EMBEDDED SYSTEMS PROJECT

Team number 37: NOISE/SOUND DETECTION AROUND CAMPUS

Arathy Rose (2018101042)

Prerna Gupta (2018101114)

Radhika Rao (2018111015)

NOISE/SOUND DETECTION AROUND CAMPUS

PROJECT DESCRIPTION

This project is expected to monitor and report the sound levels received at various places inhabited by the community and present it suitably.

As the IIITH campus is bounded by two main roads (CR Rao road and ISB road), this project determines the duration and days on which the traffic noise would be maximum and discuss ways to control it.

The campus is also quite close to the Gachibowli stadium. The noise from the stadium is also monitored and if it crosses a certain limit (during night times), the situation can be dealt with suitably.

USE CASE

PROJECT OBJECTIVE

- To design a circuit/IoT device that would measure the sound level(in decibels) and perform analytics on it. This tentatively involves recording the frequency and timing of the event when sound exceeds ambient sound level (above 85 dB).
- Using the above statistics, it is possible to create a noise map of the different areas in campus, which can be used in the future for allocating residents to less noise prone areas.
- Possible additional features include warning bulb, sending alerts on phone via WIFI, determining the cause of the noise (that is, whether the noise is produced by the traffic or some procession on the roads, or by some event occurring in the stadium, or the inhabitants themselves) etc.

SCOPE: CONSTRAINTS:

- The performance of the device would depend on server capacity, WIFI speed and gateway quality, and also on the amount of possible storage in the server
- The amount of processing that can be done on the sound depends on the quality of sound, which in turn, depends on the sensitivity of the sound sensor.
- The sensor might record incorrect values due to a sound produced really close to it.
  - Solution: Take the weighted average of the values recorded by 2/more sensors placed at the location of interest

WORKFLOW

- The sound sensor records the sound, converts it into voltage signals, and sends it to the board for processing via serial communication wires.
- The code uploaded on the board checks if the value reported by the sensor meets the range requirements, has an error, etc.
- If the sound detected is greater than the threshold value, then an alert is sent to the GPIO device (current plan is to just glow a bulb near the area of loud sound, and in case there is no improvement in the sound levels even after 30 minutes, a notice can be sent to the concerned authorities)
- If it passes the conditions, the data from the sensor is sent through a gateway to a cloud (virtual private server) .
- There is a one M2M connection between the board and server.
- At the server, further analytics would be done to monitor the noise at different times of the day and days of the week, and also to determine the source of the sound (extension of the project).

COMPONENTS

- ESP 32 NodeMCU Development Board
- Sound sensor with sound recording capabilities(extension to the project)
- A GPIO device that can alert in case the sound is either too high or low
- Gateway
- Server
- Other components required for making the circuit like the breadboard, resistors, wires, light bulbs, etc.

INPUT SIGNAL

- The sound sensor records the sound in the surroundings and converts it to a digital form using an ADC
- The sensor would consist of a microphone and an ADC on a chip
- The sound signal obtained would be sent to the board (via communication lines) for further processing and for sending to the server

