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DETECTING AND MONITORING NOISE POLLUTION WITH ARDUINO UNO: AN INNOVATIVE APPROACH

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A B S T R A C T

Noise pollution is a serious environmental and health issue that affects millions of people around the world. In this comprehensive paper, we present a low-cost and easy-to-build noise detection system that can effectively measure the sound intensity in an environment and alert the user when it exceeds a certain threshold. The system is ingeniously composed of microphones connected to sound modules, an LCD display, and LEDs. The two strategically placed microphones capture sound waves, convert them into electrical signals, and feed them into the module. The sound sensor module, which is ingeniously based on the operational amplifier, compares the sound signal with a setpoint value and outputs a digital signal indicating whether the sound level is above or below the threshold. The LCD display shows the sound level in decibels, and an LED glow when the sound is too loud, providing a visual cue. The system can be powered by a 5V DC source or any other system with a USB port, and it can be easily calibrated using a potentiometer. We demonstrate the functionality and performance of our system across various sound environments, showcasing its versatility. We also discuss the potential applications and limitations of our system, along with some prospective improvements, offering a roadmap for future development.

1. INTRODUCTION

This project is an innovative application of sound detection sensor modules, which are designed to capture sounds from the surrounding environment. These sounds are then converted into decibel values, providing a quantitative measure of the noise level. If the system detects noise that exceeds a certain threshold, it initiates appropriate measures to alert the user. This is visually represented through the illumination of an LED. In the event of a louder sound, a second LED is activated, providing a clear and immediate visual indication of elevated noise levels.

The primary objective of this project is to develop a cost-effective and efficient noise detection system. This is achieved by leveraging readily available sensors and an Arduino UNO, a robust and versatile microcontroller.

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The resulting device is not only affordable but also highly effective in monitoring noise levels.

One of the key advantages of this system is its versatility. It can be seamlessly integrated into a wide range of settings, both commercial and non-commercial. For instance, it can be used in police stations to monitor noise levels in holding cells, in train stations to detect unusually loud sounds that could indicate a problem, in residential buildings to ensure a peaceful living environment, and in playground areas to monitor noise levels during playtime. Looking ahead, the project envisions incorporating seamless wireless connectivity. This would allow for flexible placement of the device without the constraints of a wired connection, making it even more versatile and user-friendly.

Additionally, there is potential for the implementation of a data monitoring feature. This feature would store sound level data over time, creating a comprehensive record of noise levels in the monitored environment. Analyzing this data would enable users to identify specific periods of noise pollution, facilitating informed decision-making and targeted interventions to mitigate noise-related issues.

A unique aspect of our project is the consideration of the direction of the noise. While many existing solutions account for the problem of noise pollution, they often overlook the importance of identifying the direction from which the noise is coming. Our project builds upon the concept of capturing sound from multiple sources and approximating the direction of the sound. This helps us determine which area is noisier and will enable the user to take subsequent measures. This feature is particularly useful in large spaces where noise may be coming from multiple directions.

Overall, this project represents a significant advancement in the field of noise detection and management. By combining advanced sensor technology with user-friendly design and functionality, it provides an effective solution to the growing problem of noise pollution. Whether it's used in a commercial setting or a residential area, this noise detection system promises to make our environments quieter and more peaceful.

2. LITERATURE SURVEY

2.1. Traffic noise source intensity emission model

In the field of environmental acoustics, a significant contribution has been made through the development of a model that predicts the intensity of noise emissions from traffic on wet asphalt roads (Cai et al., 2017). This innovative model accurately predicts the single vehicle pass-by sound pressure level on a wet asphalt road and is based on extensive traffic noise measurements, including various parameters such as speed, sound pressure level, and frequency spectrum. The validity of this model has been rigorously confirmed through a series of statistical tests and compared with existing models developed for dry asphalt roads, demonstrating its robustness and reliability. Furthermore, the literature provides a detailed analysis of the difference in sound pressure level and frequency characteristics between vehicle noise on wet and dry asphalt roads. It has been found that the presence of water on the road surface increases the sound pressure level at high and medium-high frequencies, while it decreases the sound pressure level at low and medium-low frequencies. As a result, the noise energy on a wet asphalt road is more concentrated at higher frequencies. These findings have far-reaching implications for traffic noise prediction and control, particularly in regions with high rainfall. The proposed model and the identified frequency characteristics can significantly enhance the accuracy of traffic noise prediction in these areas. Moreover, the insights gained from this research could be applied to noise control measures, such as the design of road surfaces and noise barriers, to mitigate the impact of traffic noise. This body of work represents a substantial advancement in our understanding of traffic noise emissions. It not only offers a more accurate model for noise prediction on wet roads but also provides a deeper understanding of the frequency characteristics of traffic noise. These insights open up promising avenues for future research and practical applications in the field of noise control and environmental acoustics.

