International Conference

Audio Forensics
"Finding Signal in the Noise"

Arlington, VA, USA
15–17 June, 2017

CONFERENCE REPORT

The Audio Engineering Society again hosted the international audio forensics research community for the premiere meeting of forensic experts, researchers, practitioners, and students. Participants from all over the world joined forces for the 2017 AES International Conference on Audio Forensics, *Finding Signal in the Noise*, held in Arlington, VA, USA, just across the Potomac River from Washington, D.C. The sequence of AES audio forensics conferences began in 2005 with the 26th AES Conference held in Denver, USA. The 33rd Conference returned to Denver in 2008, followed in 2010 by the 39th Conference in Hillerød, Denmark, back to Denver for the 46th Conference in 2012, and London, U.K., in 2014.

Conference participants hailed from more than a dozen countries, and, as has become traditional, the delegates included a great combination of experienced forensic examiners and law enforcement professionals, software developers, educators, students, and many individuals new to the audio forensics field.

Conference cochairs Daniel Rappaport and Jeff M. Smith wisely chose to convene the meeting at the Holiday Inn Arlington at Ballston, conveniently near the Ballston Metro station served by the Orange and Silver lines. Durand Begault and Douglas Lacey served as cochairs for the paper sessions, while Catalin Grigoras and Eddy Brixen organized the workshop sessions. Keith McElveen and Jake Hall cochaired the exhibition of audio forensics products and services.

Arlington, Virginia, is perhaps best known as the home of two significant U.S. military landmarks: Arlington National Cemetery, the resting place of highly honored military veterans, and the Pentagon, the vast headquarters of the U.S. Department of Defense. Arlington is also noted for its schools, shopping, street-side restaurants, and parks, plus an extensive network of bicycle routes and paved trails for nonmotorized commuting and recreation. The hotel meeting area and the surrounding community were perfectly suited for the conference, and enabled the small face-to-face discussions that are the most valued feature of AES international conferences.

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From left, conference cochairs Jeff Smith and Daniel Rappaport with Catalin Grigoras (right)

CONFERENCE OPENING

The conference opened at 9 a.m. on June 15 with a welcome by Dan Rappaport and Jeff Smith. The organizers welcomed participants from around the world,and thanked the conference planning team. Dan Rappaport noted that the conference nearly coincided with the 45th anniversary of the infamous break-in at the Watergate Complex (June 17, 1972) that ultimately led to important work in audio forensics with the examination of surreptitious analog tape recordings made in the Nixon White House.

The cochairs also thanked the sponsors and exhibitors, led by Gordon Reid and Platinum Sponsor CEDAR Audio Ltd. Other exhibitors and sponsors included Devin "Doc" Kylian of Audionamix, Brandon Carroll of iZotope, Don Tunstall and Jeff Hunter of Salient Sciences, and Keith McElveen of Wave Sciences. Sound reinforcement was provided by Optimum Audio, an A/V production company based in the Washington, DC area and owned by AES member Ralph Sordyl. The exhibitors set up hands-on demonstrations in the hall adjacent to the meeting room, providing the opportunity for discussion and interaction with the vendors.

Exhibitors staged hands-on demonstrations of audio forensic equipment in an adjacent hall.

Keynote Lecture

Two individuals involved in investigations for the Metropolitan Police Department (MPD) for the District of Columbia presented a captivating conference keynote address. MPD Detective Dale Sutherland (now retired) and Detective Alvin Cardinal described several examples of their use of audio and video surveillance in narcotics and firearms investigations. The detectives explained that audio/video documentation is considered essential for law enforcement prosecution of these crimes, as contemporary courts are unlikely to support a conviction based solely on an officer's oral testimony.

The detectives explained several examples of "inside" operations in which the police set up a fake storefront business, such as a sham recording studio, that would have the video cameras and audio surveillance equipment installed and concealed in advance. The suspected criminals would come to the "business" and get comfortable with the surroundings, while all the time the law enforcement team was recording the interactions.