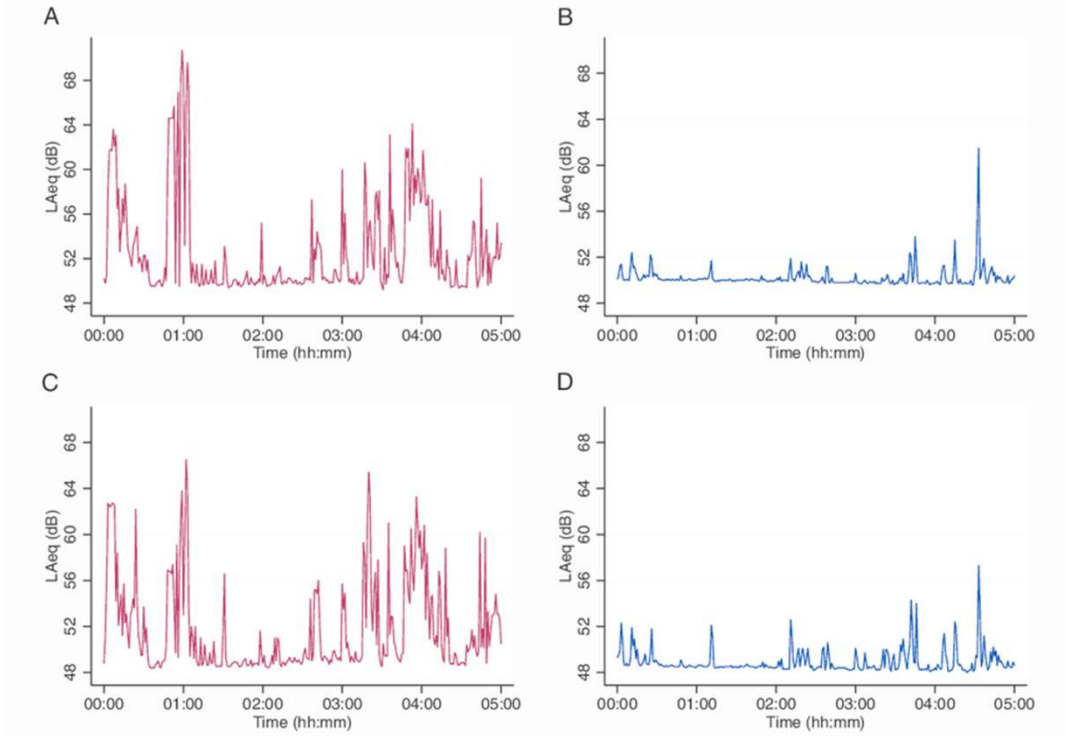
At the board..

- The code uploaded on the board processes the sound signal obtained from the sensor.
- It removes the Gaussian white noise (if the time latency in doing this is very high, then this processing can be pushed to the server side)
- It also checks the loudness of sound by calculating its dB value using the formula: $dB_m = 10 \log_{10}(10/6) + 20 \log_{10}(V)$. (Source: https://forum.arduino.cc/index.php?topic=534279.0)
- If the dB value reported is more than the threshold value, the board would send a high voltage signal to some GPIO device (like a light bulb in a common area) so as to alert the source of sound (in case it is a person/group of people) to stop the sound.
- If the value reported by the sensor is valid (that is, the value meets the range requirements) it is sent to the server via a gateway using Wi-Fi.

At the server…

- There is a one M2M connection between the board, the gateway and server.
- At the server, further analytics would be done to monitor the noise at different times of the day and days of the week, and also to determine the source of the sound (extension of the project).
- Sample analytics may include
  - A graph of the amplitude of sound with time of the day, given the day
  - A graph of the mean amplitude of sound for each time slot and day, for each month
  - A report on the number of incidents (Noise level becoming above the threshold value)
  - A noise map of the campus (extension of the project)
  - A 3D noise map of the hostels (due to the traffic, which cannot be controlled by the campus) that can be used in the future to design better noise-free and comfortable hostels.

Sample graph with the values



https://www.researchgate.net/figure/LAeq-values-of-measurement-1-M1-during-core-night-time-Shown-is-door-N1-D-upper_fig4_303707588

