International Journal of Advanced Research and Publications
ISSN: 2456-9992

Enhancing Library Silence: NOISYFIER-SVM With Machine Learning Analysis

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Abstract: Noise remains a persistent concern in library environments, affecting both library patrons and facilitators alike. In response to this issue, the present research delved into a study aimed at addressing this isolated challenge. The primary objective of this investigation was to design and develop a novel device employing robotics and Arduino mechanisms to mitigate the negative impact of noise within library premises. The device's capabilities were thoroughly tested at Luis Y. Ferrer Jr. Senior High School, providing crucial insights into its effectiveness. The device's functionalities were calibrated according to meticulous planning and 3D design executed by the researchers. The Noisyfier incorporates a Sound Sensor Module capable of receiving and detecting sound intensity, while an alarm system with a buzzer is triggered when the sound level surpasses a predefined decibel limit. Precision testing was conducted to validate the device's performance, and a strong positive correlation with conventional decibel meters was observed. By utilizing MATLAB's Support Vector Machine (SVM) algorithm with a threshold value of 81.5 to discern the binary association between the 'device' and 'db meter,' the obtained correlation coefficient of 0.90476 and classification accuracy of 0.98556 showcase the device's robust performance in noise detection. The Noisyfier demonstrated remarkable efficacy as a noise monitoring device specifically tailored for library environments, and this claim is substantiated by rigorous statistical data and comprehensive analysis. To facilitate further research endeavors in this area, future researchers are encouraged to explore durable power sources and consider device modifications that enhance its portability and ease of use.

Keywords: Library Noise, Support Vector Machine, Noise, Noise Detector, and Notifying Device

1. Introduction

While studying, learners tend to find the proper space in order to maximize their learning experience. However, having the right place to learn and study does not mean that everyone can avoid unwanted factors which may affect one's ability to learn. Noise is one of the major issues addressed by students who want a quieter space for studying [3]. Another study emphasized that background noise, especially unintelligible background speech, proved to negatively affect one's cognitive performance [1]. For students to utilize their learning space, minimizing these unwanted noises should be done. One way is by studying in the library. Library provides its patrons the accessibility of resources and a good environment for learning [4].

Noise is a persistent source of concern in libraries which makes the library patrons and administrators seem concerned. Literature suggests that patrons adhere more to quiet policies when there is an event in the presence of an authoritative figure or a monitoring presence area [2]. Background noise level will range to 40-50 dBA for libraries outside the university or schools, but in schools the upper limit of the noise level is only 45 dBA. Thus, sound monitoring devices were utilized to address this issue.

The utilization of robotics in this field is an essential innovation to help mitigate the negative effects of noise in libraries to patrons' ability to focus. The automated noise detector and notifying device is equipped with a sound sensor and an alarm system using a buzzer. The device is fully automated, it doesn't need any supervision and it operates through the help of an energy source. The device is also equipped with a light crystal display (LCD) that provides and displays warning phrases when students exceed the acceptable noise level in a library. Aside from that, it is also attached with three different colored LEDs which correspond to three different levels of noise (soft, moderate, and loud). With all these mechanisms, noise within the library is closely monitored, and library patrons are reminded and refrained from making excessive noise without needing the supervision of librarians.

The library is the number one learning space option for students, keeping its environment noise-free will optimize their study concentration and learning motivation. Thus, the proponents developed a sound monitoring device that will help to reduce the noise in the library's learning environment, and create and maintain an ideally quiet place for students who want to focus on their study

2. Methods

2.1 Noise Detector and Notifying System

The noise detector and notifying device was made up of different components namely, microcontroller, sound sensor module, buzzer, liquid crystal display (LCD), and light-emitting diode (LED). Plywood was utilized in constructing the chassis since it has the ability to withstand moisture. Moreover, its versatility, durability, and affordability were also the factors that were considered in choosing it as the primary material to be used in constructing the chassis.

2.2 Sound Sensor Module

The development of the sound sensor module in this device was to detect existing sound or noise produced in the libraries. When the sound sensor module detects noises or sounds through sound intensity, it is converted into electric signals, through the aid of a microphone which converts the air to pressure vibration into an electrical signal which triggers the sound sensor module and alarm whenever it reaches the maximum noise level. With the help of a microphone that converts air to pressure vibration into an electrical signal in which when it reaches the maximum noise decibel it will trigger the sound sensor module and alarm.

