A general-purpose pipeline to interface the Tympan hardware with an external computer

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4aPP, Open Source Audio Processing Challenge Results

Hackathon Challenge Presentations

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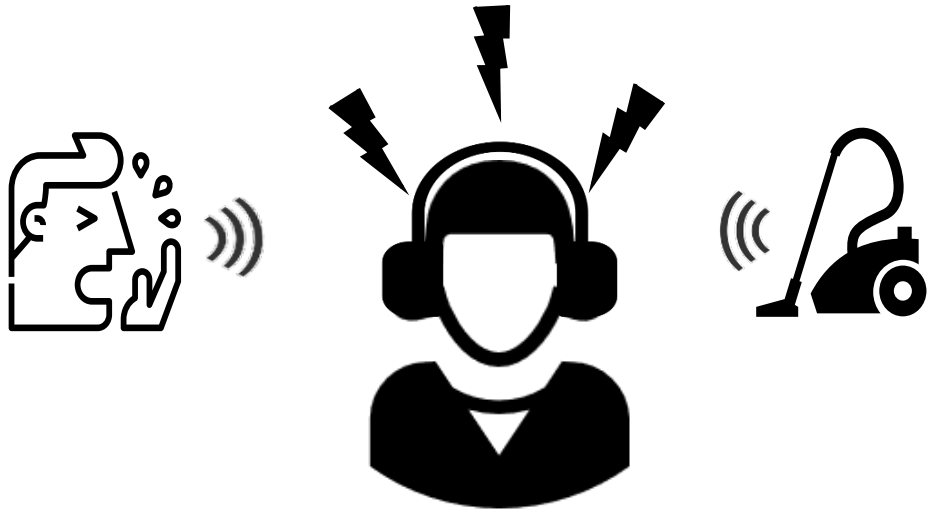
2 Decreased sound tolerance

“The feeling is so intense it feels like pain, I know it’s not pain but it reminds me, it’s very very similar to physical pain” (from Landon et al., 2016).

→ Hearing protectors are often used to alleviate sound-induced distress (Neave-DiToro et al., 2021; Jastreboff & Jastreboff, 2014).



3 Over-attenuation

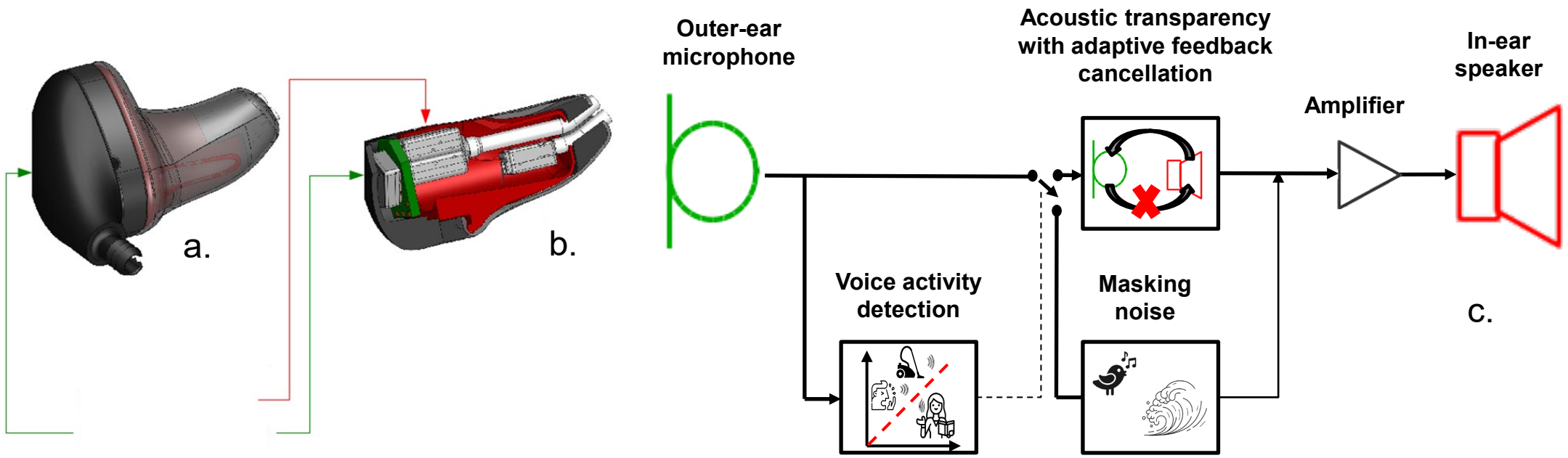
Conventional hearing protectors attenuate all sounds.

