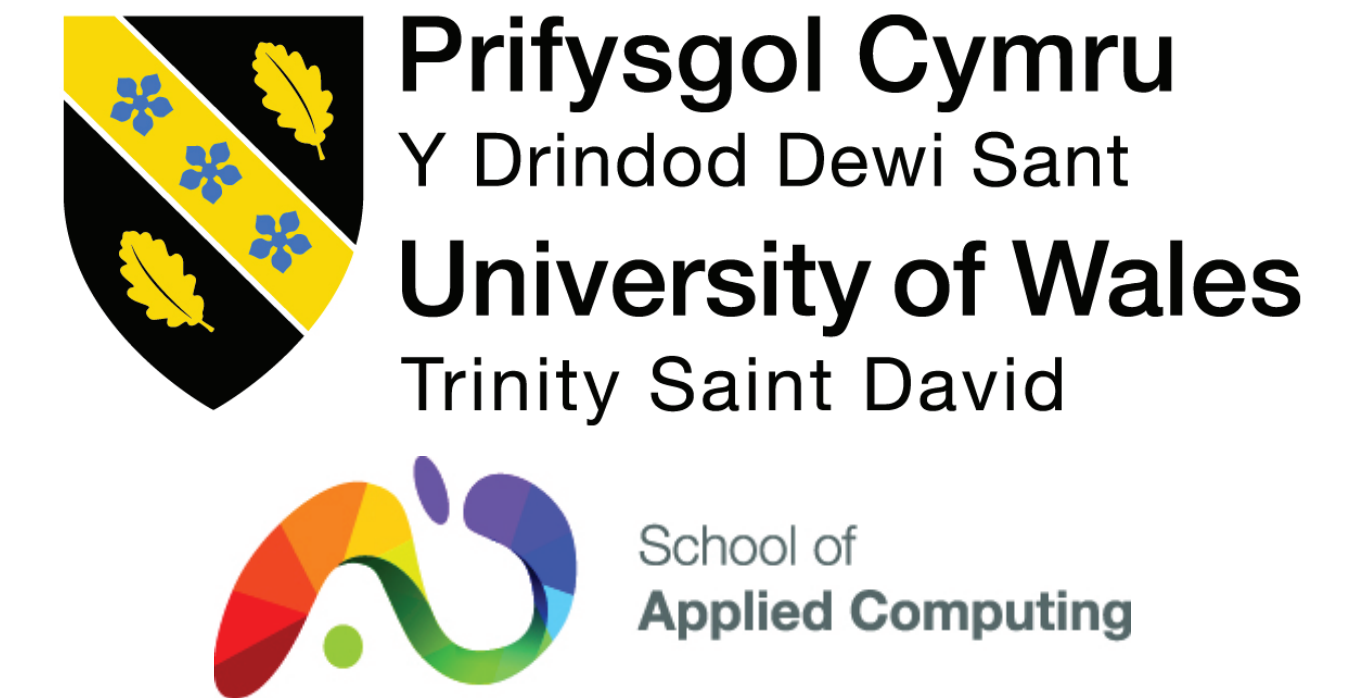


Preventing Hearing Damage with Real-Time Noise Monitoring

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Conclusion

- Developed a compact (71 x 64 x 51mm), low-cost (£17.97) device to help musicians and home studio users monitor noise levels and avoid hearing damage.
- The Device measures real-time dB levels, calculates safe exposure times, and issues alerts when the safe duration has been exceeded.
- Built using affordable hardware
 - MEMS microphone
 - ESP32 microcontroller
 - Custom 3D-printed casing
- The desktop application provides a clear interface with visual and auditory alerts.
- The system achieved a System Usability Scale score of 89.5 in user testing.
- Future improvements include wearable models, DAW plugin integration, device customisation, and commercialisation.

