easily.

Speaker Subsystem: We have two options for how the speaker subsystem will be realized. The first, and most likely option, will be to use bluetooth chip on the ESP32 board to connect to a person’s phone or computer. The chip will receive audio data that is played and send it to the microcontroller, which will decode the audio and send it to a speaker. If this is the case, we will use a general purpose speaker, driven directly. The problem with this approach is that we must design the code to connect to the phone and decode the audio, as well as develop a way to drive the speaker. All of these features already exist, relatively cheap and in a small package, in consumer bluetooth speakers; for example, the Jemma A10 Bluetooth Speaker can be purchased for only $15. To save time, cost, and processing power, we could offload some of the work to a pre-built speaker like this. The buttons on the unit can be wired into the microcontroller to allow us to power it and change settings as necessary, but instead of managing the bluetooth and audio data ourselves, it will be done by a system that we know works.

Internet Subsystem: The internet subsystem will use the Sparkfun ESP32 to connect to the internet via WiFi. This part was chosen for several reasons, most importantly that it is readily accessible and well documented. It is very popular with the arduino community, meaning that not only is it reasonably priced, but there is a wealth of helpful information online on how to set up and use it. It runs within our power specifications, integrates well with our PIC microcontroller, and is easy to set up. In addition, because the microprocessor onboard is programmable, it is possible for us to offload some of our processing needs to the ESP32 to free up the PIC.

Open Questions

Will one microcontroller be powerful enough to run the multiple displays or will additional ones be required?
Will the available news sources be limited to specific preset websites or can the user enter their own preferred source?
Are the displays going to be limited to white text on black background or can other colors or graphics be used?
Should the bluetooth speaker be separate from the bluetooth system?
Should the full news story be displayed, or just the headlines?

Major Component Costs

Product	Details	Website	Quantity	Cost
LCD display	3.5” Diagonal	https://www.amazon.com/Raspberry-Display-Kuman-480x320-Interface/dp/B01CNJVG8K/ref=sr_1_1?ie=UTF8&qid=1477339855&sr=8-1-spons&keywords=spi%2Bdisplay&th=1	4	$21.99 each
Wall Adapter Power Supply 5V	5V DC 2A	https://www.sparkfun.com/products/12889	1	$5.36
Two-way mirror (glass)	2’ x 1.5’	http://www.twowaymirrors.com/glass/	Tentative	$135.00

Two-way mirror (acrylic)	2' x 1.5'	http://www.twowaymirrors.com/acrylic-two-way-mirror/	Tentative	$135.00
Passive Infrared Sensor	Detects radiation	https://www.adafruit.com/product/189	1	$9.95
WiFi/Bluetooth Chip	Sparkfun ESP32	https://www.sparkfun.com/products/13907?_ga=1.142623414.244294162.1480953867	1	$17.96
Mounting Hardware	Wood, bolts, etc.	Home Depot, Lowes	Assorted	$25
			Total:	$281.23

Conclusions

Through the clever marriage of microcontroller technology and a 2 way mirror, it is possible to streamline the process of gathering news, and other useful information. By taking advantage of the time that people already spend looking into the mirror, SmartMirror can increase the productiveness of anyone's morning or evening routine presenting them with instant access to weather conditions, the date and time, and other useful information. As modern lifestyles continue to evolve towards accomplishing large amounts of work limited amounts of time, any increase in the productivity of already mandatory tasks becomes increasingly more beneficial. The goal of our project is the creation of a product that can allow a person to efficiently complete everything they need to do to prepare for the day, all in one place and at the same time.

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