Classroom Occupancy and Noise Analytics

This project will include 2 ESP32s. Both ESP32 will have PIR (Passive InfraRed), temperature, and humidity sensor. They will be used to collect audio waveforms in the room. They will also measure the temperature and humidity of the environment. We will use a MAX4466 mic to detect noise in the classroom, a passive infrared sensor to detect the presence of people in the classroom, and humidity/temperature sensors as a secondary indicator of room occupancy.

The sensors will be used to create a noise profile that devices in the room can adjust to. Some potential applications for this include a TV being muted or decreased in sound as a teacher is speaking, or conversely, become attenuated to play sound over the background noise or classroom chatter. The creation of a noise profile will be done with Raspberry Pi and will use the ARM build of Reaper as its sound suite. This Raspberry Pi works as the aggregator.

The second Raspberry Pi will work as a decision node by taking all the inputs from the thermals, visuals, and noise profile of the room to adjust the noise management software with respect to the environmental goals. The devices will communicate with each other through MQTT in a mesh network configuration, connected to a generic access point. ML/AI will be used to determine the environment and the best way to process the sound to create a noise managed room. The closed loop follows the following lifecycle: sense, intelligence actuates, and corrects for feedback or noise until the speaker is heard. The two devices being actuated include the speaker and the display.

As an example of Reaper in action, Figure 1 shows a colorful spectral analysis of a noisy classroom where different colors represent intensities potentially suggesting presence of consonants and patterns in speech. Further analysis of the sound can be done through clustering to find additional groups. In Figure 2, a general noise profile is created when the noisy classroom is generated, showing peaks in frequency response graphs that can be trained as data points for a future ML/AI IoT device.

For the machine learning model, random forest regression works well with sound analysis according to various white papers. The model will train on sound sensed in simulated noisy environments, which will actuate the speaker to adjust its sound equalizer accordingly.

The project will require using a separate MAX4466 microphone module. This is included in the kit. Additionally, another microphone is recommended for this kit specialized for recording and voice recognition, the Fermion: I2S MEMS Microphone.

