ECEN 260

Final Project

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1 Project Overview

The purpose of my final project was to create a system that would allow the user to access certain functionalities via their cell phone. The user would be able to send text and audio prompts requesting an action. In response an AI agent will respond in a JARVIS (from Iron Man) like manner so that the user would feel more heard. If the user asked to turn on or off the living room light it woudld turn on or off respectivly. If the user sends an image then it would be displayed on the display for the users enjoyment.

1.1 Objectives

- Learn to display images on a display using SPI communication
- Connect the STM board to the cloud via a python script
- Connect Telegram to the cloud via n8n
- Make the STM board responsive to text, audio and images sent via telegram

2 Project Design

What specified need(s) your project is designed to meet. My project is meant to be a type of household assistant. Able to respond to users messages and requests. The requests that are coded in right now is to turn on a living room light to prepare the house for when the user comes home so they don't trip. It also can display images the user sends over chat. Now images may not fulfill a need directly but what if you wanted to update a calendar on the wall or make a digital picture book there are other needs this technology can solve.

how you considered public health, safety, and welfare as well as global, cultural, social, environmental, and economic factors. In regards to safety it is a top priority. The system is well built and is not likely to cause bodily harm to anyone either by choking, explosion, or by sparking a fire. The only safety concern is to the users data and hackers due to it connecting to the cloud. However there are checks and safety guards that can be easily added if the need arose but for the time being it is safe for our needs for the project. It doesn't solve health in any way other than the fact it will not decrease one's ability to be in good health. The main need it helps solve is that of welfare. Imagine coming home and it is dark wouldn't it be nice to turn on a light. That is exactly something this system can do. It would even be easy enough to make it so by entering a message it will unlock your house so you don't have to. A cool feature is that it can send images to the board to be displayed via phone. One use of this could be parents being away from their kids wanting to send them something to bring them joy or remind them that they are missed and loved could send an image to the display so the kids can see it. When it comes to global, cultural and social. We found that considering each one was not necessary at this time as they mainly served the same purpose in regards to this project as anyone is able to use our system except perhaps the blind they would have difficulty with tech. For economical we did consider how to make it cheaper and the best way we could come up with was to design our own circuit board with only the completely necessary components to ensure cost remained low

What three major course concepts you integrated into your design and how they contribute to the system. The first would be UART and DMA. UART was sufficient for sending text messages however once we decided to send images we had to use DMA. One use of this was that we were able to do other things while we waited for the whole image to load. Another reason was we had to send the data in chunks because it was so big making DMA really the only option. We used a display to display text and images. The final engineering principle we used was that of interrupts. we used UART receive interrupts to trigger DMA transfers to ensure that things ran efficiently.

3 Specifications

In this section I will outline how the system works briefly. This app connects your the Telegram app which you can download on your phone to the STM board. This is done by setting up an n8n workflow which helps with automation and connecting APIs very easily. This workflow can recognize Telegram messages including text, audio and images. It then interprets the users request into the needed command and saves it so that when we are ready for the commands we can access it. Going to our STM board we have an led and a display connected. They don't do anything until the press of the on board blue button. Once press it sends serial communication to the computer which my python script catches. It then checks what was sent to it and if the command was sent to check for commands that can be sent it does that. Once it connects to the cloud it gets the command and sends it back over serial communication to the STM board. At which point the STM board interprets the command and will either turn on or off the off board blue led or display an image. For the schematic see: 4. For the n8n workflow see Figure 3 7.

3.1 Operating Procedures

- Connect the STM board to the computer
- start up the python script
- open telegram

3.2 Known Limitations

- If trying to load more than one command at a time there will be a glitch. The first text item will be the one that is used while the others will be updated to their sent states however they will not have been sent in reality.

3.3 Parts List

- 1.8" ST7735 color GLCD with SPI controller
- Nucleo-L476RG board and USB cable
- several jumper wires
- laptop w python script to run
- phone to run telegram

4 Schematics

My final Project had several components a STM board, a display, a led, the cloud and telegram (phone app). See Figure 1 for the schematic of the wiring for this lab.