The predeployment of surveillance gear makes it easier for the officers to have a remote control system in a separate secret booth on the premises, and an operator who can pan and zoom the hidden cameras in real time. The detectives mentioned that one of their challenges was maintaining the apparent legitimacy of the contrived storefront business; the undercover officers and surveillance operators had to be careful to avoid drawing any suspicions as they prepared the establishment and ran the undercover operation. By choosing a recording studio as the false venue, the undercover officers lured the suspects into thinking that a rap music album was in the works, while also making individuals in the neighborhood less wary to see people coming and going with audio/video equipment.

Dale Sutherland, left, and Alvin Cardinal discuss audio and video surveillance in their keynote on narcotics and firearms investigations.

Detective Sutherland spoke about the current technical and policy challenges of having many uniformed officers wearing personal recording equipment as part of their regular routine. The sheer volume of recordings makes it difficult to archive everything in an effective manner, and concerns about expectations of privacy when members of the public are being routinely recorded by law enforcement during everyday activities arise in most jurisdictions.

The detectives noted that judges and juries are starting to expect very high-quality video and audio for surveillance evidence presented in court, so there is an interest in moving from the simple and grainy black-and-white analog video camera systems to higher-quality digital video.

TECHNICAL PROGRAM—DAY 1

Signal Analysis Papers

Following the fascinating keynote presentation, the first technical session of the conference included two papers.

The first paper, "Gunshot Acoustics: Pistol vs. Revolver," by Rob Maher and Tushar Routh of Montana State University, Bozeman, MT, USA, described the authors' recent work in measuring gunshot sounds with a specially-constructed multimicrophone apparatus designed to record the firearm's brief muzzle blast sound without acoustic reflections. Maher explained that the muzzle blast sound from a handgun is directional, being loudest in the direction the gun is pointing, and less loud at azimuths to the side or behind the firearm. What's more, the gunshot sound produced by a revolver handgun may include not only the sound emanating from the end of the muzzle, but also sound emitted at the small gap between the revolver cylinder and the barrel. The gap sound starts as the bullet begins its travel down the barrel, so the gap sound precedes the muzzle blast sound by a few hundred microseconds when observed at certain azimuths. For a forensic recording in which the microphone was

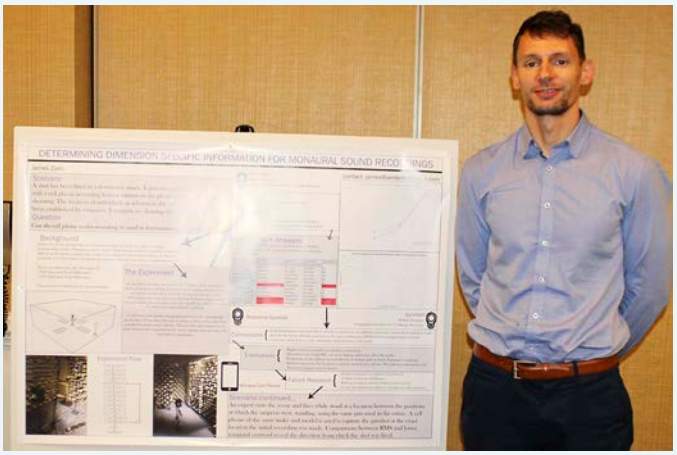
located off to the side of the firearm, it is possible that the gap sound could be detected in the recording, which would allow a forensic examiner to distinguish a revolver from a pistol with a sealed breech.

The second paper was coauthored by William Tuccio and Joseph Gregor of the National Transportation Safety Board, Washington, DC, and Bill Schuster of Honeywell Aerospace, Phoenix, AZ. Bill Tuccio presented the work, entitled "Deriving Engine Power from a Cockpit Voice Recording in an Accident Investigation." The paper considered the cockpit voice recorder (CVR) information from an aircraft crash that occurred on November 10, 2015, taking the lives of nine passengers and crew onboard.

