MATTERMATH FORENSIC AUDIO ISOLATION

Deterministic Digital Signal Processing and Daubert-Compliant Verification

Abstract

As machine learning and Generative AI increasingly populate the commercial audio processing market, the forensic admissibility of digital audio evidence is under unprecedented threat. Generative models operate on stochastic principles—hallucinating missing audio data to produce subjectively pleasing results—which fundamentally violates the principles of forensic evidence handling. The MatterMath Engine eschews artificial intelligence entirely. This paper outlines our non-stochastic, mathematically deterministic methodology utilizing Time-Variant Spectral Subtraction and introduces the Digital Null Test as a verifiable proof of evidentiary integrity suitable for federal and state evidentiary hearings.

1. The Admissibility Crisis: Stochastic AI vs. Deterministic DSP

In forensic proceedings, audio enhancement must isolate existing evidence without introducing artifacts or synthesizing non-existent data. Modern AI tools utilize neural networks that predict and generate waveforms based on training data. Consequently, the output is non-deterministic; processing the same file twice may yield different acoustic results. Because the internal processing of these models is a "black box," they fail the testability and error-rate requirements of *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993).

MatterMath relies strictly on classical Digital Signal Processing (DSP), grounded in the physics of acoustics. Our methods do not *guess* what a speaker said; they mathematically subtract identified noise profiles from the total signal, leaving the underlying target frequencies intact.

2. Core Methodology: Time-Variant Spectral Subtraction

The foundation of the MatterMath Engine is advanced Spectral Subtraction. A contested audio recording, in the time domain, is defined as a discrete-time signal composed of the target speech signal and additive background noise:

$$y(n) = s(n) + d(n)$$

Where $y(n)$ is the recorded audio, $s(n)$ is the target speech, and $d(n)$ is the intrusive noise.

To isolate the speech, the MatterMath Engine transforms the signal into the frequency domain using the Short-Time Fourier Transform (STFT):

$$Y(\omega, k) = S(\omega, k) + D(\omega, k)$$

Unlike subjective equalization (EQ) adjustments performed manually by an audio engineer, our system identifies the noise magnitude spectrum \vert{}\hat{D}(\omega, k)\vert{} during intervals lacking target speech. The system then applies a deterministic subtractive algorithm across the entire file:

$$\vert{}\hat{S}(\omega, k)\vert{} = \max\left(\vert{}Y(\omega, k)\vert{} - \alpha \vert{}\hat{D}(\omega, k)\vert{}, \beta \vert{}Y(\omega, k)\vert{} \right)$$

Here, \alpha represents the subtraction factor and \beta represents the spectral floor (ensuring mathematical limits are respected without generating artificial artifacts). The isolated speech signal is then precisely reconstructed using the phase of the original raw recording:

$$\hat{S}(\omega, k) = \vert{}\hat{S}(\omega, k)\vert{} e^{j \angle Y(\omega, k)}$$

Because the original phase \angle Y(\omega, k) is preserved, the temporal placement of syllables, transients, and environmental acoustic markers remains perfectly intact and mathematically verifiable.

3. The Digital Null Test (Visual & Acoustic Proof)

The most common attack during cross-examination is the accusation that the forensic process deleted or altered exculpatory speech. MatterMath neutralizes this attack via the **Digital Null Test**.

Upon processing, our engine yields three outputs:

- **Track A:** The Original Raw Evidence
- **Track B:** The Isolated Speech
- **Track C:** The Delta Noise Track

The Delta Noise Track is generated by performing a strict phase inversion and summing the Raw and Clean tracks:

$$C(n) = A(n) - B(n)$$

Track C contains exactly and exclusively what was removed from Track A to create Track B. By allowing opposing counsel and independent experts to audition Track C, MatterMath proves a negative: **if human speech cannot be heard in the Delta track, no human speech was destroyed during the isolation process.**

Conclusion

In summary, MatterMath provides a deterministic, mathematically verifiable approach to audio forensic isolation that satisfies the rigorous demands of Daubert-compliant admissibility, ensuring that the integrity of evidence remains preserved without stochastic interference.