NOISE MINIONS

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*Abstract:*Noise pollution is increasing in the daily life with the urbanization of the society. It has a big impact on the society disturbing mental peace and affecting the health of the society. The government is taking actions to reduce noise pollution. The objective is to help the government reach the goal by highlighting areas where noise pollution is high. The goal is to explore a simpler way to measure and calculate noise levels and display it easily on a heat map. The proposed system includes development of an android application which runs in the background and repetitively records audio snippets, measures the noise level of the audio snippet and uploads it to a server. There it is processed and displayed on a heat map. This map makes easier for the government bodies and the users to locate the noisy areas in the cities and do proper city planning and take proper actions to reduce noise pollution.
Index Terms - Crowd-sourced Noise Minions; Android application; Heat Map.

I.   INTRODUCTION

Noise is a sound that is very loud or irritating which causes disturbance. Hence noise means unwanted, disturbing, annoying sound which is caused by human activities. This includes vehicles and traffic on the roads, many industries, construction sites, and clubs. Unwanted noise can come from many sources.

If living in noisier environment, the following diseases have increased probability. They are sleep disorders, hearing impairment, stress, irritation, etc. Also the noise causes annoyance, irritation, sleep disturbance, stress and it leads to less concentration, less focus and irritation which causes poor performance at the workplace for students, employees, workers, etc. and at many more offices, workplaces and to the people. This also affects the growth and development of the country and also affects the world in a drastic way.

The government uses very expensive equipment to detect noise levels. Even though they are expensive they are handled in improper way which damages the equipment. To take the measurement of the noise levels government employees have to travel to that particular place and then record the readings. The reading measured may be inaccurate due to human error or instrumental error. Hence it is a very tedious task also the inaccuracy rate is high in measuring the noise levels. Replacing the old methodology by new technology makes the task easier, simpler and effortless.

The main function of the application is to run in the background on the smartphone, keep track of the surroundings and periodically record audio snippet, capturing the surrounding environmental noise at the current place at a current time wherever the smartphone is located. From the recorded audio file, the amount of noise level is measured and the data is sent to the server. With the help of the obtained data, the heat map is generated.

The word "Minion" means a follower who follows or serves someone more important. As we are using smartphones as a source of data which wander or travel around the cities and provide us the required data we referred those smartphones as "Minions". And as these smartphones measure the noise level, hence we titled them as "Noise Minions".

The main objective of Noise Minions is that the application will only locate the noisy areas. It only keeps track of the noise levels of the areas wherever the smartphones will travel and highlight the areas with more noise. With the obtained data the government can make proper city planning to reduce the noise pollution caused in the areas. The output of the noise minions is that it will only produce a heat map which displays the noise levels of the different areas. Using this data can contribute to reduce noise pollution by providing it to the government bodies.

II.   RESEARCH

In general, long or repeated exposure to sound at or above 85 decibels noise can cause hearing loss and the human ear can tolerate noise levels up to 85 dB and noise beyond that affects productivity and quality of life. The decibel levels of common sounds above 80 dB are considered as 'loud' while the decibel levels of common sounds between 100-125 dB are termed as 'uncomfortable' [1].

Central Pollution Control Board (CPCB) has laid down the permissible noise level in India for different areas. In industrial areas, the permissible limit is 75 dB for daytime and 70 dB at night. In commercial areas, it is 65 dB and 55 dB while in residential areas it is 55 dB and 45 dB during daytime and night respectively. Additionally, there is a category called 'silent zone' which includes areas that lie within 100 meters of the premises of schools, colleges, hospitals and courts. The permissible noise limit in this zone is 50 dB during the day and 40 dB during the night [1].
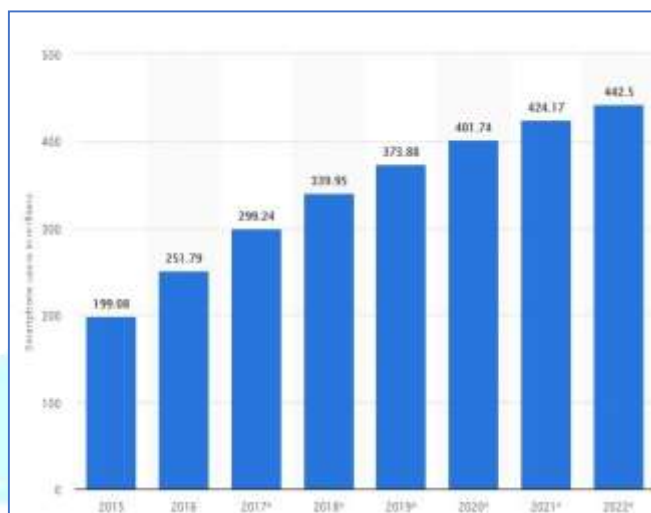

Fig. 1 - Number of smartphone users in India from 2015 to 2022 (in millions) *

According to a survey by Statista Research Department, the statistics shows the total number of mobile phone users worldwide from 2015 to 2022 given in the fig. 1. For 2017, the number of smartphone users in India is estimated to reach 299.24 million, with the number of smartphone users worldwide forecast to exceed 2.3 billion users by that time. It is expected that, by 2017, almost a third of the total global population will use a smartphone. The number of smartphone users worldwide is projected to amount to nearly 2.7 billion by 2019. Around 67% of the world population uses mobile phones. number of smartphone users worldwide is projected to amount to nearly 2.7 billion by 2019. It is expected that, by 2017, almost a third of the total global population will use a smartphone [2].

