ME102B Fall 2020
Final Project

Literally Just A Sign

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Description:

The basic problem: my family busting into my room when I was in VR, despite closing my door. Due to the nature of the VR tracking system in my room, opening the door could cause tracking issues. It was also generally inconvenient to have someone enter your room while you were in another reality, so I thought I could make this “do not enter” a bit more obvious with a visual indication that I was actively in VR.

The hardest part of any project is figuring out what to do, and the second hardest part is consciously acknowledging the scope of what is available to prevent oneself going off into impossible tangents. What I had was extremely simple: a motor, some buttons, a (just about fixed) 3D printer, and a few days' time, which soon was simplified to just RGB LEDs, some buttons, a just-about-functional 3D printer, and less days.

Design Process:

There are two main components: the sensor, and the “actuator”.

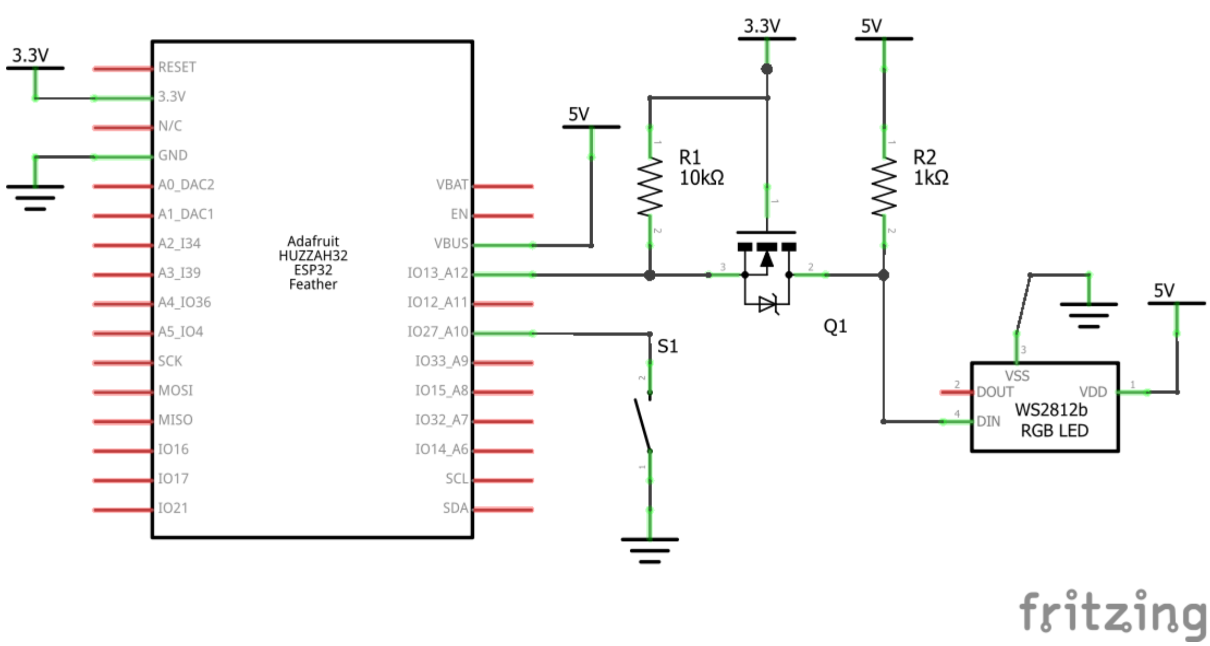
Sensor: Since I rarely closed my door unless I was in VR anyways, the abstract condition of “in VR” could be implemented by the simple condition of “door is closed”. With my available resources, there were 2 ways I could do this: with an ultrasonic for contactless detection, or with a physical button. The contactless part of the ultrasonic was attractive, but the setup both mechanically and electrically more complex, with the worst aspect being the need to constantly “poll” the sensor for distance information. Buttons on the other hand, are easy to use but have stricter interface constraints. Luckily for me, I had a couple large arcade-style switches with long actuation arms that made the choice to use a button easy.

