ECE 445
Senior Design Laboratory
Project Proposal

Distributed Light System using Voice Recognition

Team 24

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1 Introduction

1.1 Problem

Traditional light switches can pose a significant problem when it comes to safety, particularly in the dark. Imagine returning home late at night, struggling to find the elusive switch in an unfamiliar room. Fumbling around in the pitch-black, you may inadvertently knock over objects, stub your toe against furniture, or collide with walls, transforming a simple task into a potential hazard. This inconvenience isn't limited to late-night scenarios; such as during emergencies, the reliance on manual switches can be precarious, leaving you in the dark when you need light the most. This problem is exasperated by the elderly or those with physical disabilities.

Even though smart switches represent a significant improvement in terms of convenience and control over traditional switches, they are not entirely immune to the challenges posed by darkness. Smart switches that lack voice recognition capabilities may still require some form of visual interaction, such as using a smartphone app. In the absence of voice commands, you might need to fumble for your phone or find it in the dark to access the app. This process, while more advanced than searching for a traditional switch, can still be cumbersome and potentially unsafe. Additionally, if your smartphone's battery is low or if the app malfunctions, you may find yourself in the same predicament as with a regular switch. So, while smart switches offer great benefits, they may not entirely eliminate the need for a backup lighting solution in situations where quick and reliable access to light is crucial.

1.2 Solution

We want to create a solution in which you can talk to a main station to turn lamps in different locations on and off. This way, one can easily access lights without needing to move around.

We want to create a base station ('main station box') containing a microphone and raspberry pi for a speech recognition system that will send signals to a circuit containing a lamp's power cable connected to a device ('lamp box') connected to the outlet in different parts of the house and use a relay to control the power from the outlet to the lamp. It will be made so that specific lights can be turned on throughout different parts in the house using voice commands. We will use Wifi to connect the main station box to each of the lamp boxes.