Among the accident investigation questions was the need to determine the engine power settings during the flight prior to the accident, but the aircraft did not have a modern digital flight data recorder, just an analog tape-based, 30-minute CVR. The CVR captured audio from three microphones: pilot headset, copilot headset, and the cockpit area microphone (CAM) located in the overhead panel between the pilots. Tuccio explained that although the cockpit audio recordings were of low quality and quite noisy, the investigators were able to extract the distinctive sounds of the two turbine spools in each of the two jet engines, and then make an estimate of engine speed and power for the 30-minutes duration of the recording.

Poster Paper

Each day of the conference, the organizers scheduled a poster paper presentation during the lunchtime exposition. James Zjalic of the National Center for Media Forensics (NCMF), Denver, CO, USA, displayed the first poster, entitled "Determining Dimension Specific Information for Monaural Sound Recordings." Zjalic's preliminary research dealt with the need to unravel the likely position of sound sources with respect to a mono recording microphone in a forensic audio recording. The room reflections and other cues can potentially provide information of importance to a forensic investigation, such as the position of a talker or the orientation of a firearm.



James Zjalic with his poster on locating sound sources from mono recordings.

Durand Begault, standing, leads a workshop on gunshot analysis featuring, from left, Rob Maher, Steve Beck, and and Kenneth Marr.

Workshop on Gunshot Analysis

After the relaxing lunch break and exposition, the technical sessions continued with a workshop on audio forensic gunshot analysis, presented by Durand Begault, Rob Maher, Steve Beck, and Kenneth Marr. Begault (Audio Forensics Center, Charles M. Salter Associates, San Francisco, CA) covered the general background and history of gunshot acoustical analysis, and the types of questions and challenges that frequently arise in this area of audio forensics. Maher presented a set of charts and diagrams showing high-resolution recordings of gunshots, and considered the features that could be present in a forensic recording that is likely to be of reduced bandwidth and lower quality than the "laboratory" recordings obtained in his research projects. Next, Steve Beck (Beck Forensic Audio Consulting, Austin, TX) reviewed several of the essential features of the human hearing system and the limitations of human listeners in assessing the impulsive and loud sounds made by firearms. These considerations are important when a forensic case involves ear-witness testimony about the characteristics of gunshot sounds reported by a human listener. Finally, Ken Marr, a forensic audio examiner with the U.S. Federal Bureau of Investigation (FBI), presented several issues in the FBI's interpretation of gunshot acoustical evidence. Marr pointed out that in many cases he finds that the microphone in a recording device will exhibit "audio shutdown," whereby the extremely loud report of the firearm exceeds the capability of the audio input, leaving essentially a dropout gap in the recording itself.

Microphone Recognition Paper

The meeting delegates enjoyed a brief break for refreshments and conversation in the exhibits area, and then reconvened for the final paper session of the day, "Performance of Blind Microphone Recognition Algorithms in the Presence of Anti-Forensic Attacks," authored by Azeem Hafeez and Hafiz Malik of the University of Michigan-Dearborn, and Khalid Mahmood, of Oakland University. Malik presented the paper, which involved an experiment to discern alterations in an audio recording based on software recognition of the particular microphone in use. The experiment with three different microphones showed that the authors' algorithm was unable to detect spliced insertions simulating an altered forensic recording. Malik concluded that further work would be needed to find a reliable and consistent methodology.

Thursday Social Event: Food and Fun on the Potomac River

Upon the conclusion of the successful first day of the conference, many attendees joined a special social event to see Washington D.C. on a scenic riverboat tour along the Potomac River. The adventure started with a bus ride from the conference hotel to the port at Old Town Alexandria Harbor, Virginia, about 10 km south of the U.S. Capitol, where the delegates boarded the excursion boat Matthew Hayes, and began the pleasure trip north on the Potomac River toward Washington.

While the delegates enjoyed food, beverages, and enthusiastic conversation, a pleasantly cool evening breeze passed over the

bow and the vessel gradually approached the beautiful skyline of Washington's monuments. After passing under the Arlington Memorial Bridge near the Lincoln Memorial, the boat passed the Kennedy Center for the Performing Arts, the Watergate Complex, and the Francis Scott Key Bridge at Georgetown before turning around and heading back to the port with the light of the setting sun.