2.2. Noise reduction by urban traffic management strategy

Numerous studies have been conducted to analyze strategies for reducing traffic noise in urban areas. Traffic noise is a significant concern in modern cities, contributing to environmental pollution and adversely affecting human health and well-being (Desarnaulds et al., 2004). As urban areas grow and traffic congestion worsens, finding effective solutions for mitigating noise has become increasingly important. These studies focus on evaluating various traffic management devices, such as speed bumps, road narrowing, crossroads, and reduced-speed zones, in terms of their ability to reduce or increase noise levels, typically measured in decibels (dB).

One common traffic management measure, speed reduction, has been shown to effectively decrease noise levels. Studies indicate that slower vehicle speeds reduce engine noise and tire friction, particularly in residential areas. Speed bumps and reduced-speed zones, for example, are often employed in areas where traffic noise is a problem. These devices force drivers to decelerate, which leads to a measurable reduction in noise emissions. Another widely used strategy is road narrowing, which reduces the width of traffic lanes, encouraging drivers to slow down and, as a result, lowering overall noise levels. Crossroads and roundabouts, although effective in improving traffic flow, show mixed results in terms of noise reduction. While they help reduce traffic congestion, the constant starting, stopping, and accelerating of vehicles can sometimes increase noise. However, well-designed crossroads and roundabouts, particularly when used in conjunction with speed reduction measures, have been found to reduce noise levels in certain scenarios.

Innovative traffic management strategies are also being explored. Selective traffic limitation is one such measure, where restrictions are placed on specific types of vehicles, particularly heavy-duty ones, during peak hours or in certain areas. Since larger vehicles contribute disproportionately to traffic noise, limiting their access can significantly lower noise levels in these regions. Low-noise driving techniques, such as promoting smoother driving behaviour and encouraging the use of quieter vehicles, have also emerged as promising approaches for noise reduction. Studies suggest that educating drivers on techniques like gradual acceleration and deceleration can reduce noise emissions, especially in congested urban areas. The quantitative synthesis of these studies provides valuable insights into how different traffic management options affect noise levels. The data show that noise reduction varies depending on the type of traffic management device used and the specific urban context. For example, while speed reduction measures are highly effective in residential areas, they may have limited impact in high-traffic commercial zones, where other strategies, such as selective traffic limitation, might be more suitable. These findings highlight the importance of context-specific approaches to traffic noise management. There is no one-size-fits-all solution; instead, a combination of measures tailored to the specific characteristics of an area is often necessary to achieve optimal noise reduction. This body of research provides a solid foundation for future traffic noise prediction and control efforts, offering practical guidance for urban planners and policymakers.

2.3. Traffic noise reduction strategy

In this comprehensive study, the authors (Lee et al., 2022) delve into the strategy of traffic noise reduction and its impact in the bustling city of Guangzhou, China. Utilising commercial software, they meticulously constructed a noise map based on field traffic flow measurements and geographic information system (GIS) data. The authors proposed the installation of L-shaped noise barriers along the main traffic arteries in areas with high noise levels. They then evaluated the noise compliance rate, the population exposure, and the group noise indicators before and after the implementation of these noise barriers. The results of their study showed that the noise barriers could significantly reduce the traffic noise level, the area under heavy noise pollution, and the population of highly annoyed people. In addition to their primary research, the authors also reviewed existing literature on the impact of traffic noise on human health, cognition, learning, and property values. They concluded by suggesting that noise mapping can serve as a valuable tool for urban planning and noise mitigation, particularly in large cities with dense populations. This study underscores the importance of strategic noise reduction measures in improving the quality of life in urban environments.

