

Project Proposal James Frew

by James Frew

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A Device for Monitoring Noise Levels and Exposure Duration to Reduce Risk of Hearing Damage

James Frew
Student University of Wales Trinity St
David
Swansea, Wales
2108660@student.uwtsd.ac.uk

Preferred Supervisor – Nik Whitehead

I. INTRODUCTION

This project aims to address hearing damage caused by prolonged exposure to medium to high noise levels, focusing on both intensity and duration. Many people involved in music unknowingly expose themselves to harmful noise levels. This issue stems from two factors: the duration and intensity of noise exposure [1]. Existing noise monitoring devices are generally designed for industrial or outdoor use, making them bulky and expensive. The goal is to create an affordable, compact device suitable for personal use on a desk.

II. EXPECTED DELIVERABLES

At the conclusion of the project, the deliverable will be a physical device that, when connected to a computer, monitors indoor noise levels and tracks the duration of the user's exposure. By recording these noise levels and calculating the continuing sound exposure over time, the system will determine when the combination of noise intensity and exposure duration reaches a level that could start causing hearing damage. It will warn the user before harmful exposure occurs. This compact device will sit on a desk and offer a more affordable option than existing solutions.

III. RECENT ADVANCEMENTS

Advancements in noise monitoring have slowed due to the field's niche status. Current technology primarily uses MEMS microphones, the most common type for noise monitoring, which are the most common type for noise level monitoring. Less common devices include the OS-11 Ambient Air Quality & Noise Level Monitoring system and pre-polarized microphones like those in the Casella model CEL-63x [2]. Development in indoor noise monitoring is limited; most advancements are focused on environmental applications, such as IoT sensor networks for smart city monitoring and AI noise source identification [3].

IV. BACKGROUND

Noise-induced hearing damage is a growing problem affecting more people, especially young individuals and musicians [4]. While people generally understand that loud noises cause hearing damage [5] [6] [7], they often overlook that exposure to sounds they don't find particularly loud can still be harmful if the exposure is prolonged [8]. Therefore, it's important for those regularly exposed to such noise

levels to monitor not only the intensity but also the duration of their exposure.

There are several existing noise level monitoring devices available [9] [10] [11] [12]. However, these systems aren't designed for regular people's use - they are almost exclusively intended for industrial applications or outdoor monitoring. The few devices built for other environments typically don't monitor exposure duration. Furthermore, existing devices are extremely expensive, limiting accessibility. They are also bulky and not suited to sit on a user's desk near their speakers or instruments.

This creates a gap where affordable, compact devices that monitor cumulative noise exposure aren't readily available. Musicians and studio workers would greatly benefit from a more accessible device, especially with the increasing number of people who write music at home, have their own studios, and expose themselves to long hours of noise while mixing music.

The project therefore aims to create a compact and affordable system to monitor noise levels and exposure times. A user-friendly and convenient design can help users act by warning them before their exposure time reaches dangerous levels. With the included software, users will have significant control over how their device functions, including the ability to inform the system about the level of hearing protection being used. The system will then adjust the safe exposure time to accommodate the actual noise levels experienced by the user.

V. PROBLEM STATEMENT

There is currently a severe lack of affordable, compact devices that monitor both noise levels and the duration of exposure, leaving individuals like musicians at risk of noise-induced hearing loss. Therefore, developing a user-friendly device that tracks prolonged noise exposure is necessary to combat hearing loss.

VI. AIM AND OBJECTIVES

The project's aim is: "To design and develop a device that accurately monitors average noise levels in an environment, providing real-time protection for users against long-term exposure to harmful sound levels".

The research objectives are:

- To explore and document the scientific principles and engineering methods behind noise detection systems, ensuring a comprehensive understanding for system development

- To critically analyse the functionality of existing noise detection devices, identifying strengths and weaknesses that will inform the design of the new system
- To design and develop the hardware and software components of the noise monitoring system, ensuring that all features align with performance requirements and user needs
- To rigorously test and validate the performance and accuracy of the constructed system by comparing its output against industry standards for noise detection

VII. RESEARCH METHODOLOGY

A. Research Philosophy

The project adopts a positivist research philosophy, emphasizing objective measurements and empirical data essential for accurately assessing sound levels and exposure durations. Since sound can be scientifically quantified and thresholds for noise-induced hearing damage are well-established [13], positivism provides a suitable framework for focusing on quantifiable data without subjective bias, ensuring reliable and universally applicable findings. Additionally, a small element of interpretivism is included during testing to gather user's subjective experiences regarding design aspects like appearance, size, weight, and convenience. This combination leads to a comprehensive evaluation addressing both the device's functional effectiveness and usability.