The participants all clearly enjoyed having a scenic and relaxing outing to conclude the first day of the conference.

A group of delegates enjoys the Potomac boat tour with Washington monuments on the skyline: from left, Michael Jessen, Dagmar Boss, David van der Vloed, and Catalin Grigoras.

TECHNICAL PROGRAM—DAY 2

Following a breakfast of pastries, fruit, juice, tea, and coffee, the second day of the conference began with several technical papers dealing with speech topics.

Speech Interpretation Session

Dennis Bergfeld and Kornel Junte of the National Police of the Netherlands described their work to understand the effects of the listening environment and playback equipment on the quality of speech transcription. As explained in their paper "The Effects of Peripheral Stimuli and Equipment Used on Speech Intelligibility in Noise," officers need to produce a speech transcript of an interview or forensic recording, and often complain that the poor quality of the recording hampers their work. The authors have found that frequently another detrimental issue is the poor playback system and noisy playback environment of the transcribing suites. The result of their experiments was that they could ensure an improved speech reception threshold (SRT) for noisy speech by paying careful attention to the playback level, limiter setting, sound isolation, and reducing distractions and interference.

Kornel Junte asks one of the many probing questions from the floor prompted by challenging papers.

Jane Foster discussed speech intelligibility with cockpit voice recorders.

In the morning session's second paper, Jane Foster of the U.S. National Transportation Safety Board described her work to assess speech intelligibility with older analog tape-based cockpit voice recorder (CVR) systems. The U.S. Federal Aviation Administration (FAA) requires CVRs in all twin engine, two-pilot aircraft capable of carrying six or more passengers. New aircraft are equipped with contemporary digital solid-state memory CVR systems, but many in-service aircraft still use older analog tape recorders. Foster explained that the current operational test of a CVR consists of recording a single test tone, but this simple test does not catch all of the possible failures in the system, such as a malfunctioning erase head. Her test procedure involved mixing test speech with recorded cockpit noise to help understand the intelligibility issues with the legacy tape-based systems. She explained that using a computational method such as the speech intelligibility index (SII) would be helpful to assess and verify CVR functional performance rather than the simple single-tone test.

The third paper of the morning session concerned automatic speaker comparison. David van der Vloed and Stefan Gfroerer of the Netherlands Forensic Institute, and Michael Jessen of the German Bundeskriminalamt Forensic Science Institute, explained the typical forensic request to determine if a recorded voice (offender audio) was an utterance made by the suspect in custody, or by some other individual. Performing forensic automatic speaker comparison when the language spoken by the suspect is different from the language of the reference population presents a special challenge. This situation can happen when the offender and suspect language is different or unusual and no matching language reference population is available. The authors conclude that the comparison can proceed under these circumstances, but care must be taken to interpret the comparison results.

Workshop on Authentication Using Acoustical Environment

Following the morning break and vendor demos, the conference turned to the topic of authentication using subtle acoustical cues that might be present in a recording, such as room reverberation and microphone idiosyncrasies. Hafiz Malik of the University of Michigan-Dearborn was the workshop presenter.

Malik pointed out the many difficulties associated with authenticating digital audio recordings, and described current research regarding potential use of telltale background sounds such as reverberation, reflections, and other characteristics of the recording environment to reveal insertions or edits. Despite the common use of terms such as "acoustic fingerprints" and "sound signature matching" that might imply unique and definitive characteristics, current research results have not yet shown

great reliability. However, research interest in this area continues to be strong, so Malik is hopeful for improved results in the future.

Members of the conference committee: from left, Eddy Brixen, Catalin Grigoras, Daniel Rappaport, Jeff Smith, Doug Lacey, and Durand Begault.