SAMPLE CODE FOR ANALYTICS

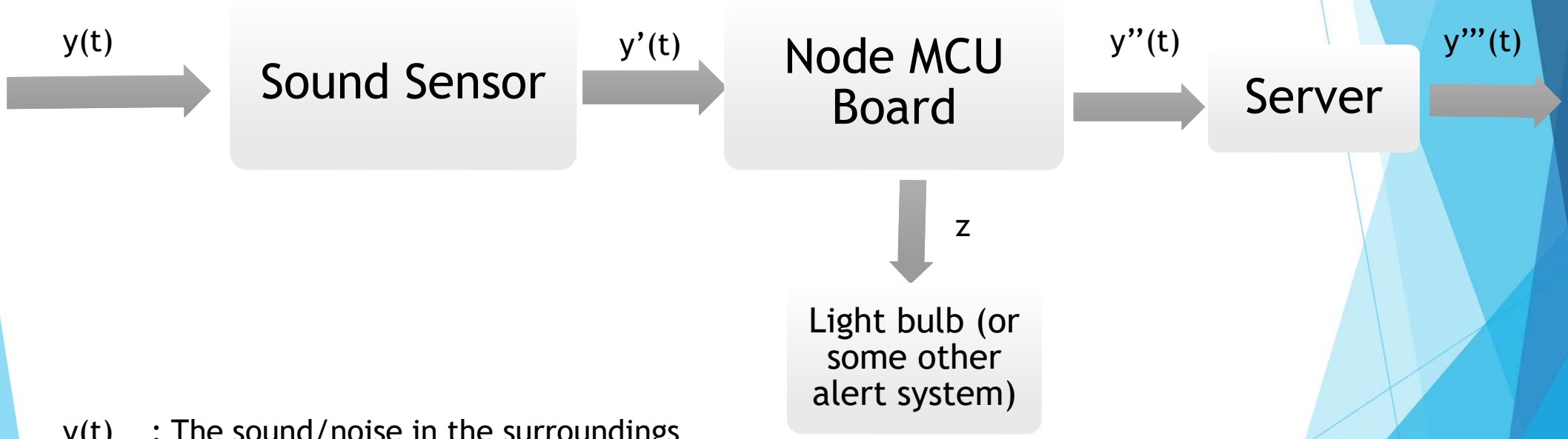
```
/*
Suppose the information obtained from the board is a packet consisting of the following details
1. Date and time stamp
2. dB value
3. Sound recording in the form of an array (data type: floating point)
4. Sensor/block number
*/
packet_list P [10000];
while(packet p = receive_from_board()):
        add_point_to_graph(date_time, dB_value)
        P.append(p)
display(all_statistics(packet_list))
```

END RESULT

With the data harvested from the sensor, we observe the following trends:

- Basic analytics on the noise disturbances (like the days/timing of these disturbances, when is it maximum, what is the mean noise level in the campus etc.)
- Tentative plan to send alerts to the concerned authorities when high noise levels occur for more than 5 minutes.
- Attempt to mitigate the noise by informing the concerned authorities
- Make a noise map of the campus to report the more noise prone areas, and suggest ways to mitigate it
- Make a 3D noise map of the hostels (by placing sensors on every floor of the hostel) and determine which floors are more noise prone.
  - Can be used in the future while designing hostels

BLOCK DIAGRAM



y(t) : The sound/noise in the surroundings
y'(t) : The sound recording
z(t) : A Boolean value that is 1 if the sound dB value is above a threshold and 0 otherwise
y''(t) : The sound recording with the additive white Gaussian noise removed. Any error in reading if present is also removed
y'''(t) : The statistical data of the sound produced

Each block explained

BLOCK	INPUT	OUTPUT	PROCESSING
Sound Sensor	Sound energy from the surroundings	Sound recording (in digital form)	Collects the sound energy from the surroundings using the mic and convert it to analog voltage signals using the ADC.
Node MCU Board	Sound recording (in digital form)	Loudness of the sound (in dB) Z Processed Sound recording	Obtain the decibel value of the sound recorded for real time feedback Sends a signal to an alert system if the noise exceeds the threshold Sends the recording with the noise removed to the server for processing
Alert System	Z	Light	A light bulb that glows if Z is 1 : used for the feedback mechanism

Each block explained…

BLOCK	INPUT	OUTPUT	PROCESSING
Server	Loudness of the sound (in dB) Processed Sound recording	Graph of the dB value and number of events with time and day and location Different statistical measurements (like mean loudness, max and min loudness per day, noisiest part of the day etc.) Places which are more prone to noise pollution than others	By placing the measurement units at different places within the campus and analysing their outputs graphically at the server end (using code written in some language like C), we can obtain the most noise prone areas within the campus. The number of the events (loudness being above the threshold) vs sensor location is also calculated. On an extension of the project, if the sound is above the threshold for a really long time (like 30 min), the sound is processed and the main reason of the sound can be determined. (traffic/students/stadium)

CIRCUIT DIAGRAM (will be drawn later)

THANK YOU!