B. Research Approach

Aligned with positivism, the project employs a deductive reasoning approach, starting with established theories about sound measurement and hearing damage. Applying these theories allows for the development and testing of the device based on scientific concepts, enhancing its reliability and effectiveness. While inductive reasoning plays a minor role in interpreting qualitative feedback from user testing, the core technical aspects rely on deductive reasoning, ensuring conclusions are based on existing theories rather than new observations.

C. Research Strategy

The project utilizes two primary strategies: development and experimentation. Development is crucial for creating a practical application that accurately monitors environmental noise. By assembling hardware and developing software to process collected data, the project employs the Feature-Driven Development (FDD) method, which allows incremental building and ensures each feature functions correctly and meets technical standards. This aligns with the emphasis on objective, measurable outcomes and facilitates efficient progress. Experimentation tests the device under various conditions to verify functionality and accuracy. Systematically testing the device's ability to monitor noise levels and detect harmful exposure thresholds ensures it is reliable and effective, enabling adjustments and improvements based on data collected during testing.

VIII. DATA COLLECTION METHODS

For the first objective - exploring the principles behind noise detection systems - data will be gathered through a literature review of academic papers, scientific studies, and technical documents. This will establish the foundational knowledge necessary for designing and developing the system.

The second objective - analysing existing noise detection systems - involves examining technical specifications, performance metrics, and use cases of current systems. This analysis will identify their strengths and weaknesses, guiding the creation of a more user-friendly solution.

For the third objective - developing the software and hardware - the feature-driven development method will be employed. Data will be collected at each development stage to identify functioning components and debug issues, ensuring each feature works correctly and allowing for incremental improvements.

The final objective - validating the system's performance and accuracy - will use multiple data collection methods. Noise levels will be measured and compared against other devices to evaluate accuracy. The system's ability to calculate average noise levels will be tested to ensure it provides appropriate warnings. Usability testing will gather feedback on design, user interface, and overall user experience, ensuring the system is accurate, meets safety standards, and is user-friendly.

IX. RISKS

Inaccurate noise measurements may lead to incorrect warnings and potential hearing damage. To mitigate this, we will conduct multiple accuracy tests and perform rigorous testing to address development bugs. Informing users that the device is intended for indoor use mitigates risks from improper application.

A. Ethical Issues

Privacy is crucial; only decibel levels will be captured, not actual audio, and users will be informed via clear guidelines. User safety is critical - mitigation includes thorough testing and disclaimers that the device is a supplementary tool. Testing procedures will ensure no harm comes to participants.

B. Legal Issues

The device must comply with relevant standards, such as those set by the Health and Safety Executive (HSE). Product liability is a concern - if the device malfunctions and causes hearing damage, there could be legal repercussions. Mitigation involves thorough testing and including legal disclaimers regarding the device's use.

X. RESULT EVALUATION

Quantitative data will be analysed by comparing the device's noise measurements with reference devices using descriptive statistics like mean and standard deviation. The system's ability to calculate average noise levels and estimate time until hearing damage will also be tested using these methods.

Qualitative data from user feedback will be collected through interviews to identify the system's strengths and

weaknesses. A thematic analysis will be conducted to uncover recurring patterns or themes in the feedback.

XI. RESOURCES

Essential hardware includes an accurate microphone like the INMP441 MEMS microphone and the Adafruit Feather M4 Express microcontroller. Both operate at 3.3V and are relatively inexpensive. The M4 Express features a micro-USB port and integrated I2S support, simplifying integration. Additional items needed are jumper cables, soldering equipment, a 3D printer for the casing, a micro-USB cable, and a computer for programming and design. A professional-grade dB monitor is necessary for testing. Required software includes the Arduino IDE, Python, and CAD software. Volunteers will also be needed to test the device.

XII. PROJECT PLANNING

A simplified Gantt chart outlines the basic project plan Fig A.1. The design and development stage comprises three sections: design, development, and initial testing, aiming to have a working prototype ready for the interim viva. During the testing and validation phase, the device will be given to trusted individuals who play instruments or work in loud indoor environments. Their feedback will be used to refine and improve the device. The finalization phase focuses on last-minute adjustments and completing the final report. Lastly, the presentation and exhibition preparation phase is dedicated to preparing for the final viva and creating the exhibition poster.

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XIV .APPENDIX

Fig. A.1. Gantt chart illustrating the project schedule:

	22nd Oct 2024	16/17th Jan 2025	29th Apr 2025	9th May 2025
Design and Development				
Testing and Validation				
Finalisation				
Presentation and Exhibition Preparation				

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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Have sent email with feedback as Nik provided handwritten pdf.

82/100

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