→ Can reduce engagement with surroundings (Pfeiffer et al., 2019a).

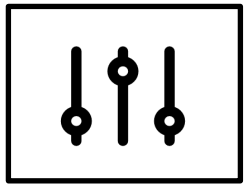
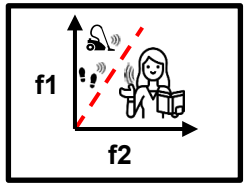
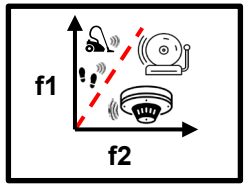
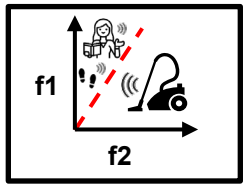
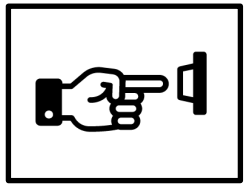
→ May worsen sensitivities over time (Formby et al., 2003; Jastreboff & Jastreboff, 2014).

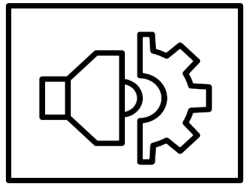
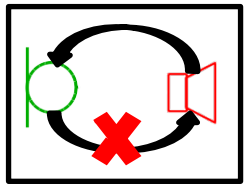
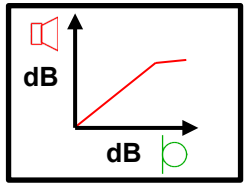
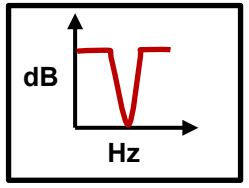
4 Project objective

→ A hearable to manage decreased sound tolerance with attenuation only when necessary.



5 Project components

	**Control of audio processing**
	**Voice activity detection**
	**Alarm sound detection**
	**Detection of distressing sounds**
	**Manual user controls**

	**Low-latency audio processing**
	**Acoustic transparency with adaptive feedback cancellation**
	**Masking noise**
	**Dynamic range limiting**
	**Frequency filtering**