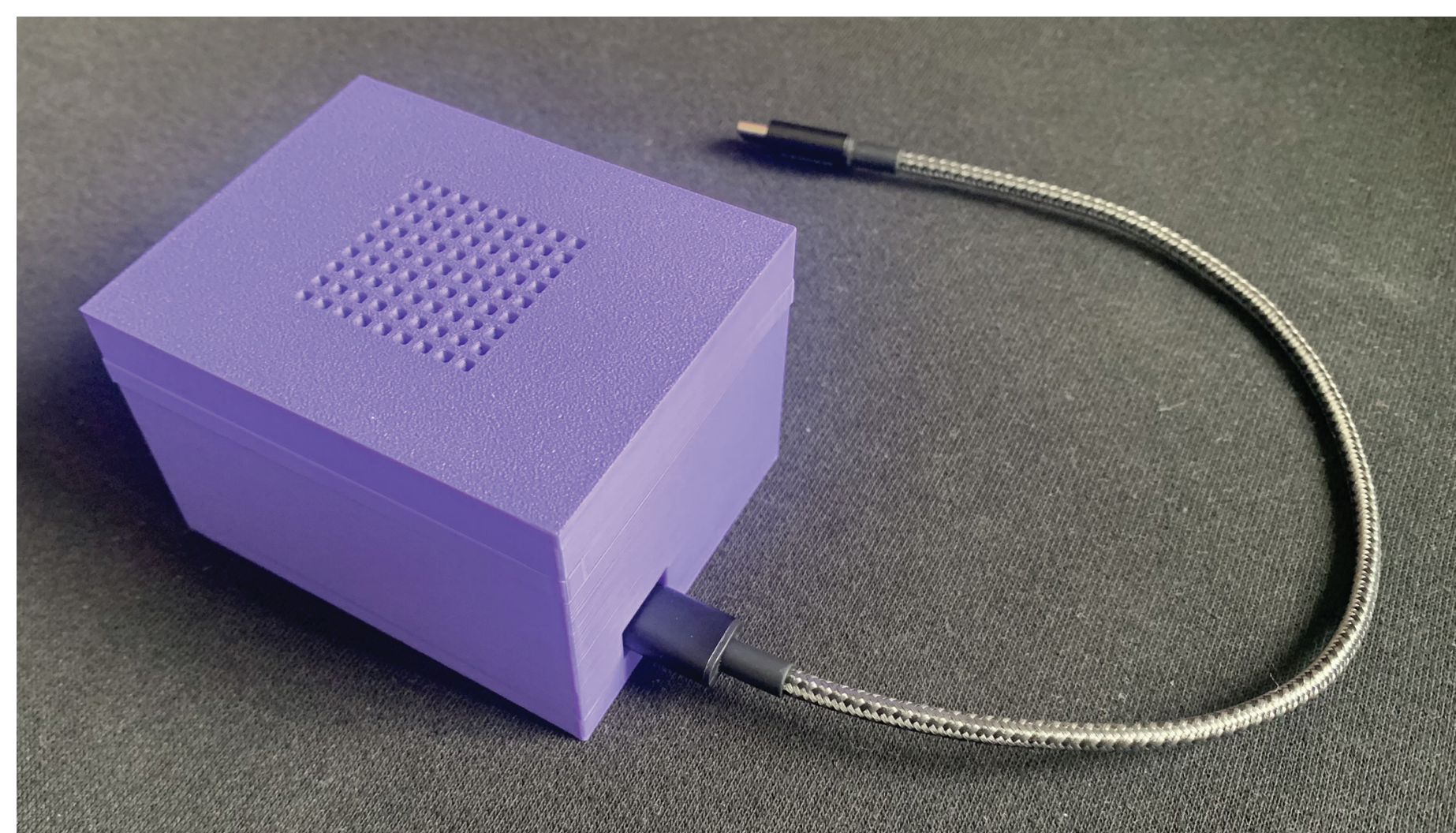


Figure 1 Final 3D-Printed Device

Introduction

Musicians and home studio users often expose themselves to high noise levels over long durations. Many are unaware that long exposure durations can be just as dangerous as loud volumes. Existing solutions are expensive, bulky, or poorly suited for individuals and small environments. This project aimed to raise awareness and prevent duration-based hearing loss.

Aim and Objectives

Design a cheap, easy-to-use system that helps users avoid hearing damage in noisy environments

Objectives

- Build a desk-based device using a microphone and microcontroller.
- Develop PC software to display noise levels and exposure times.
- Calculate the safe remaining time based on dBA.
- Alert users when exposure becomes unsafe.
- Calibrate for accuracy and test with real users.

Research Overview

The project explored safe exposure limits from WHO [1] and NIOSH [2], alongside Leq, dB A-weighting, and average sound level algorithms. Research examined MEMS microphones and microcontroller platforms to guide hardware selection. It also covered digital signal processing, buffering methods, and user interface design. These findings shaped the system's design and helped ensure both accuracy and usability.

