PAMBOX: A Python auditory modeling toolbox

Alexandre Chabot-Leclerc

Centre for Applied Hearing Research, Technical University of Denmark

@AlexChabotL pambox@alexchabot.net http://pambox.org

Goals

- Collect published models of auditory processing.
- Simplify comparisons across models by standardizing the interface for models that perform similar tasks.
- Make components reusable and easy to inspect and modify.

Problems and inspiration

- Intelligibility prediction work often involves comparisons across models, but the source code is rarely available. Additionally, reference levels and interfaces are often completely different.
- `scikit-learn`'s approach of providing a *consistent* interface for all methods is a strong inspiration.
- The Auditory Modeling Toolbox (Søndergaard and Majdak, 2013) is a similar attempt at collecting published auditory models, made for Matlab. Although component are well tested, they are hard to reuse.

PAMBOX's structure

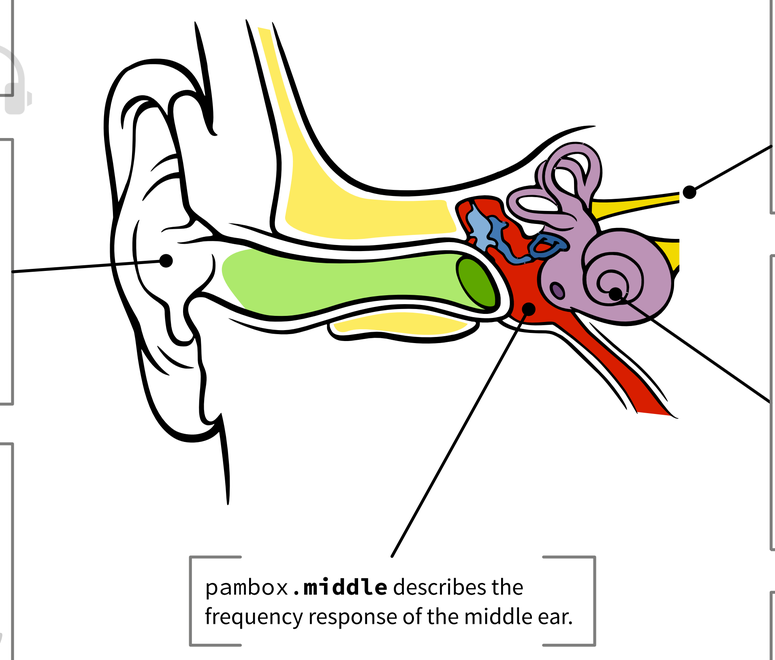
`pambox.audio` is a thin wrapper around `pyaudio` to simplify the playback of numpy arrays.

`pambox.outer` contains classes and functions related to the outer ear, such as:

- Head-related transfer functions (HRTFs);
- Headphone + ear transfer functions.

`pambox.utils` provides useful function for manipulating signals, and converting data, e.g.:

- set or measure a signal's level;
- add two signals of different lengths;
- apply filtering via FFT.



`pambox.middle` describes the frequency response of the middle ear.

`pambox.central` provides model stages from the central auditory pathway.

- Decision metrics;
- Modulation filtering;
- Ideal observer;
- Optimal detector.

`pambox.inner` regroups inner ear functions, such as:

- Cochlear filtering;
- Inner hair cell envelope extraction;
- Adaptation;
- And other filter banks.

`pambox.speech` contains speech intelligibility prediction models as well as "helper" functions to simplify experiments and comparisons across models (see section below).

Planned modules

`pambox.mono`: will regroup published models making complete predictions of monaural percepts, such as:

- Gap detection threshold;
- Modulation threshold;
- Masking;
- Signal detection.

`pambox.binaural` will contains models predicting binaural percepts, such as:

- Interaural level and time differences (ILDs and ITDs);
- Source localization.

Predicting speech intelligibility

Predicting speech intelligibility consists of predicting how well speech is understood in a given situation. Intelligibility experiments tend to have similar components, as illustrated below.