2.4. Double decision optimization model

The study (Huang et al., 2015) presents an innovative approach to addressing urban traffic noise by integrating environmental capacity constraints. The researchers develop a bi-level programming model that couples traffic noise calculation with traffic assignment to optimize traffic flow while controlling noise pollution. In the upper-level model, the goal is to maximize road network traffic flow without surpassing the noise capacity thresholds in different areas. At the lower level, traffic is distributed across the network based on user equilibrium, ensuring a realistic representation of traffic flow behaviour. The methodology is tested through a real-world case study in Shinan District, Qingdao, China. The authors evaluate the noise reduction effectiveness across various scenarios, revealing the potential of this approach for mitigating urban traffic noise. Their analysis underscores the importance of balancing traffic flow optimization with noise management, offering a novel solution to a growing urban issue.

Furthermore, the study explores the limitations of the proposed methodology, including assumptions made in noise modelling and traffic flow assignment. Despite these constraints, the research offers valuable insights for urban planners and policymakers seeking to reduce traffic noise while maintaining efficient transportation networks. The application of this methodology holds promise for cities facing similar challenges, potentially leading to more sustainable and liveable urban environments. This study thus marks a substantial advancement in the intersection of traffic management and environmental protection.

2.5. Mingliang method

The authors (Li et al., 2014) present a comprehensive study investigating the material properties and surface characteristics of thin layer surfacing, a widely used technique for reducing tyre–road noise. By employing advanced methodologies such as CT scanning, laser profilometry, and P–U free field technology, they conduct detailed measurements of mixture composition, surface texture, and sound absorption. Their research examines a range of influencing factors, including air voids content, aggregate size and shape, binder content, and degree of connectivity, to understand their effects on the texture and absorption properties of thin layer surfacing. The findings reveal that connected air voids content plays a pivotal role in determining sound absorption capabilities, while coarse aggregate size has a significant impact on surface texture. These insights emphasize the importance of material composition and structure in designing noise-reducing surfaces. To further enhance understanding, the authors develop regression equations that link the material properties to the surface characteristics, offering a quantitative method for predicting performance based on these variables. The study highlights the effectiveness of CT scanning and P–U free field technology as critical tools for analyzing the acoustic properties of road surfaces. These technologies provide a deeper understanding of how material properties affect noise reduction, representing an important contribution to the ongoing efforts in noise control research. By advancing knowledge in the field, the authors offer valuable guidance for future development of noise-reducing pavements, paving the way for more efficient solutions in reducing tyre–road noise. This research holds significant implications for the design of quieter, more sustainable transportation infrastructure.

2.6 Traffic noise and traffic light control model

In their study, the authors (Stoilova & Stoilov, 1998) investigate the potential of controlling traffic lights based on real-time traffic noise measurements. They introduce two optimization models—one for one-way intersections and another for two-way intersections—designed to minimize noise levels generated by idling vehicles at traffic signals. Both models employ a bi-level programming approach, integrating noise calculation and traffic assignment models to optimize signal timings for noise reduction. The methodology is tested through a case study in a congested urban area in Sofia, Bulgaria. Various scenarios are evaluated to assess the effectiveness of the models in reducing traffic noise, particularly during peak congestion periods. The results indicate that the noise-based signal optimization approach can outperform traditional queue-based models in lowering the noise levels produced by waiting vehicles. The authors also emphasize that by directly considering noise levels in traffic signal optimization, a more environmentally friendly approach to traffic management is achieved. In comparing their models with conventional queue-based systems, the authors highlight several advantages of the noise-driven approach. For instance, it not only reduces noise pollution but also has the potential to improve the overall urban soundscape. However, they also discuss the limitations, such as the need for accurate noise monitoring systems and the complexity of implementing such models in real-time traffic systems. Ultimately, the study demonstrates that traffic noise monitoring can serve as a valuable tool for optimizing traffic signals, contributing both to improved traffic flow and environmental protection. This research opens new avenues for integrating noise control into urban traffic management, paving the way for more sustainable and quieter cities.