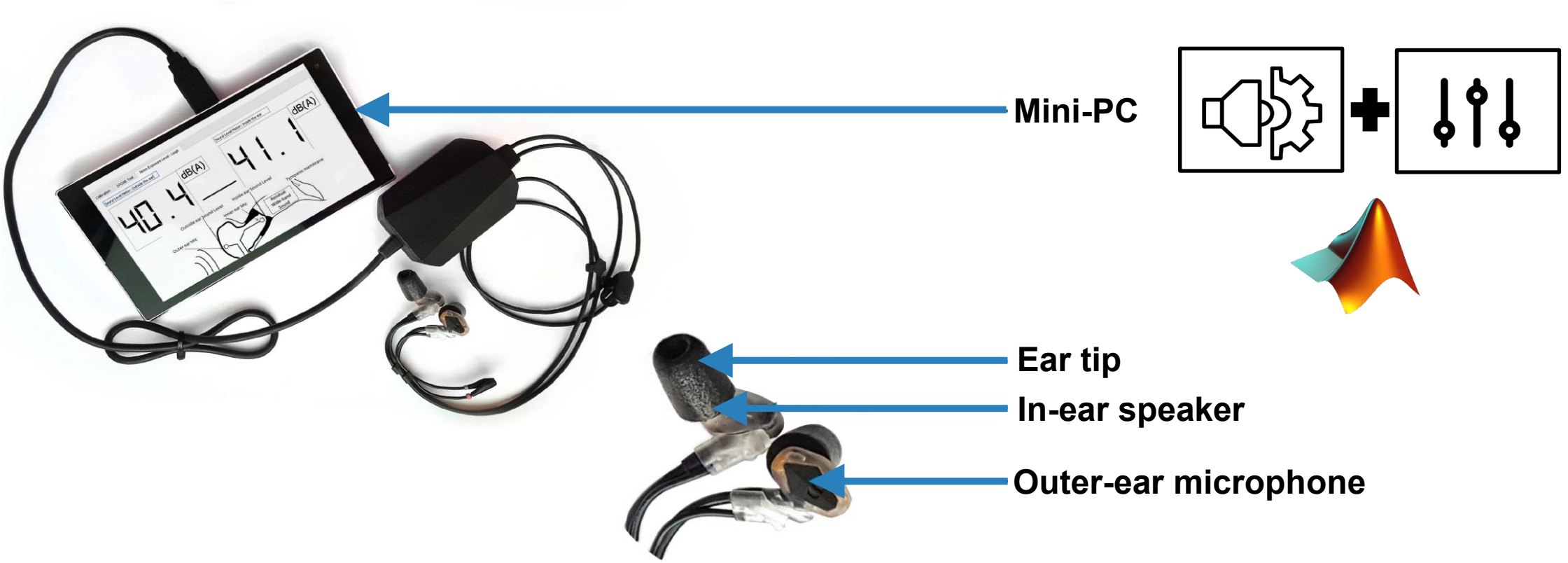
6 Audio processing latency requirements

Delay between original & actively transmitted signals

- Multiple perceptual effects
  - Two distinct audio signals (echo threshold)
  - Audiovisual asynchrony (lip sync error)
- These effects may differ for individuals with decreased sound tolerance
  - E.g. audiovisual temporal processing differs in children on the autism spectrum (Noel et al., 2017)
- Hearing aid latency: usually < 9-10 ms (Alexander, 2016)

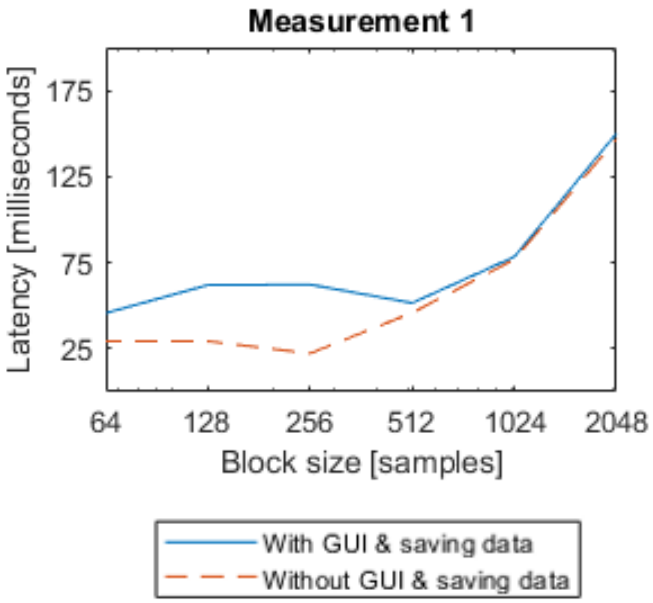
Prototype #1: Mini-PC

Auditory research platform 3.1: device developed within CRITIAS

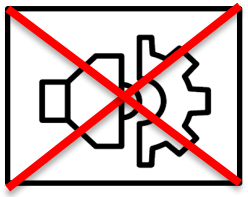


Prototype #1: Challenges

- Measured latency of passthru in Matlab:
  - Fixed sampling rate of 44.1 kHz
  - Varied block size, if GUI + recording
- Minimum: 22 ms
  - Block size of 256, w/o GUI + recording
  - 57 ms in later measurement