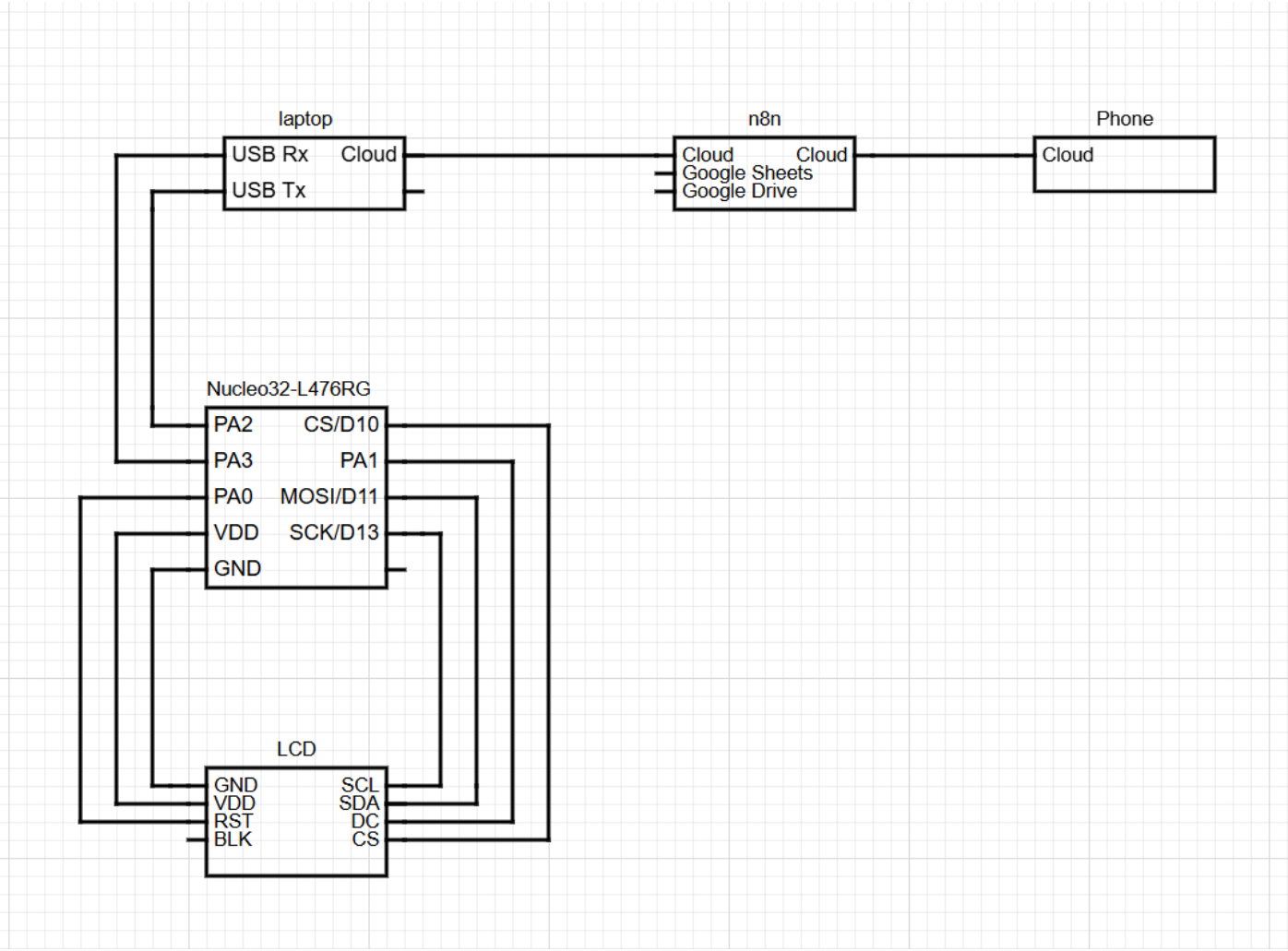

Figure 1: Completed schematic

5 Test Plan and Test Results

The goal of this test plan is to ensure that anyone is able to test the functionality and usefulness of my final project so long as they have the system built. If you would like to test this yourself ensure you following closely to the test scenarios they will not lead you astray. For a demo of what this project does please check out the following YouTube video: `https://www.youtube.com/watch?v=-reD3cRZxqs`