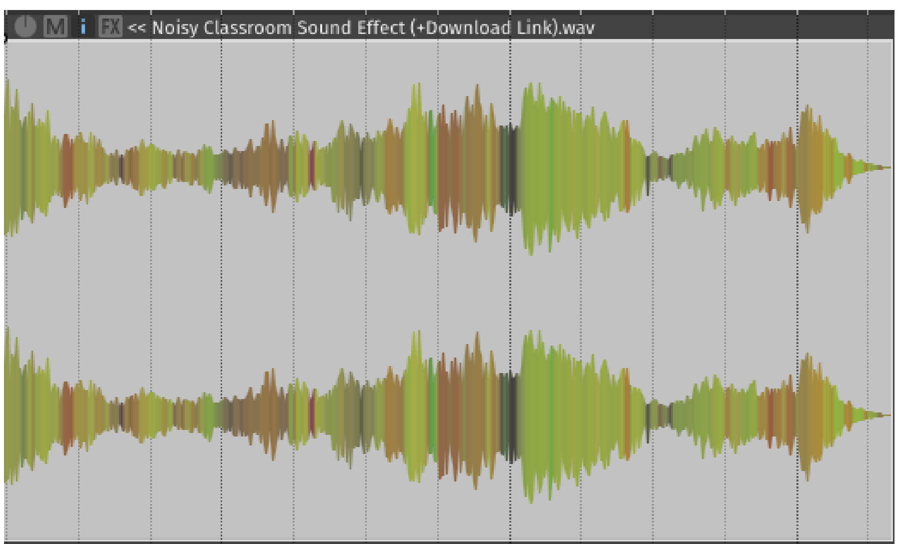

Figure 1: *Spectral waveform for a noisy classroom, in Reaper*

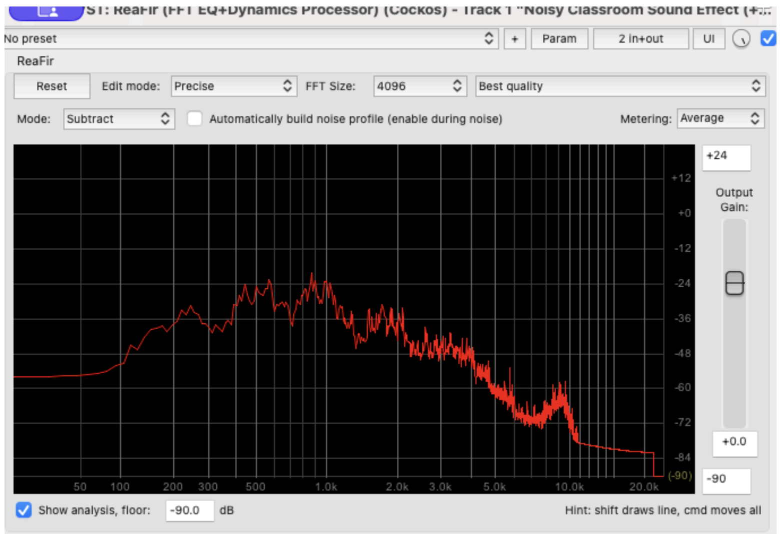

Figure 2: *Sound profile of a noisy classroom, in Reaper*

Table 1: *List of Materials*

Materials	Quantity	Cost
ESP32-WROOM-32	2	Included in Lab Kit
MAX4466	2	Included in Lab Kit
Jumper Wires	1 set with all types	Included in Lab Kit
Raspberry-Pi 4 Model B	2	Included in Lab Kit
HC-SR501	2	Included in Lab Kit
Dweii Loudspeaker JST-PH2.0	2	Included in Lab Kit
AHT10	2	Included in Lab Kit
Fermion: I2S MEMS Microphone	1	$4.99 on DigiKey
Raspberry Pi 27W USB-C PSU - Black	2	$11.99/Unit from MicroCenter

Table 2: Project Update for Project

Week #	Milestones
1	Get mic input
2	Create sound profile
3	Model predicts noisiness
4	Sound treatment
5	Final demonstration