The data obtained is crowd-sourced data. It is obtained from people using smartphones who have installed this application in their smartphones. This is the crowd from which we will get the data. The number of people using the smartphones is very high and already sufficient as mentioned above. Hence the data is crowd-sourced and more the crowd more is the accuracy of data.
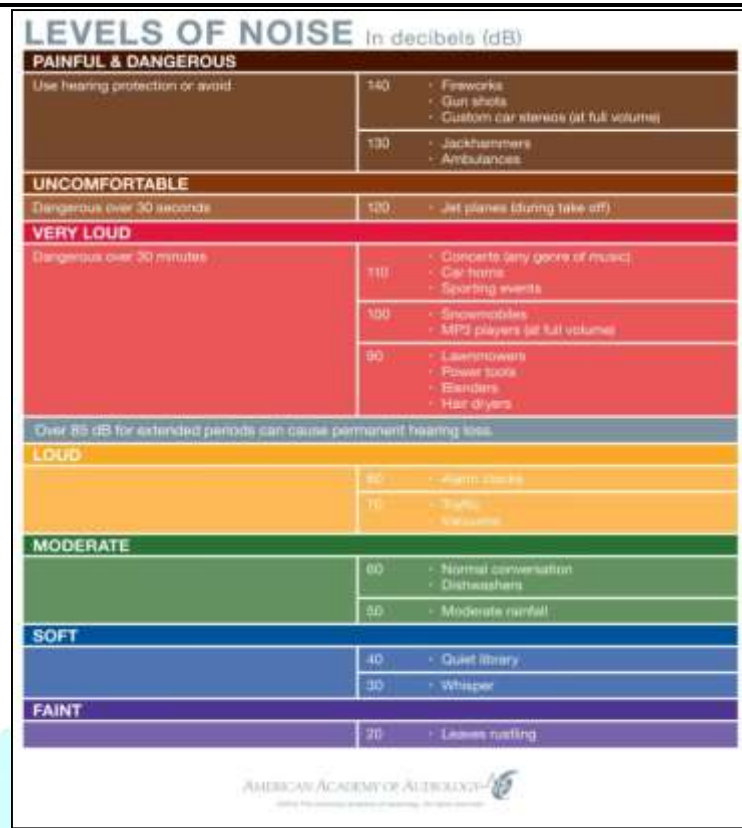
Fig. 2 - Levels of Noise in decibels (dB)

The figure 2 displays the levels of noise at different places. This data is obtained from the American Academy of Audiology [3]. It displays the amount of noise in decibels and explains how much amount of noise in decibels is suitable and how much amount of noise is uncomfortable. As shown in the fig. 2 noise above 85 decibels is very loud and above 100 decibels is much more uncomfortable.

III.   METHODOLOGY

An android application is used for collecting the data. This android application is the main source for collecting the data and generating the heat map. This data is crowdsourced i.e. the data is obtained from the android application users which travel through various areas of the cities. It requires that user should install this application on his/her android smartphone. Android device's microphone's sensitivity may be different from other device. Due to this, after installation user has to calibrate microphone. This application runs in background on users' smartphone. It records audio snippets using Microphone of device. Audio snippets are recorded after a certain fixed interval of time in the android application. The users need not to perform any task to record the audio snippet. Our mobile application records audio snippets autonomously. From the recorded audio snippet sound pressure level i.e. the noise intensity in decibels is measured. The Privacy policy is not violated as only decibel value is calculated and then audio recording is dumped. The calculation of decibel value is done by the formula stated below.

Sound pressure level (SPL) or acoustic pressure level is a logarithmic measure of the effective pressure of a sound relative to a reference value.Sound pressure level, denoted L_p and measured in dB, is defined as shown in Eq.(1)

$$L_p = 20\log_{10}(\frac{p}{p_0})\,\mathrm{dB} \qquad (1)$$

Where,

p is the root mean square sound pressure;
p_0 is the reference sound pressure;
1 Np is the neper;
1 B = (1/2 ln 10) Np is the bel;
1 dB = (1/20 ln 10) Np is the decibel.