Poster Paper

For the second poster paper of the Conference, Mitchell McLaren, and Aaron Lawson of the Speech Technology and Research (STAR) Laboratory, SRI International, Menlo Park, California, presented "Handling Multi-Speaker Audio in Forensic Speaker Recognition." The poster explained their technique to identify the talker of interest in a recording containing multiple talkers, with the goal of automatically identifying all instances of that particular talker throughout the recording. This automated process is helpful when the subject recording is a dialog, such as a conversation between two individuals. The proposed method, known as hybrid speaker diarization, uses a human annotator to identify initially the talker of interest, and then the automated system uses the sample as the target to identify throughout the entire recording. The results are promising in both speed and precision.

Workshop on Forensic Automatic Speaker Recognition

Following the lunch break, the conference program returned with a special workshop on automatic speaker recognition (ASR). Antonio Moreno of Nuance Communications and Eliud Bonilla of Johns Hopkins University Applied Physics Lab described several of the key principles and challenges of ASR systems for forensic purposes.

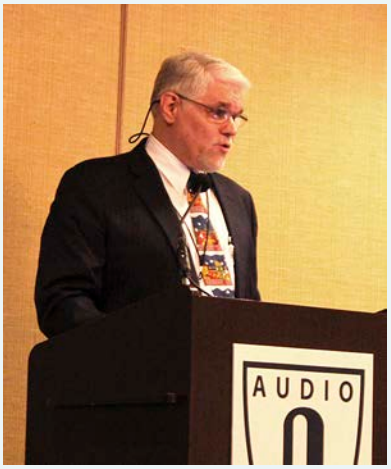
Moreno explained that automatic speaker recognition is ideally a biometric system, in which the features of an unknown talker's speech are compared to a database of stored features from many known talkers, and a decision is made regarding the likelihood that the unknown talker uniquely matches one of the known talkers. The database contains interspeaker variability, which is desired because this represents the speaker-to-speaker differences. However, the database also includes intersession variability, which is not desired because it represents the extrinsic characteristics of the recording channel, recording environment, and other session-to-session differences. Ultimately, the ASR system designer needs to suppress the intersession variability and produce a likelihood ratio: the probability that the test signal matches the suspect, divided by the probability that the test signal is from someone other than the suspect.

Bonilla noted many of the practical perspectives for ASR. While the intention is to have an automatic system, the system's operation still requires careful choices and interpretation. Bonilla explained that automatic speaker recognition is sometimes referred to as speaker identification or speaker comparison, and the forensic examiners come from diverse backgrounds such as speech pathology, phonetics, law, criminology, or a science field, and these differences can lead to different interpretations and biases. He recommended that practitioners gain experience by practicing with challenging material and keeping meticulous notes of all casework.

Speaker Recognition Papers

A pair of interesting research papers on speaker comparisons wrapped up Day 2.

The first paper dealt with the problem of automatic speech recognition when the test speech has a poor signal-to-noise ratio (SNR). "Training 'On The Fly' to Improve the Performance of Speaker Recognition in Noisy Environments," by Ahmed H. Al-Noori, Philip J. Duncan, and Francis Li of the University of Salford, U.K., described their work to detect the noise level and characteristics of the input signal. They developed a system to pass the input signal through an SNR estimator, and if the SNR is found to be low, a noise profile estimate is determined for the noisy signal, and the estimated noise is mixed with the example speech signal database to create new noisy speech signals, which are then used "on the fly" to re-train the speech model. This approach is found to decrease the mismatch between the test signal and the example speech database, and provides promising results especially when the speech is contaminated by noise that remains relatively constant with time. The proposed method differs from the usual approach, which is to try to remove or ameliorate the noise in the test signal prior to the matching process with noise-free examples.



Eliud Bonilla discusses the practicalities of automatic speaker recognition.

The second paper, "On the Relevance of, Jitter, Shimmer and HNR Acoustic Parameters in Forensic Voice Comparisons Using GSM, VOIP and Contemporaneous High-Quality Voice Recordings," was by Vânia Fernandes and Aníbal Ferreira of the University of Porto, Portugal. The authors explained their experiment to determine if several characteristic features of recorded speech survive common encoding algorithms, such as GSM for mobile phone conversations in European digital cell phone networks. The authors used a database consisting of special speech recordings by native Portuguese speakers. Interestingly, the panel of talkers was chosen to be twins and triplets, allowing a rather unique comparison of vocal features for individuals with very similar physical anatomy. The clean speech and simultaneously compressed speech examples were used to calculate the speech parameters for both the unmodified recordings and for the digitally compressed recordings. The results showed that there were some effects attributable to the different speakers and the different recording channels, and the

effects varied with the particular choice of speech parameter being compared.