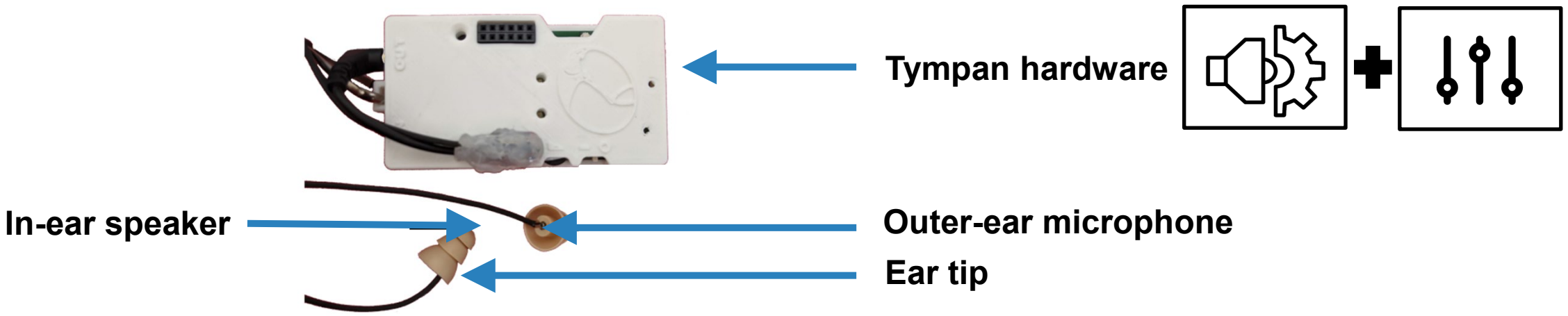


→ PC not suitable for low-latency audio processing



Prototype #2: Tympan

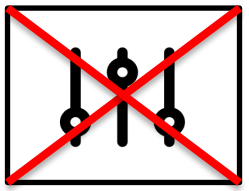
Tympan Open-Source Hearing Aid Platform, Rev-D + CRITIAS earpieces

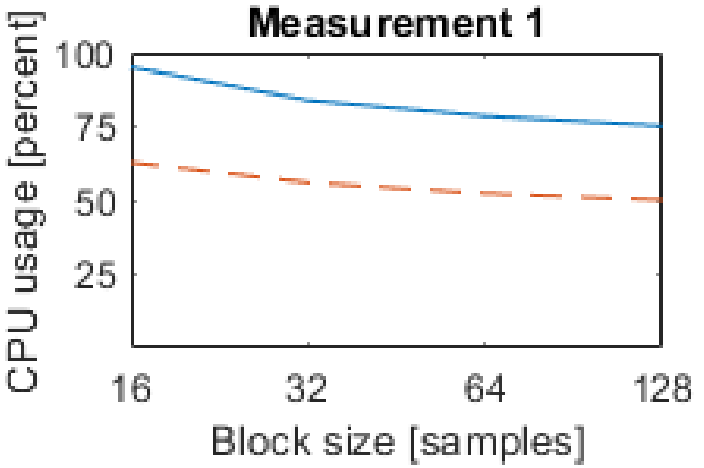


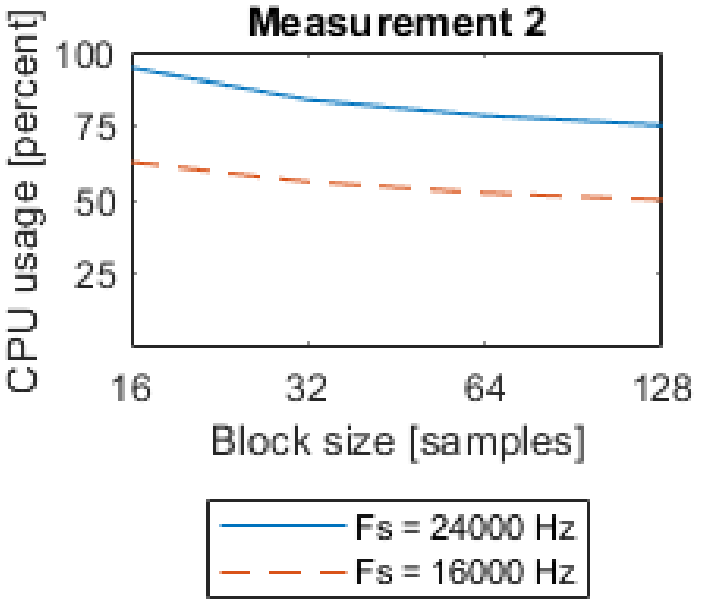
Prototype #2: Challenges

- CPU usage
  - Rev-D: 91% for 1-channel 8-band IIR WDRC with AFC, fs = 24000 & block size = 16
  - Rev-E: 97% for 2-channel 16-band FIR WDRC, fs = 44117 & block size = 16
- Need to adapt machine learning algorithms for embedded system

→ Tympan well-suited for real-time audio processing, but limited for automatic control of audio processing