2.7. Wong method

In this insightful study, the author (Wong et al., 2002) conducts a thorough analysis of the results of a community survey on environmental noise in Hong Kong. Utilising telephone interviews, data was collected from 2000 respondents residing in different districts. The survey revealed that noise pollution ranked as the third most concerning social issue, following air pollution and security. Traffic noise emerged as the primary source of noise annoyance, followed by construction noise and aircraft noise. Interestingly, the survey also revealed that while most people affected by noise suffered from distraction and sleep disturbance, they did not lodge complaints or take any action against the noise. The author also conducted supplementary surveys in areas previously affected by severe aircraft noise from the old airport, and observed a correlation between noise exposure and annoyance. The article concludes by suggesting that more noise control measures and public education are needed to improve the noise environment and enhance the quality of life in Hong Kong. This study underscores the importance of community engagement in addressing environmental issues and offers valuable insights for policymakers and urban planners.

2.8. Autonomous noise monitoring system

In this study, the authors (Mello & Fonseca, 2023) designed a noise monitoring system utilizing digital MEMS microphones, Arduino-compatible microcontrollers (Teensy and ESP32), and an Android application for seamless configuration and control. The system offers Bluetooth connectivity between the Android app and the microcontroller, allowing users to easily manage and control the setup. Once initiated, the noise monitoring system operates autonomously, recording noise data onto an SD card. This stored data can then be wirelessly retrieved and uploaded to an online spreadsheet, streamlining the process of noise data collection and analysis. To test the effectiveness of the system, it was deployed in an office environment for a one-hour period. During this trial, the system successfully recorded noise levels, and the data was efficiently retrieved and stored without any issues. The authors highlight the simplicity and flexibility of their system, which is easily portable and can be configured for different environments and noise monitoring requirements. This system has promising applications in indoor noise monitoring, particularly in offices or other enclosed environments where noise control is essential for productivity and comfort. Furthermore, the authors suggest that this setup can be used to evaluate the effectiveness of noise reduction or control projects, providing real-time data to assess improvements. The integration of wireless data transmission and compatibility with online platforms also makes it a cost-effective solution for long-term noise monitoring. The noise monitoring system represents a significant advancement in accessible and efficient noise assessment tools, particularly in indoor settings. It holds potential for widespread adoption in offices, homes, or other environments requiring noise control and monitoring.

2.9. Power efficient audio acquisition system

The authors (Fallis et al., 2020) presented a power-efficient design for a testbed developed for a smart microphone system. This system is particularly relevant for applications where energy conservation is crucial, such as in battery-powered devices used in remote monitoring or smart environments. At the core of the system is a microcontroller (Node MCU) and an Analog-to-Digital Converter (ADC), both of which are designed to dynamically switch between high and low power modes, depending on the surrounding environmental noise levels. This approach allows the system to optimize power consumption by only activating high-power components, when necessary, specifically during spikes in acoustic noise.

The key innovation in this design lies in its ability to balance performance with power efficiency. The smart microphone system operates in a low-power mode during periods of relative quiet and only switches to a high-power state when it detects a significant increase in noise. This is achieved through the microcontroller and ADC, which constantly monitor the acoustic environment. The system's ability to respond dynamically to noise spikes makes it ideal for environments where noise patterns are unpredictable, such as urban areas or industrial settings. To further enhance the power efficiency of the system, the authors evaluated three different wireless communication technologies: WIFI (2.4 GHz), Bluetooth Low Energy (BLE) 4.0, and Zigbee. These technologies were chosen for their varying power consumption profiles and transmission ranges, allowing the authors to assess which is most suitable for a power-sensitive application like the smart microphone system. WIFI, while offering higher data rates and greater range, typically consumes more power compared to BLE and Zigbee. In contrast, BLE 4.0 and Zigbee are known for their low power consumption, making them ideal for applications where battery life is critical. The authors tested each wireless technology under different conditions to determine their impact on the overall power consumption of the node.