1.3 Visual Aid

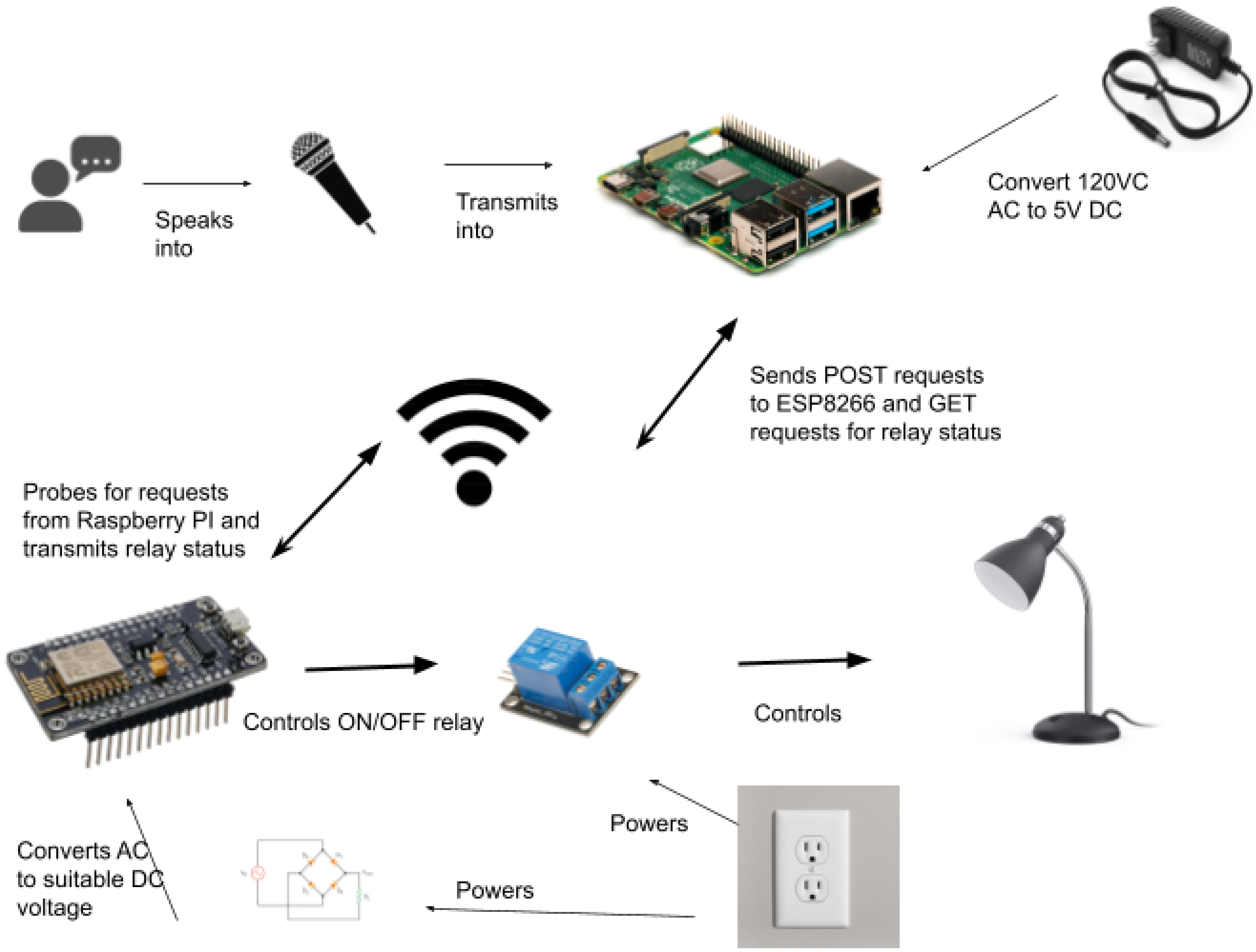

Figure 1: High Level Overview of our System

1.4 High Level Requirements:

1. Microphone is able to recognize 6 commands with 80% accuracy from a maximum of 1 ± 0.5 meter from the main station box. The commands will be "Outlet 1 On", "Outlet 1 Off", "Outlet 2 On", "Outlet 2 Off", "All Outlets On", and "All Outlets Off".
2. Supports up to two independent lamp boxes that can communicate with the main station box from a maximum of 5 ± 1 meters away.
3. Visual feedback from the lamp boxes will be displayed within 3 ± 2 seconds of the microphone picking up the command.

2 Design

2.1 Block Diagram:

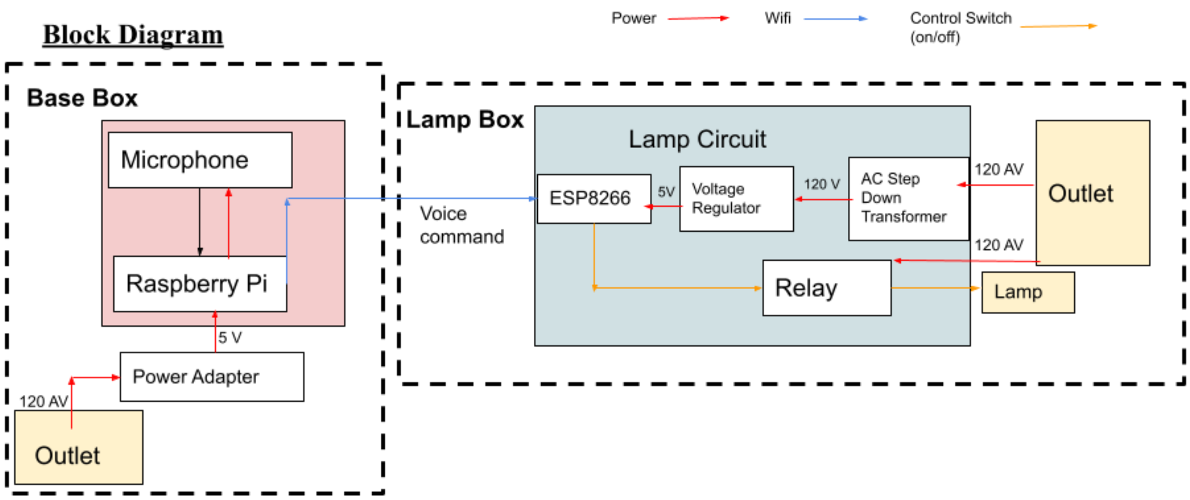

Figure 2: Block Diagram

2.2 Subsystem Overview

2.2.1 Main Station Box

The role of the main station is to perform 2 core functions: First, it needs to communicate with the other ESP8266 modules. It will need to probe the ESP8266 modules to receive current status on the relay, whether the relay is on or off. It will also need to be able to send data to the ESP8266 in order to perform a request. Second, the Raspberry Pi will house a microphone to pick up any voice commands, and then the microphone will send data to the Raspberry Pi in order for it to perform voice recognition. This will also contain the voice recognition method in the Raspberry Pi.

2.2.2 Voice Recognition Method

We will be using existing Raspberry Pi modules, such as the Google Speech API or the spchcat tool, to translate the sound data the microphone picks up into data the Raspberry Pi can work with. This software will be in the Raspberry Pi and will use the microphone from the main station box.