Actuator: For “showing” I was in VR, the original plan was to incorporate more mechanical aspects to the signage and have a motor running a linear actuator, pull back a cover to reveal a sign that said “VR Active”. But given the time constraints and additional complexity of having to mount everything to the wall, in addition to having no basic building platform for the mechanical parts, the idea was eventually scrapped for a *bright* visual indication instead. After a couple of prototype plates to verify the idea, I eventually settled on a simple box that housed a string of (self-soldered) WS2812 LEDs, with a top plate consisting of a cutout of the original "VR Active" sign design and a white HDPE plate used as a diffuser.

Design Details

Circuit:

1. Button: the momentary button used for the door state detection was a standard 2 connector arcade-style microswitch with a long, straight actuation arm. Electrically, it is certainly overkill, but it's design inherently simplified the problem of how to detect a closed door without damaging the button or mount, and given the time and resource constraints there were no better choices. To connect to the breadboard, a modified set of jumper wires were used, with one end replaced with a female spade connector.
2. Power: As this is intended to be a semi-permanent installation at my door, this would be powered by a 5V, 2A wall-wart instead of USB power. This proves especially useful when considering the use of the WS2812s.
3. WS2812 LEDs and Control: These popular RGB LEDs (found as "Adafruit NeoPixels") are both beautiful as well as power-hungry. To prevent any issues related to power, these pull straight from the 5V wall supply. The Adafruit Huzzah's 3.3V logic needed to be shifted to match the 5V in order to prevent possible data issues over the 14-LED long chain. Since the data lines are not high power, I simply used the BS170 MOSFET from the lab kit rigged up a simple logic shifter to translate the 3.3V logic from the microcontroller into 5V logic. To prevent problems at the speed (800kHz) that the data line of the LEDs run at, the resistor at the 5V logic side was set to 1KOhm to reduce the rise and fall time of the data signal.