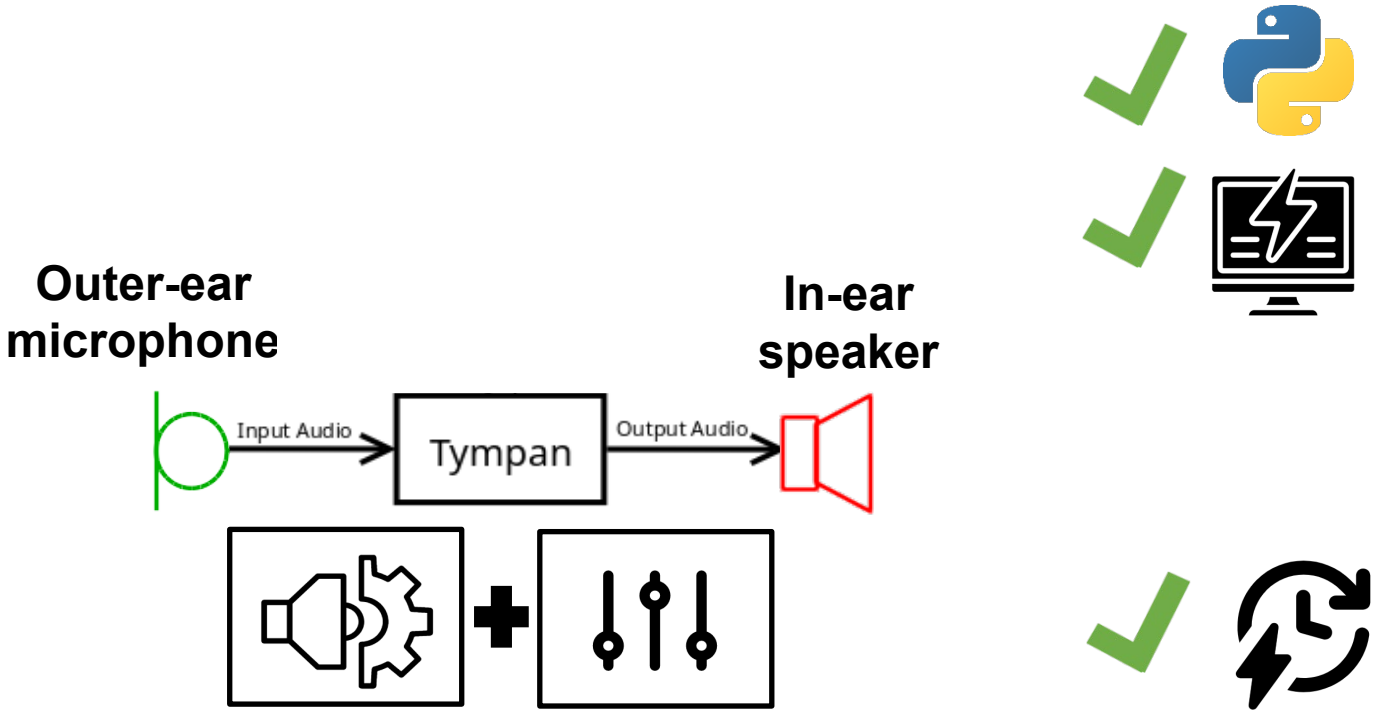






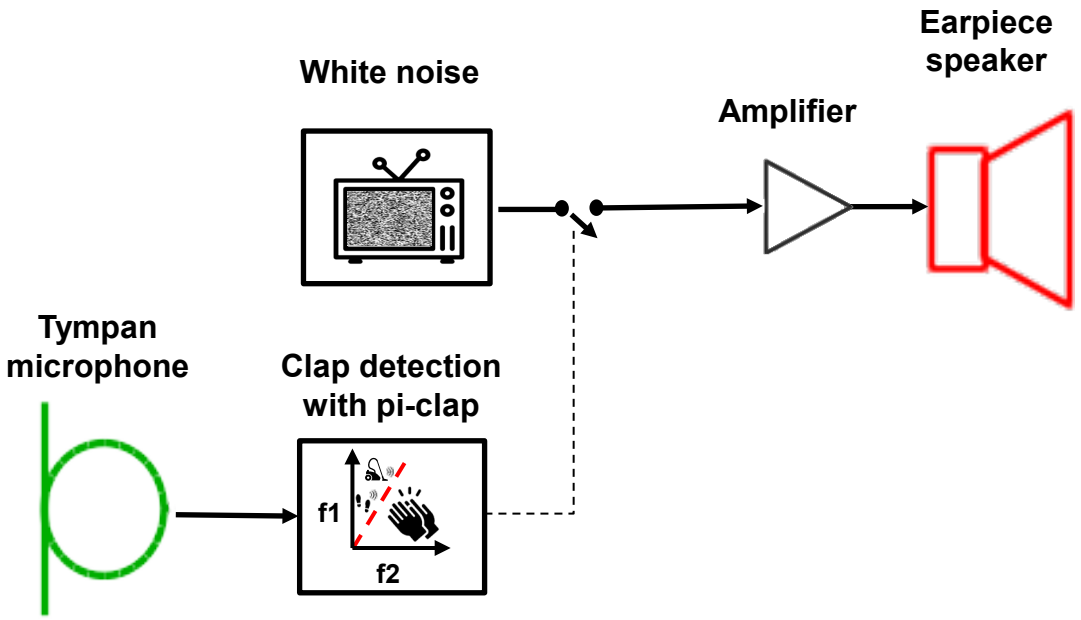
Prototype #3: PC + Tympan