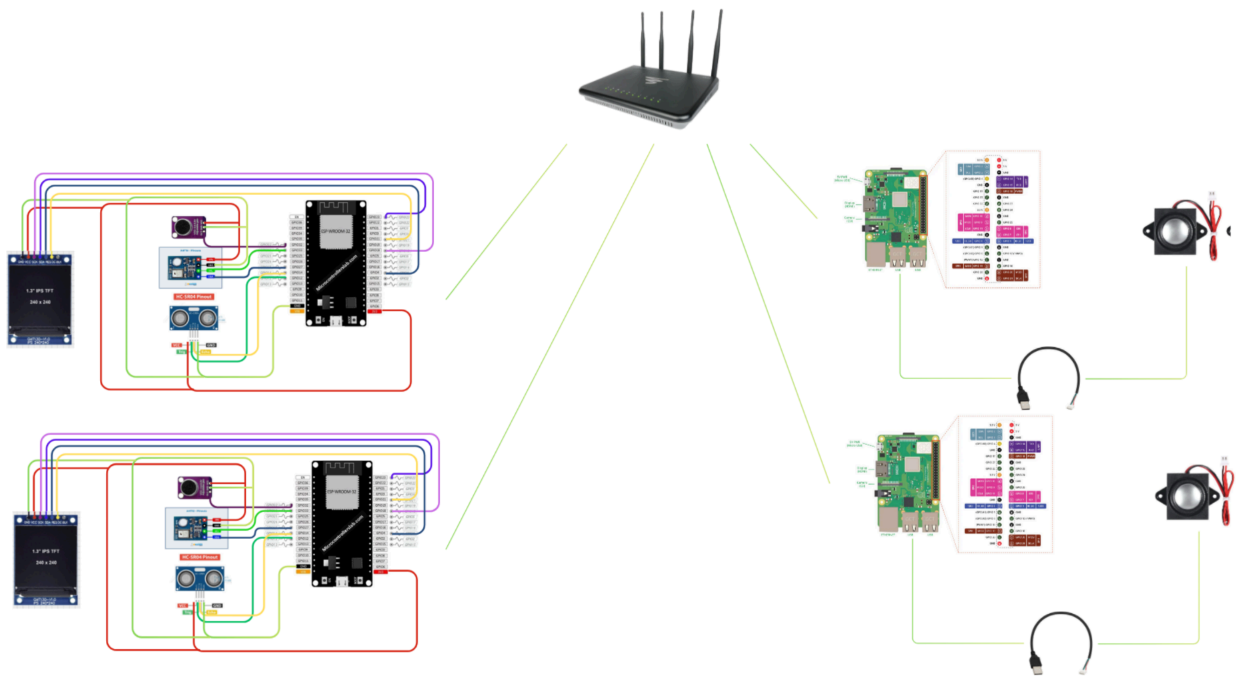

Figure 3: *Functional Block Diagram for our Project*

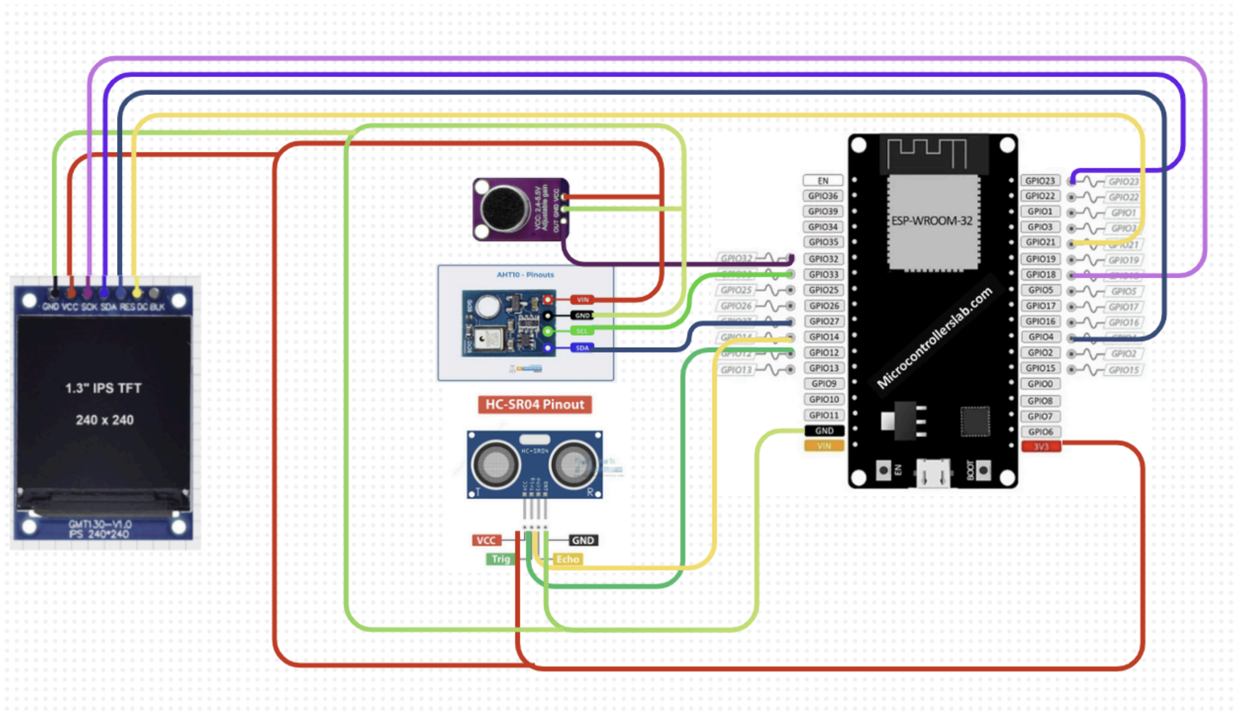

Figure 4: *Pin connections on ESP32*

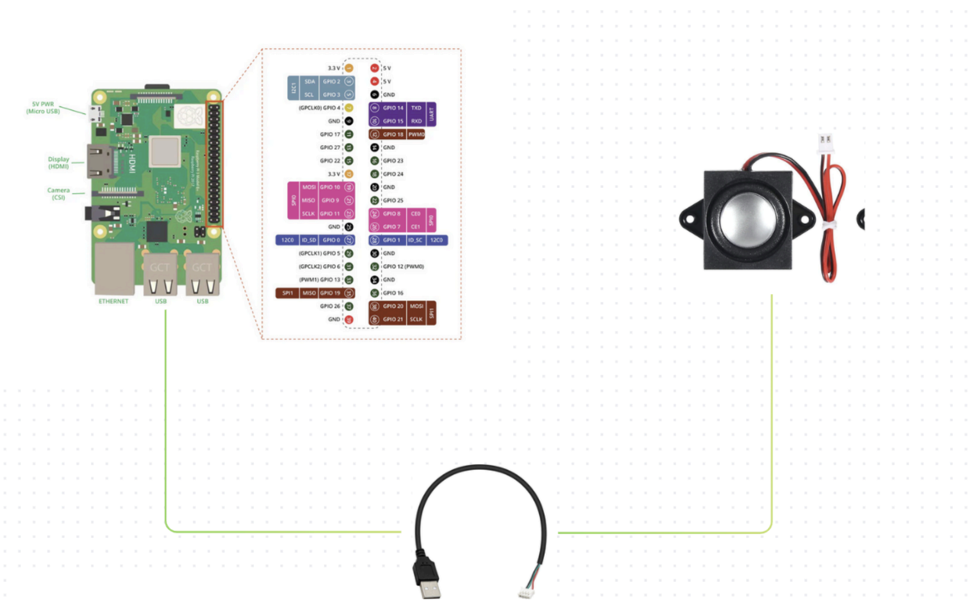

Figure 5: *Connections on Raspberry Pi*