Supplementary Materials

Compressed Sensing for Characterization of Tinnitus

Alec Hoyland, Nelson Barnett, Benjamin W. Roop, Adam C. Lammert

This document contains a description of additional experiments to find a performant stimulus generation method and a discussion of sparsity in tinnitus signals. The code for all experiments is freely available at https://github.com/alec-hoyland/tinnitus-project and the data are available upon request.

I. Stimulus Generation

In the context of this paper, a stimulus generation method is a process that generates a random waveform that is:

1) auditorally-distinguishable
2) statistically uncorrelated, and
3) similar to tinnitus percepts.

Additionally, compressed sensing requires that the matrix of stimuli should satisfy the restricted isometry property, which many random matrices do with high probability (*e.g.* Gaussian random matrices) [1], [2].

A. Auditorally-Distinguishable Stimuli

We used mel-frequency binning to ensure that our stimuli were auditorally-distinguishable. The mel scale is a perceptual scale of pitches judged by listeners to be equal in distance from one to another (Fig. 1) [3].

The formula

$$m = 2595 \log_1 0 \left(1 + \frac{f}{700}\right) \tag{1}$$

converts f Hz to m mels.

Furthermore, to reduce the system complexity by more than 80x, we implement tonotopic binning, where the frequency scale is binned along 100 equally mel-spaced bins.

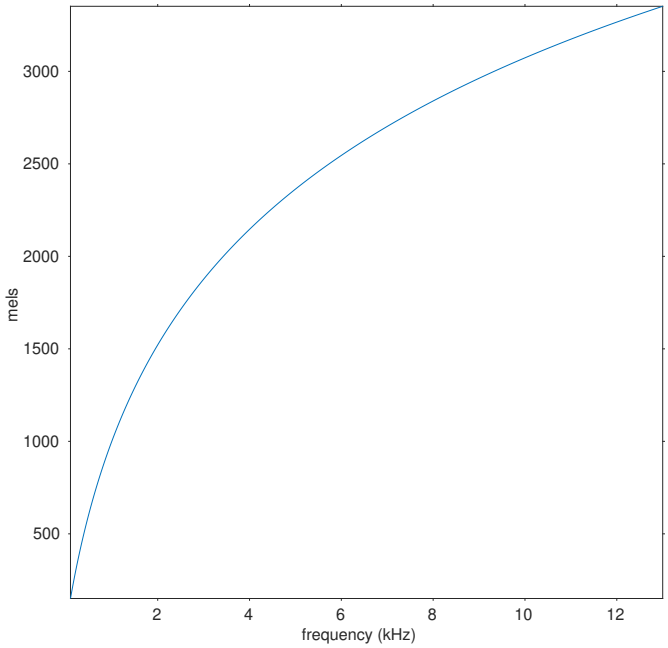

Fig. 1. The relationship between Hz and mels is logarithmic.

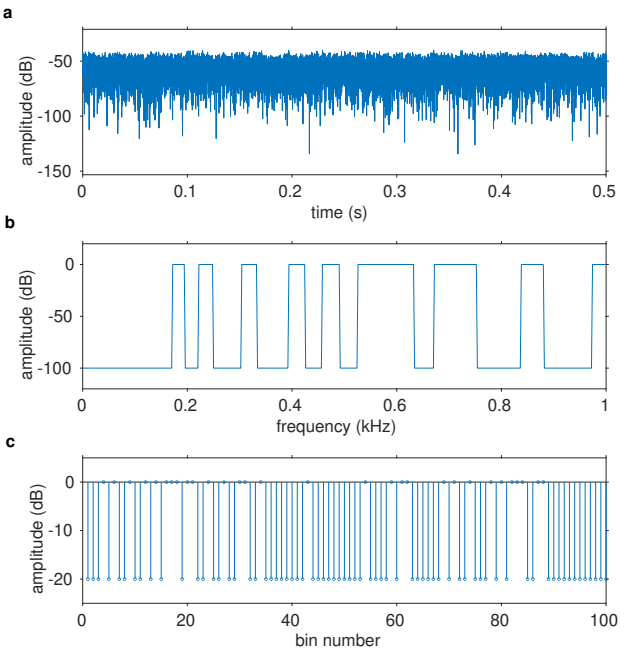

Fig. 2. The relationship between Hz and mels is logarithmic.

References

[1] E. J. Candès, "The restricted isometry property and its implications for compressed sensing," *Comptes Rendus Mathematique*, vol. 346, no. 9, pp. 589–592, May 2008.

[2] E. J. Candes and M. B. Wakin, "An Introduction To Compressive Sampling," *IEEE Signal Processing Magazine*, vol. 25, no. 2, pp. 21–30, Mar. 2008.

[3] L. S. Hamilton, Y. Oganian, and E. F. Chang, "Topography of speech-related acoustic and phonological feature encoding throughout the human core and parabelt auditory cortex," p. 2020.06.08.121624, Jun. 2020.