One of the key findings from these tests was that, by optimizing the system's power management and utilizing low-power communication protocols, they were able to reduce the power consumption of a node by an impressive 97% when the testbed was in an idle state. This significant reduction in power usage highlights the effectiveness of the design in conserving energy during periods of inactivity, which is essential for extending the operational lifespan of the device in real-world applications. The ability to drastically reduce power consumption in idle mode is especially important for devices deployed in remote or difficult-to-access locations, where battery replacement or recharging may not be feasible on a frequent basis

2.10. Noise monitoring system using IOT

The authors (Marques & Pitarma, 2020) proposed a modular and scalable solution for enhancing health and well-being through the use of IoT (Internet of Things) and mobile computing technologies. Their objective was to develop a real-time monitoring system for improved acoustic comfort, with compatibility for mobile computing, data visualisation, analysis, and notifications.

The wireless solution is built around the ESP8266 microprocessor module, which supports the IEEE 802.11 b/g/n networking protocol. Data collected by the system is stored in a SQL Server database. To facilitate data access and user interaction, the authors developed a mobile application called 'iSoundMobile.' This approach offers advancements in installation and configuration, thanks to the utilisation of wireless communication technology.

2.11. Smart Audio Sensing for anomaly detection

The authors (Antonini et al., 2018) proposed a design framework for smart audio sensors able to record and pre-process raw audio streams, before wirelessly transmitting the computed audio features to a modular IoT gateway.

Teensy, is a versatile and powerful development platform for embedded projects compatible with the Arduino Environment, thanks to the Teensy Duino libraries. These libraries provide additional features and operations for real-time audio processing. This enables developers to create sound-reactive projects with reduced costs.

A noise detection algorithm was also built as a microservice which is capable of detecting audio anomalies in real-time. They adopted two different anomaly detection algorithms, namely Elliptic Envelope and Isolation Forest, that were purposely trained and deployed on an affordable IoT gateway to detect anomalous sound events happening in an office environment.

2.12. SNL based detection system

Authors (Rajagukguk & Sari, 2018) implemented a Sound Noise Level (SNL) detector to measure noise levels, using the Arduino Uno for data processing. The instrument functions as a noise detector, capable of displaying noise level notifications on an LCD indicator and through a beeper. The system utilises a condenser microphone and the LM567 IC op-amp to convert sinusoidal sound waves into AC signals, which are then interpreted by the Arduino Uno. The setup includes indicator LEDs, a sound beeper, and a 16x2 LCD screen. This SNL detector can accurately measure and display noise levels within a range of 50-100 dB and provides audiovisual notifications for detected noise levels.

3. NOISE DETECTION AND MONITORING MODEL

3.1. Experimental setup

The components employed in the project include a microcontroller, potentiometer, LCD, sound sensors, and LEDs. The components employed in the project include a microcontroller, potentiometer, LCD, sound sensors, and LEDs, as shown in Figure 1.

The microcontroller chosen to interface with all the sensors, LCD, and LEDs, and to execute the necessary operations, is the Arduino Uno R3. This selection is cost-effective for a project of this scale. The Arduino Uno R3 is highly versatile, facilitating rapid prototyping and iteration through various ideas and approaches.

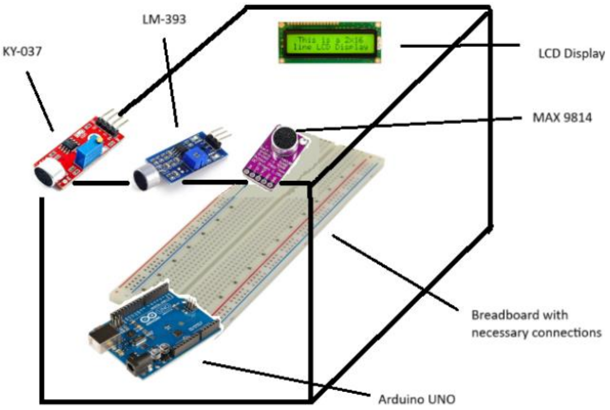

Figure 1. Experimental Setup

The external view of the experimental setup is shown in Figure 2. We use the JHD162A, a 16×2 LCD, to display the volume or sound-intensity level to the user whenever sound is detected in the surroundings. To regulate the contrast of the displayed text, a 10k-ohm potentiometer is employed. The connections to the data pins are established in parallel.

