National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Information Technology and Software

Statistical Audibility Prediction (SAP) Algorithm

Determining the audibility of sound

Noise is difficult to escape in our daily lives. Such noise is generated by transportation vehicles, industrial equipment, hospital machines, phones, alarms, crowds, and more. Some sounds we want to suppress (e.g., airplane noise vs. conversation) and others we want to enhance (e.g., our ringing phone vs. subway noise). Predicting the extent that one sound is heard over another is difficult, yet could help engineers to better design for sound management.

Innovators at the NASA Langley Research Center (LaRC) and the National Institute of Aerospace (NIA) have developed an algorithm for Statistical Audibility Prediction (SAP) of an arbitrary signal in the presence of noise. The SAP algorithm compares the loudness of signal and noise samples at matching time instances to assess audibility versus time. The continued development of this algorithm could allow engineers to suppress how we hear noise relative to sounds of interest. SAP can be implemented either as software or hardware. The algorithm has been tested using subject response data gathered in the Exterior Effects Room (EER) at NASA LaRC.

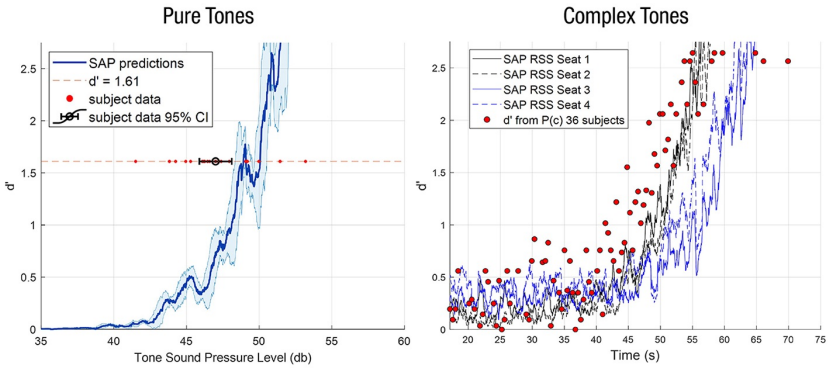
BENEFITS

- Less noise pollution: Can help engineers design systems that generate noise that is less bothersome.
- Better sound selectivity: Can lead to systems that generate sounds more likely to be heard over background noise.
- Enhanced understanding of audibility: Can assist scientists and engineers to better understand why certain sounds are more or less audible than others, thus further enhancing sound design.

THE TECHNOLOGY

A method for predicting the audibility of an arbitrary time-varying noise (signal) in the presence of masking noise is described in "An Algorithm for Statistical Audibility Prediction (SAP) of an Arbitrary Signal in the Presence of Noise" published in the Journal of the Audio Engineering Society (Vo. 69, No. 9, September 2021). The SAP method relies on the specific loudness, or loudness perceived through the individual auditory filters, for accurate statistical estimation of audibility vs. time. As such, this work investigated a new hypothesis that audibility is more accurately discerned within individual auditory filters by a higher-level, decision-making process. Audibility prediction vs. time is intuitive since it captures changes in audibility with time as it occurs, critical for the study of human response to noise. Concurrently, time-frequency prediction of audibility may provide valuable information about the root cause(s) for audibility useful for the design and operation of sources of noise. Empirical data, gathered under a three-alternative forced-choice (3AFC) test paradigm for low-frequency sound, has been used to examine the accuracy of SAPs.

Future work should involve additional studies to examine the performance of SAP with realistic ambient noise and signals with higher-frequency content.



The graphs shown illustrate validation test cases using pure tones (left) and complex tones
(right). The algorithm predictions for low frequency signals show agreement to subject
response data.

APPLICATIONS

The technology has several potential applications:

- Noise management
- Sound engineering
- Transportation vehicles (e.g., aircraft, rotorcraft, drones, unmanned aerial vehicles, trucks, automobiles, trains, buses, etc.)
- Industrial equipment (e.g., as found in factories, hospitals, businesses, residences, etc.)
- Communication decives (e.g., phones, alarms, etc.)
- Hearing aids
- Signal processing

PUBLICATIONS

Patent Pending

M. Rafaelof, and K. Wendling, "An Algorithm for Statistical Audibility Prediction (SAP) of an Arbitrary Signal in the Presence of Noise," J. Audio Eng. Soc., vol. 69, no. 9, pp. 672-682, (2021 September.)

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LAR-19736-1, LAR-TOPS-360

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NP-2022-02-3028-HQ