C8 An Audio Enhancement Framework for Forensic Purposes

Catalin Grigoras, PhD, 1020 15th Street, Ste 8I, Denver, CO 80202; Jeff M. Smith, MS, National Center for Media Forensics - CU Denver, 1150 10th Street, Arts Building, Suite 177, Denver, CO 80204; and James Zjalic, BSc, 22 Lowfield Close, Birmingham, England B62 0ez, UNITED KINGDOM*

After attending this presentation, attendees will better understand digital audio enhancement processes, limitations, and principles in order to inform a framework that will provide optimal results when performing audio enhancement for forensic purposes.

This presentation will impact the forensic science community by demonstrating that although there are many processes available to the forensic audio analyst, the order in which they are executed is vital in achieving the best results possible, as each tool used is used in isolation and modifies the signal in a unique way based on algorithms applied. The input of the next processor in a sequence is determined by the output of the previous, and this chain has a cumulative effect that provides differing enhancement results. A hypothesis that there is an optimal sequence of operations to produce the best results when performing audio enhancement is central to the research conducted for this presentation. There are currently various papers available detailing the individual methods of audio enhancement, but no document exists that provides a framework for the interaction of these processes.

The methodology proposed is agnostic, endorsing no specific software. It is based on scientific principles to future-proof the research from software developments and to allow the framework to apply to a range of individuals, including those who use free open source tools to those who work within agencies that have access to the latest, high-end software.

The goal of a forensic audio enhancement is to improve intelligibility and/or listening quality while maintaining the subjective speech interpretation and/or facilitating scientific measurements (e.g., gunshot, phonemes).[1] For this to occur, it is of the utmost importance that the desired signal is unchanged. To understand how this can be achieved, an investigation in the form of critical listening and Fast Fourier Transform (FFT) signal analysis is first performed to create a strategy that can be followed during the enhancement procedure to produce optimal results.[2] For this to be possible, a scientific review of techniques was performed and a critique of how various processes can be applied to specific issues present in forensic audio recordings was created. A logical framework was then devised, based on the knowledge of how various techniques alter the input of a processor and the signal information that is required by future processes in the chain.

The enhancement processes available to the audio analyst generally fit into six categories: source separation, distortion repair, filtering, noise reduction, de-reverberation, and amplitude correction.[3] Experimental results applied to the same input signal reveal that when several processes using identical settings are applied, the output varies in areas such as speech-to-noise ratio, artifact reduction/accumulation, intelligibility for transcription, and subjective audio quality. As each recording is infinitely different, the structure of the framework is not designed to be strictly adhered to step by step. There may be occasions when some steps are unnecessary due to the inherent character and noise present on each recording, but this will likely be discovered during the analysis stage.

This presentation will illustrate the scientific reasoning behind the proposed framework, results of the experiments, and, finally, an enhancement framework demonstration, from signal analysis to the audio output stage. Best practices such as note-taking, manipulation vs. enhancement, and evidence deliverables will also be highlighted, with the goal of attendees leaving with the practical know-how for optimal enhancement of forensic audio within the working environment.[4]

Reference(s):

1. Bruce E. Koenig, Douglas S. Lacey, and Steven A. Killion. Forensic Enhancement of Digital Audio Recordings. *Journal of the Audio Engineering Society.* 55, no. 5 (2007): 352–371.
2. Anthony T.S Ho and Shujun Li. *Handbook of Digital Forensics and Multimedia Data Devices.* (UK: John Wiley & Sons, Ltd, 2015).
3. C Grigoras and JM Smith. Audio Enhancement and Authentication. *Encyclopedia of Forensic Sciences.* Second Edition (Elsevier Ltd, 2013), 315–26.
4. SWGDE. Best Practices for Forensic Audio. October 8, 2016.

Forensic Audio, Audio Enhancement, Methodology

*Presenting Author