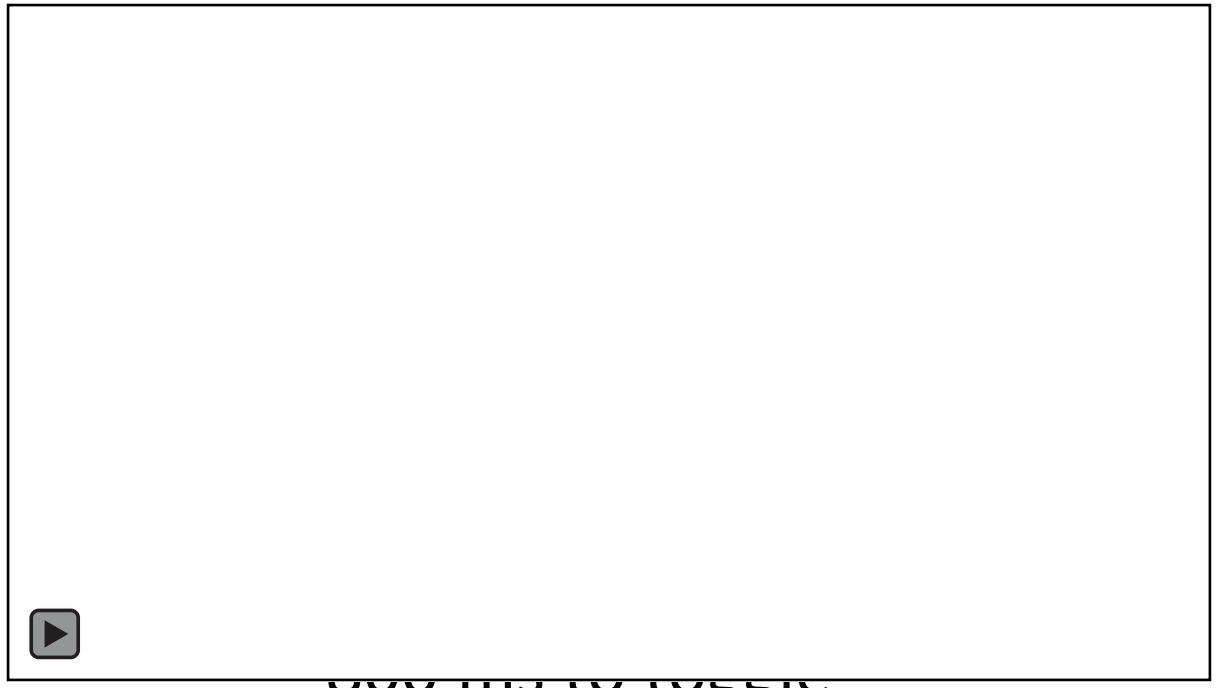
→ Pipeline to interface Tympan with an external PC