- Test Scenario #1
  - Step 1: on Telegram type a message including something about turning on the living room light.
  - Step 2: click on board blue button.
  - Expected result: text message was sent back to the user confirming the light will be turned on and blue led turns on.
  - Actual result: received the message and blue led turned on.
- Test Scenario #2
  - Step 1: on Telegram send an audio file asking to turn off the light.
  - Step 2: click on board blue button.
  - Expected result: receive a text message confirming the light will be turned off and the blue led should turn off.
  - Actual result: received text message and the blue led turned off.
- Test Scenario #3
  - Step 1: on Telegram send text without anything about the light nor living room light.
  - Step 2: click on board blue button.
  - Expected result: message received no changes on the board.
  - Actual result: message received no changed on the board were made.
- Test Scenario #4
  - Step 1: on Telegram send an audio file without anything about the light nor living room light.
  - Step 2: click on board blue button.
  - Expected result: message received no changed on the board.
  - Actual result: message received no changes were made on the board.
- Test Scenario #5
  - Step 1: on Telegram send an image.

  - Step 2: click on board blue button.
  - Expected result: the image will be displayed on the display.
  - Actual result: the image was displayed.

- Test Scenario #6
  - Step 1: on Telegram send text asking to turn on the living room light.
  - Step 2: on Telegram send audio file asking to turn off the living room light.
  - Step 3: on Telegram send an image.
  - Step 4: click on board blue button.
  - Expected result: The living room light should turn on while all other commands are received but not processed.
  - Actual result: the led turned on and the messages were received and ignored.

6 Code

The code provided in Section 6.1 demonstrates the use of UART, DMA, and Interrupts. Instead of stopping the processor for each byte of data received of the image we collect the data in the background using DMA. Then once we have all of the chunks of the image we set a flag to true signaling that our image is ready to be displayed. I have included the main.c and python script in a GitHub repository if you would like to see how this code is used in practice. Know though that you will have to copy the main.c code into a STM project as I was unable to load the project into GitHub at the time of creation of this report. You can find the repository here: `https://github.com/awesomedude33/ecen-260-final-project/tree/main`

6.1 Code selection from main.c

```
// This function is called automatically via Interrupt when DMA fills the
    buffer
void HAL_UART_RxCpltCallback(UART_HandleTypeDef *huart) {
    // Check if the interrupt came from the correct UART instance
    if (huart->Instance == USART1) { // Or USART2, etc.

        // 1. Process the "chunk" of data currently in the buffer
        // (e.g., Send this chunk to the display drawing function)
        DrawImageChunk(rx_buffer);

        // 2. Restart the DMA to listen for the next packet
        // This creates the continuous loop of receiving data
        HAL_UART_Receive_DMA(&huart1, rx_buffer, CHUNK_SIZE);
    }
}
```

