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Design and Laboratory Validation of an Inexpensive Noise Sensor

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Background

- Noise is a pervasive workplace hazard that can vary both spatially and temporally
- Workplace noise maps can be generated by a mobile researcher using an expensive reference sound level meter (SLM)
- The temporal representativeness of noise measurements may benefit from the use of a stationary network of inexpensive noise monitors

Objectives

- Design a noise sensor (<$100) that reports A-weighted sound pressure levels, is independent of a cell phone, and is compact
- Evaluate performance of noise sensor
  - Precision: Coefficient of variation less than 10%
  - Accuracy: Within ±2 dB of Type 2 Reference SLM

Methods

Equipment

- Inexpensive Noise Sensor (Figure 1, ~$70)
- Type 2 Sound Level Meter (SLM,~$1,800)
  - NTI XL2 Audio and Acoustic Analyzer with M4260 microphone

Test Levels

- Ambient noise in quiet office
- Pink noise at 65 dBA, 75 dBA, 85 dBA
- SLM Calibrator at 94 dBA

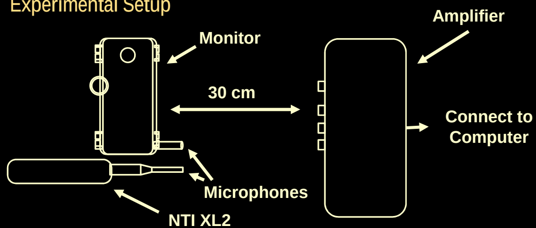
Data Collection

- At each test level, record sound level every 2s for 30s
- Determine 30s average for both instruments at each test level

Performance Metrics

- Bias by test level and overall for two ranges
  - 65 to 94 dBA
  - 75 to 94 dBA
- Precision (Coefficient of variation-CV)
- Slope and Intercept
- Correlation

Experimental Setup



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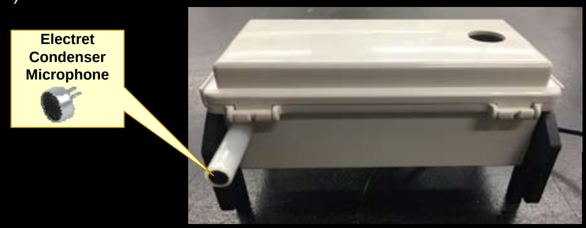
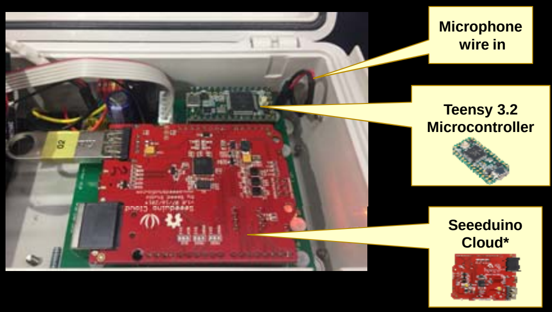
Sensor Design

A) Monitor Exterior

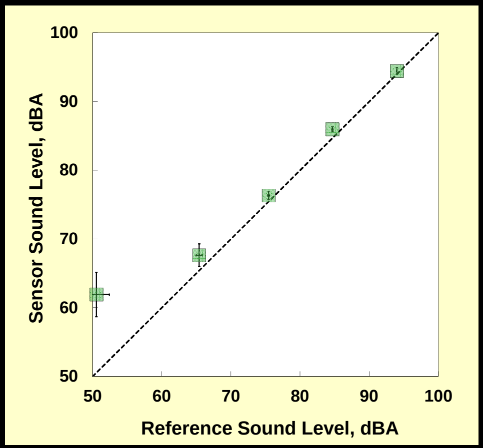


B) Monitor Interior



Results

Mean, A-weighted decibel measurements from sensor vs. SLM at 5 test levels. Points represent means of the individual sensor means at each test level, n=46 sensors



Results, continued

Table 1: Mean sound pressure levels, standard deviation, and coefficient of variation at five target dBA levels (side by side, 65, 75, 85, 94 dBA). Acceptance criterion was ±2 dBA from reference SLM, n= 46 monitors.

	Mean ± SD (dBA), CV (%)			
	Reference	Monitor	Mean Bias, %	% Within ±2 dBA
Ambient	50.6 ± 1.9, 3.8	62.0 ± 3.2, 5.2	18.3	2.1
65 dBA	65.4 ± 0.45, 0.69	67.7 ± 1.7, 2.4	3.22	62
75 dBA	75.4 ± 0.13, 0.18	76.3 ± 0.55, 0.72	1.15	98
85 dBA	85.2 ±0.12, 0.13	85.9 ± 0.37, 0.43	0.83	100
94 dBA	94 ± 0, 0	94.4 ± 0.49, 0.52	0.48	100

Table 2: Correlation, slope and intercept, bias and coefficient of variation results for noise sensors from 75 dBA to 94 dBA, n= 46 monitors.

	Mean	Std. Dev	5th Percentile	95th Percentile
Slope	0.98	0.03	0.94	1.00
Intercept, dBA	2.65	2.45	-0.41	6.67
Correlation, r	1.00	0.001	1.00	1.00
Overall Bias, %	0.83	0.46	0.06	1.6
Overall CV, %	0.76	0.27	-	-

- Inexpensive noise sensor (~$30 for components) provided similar sound pressure level measurements in dBA to a substantially more expensive, Type 2 reference SLM (~$1,800)
- Ninety-four percent of noise sensors were within ±2 dBA of the reference SLM from 75 to 94 dBA
- Coefficient of variation of sensors (CV) was 0.76% from 75 to 94 dBA
- Sensors are independent of smartphone and compact

Conclusions

- New, inexpensive noise sensor (~$70) responded similarly to more expensive reference sound level meter from 75 to 94 dBA
- Noise sensor can be used for a variety of applications, including incorporation into a sensor network

Acknowledgements

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