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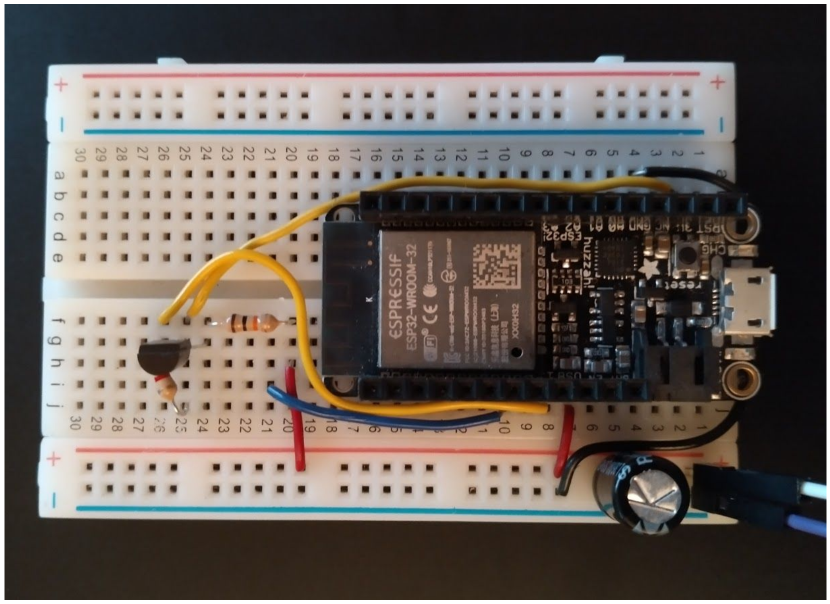
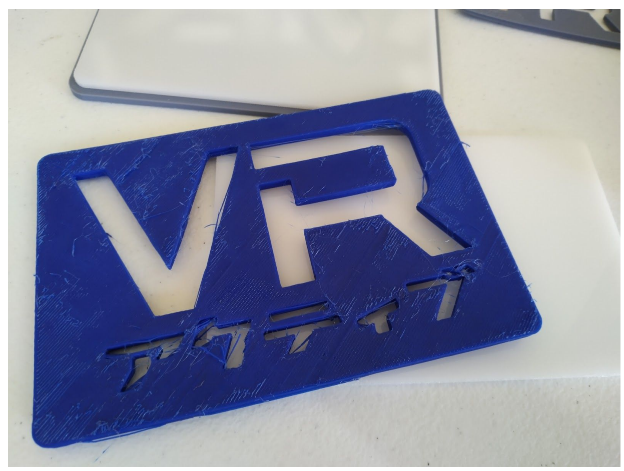
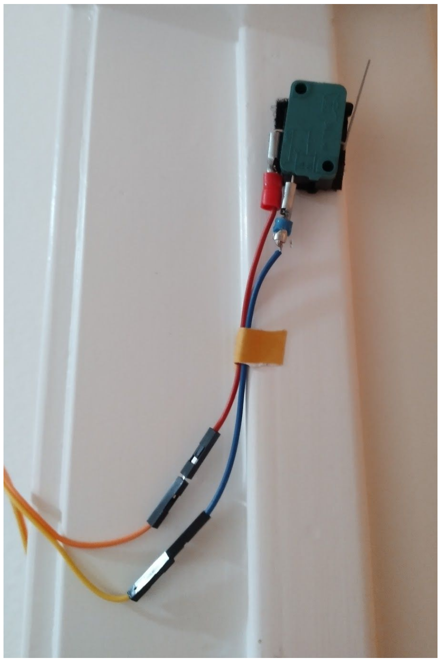
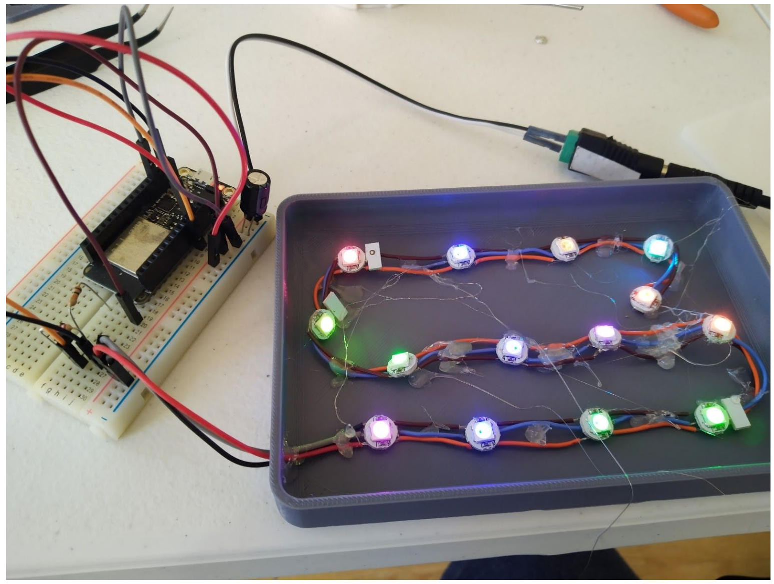