The sound or noise detected in this module was automatically recorded to the device itself. The Sound sensor module was connected at the circuit wherein it detects sound or noise on its surroundings. The captured data from the sound sensor module was displayed to the LCD and on its designated signal pin where LED is input produced light depending on the noise level. However, once the sound or noise detected reaches the limit or the maximum level of

2.3 Alarm System

An electronic buzzer was utilized for the execution of functions of the device. An input voltage of 6 to 9V proved to be sufficient in making the device work without the risk of damaging its components. Furthermore, Noisyfier fulfilled its purpose by eliminating and minimizing as much unnecessary noise there is in libraries. This helps patrons in avoiding as much distraction as possible whenever they are in a library, maximizing their learning and studying experience.

The alarm system was programmed to detect noises with the utilization of the sound sensor. The device sends out a sound signal whenever there are noises detected that exceed the noise threshold. An intended delay was placed in detecting noises in order to avoid a loop with the transmission of the sound signal.

2.4 LCD and LED Display

A liquid crystal display (LCD) with an I2C Module and a screen dimension of 16 x 4, was used as the main display of the device. Also, the researcher utilized three varying colors of light-emitting diode (LED), these are red, blue, and yellow, and each has a corresponding function and indications.

In the construction of the device, the researchers visualized the device as a screen displaying as outputs of received sound waves as it reaches the integrated threshold limit. Therefore, they placed an LCD to project real-time values and indications to assess and inform users about the noise intensity received by the device. This enabled the device to be efficient and accessible for public use. On the other hand, the assistance of a LED as a blinking visual display simply captured the attention of users with regard to the intensity of noise circulating in the room, the color varies according to the value of noise.

This feature corresponds to LCD's function, wherein a particular-colored LED will light up if the device recognizes a frequency that corresponds to its programmed value. The signals will initially be passed through and received by the LCD which will be the first to display the output and corresponding notation. After this, it will immediately be transmitted to the LED which gives light and color notifications.

2.5 Power Supply Distribution Unit

Figure 4 presents the block diagram of the power supply distribution throughout the components, LED, LCD, buzzer, sound sensor, and microcontroller which is needed to be identified upon the construction of the noise detection and notifying device. The operating voltage of each component was presented in the diagram. Operating voltage is a level of voltage that has been set in order for the device to operate.

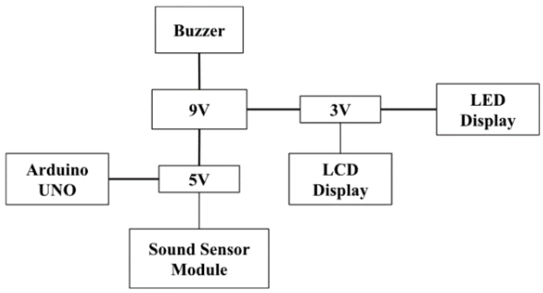

Figure 1. Block Diagram of the Power Distribution

2.6 Block Diagram

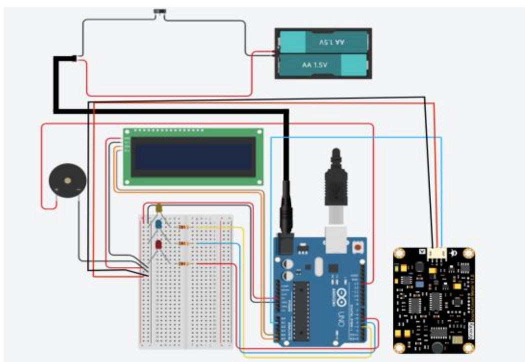

Figure 2. Block Diagram of the System

2.7 Software Development

The device utilized Arduino as the microcontroller. According to Urkude (2016), the Arduino microcontroller is an easy to use, powerful single board computer that earned recognition across the market and technological development and fields. Additionally, it is open-sourced, and the public has access to its development software. Thus, the proponents used Arduino Integrated Development Environment (IDE) as the software to edit and develop sketches for the code of the device. Moreover, the study of Chedup (2021) shows that Arduino IDE excels at complex and laborious program codes and functions. Given that the function of the device has a complex program flow, the proponents considered Arduino IDE.

The software utilizes the C++ language as it is more abundant with computers and modern technology (LaMeres, 2023). Additionally, such solutions make it possible to isolate low-level code fragments into separate program objects, focusing on their study and possible transformations into more reliable code (Legalov et al., 2022).