2.2.3 Lamp Box

The system will use the ESP8266 microcontroller to receive voice commands from the main station box. The lamp will be plugged into the lamp box. The lamp box is connected to an outlet which will power any necessary functions it needs to perform. It will also perform any necessary voltage conversion needed to power the ESP8266. Upon receiving a command, the microcontroller will activate or deactivate the relay, thereby controlling the electrical flow to the lamp, effectively turning it on or off.

2.3 Subsystem Requirements

2.3.1 Main Station Box

1. A power adapter will convert the 120V from the outlet into 5V to power the Raspberry Pi.
2. The Raspberry Pi will be connected to the microphone to receive voice commands and to power the microphone with 5V.
3. There will be a cooldown of 4 ± 1 seconds between each successful voice command recognized.
4. Our microphone will detect voices between 20dB to 60dB.
5. Send commands to ESP8266 using Wifi signals on the LAN network using 2.4 GHZ network

2.3.2 Voice Recognition

1. Perform voice recognition using Raspberry Pi and software modules such as espeak, google voice api, and/or spchcat, with 80% accuracy.
2. Can accurately perform voice recognition of the six commands (listed in high-level requirements) from three different voices.

2.3.3 Lamp Box

1. Lamp box will connect to a 120V outlet to power the lamp; this will be controlled by the relay to turn the connection from the outlet to the lamp on or off depending on the signal from the ESP8266.
2. Our transformer will convert the 120V power from the outlet from AC to DC.
3. Our voltage regulator will regulate the voltage to 5V to power the ESP8266.
4. The relay should be able to withstand fluctuations in voltages due to directly connecting to 120V mains voltage.

2.4 Tolerance Analysis

We need to make sure our voice recognition will recognize someone speaking at 60 dB, the normal volume for human conversations. Our microphone should be able to pick up commands issued from a meter away.

To find the intensity of a noise a certain distance away, we can use the sound density equation (eq 1) to see how loud a sound would be a certain distance away

$$\text{(eq. 1)}\ I = \frac{P}{4\pi r^2}$$

We can see that the sound level will decrease exponentially as we get further away. If we are given the intensity and distance away, we can use that as a reference to calculate the intensity of that same noise at a different distance away as well. (eq. 2)

$$\text{(eq. 2)}\ \frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

Decibels are a relative measure of sound intensity, so we can't plug them directly into eq 2. Instead we will use another equation (eq 3) to find the different intensity at different distances of the same sound.

$$\text{(eq. 3)}\ I(db)_2 = I(db)_1 - 20log(\frac{r_2}{r_1})$$

For example, if a voice's intensity is picked up as 60 dB from 1 cm away, then that would have an intensity of 20 dB when it is 1 m away. We need to make sure to make sure our microphone can pick up a range of sound intensities from 20dB to 60dB, so we either need a microphone that has a sensitivity that can operate from those ranges or we need an amplifier to match the decibel levels at different distances.

3 Ethics and Safety

In terms of ethics, we followed the IEEE Code of Ethics [1]. As engineers, we know that technologies have the ability to affect someone's life and we hold ourselves to the highest ethical standard when working professionally including but not limited to:

1. **Protect the safety and privacy of the public** [1]
   IEEE Code of Ethics states "to respect and protect the privacy of individuals." Our voice recognition system will not store any data offsite to ensure data privacy of individuals.
2. **Ensure that we treat each team member with respect and ensure that each person on the team follows the code** [1]
   In order to establish good communication between the team and TA, we established a Discord server to communicate meetings and deadlines. With our GitLab repository, we store a journal detailing each member's work to not only keep track of technical details but also attributing contributions correctly.
3. **Consistently learning and improving our abilities during the process** [1]
   The purpose of this class is to give us an opportunity to demonstrate the skills we have learned and apply them to a real world application. We will follow all required protocols, such as the CAD training, as well as consult our TAs and professors to ensure that requirements and deadlines are being met. We will also consistently ask for feedback to ensure that we are doing the best that we can.

In regards to safety regulations:

1. We will be connecting AC 120V directly to our circuit. To ensure safety, we will wear necessary equipment such as safety gloves to minimize risk of injury.
2. We will ensure that our project follows any relevant license terms of service for all software used.
3. When building any physical materials needed for our project, we will follow the required safety guidelines in the OpenLab to ensure the safety of everyone involved.

References

[1] IEEE. “”IEEE Code of Ethics”.” (2016), [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html (visited on 02/08/2020).