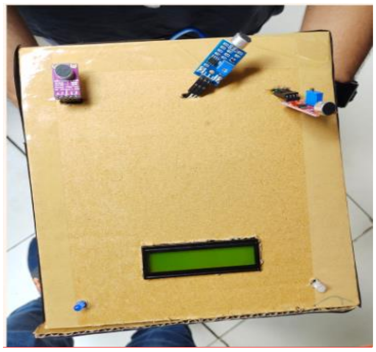

Figure 2. Experimental Setup

The sound sensors employed in the project encompass the CZN-15E, a mic-based sensor with the LM393 IC acting as a voltage comparator. Additionally, we use the MAX9814, a cost-effective, high-quality microphone amplifier featuring automatic gain control and a low-noise microphone bias. The KY-037 is also incorporated, functioning as a high-sensitivity sound detection module with both analog and digital inputs. It utilises a condenser microphone and an LM393 voltage comparator.
To provide visual indicators for the environmental state, we integrate two LEDs:

The blue LED signifies the presence of any sound.

The white LED signals a loud noise or disturbance.

3.2. Connections

The LCD requires four parallel data pins to display a character, so we connect digital pins 5, 4, 3, and 2 to the LCD pins D4 to D7, respectively. The Register Select (RS) and Enable (EN) pins are also connected to digital pins 12 and 8.

Furthermore, we connect digital pins 6 and 7 to the CZN-15E and KY-037, respectively. Analog pins A0 and A2 are linked to the KY-037 and the MAX9814, respectively. In addition, digital pins 10 and 8 are utilised to send signals to the blue and white LEDs, respectively.

3.3. Working

Before deploying the system directly, it's crucial to calibrate our sound sensors accurately. The sensors we are using, the KY-037 and the CZN-15E, come with an in-built potentiometer which controls the sensitivity of the microphone. We adjust the potentiometer based on the environment the system is situated in. For instance, in a noisy environment, we set the potentiometer to a relatively high sensitivity.

The CZN15E sensor plays a key role in our system as it continuously monitors the environment for any sound in a loop. When the digital pins of this sensor detect a sound in the environment, they go high. This triggers the counter, the blue LED, and the MAX9814, KY-037 to start sampling the sound. We then map the output of these sensors to a decibel value using the Sound Intensity Level (SIL) function. In this state, the LCD begins to display the decibel value. If the resulting value surpasses a certain threshold (which we have arrived at after conducting several tests), we classify the sound as noise, and consequently, the white LED is turned on. We continue sampling the audio until there is no sound or the counter reaches its maximum count.

With the strategic placement of two different sensors in two different directions, our system can also approximate the direction of the noise source. This feature can be particularly useful in pinpointing the origin of disturbances in a given environment. This capability enhances the system's effectiveness in managing noise pollution, making it a valuable tool for both residential and commercial settings.

3.4. Formula

$$I = \frac{\Delta p}{2\rho v_w} \quad (1)$$

I = Intensity of sound

$\Delta p =$ Pressure Variation

$\rho = Density\ of\ the\ medium = 1.1614\ \frac{kg}{m^3}\ (in\ air)$

$v_w = Speed\ of\ sound\ in\ the\ medium = 343\ \frac{m}{s}\ (in\ air)$

$$\beta = 10\ log(\frac{I}{I_0}) \quad (2)$$

$$\beta = Sound\ Intensity\ Level\ (dB)$$

$$I_0 = Reference\ Intensity = 10^{-12}\frac{W}{m^2}$$

4. RESULT

We conducted further tests on the noise-detection system in different environments, as shown in Figures 3 and 4, and analysed the outputs to refine the device's calibration.