The code written as a sketch in Arduino IDE in C++ language was used as the function of the device itself. The code was written at this flow: As the noise enters the device, it will be measured by the sensor then if the noise reaches a certain threshold, the device will emit visual feedback, lights and alarms. In order to make this function, the proponents used Arduino IDE.

2.8 Installation Design

The device's exterior structure consisted of the sound sensor module, buzzer, LED, and LCD display. The sound sensor module detects noises within the set threshold and triggers the heavy-duty buzzer to produce a loud sound that serves as an alarm. The LCD displays the frequency perceived, as well as its equivalent noise level, while the LED's of three different colors light up if their equivalent value is met by the noise perceived. The whole system is controlled by Arduino UNO R3, and the Arduino IDE software is used to run the device.

Figure 3. Exterior Design of the Device

3. Results

The Library Noise Detector and Notifying Device was designed primarily to provide the real-time status of noise within a library and to remind students whenever they exceeded the maximum appropriate dBA inside the library. The main purpose of the system was to develop a low-cost automated alarm and notification system which could operate without the supervision of librarians or library facilitators.

The noise detector and notifying device was composed of Arduino Uno as its microcontroller and 4 main components such as the sound sensor module, buzzer, 16x4 LCD, and LEDs. The device was supplied and powered using the 3.7 V, 2200 mAh lithium-ion batteries.

Figure 4. Final Output of the Device

The sound sensor module was used to detect sound in its ADC value which is then converted into dB value with the help of programmed sketch in Arduino IDE. The Arduino UNO was used to store the program, and control and give commands to 1 input component which is the sound sensor module, and to the 3 output components which are the buzzer, LCD, and LEDs.

3.1 Preliminary Evaluation

During the preliminary evaluation, the device was positioned in close proximity to a decibel meter to ascertain the precision of its detected values in comparison. To assess the device's accuracy in detecting noise, the microphone sound sensor was configured to capture sound every 1 second, and the sensor's readings at each interval were subsequently compared to the measurements obtained from the decibel meter.

In the initial evaluation process of the device, the device's accuracy in detecting noise was assessed by the proponents in three (3) different library facilities within General Trias City. The device was positioned closely to a decibel meter, with both components to perceive real time sound in the library in which its detected values were put in comparison. The microphone sound sensor was configured to capture sound every 1 second where the readings at each interval were compared to the obtained values of the decibel meter.

Prior to examining the correlation between the measurements acquired by the device and the decibel meter, the proponents conducted a descriptive analysis of the average values within the two groups. The calculated mean of 61.3644 for the measurements obtained by the device indicates that, on average, the device recorded a value of approximately 61.3644. This mean value serves as a central point around which the individual measurements tend to cluster. On the other hand, the mean calculated from the dataset of the decibel meter was 61.9639. These results from the decibel meter's measurements indicates that most of the individual measurements from the decibel meter are centered around this value.

3.2 Final Evaluation

Figure 5. Evaluation of the device in various library settings

Table 1. Analyzing the Scores Obtained During the Evaluation Using Descriptive Analysis

	N	Minimum	Maximum	Mean	Std. Deviation
objstability	30	7.00	10.00	9.3333	.92227
effectiveness	10	6.00	10.00	8.9000	1.37032
accuracy	20	8.00	10.00	9.4500	.68633
sysstability	40	7.00	10.00	9.5500	.90441
Valid N (listwise)	10				

Through the utilization of descriptive statistics, the researchers were able to determine the performance of the device based on the following categories: object stability, effectiveness, accuracy, and system stability which was evaluated by different group of individuals including professionals, librarians, and students using likert scale distributed through questionnaires. Based on the results on the table 4 above, the recorded mean for the object stability of the device was at approximately 9.3, which means that the device is durable and possesses good quality.

Moreover, according to the data presented for the effectiveness of the device, the mean was significantly high at approximately 8.9. The results stated that the device was effective in mitigating noise in the library. Although the buzzer produces sound, it does not affect the result obtained due to the delays set in the program.

On the other hand, the average accuracy recorded by each evaluator was 9.45, which is close to 10. Consequently, the evaluators reached a consensus that the device demonstrates a high level of accuracy in collecting data, specifically in capturing sound waves and displaying them through three intended methods: LCD screen display, LED indicators, and buzzer notifications. Moreover, when compared to the decibel meter, the device received a significantly high average score, further indicating its remarkable precision.