Design and Implementation

- INMP441 MEMS microphone with ESP32 microcontroller
- Python desktop app developed using PyQt6
- Calibrated against a professional sound level meter
- Visual and auditory alerts trigger when safe limits are exceeded
- Manual calibration setting included to improve accuracy

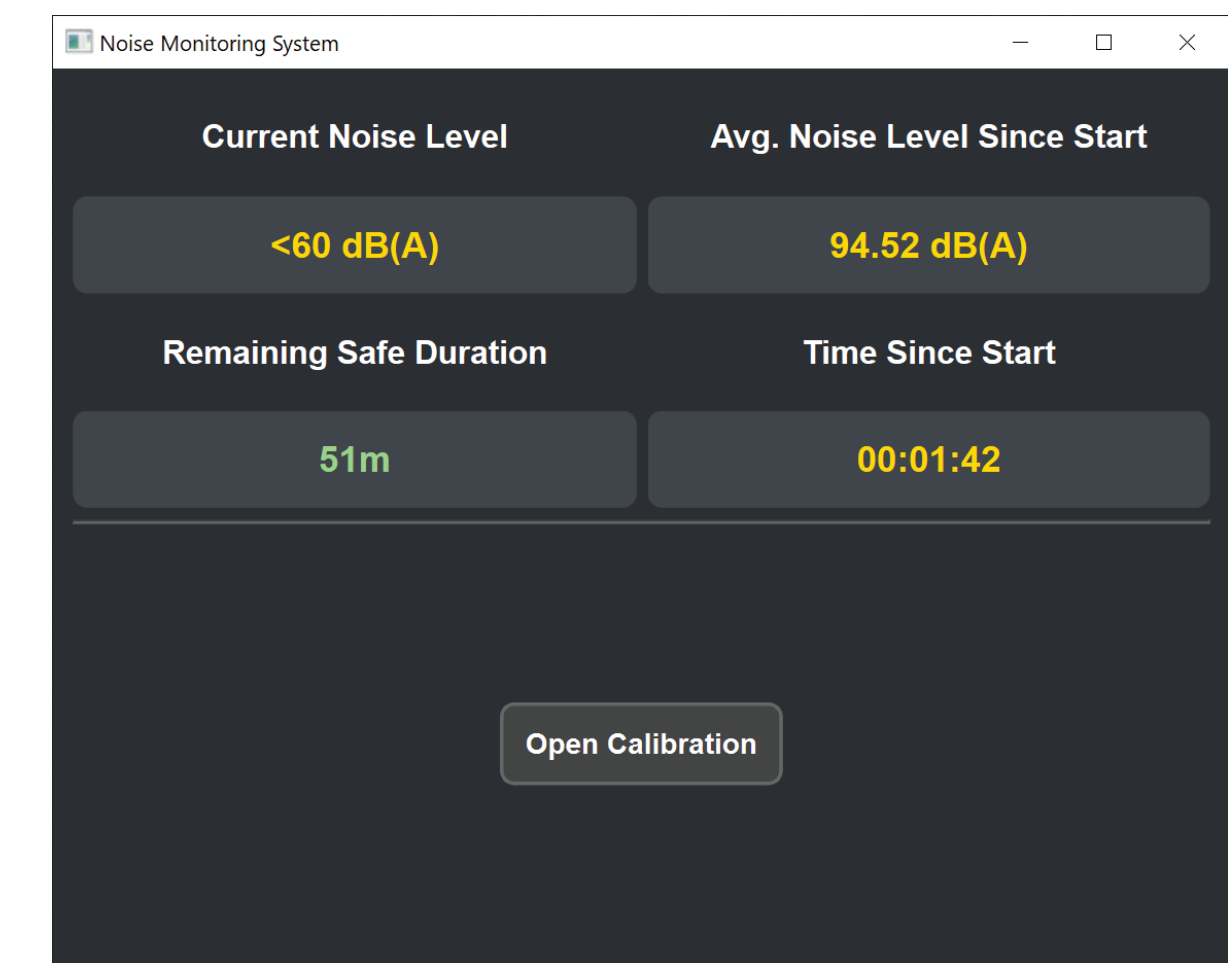


Figure 2 Desktop Application Main UI Screen

Testing and Results

- Device tested in home and studio environments
- Compared against a calibrated sound level meter and given a dB offset to adjust for accuracy
- Followed NIOSH [2] 85 dBA / 8-hour exposure rule for alert thresholds
- Five users tested the system independently
- Achieved a System Usability Scale score of 89.5 (Grade A [3])
- Feedback confirmed clear interface and ease of use

[1] "Noise and Hearing Loss," National Institute for Occupational Safety and Health (NIOSH), 30 January 2024. [Online]. Available: <https://www.cdc.gov/niosh/noise/about/noise.html>. [Accessed 20 November 2024].

[2] "Deafness and hearing loss: Safe listening," World Health Organization, 29 May 2024. [Online]. Available: <https://www.who.int/news-room/questions-and-answers/item/deafness-and-hearing-loss-safe-listening>. [Accessed 20 November 2024].

[3] N. Thomas, "How To Use The System Usability Scale (SUS) To Evaluate The Usability Of Your Website," [Online]. Available: <https://usabilitygeek.com/how-to-use-the-system-usability-scale-sus-to-evaluate-the-usability-of-your-website/>. [Accessed 10 April 2025].