12 Prototype #3: Hackathon project

White noise player toggled with clap detection

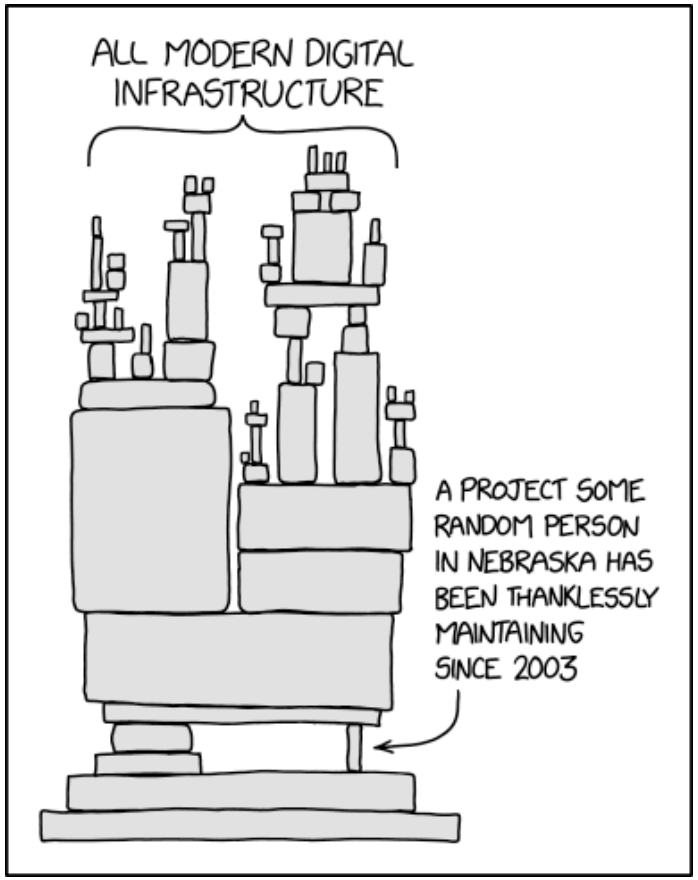




Prototype #3: Challenges

Not a simple addition to Tympan library

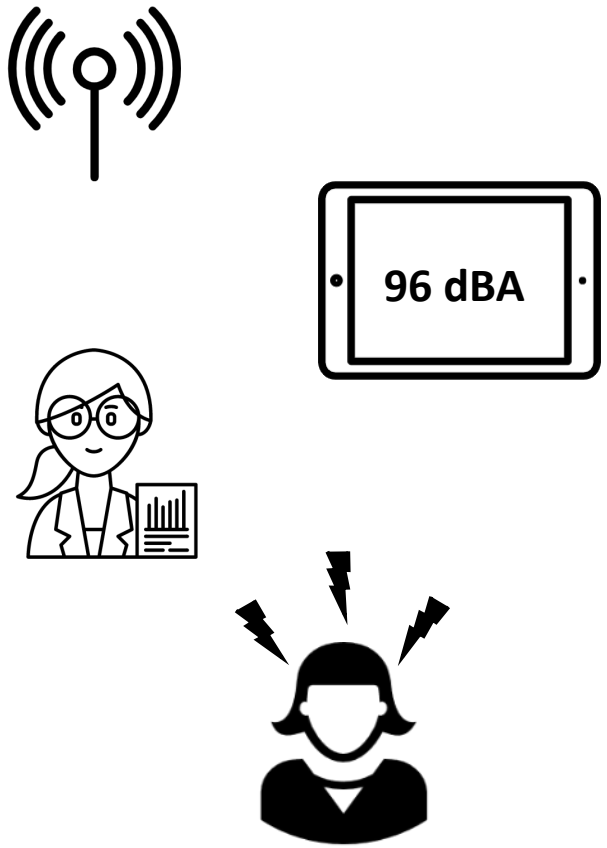
- Tested on Python 3.8.10, Arduino 1.8.15 & Teensy 1.54
  - Needed to modify Teensy library
- Had to adapt code to new machine (Ubuntu → Windows)



Source: xkcd

14 Future possibilities

- Potential extensions of pipeline:
  - Wireless transmission
  - GUI to inform device usage
  - Software to record “in situ” research data



- Promise of open-source hardware & software for decreased sound tolerance research

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CRITIAS

Centre for Interdisciplinary Research in Music Media and Technology

ÉTS Le génie pour l'industrie — ÉCOLE DE TECHNOLOGIE SUPÉRIEURE — Université du Québec

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