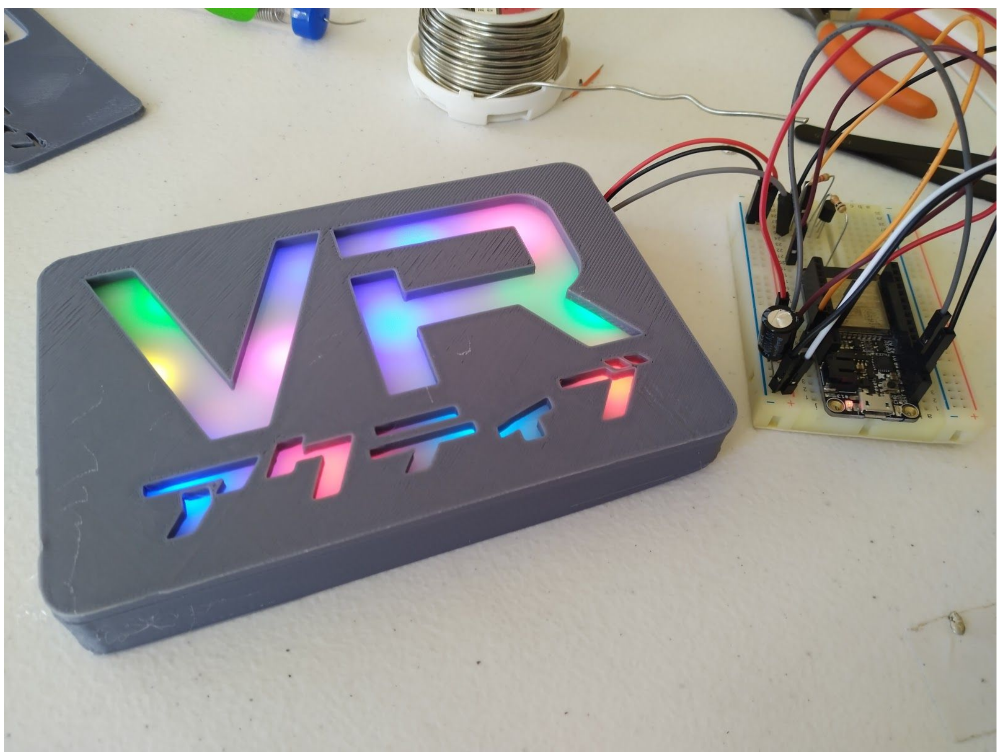
Mechanical Design

The design is quite simple, but the execution took longer than expected. 3D printing makes the *making* of designs fast. Designing, well, still takes time.









Adding Functionality

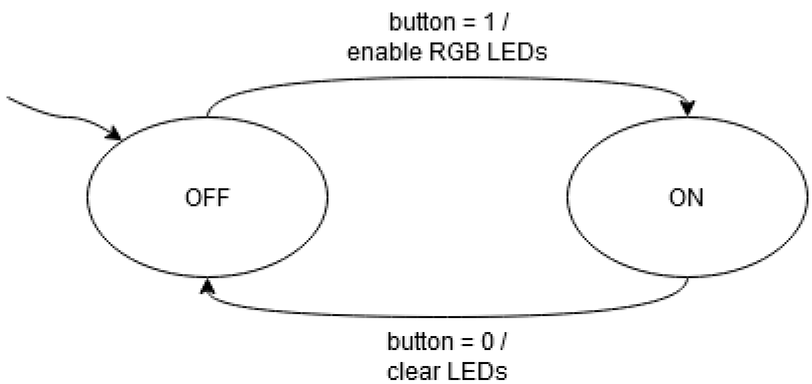
Given what's powering the NeoPixels is a ESP32, it leaves open possible "smart" features that can be added via code, such as monitoring a Twitch Stream or checking my Discord or Steam status to see if I am actually in VR instead of relying solely on the input implementation that is the door.

Cut Design

The original design had a much more “mechanical” aspect to it, involving a DC motor driven, 3D printed rack-and-pinion linear actuator that would physically move the sign, or at least, a cover over it. The idea was eventually scrapped to do time constraints relating to designing it to be wall-mountable with limit switches. Behaviorally, it would have been the same as the current.

Finite State Machine

The behavior of this machine is trivial, with 2 states and a single pure (binary) input. The system starts in the “OFF” state (with the state names referring to the state of the LEDs), and transitions to the “ON” state if the button is pressed. The machine transitions back to the “OFF" state if the button input is released.



Code

The code took a bit more thought than one might first consider, given the simplicity of the state machine. The first bit of additional complexity is reading the button input by GPIO interrupt instead of polling, to allow for accurate button response. The second is debouncing that signal to prevent undesired rapid state switching. The third is controlling the colors of the LEDs with a ISR timer, since simple delays cannot be used in a responsive system such as this.