Assessment of SoundProof and Mobile Noise Mapping Tools for Individual Noise Profile Construction

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Introduction: Current Individual Noise Measurements are Limiting and Questionable

- Noise Pollution: A Pressing Urban Problem
  - Prolonged exposure to high levels of noise pollution (unwanted, annoying, and physically harmful sounds produced by human activities) leads to a series of health and psychological problems.
    - Causes physical health problems such as hearing impairment, tinnitus, and stress related outcomes (hypertension, heart attack, stroke, and etc.)
    - Triggers bodily hormonal changes, leading to psychological panic attacks, depression, forgetfulness, sleep disturbances, and aggression
  - Accurate individual noise measurements are difficult and expensive to obtain and update, limited only to outdoor locations of interest, and are extremely labor intensive.
    - Requires trained officers to walk around with fragile, costly sound pressure level (SPL) meters
  - Current health studies related to noise pollution use relatively inaccurate noise data collected through self-reporting, computer modeling, and/or outdoor measurements.

- Development of SoundProof and Noise Mapping Tools to Measure and Evaluate Noise Pollution
  - Mobile noise mapping tools (i.e., NoiseTube and EarPhone) rely on “crowdsourcing” to recover outdoor noise maps from random and incomplete samples.
    - Recorded real-time raw acoustic samples from the mobile microphone are filtered through a signal processing module that computes a A-weighted equivalent noise level (Leq) and geo-tags the sample with global positioning system (GPS) coordinates.
    - Computed Leq values are questionable because the central server requires multiple sources of input for maximum Leq precision and accurate noise map reconstruction.
  - SoundProof is a mobile phone tool that constructs individual, rather than collective, noise profiles for health research/analysis.
    - Samples with a higher frequency and rate in both indoor and outdoor environments

Problem Description: Validation of EarPhone, NoiseTube, and SoundProof with SPL Meter

- Walking Campaign to Collect Noise Data
  - Carried three Nokia N95 phones and SPL meter
  - Collected data along two routes (4.4 and 3.4 miles) that circled the Westwood area and UCLA campus perimeter
    - Included Westwood Blvd, Wilshire Blvd, and 405 Freeway (areas of very dense traffic and high noise), residential neighborhoods (moderate noise), and schools, hospitals, and parks (low noise)
    - Sampled noise during different times of day (morning: 7 to 9 am; afternoon: 4 to 6 pm)
    - Stationary sampling conducted at the corner of Westwood Blvd and Le Conte Ave for 30 minutes

- Data Synchronization and Analysis
  - Python script averages Leq values of all files by minute (to account for different sampling rates) and synchronizes all data files to one .csv file based on time stamp.
    - EarPhone suffered from faulty Leq computation
      - Python script written to compensate for commented out logarithmic function and need for a calibration offset.
    - Data analysis (correlations, plots, etc.) done in R

Problem Evaluation: SoundProof and Noise Mapping Tool Measurements Are Inaccurate

- SoundProof Contains Potential While Noise Mapping Tools Are Inadequate for Daily Noise Profile Construction
  - Mobile noise measuring and measuring tools profiles are inaccurate representations of actual Leq values.
    - SoundProof and EarPhone readings underestimate actual Leq readings from the SPL meter while NoiseTube readings overestimate.
      - If mobile readings are highly correlated with SPL meter readings and both follow similar trends, then mobile phone Leq can be corrected with an addition of a calibration offset ranging from ~10 dB (for NoiseTube) to 20 dB (for EarPhone and SoundProof).
  - SoundProof’s noise profiles are completely different than that of noise mapping tools’.
    - Extremely low correlation, ranging from -0.15 to 0.3, between SoundProof readings and noise mapping tool readings.
      - EarPhone readings are extremely flat (compared to that of other tools and the SPL meter), showing that the Leq computation may need further adjustments and refinement or application may need to be recompiled and tested.
  - SoundProof displays a relatively accurate interpretation of individual noise throughout a variety of environments for it follows SPL meter trends.
    - High correlation (0.71) between SoundProof and SPL meter existed during UCLA perimeter run and stationary data collection.
      - May suffer from a slower response time over certain intervals, resulting in an inability to account for quick spikes in noise due to changes in environment (ie. from outdoor to indoor or in and out of tunnels) or fast, moving noise sources (ie. ambulance or police siren)
  - Mobile noise mapping tools have extremely inconsistent sampling rates.
    - Reliance on GPS locking and network signal to conduct sampling results in varied or no sampling during intervals of interference or no signal
      - NoiseTube automatically force closes after collecting ~600 data samples, resulting in data loss during the minutes of inactivity and making it tedious to run for long sampling periods
  - Raw noise mapping tool data experiences intense amounts of fluctuation in a period of seconds.
    - During areas of generally consistent noise, NoiseTube Leq values continue to fluctuate from 50 to 80 dB, resulting in unreliable and unreadable data (see plot on left).
      - Low correlation, ranging from -0.1 to 0.4, existed between EarPhone and NoiseTube, and the SPL meter
      - Can afford to do so as long as averages are consistent since noise maps (see right) are color coded based on Leq ranges and do not require exact Leq readings.