The commonly used reference sound pressure in air is shown in Eq.(2)

$$p_0 = 20\,\mu\mathrm{Pa} \qquad (2)$$

which is often considered as the threshold of human hearing (roughly the sound of a mosquito flying 3 m away). The proper notations for sound pressure level using this reference are $L_{p/(20\ \mu Pa)}$ or L_p (re 20 μPa), but the suffix notations dB SPL, dB(SPL), dBSPL, or dB_{SPL} are very common, even if they are not accepted by the SI.[4] Using the above Sound Pressure Level formula sound intensity is calculated in

the android application itself.　After calculation, data is sent to the server which includes the sound intensity of the audio snippets, randomly generated device id which is unique for each device and GPS coordinates i.e. latitude and longitude. At the server, this data is stored in database along with date, time. The data generated from mobile devices are used for pattern generation. Using MapReduce technique, different patterns with respect to month, date, weekday, and time are produced. These patterns are stored in another table in database. The patterns are stored in noisepattern table and data according to date is stored in noisebydate table.

The Google map API for JavaScript is used for google map. The UI design contains two tabs History and Pattern. Both tabs contain different sliders of date, month, weekday and time. The user can select knob of any slider or combination of knobs of one or more sliders. The knobs of sliders of weekday and date can't be selected at a time because it can create conflict. When knob of any slider is not selected then the heatmap without any constraints of month, weekday, date and time is generated. The data request is made from the .jsp file of map on selection of knob of slider. The requested data is sent to .jsp file in form of JSON array. The data is sent through Ajax. The data when received by .jsp file, noise level values are assigned to the weights and heatmap layer is generated according to it.

IV.　　RESULTS AND DISCUSSION

The Noise Minions help us to identify the silent zones and the noise zones on the map. The accuracy of the map is only dependent upon the number of users of this application. More is the number of users of this application; more is the accuracy in a particular zone and vice versa. More are the number of active smartphones, more is the accuracy of the map. The resultant heatmap is shown in the following figures.
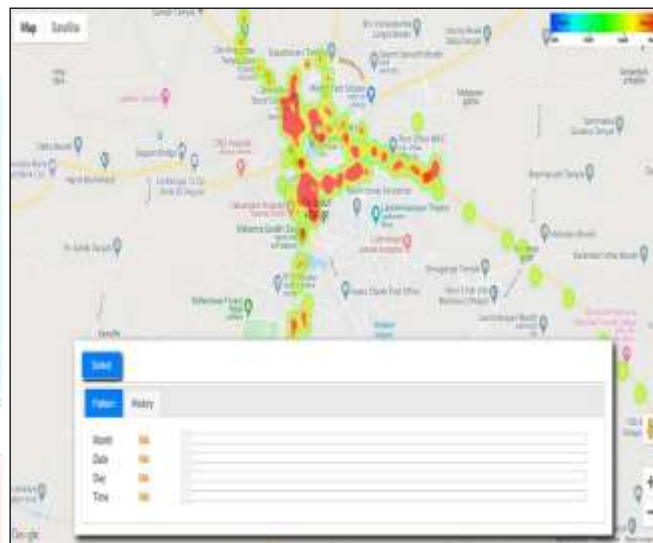

Fig 3 – Heatmap of Solapur City

Figure 3 shows the heatmap of Solapur city. As the Pattern tab is selected the heatmap is generated according to noisepattern table. The color bar on the right hand top corner describes the color for respective noise level from dark blue, green, yellow and at last red, from lowest to the highest noise level. The above map has color only on the locations at which the devices travel. Hence only few regions are colored and showing green yellow and red color. To get the noise pattern of the desired date, day, month or year, just select the respective knob on the sliders at the bottom of the map. Regions colored red describe that the noise in that particular area is high.
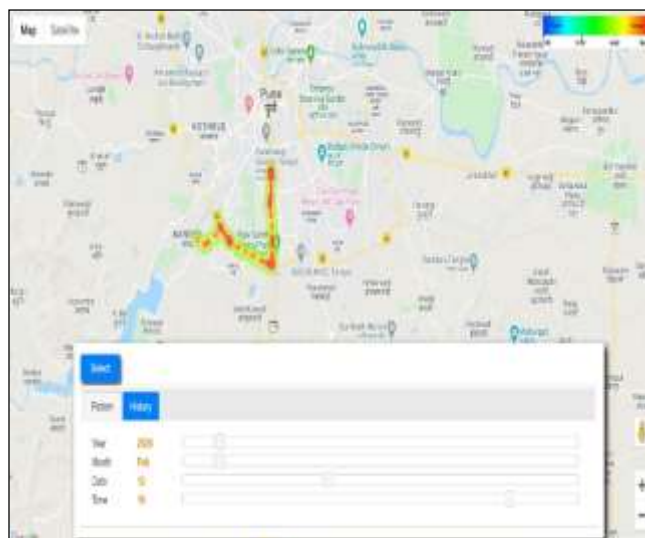

Fig. 4 – Heatmap of Pune City

Figure 4 shows the heatmap of Pune City. As the History tab is selected, the heatmap is generated according to noise by date table.

V. CONCLUSION

We can conclude that Noise Minions using smartphones is capable of highlighting the noisiest areas. As mentioned before, the results are not absolute, and might not be suitable to directly base decisions on, but they can help find the areas that need more focus. It requires an important precondition to be met, in order for it to be useful. It needs to have enough users attracted to the project to cover the target area with satisfying resolution (both temporal and spatial). This can be achieved by targeted campaigns, advertisements, etc.

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