For system stability, which includes the evaluation for the performance of the following components: LCD display, LED indicators, alarm system, and power source. Based on the table, system stability got a significantly high average score of 9.55, which has the highest calculated mean out of the 4 categories. This data shows that the aforementioned components exhibit outstanding performance.

4. SVM Algorithm

Support Vector Machine (SVM) was used for the final data analysis due to its capability to handle binary classification tasks with high accuracy and generalization. SVM is designed to handle binary classification tasks effectively, aiming to find the optimal hyperplane that best separates the two classes in the feature space. To compute the binary classification the following commands were used.

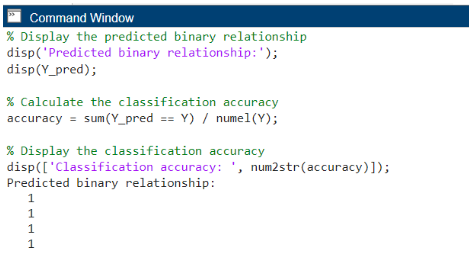

Figure 6. Command window for binary classification

We've set a threshold value of 81.5 to determine the binary relationship between 'device' and 'db meter' (1 for values greater than the threshold, 0 otherwise). We then use SVM classification to predict the binary relationship based on the 'device' data and calculate the classification accuracy to evaluate the model's performance. The final result for classification accuracy is 0.98556 with correlation coefficient of 0.90476 which states that the model accurately predicted the class labels for the 'db meter' and the 'device' with high precision, indicating a very reliable performance in noise detection.

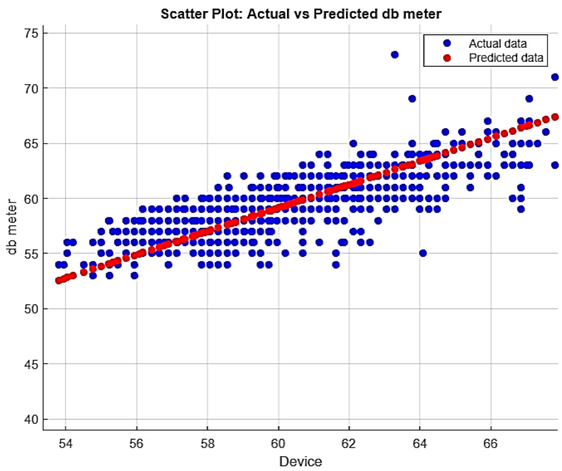

Figure 7. Scatter plot of the device and the predicted data

5. Conclusion

Noisyfier is a device that aids in mitigating the noise within the library premises. The creation of the device enabled the library patrons to focus better in their work and be disciplined in controlling their voice. The device was tested in three different libraries around General Trias City, Cavite, and the results of the testing process of the device was compared to a decibel meter which revealed that the level of precision of the detector has a strong positive correlation to the obtained data from the decibel meter. Furthermore, the device performance on the testing was also evaluated in three different categories: object stability, effectiveness, accuracy and system stability by different groups of individuals including professionals, librarians and students using likert scale distributed through a given questionnaire. The results revealed that the device exhibits outstanding performance in mitigating and controlling noise inside the library premises.

References

[1]. Braat-Eggen, E., Reinten, J., Hornikx, M., & Kohlrausch, A. (2021) The Effect of Background Noise on a "Studying for an Exam" Task in an Open-Plan Study Environment: A Laboratory Study. Front Built Environ, 7(687087). doi: 10.3389/fbuil.2021.687087

[2]. Lambert-Porter, R. (n.d.). Designing Libraries & Learning Centres for Good Acoustic.

[3]. Lange, J., Miller-Nesbitt, A. & Severson, S. (2016). Reducing noise in the academic library: the effectiveness of installing noise meters. Library Hi Tech, 34(1). 45-63. doi: 10.1108/LHT-04-2015-0034

[4]. Yelinek, K., & Bressler, D. (2013). The Perfect Storm: A Review of the Literature on Increased Noise Levels in Academic Libraries. College & Undergraduate Libraries, (20)1.

[5]. Zotoo, I., Liu, G., & Lu, Z. (2022). International Journal of Library and Information Science Studies, 8(1). 9–18. doi: 10.37745/ijliss.15/vol8no1pp.9-18