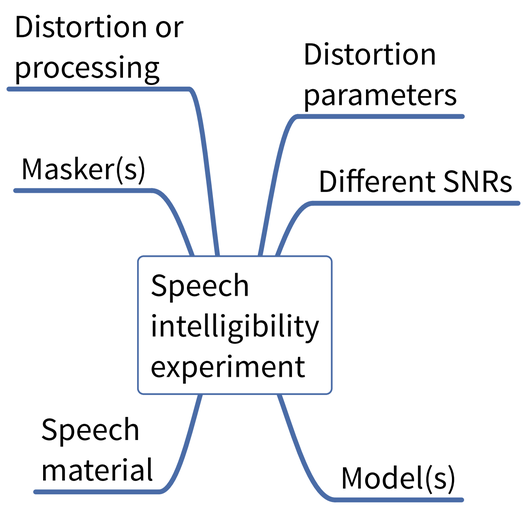


Fig. 1: Elements of a speech intelligibility prediction experiment.

`pambox` provides an interface to run experiments with an arbitrary number of models, SNRs, and distortion parameters. Currently, each experiment is treated as having a single speech material and a single "distortion", although that could be extended.

The preprocessing stage can easily be modified or replaced by overriding the `preprocessing` method of the `Experiment` class. This allows, for example, to apply the level adjustments before the distortion, or to apply processing to both the target and the maskers.

Below is an example of a complete speech intelligibility prediction experiment. Two models are compared, in a condition with a speech-shaped noise masker.

```python
from pambox.central import IdealObs
from pambox.speech import Sepsm, MrSepsm, Material, \
    Experiment

# Define models and "experimental setup".
models = [Sepsm(), MrSepsm()]
material = Material(
    root_path='stimuli',
    path_to_sentences='sentences',
    path_to_ssn='ssn.wav')
snrs = range(-9, 4, 2)

# Run experiment, transform outputs, and plot results.
exp = Experiment(models, material, snrs)
df = exp.run()
obs = IdealObs()
df = exp.pred_to_pc(df, obs.snrenv_to_pc)
exp.plot_results(df)
```

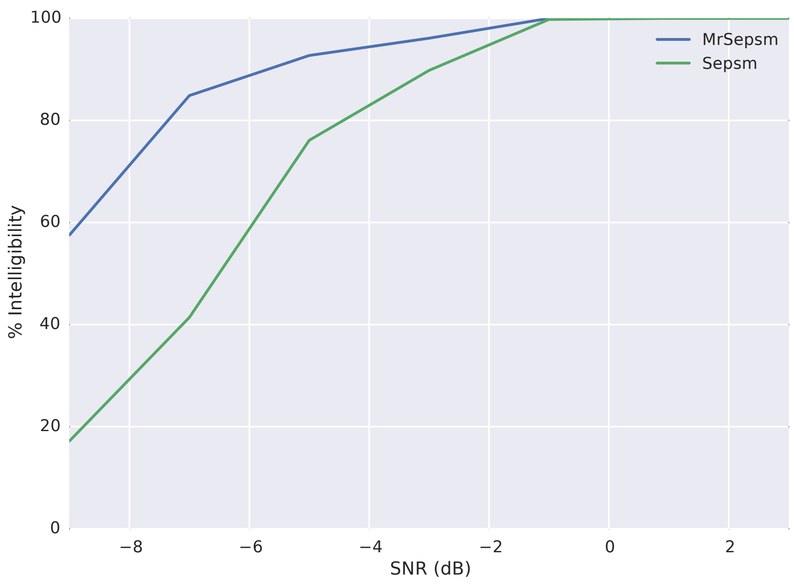


Fig. 2: Predicted speech intelligibility as a function of the SNR for two models, the sEPSM and the mr-sEPSM.

Development

- Depends on the usual suspects: `numpy`, `scipy`, `pandas` and `matplotlib` and with `pyaudio` as an optional dependency.
- Licensed under the 3-Clause BSD license.
- Docs at `http://docs.pambox.org`, thanks to ReadTheDocs!
- Hosted on Github.

Conclusions

- `pambox` is still in its infancy. Very few auditory models are currently written in Python; it would require a considerable effort to reimplement existing models.
- However, implementation of models whose code was not released would be a great help.
- `pambox` needs contributions of models stages and complete models.

`http://pambox.org`

Acknowledgements

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References

Chittka, L. and Brockmann, A. (**2005**). "Perception space—the final frontier", PLoS Biology **3**, e137, modified (Fig. 1A/Large version), vectorised by Inductiveload.

Søndergaard, P. and Majdak, P. (**2013**). "The auditory modeling toolbox", in *The Technology of Binaural Listening*, edited by J. Blauert, 33–56 (Springer, Berlin, Heidelberg).