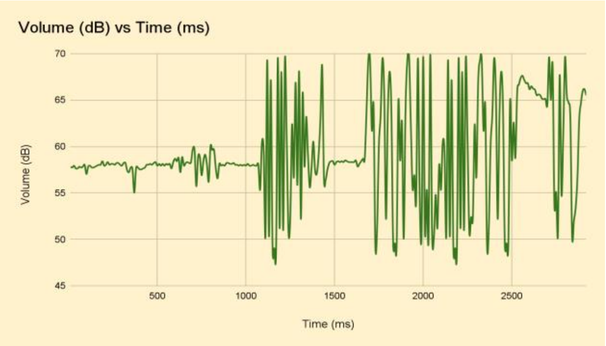

Figure 3. Volume vs Time graph-1 (Classroom)

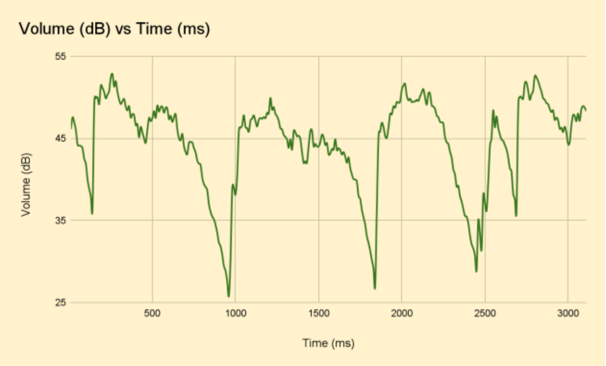

Figure 4. Volume vs Time graph-2 (Conversation)

The analysis of these graphs leads us to the following conclusions:

● Noise threshold value:

For the classroom environment, any value above 60 dB can be classified as noise (see Figure 3). For the conversation environment, the threshold is set at 45 dB (see Figure 4). It is important to note that "noise" is subjective and can be perceived differently based on the ambiance of the current setting.

● Silence:

From the Figure 4 graph (conversation), a dip in the decibel level can be seen between the peaks. These dips represent moments of relative silence or lower noise levels. Despite these quieter intervals, the system continues to monitor the sound due to the counter, allowing consistent tracking of environments with fluctuating noise levels.

These findings demonstrate the versatility and sensitivity of our noise detection system, making it a valuable tool for monitoring and managing noise pollution in various settings.

5. FUTURE SCOPE

The current system for monitoring noise pollution has demonstrated its effectiveness in detecting and displaying noise levels in real-time. However, there is significant potential for further development and enhancement to expand its applications and increase its overall impact.

One promising direction for future development involves integrating wireless connectivity, such as wi-fi or bluetooth. This would enable the system to be monitored remotely through a dedicated smartphone application or website, enhancing the system's portability and facilitating seamless data transfer between the monitoring device and the user.

Another potential upgrade is the incorporation of data logging features. This would allow the system to capture and record noise levels over extended periods, providing a comprehensive overview of noise pollution trends within a specific area. The analysis of this data could reveal patterns and trends that would otherwise remain unnoticed.

Furthermore, the integration of gps tagging could provide the ability to trace the origins of noise to precise locations. This, combined with the use of multiple interconnected devices, could allow for the use of triangulation techniques to isolate the source of the noise.

On the hardware front, the system could be enhanced by incorporating a mems directional microphone. This would enable the system to identify the predominant sources of noise in an environment with greater precision. Additionally, the system could be supplemented with other sensors, such as temperature and humidity sensors, allowing for the correlation of noise data with environmental conditions.

The inherent modularity of the system makes it well-suited for the seamless integration of these improvements. Beyond real-time monitoring, future iterations of the system could incorporate communication features to provide alerts and recommendations to users, helping them to mitigate their exposure to noise.

Integration with smartphones and wearable devices could enable personalised noise control and cancellation, offering a comprehensive and user-centric approach to managing noise pollution. This would not only help to minimise the impact of noise pollution on individuals but also contribute to broader efforts to address this significant environmental and public health issue.