7 Visuals

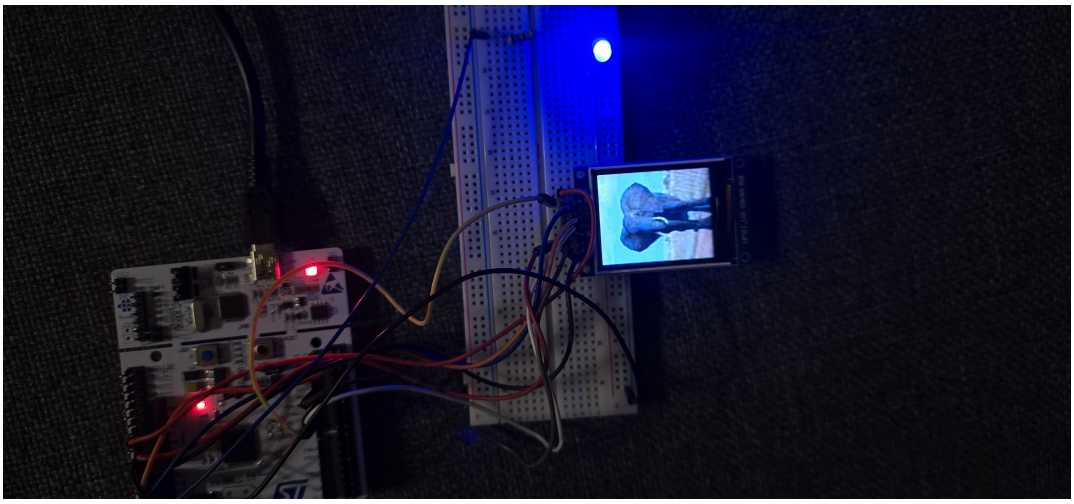

Figure 2: living room led on and image successfully loaded

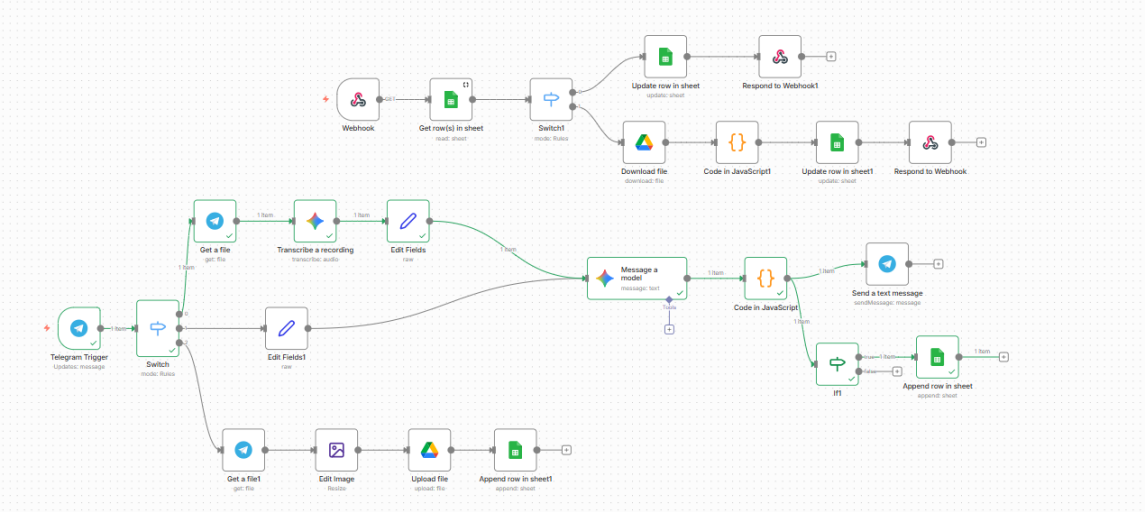

Figure 3: n8n workflow used to connect telegram to the python script via webhook

8 Conclusion

To conclude this project contained a lot of aspects. I first had to get the STM board able to write to an led and send data to a display. Then to get the onboard button to be a trigger that send data over serial communication to the laptop. We had a python script running on my computer checking for data on that serial channel. If that data was asking to check if there was any data ready for the STM board it would check then send it over. To get that data in a spot that could be accessible to the python script I made a n8n automation workflow that allow us to connect a few different APIs like Telegram to each other.

This lab taught me much. At first glance it seemed like a really ambitious project I would be hard pressed to accomplish on time. However once all of the parts were broken down it became rather easy the hard part was connecting all of the parts. One of the most useful things I learned was that of the DMA and how we can receive data in the background mean while the rest of our program continues. Then once we have all of the data we trigger some code. That is how I was able to get the images set up and working because there was no way to receive all of the data all at once without crashing the program so by using DMA we were able to work around that. In all this project has helped me understand how I could create a real world product that could be used as a home assistant.

References