The fascinating second day of the conference concluded with a cocktail reception in the hotel's bar and dining area. Much of the conversation flowed naturally from topics discussed in the technical session, and the delegates enjoyed some time to meet new acquaintances, introduce spouses and other accompanying guests, and to renew professional friendships.

TECHNICAL PROGRAM—DAY 3

The final day of the conference featured seven technical papers and a special workshop on audio forensic authentication.

Authentication Papers

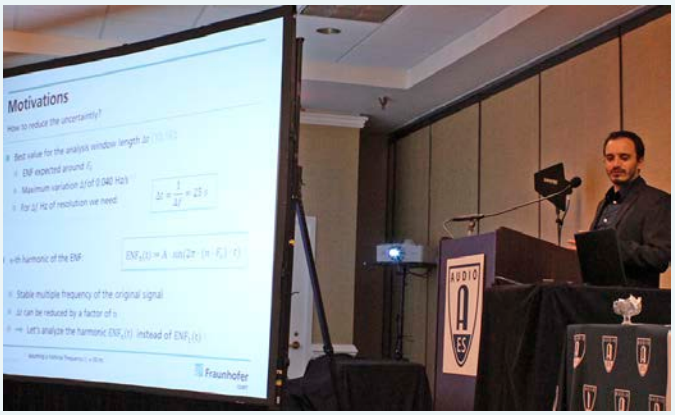
Leading things off on Saturday morning was a paper about electrical network frequency (ENF) analysis by Luca Cuccovillo and Patrick Aichroth of the Fraunhofer Institute for Digital Media Technology, in Germany. ENF analysis refers to a technique for extracting any residual hum in an audio recording that is attributable to crosstalk from the AC power system into the audio system. If the recording is of sufficient duration to allow the AC power hum signal to be compared to a known database of the aleatoric variations in instantaneous AC line frequency, an examiner can make a judgment about the recording's authenticity regarding the time and place it was made. The paper, "Increasing the Temporal Resolution of ENF Analysis via Harmonic Distortion," described the authors' work to isolate the ENF signal and deliberately distort it to create harmonics. The rationale is that a small change in frequency of the fundamental (i.e., ~50 Hz in Europe and ~60 Hz in North America) gives a multiplied change in frequency for the harmonics (2x, 3x, 4x, etc.). The results indicate that the proposed technique is useful for detecting possible tampering with recorded forensic audio.

Next, James Zjalic of NCMF in Denver, Colorado, described a project to develop a device capable of monitoring ENF at a remote location and reporting the information back to an online server. The device would be useful in creating an ENF database for a location not easily monitored, such as a distant country or a war region. The paper, "A Low Cost, Cloud Based, Portable, Remote ENF System," was coauthored by Catalin Grigoras and Jeff M. Smith, also of NCMF.

A third paper on authentication approached the problem from the viewpoint of signal analysis and interpretation. Researchers from the College of Engineering in Pune, India, studied how an estimate of the background reverberation present in a forensic recording could be used to identify insertion edits with differing reverberation than the original material. Rashmika K. Patole presented "Reverberation-Based Tampering Detection in Audio Recordings" on behalf of her coauthors, Gunda S. Kore and Priti P. Rege. The research results were interesting, but future work will need to address recordings in which the position of the talkers and/or the microphone changes during the recording, or in which automatic gain control or other dynamic processing is present in the recording channel.