6. CONCLUSION

This comprehensive paper meticulously examines a variety of engineering, planning, and regulatory strategies aimed at mitigating the widespread issue of noise pollution. The primary objective of this paper is to provide a detailed evaluation of these strategies, consolidating key research insights to facilitate informed decision-making in the field of noise pollution management. Through an exhaustive analysis of the quantitative impact of each intervention and the critical factors influencing their effectiveness, the paper aims to lay the groundwork for the development of customised, cost-effective solutions. These solutions are designed to cater to the unique needs of diverse environments, ranging from bustling urban centres to peaceful rural landscapes. By presenting a cost-effective and portable implementation of a noise monitoring system, which includes the ability to record noise in different directions, the paper aspires to guide the effective application of these measures. The ultimate goal is to ensure a significant reduction in the harmful effects of noise in one's surroundings, thereby enhancing the quality of life for individuals and communities. In conclusion, this paper provides the blueprint for an intelligent, customisable, and scalable noise monitoring platform. It not only addresses the current challenges in noise pollution management but also paves the way for future innovation, including potential advancements in sensor technology, data analysis techniques, and user interface design. The insights and recommendations presented in this paper serve as a valuable resource for researchers, policymakers, and practitioners in the field of environmental management, contributing significantly to the ongoing discourse on noise pollution mitigation.

References:

Antonini, M., Vecchio, M., Antonelli, F., Ducange, P., & Perera, C. (2018). Smart audio sensors in the internet of things edge for anomaly detection. *IEEE Access, 6,* 67594–67610. https://doi.org/10.1109/ACCESS.2018.2877523

Cai, M., Zhong, S., Wang, H., Chen, Y., & Zeng, W. (2017). Study of the traffic noise source intensity emission model and the frequency characteristics for a wet asphalt road. *Applied Acoustics, 123,* 55–63. https://doi.org/10.1016/j.apacoust.2017.03.006

Desarnaulds, V., Monay, G., & Carvalho, A. (2004). Noise reduction by urban traffic management. In *Proceedings of the ICA 2004.* Kyoto, Japan: The International Commission for Acoustics.

Fallis, E., Spachos, P., & Gregori, S. (2020). A power-efficient audio acquisition system for smart city applications. *Internet of Things, 9,* 100155. https://doi.org/10.1016/j.iot.2019.100155

Huang, B., Pan, Z., & Wang, G. (2015). A methodology to control urban traffic noise under the constraint of environmental capacity: A case study of a double-decision optimization model. *Transportation Research Part D: Transport and Environment, 41,* 257–270. https://doi.org/10.1016/j.trd.2015.09.026

Lee, H. M., Luo, W., Xie, J., & Lee, H. P. (2022). Traffic noise reduction strategy in a large city and an analysis of its effect. *Applied Sciences, 12*(12), 6027. https://doi.org/10.3390/app12126027

Li, M., van Keulen, W., van de Ven, M., Molenaar, A., & Tang, G. (2014). Investigation on material properties and surface characteristics related to tyre–road noise for thin layer surfacings. *Construction and Building Materials, 59,* 62–71. https://doi.org/10.1016/j.conbuildmat.2014.02.050

Marques, G., & Pitarma, R. (2020). A real-time noise monitoring system based on the internet of things for enhanced acoustic comfort and occupational health. *IEEE Access, 8,* 139741–139755. https://doi.org/10.1109/ACCESS.2020.3012919

Mello, F. R. D., & Fonseca, W. D. A. (2023, February). Autonomous noise monitoring system based on digital MEMS microphones: Development of a smartphone application for remote communication. In *INTER-NOISE and NOISE-CON Congress and Conference Proceedings* (Vol. 265, No. 2, pp. 5650–5661). Institute of Noise Control Engineering.

Rajagukguk, J., & Sari, N. E. (2018, March). Detection system of sound noise level (SNL) based on condenser microphone sensor. In *Journal of Physics: Conference Series* (Vol. 970, No. 1, p. 012025). IOP Publishing. https://doi.org/10.1088/1742-6596/970/1/012025

Stoilova, K., & Stoilov, T. (1998). Traffic noise and traffic light control. *Transportation Research Part D: Transport and Environment, 3*(6), 399–417. https://doi.org/ 10.1016/S1361-9209(98)00017-0.

Wong, C. L., Chau, W., & Wong, L. W. (2002). Environmental noise and community in Hong Kong. *Noise and Health, 4*(16), 65–73. https://doi.org/10.3397/IN_2022_0831

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