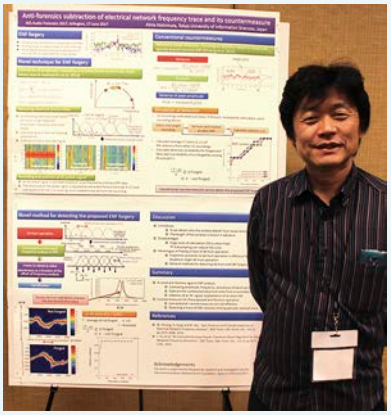
Workshop on Authentication

Before breaking for lunch, Bruce Koenig of BEK TEK LLC, Stafford, Virginia, and Catalin Grigoras of NCMF, Denver, Colorado, presented a tutorial workshop touching on many important aspects of audio forensic data handling and authentication. Koenig shared several intriguing anecdotes about the challenges and requirements of a contemporary audio forensics engagement, beginning with chain-of-custody concerns and ending with proprietary formats and potentially hidden data. He also mentioned that investigations these days often involve multiple simultaneous recordings obtained from different devices present in different places at the incident scene, and investigating the consistency of these recordings is important. Grigoras added several key points of advice, particularly regarding examination errors with incorrect device settings and file translation problems. Both men encouraged audio forensic examiners to document their work meticulously.



Luca Cuccovillo of Fraunhofer discusses ENF analysis, winning the best paper award at the conference.

Bruce Koenig introduces data handling and authentication.


Akira Nishimura discusses how to deal with forgers who know forensic audio methods.

Poster Paper 3

The third exhibition poster dealt with ENF, but in this case, the possibility that a clever adversary would arrange to alter the ENF of an existing audio recording to make it appear that the recording took place at some other time. The poster paper by Akira

CONFERENCE COMMITTEE

Cochairs: Daniel Rappaport and Jeff Smith
Papers: Durand Begault and Doug Lacey
Workshops: Catalin Grigoras and Eddy Brixen
Exhibition: Keith McElveen and Jake Hall

Nishimura of Tokyo University of Information Sciences, Japan, was entitled "Anti-Forensics Subtraction of Electrical Network Frequency Trace and its Countermeasure." The poster pointed out some of the difficulties in establishing authenticity of digital audio evidence, especially when presented with the possibility of a skilled forger who knows the common methods of audio forensic analysis.

Audio Data Storage and Metadata Papers

All too soon for the delegates, the third day of the Conference reached the final paper session following the lunch break: four papers concerned with various aspects of digital audio files and metadata.

Bruce Koenig and Douglas Lacey of BEK TEK LLC returned to the podium to present their paper, "Forensic Authenticity Analyses of the Metadata in Re-Encoded iPhone M4A Files." They described several experiments in which audio files recorded on an iPhone in M4A format were transferred to a computer, simply opened, and then saved under a different name without waveform alteration ("Save As…"). They found that even in the case of no deliberate alteration, some software packages will alter the metadata information of the file. Metadata refers to auxiliary bytes in the file that contain descriptive information such as the software version, file offset pointers, user comment text, and so forth. The authors concluded that a forensic examiner could identify a potentially altered iPhone M4A file by noting changes to the metadata.

The second paper in the session was "Triage Approach for the Forensic Analysis of Apple iOS Audio Files Recorded Using the Voice Memos App." The paper described the work of Jeff Smith and Catalin Grigoras of NCMF, along with Douglas Lacey and Bruce Koenig of BEK TEK, to examine the detectability of edits or other file alterations made to audio files recorded in the standard "Voice Memos" app in the iPhone operating system. Voice Memos is a simple audio recorder that allows for a pause in the middle of a recording, as well as simple insert and trim editing of audio files within the app. The authors experimented with several different versions of the iOS operating system and different versions of Voice Memos to see what metadata traces could exist after audio alterations of a prior recording. The empirical work resulted in a very useful decision tree that an examiner could use to do a quick assessment of the integrity of a Voice Memos recording.

Catalin Grigoras and Jeff Smith stayed at the podium for the next paper, which described their empirical work with dozens of portable digital audio recorders ("Large Scale Test of Digital Audio File Structure"). Essentially every recorder make, model, and firmware revision generates distinguishable metadata information, as did the software packages they examined. Grigoras concluded with a strong recommendation that audio forensic examiners always review the file metadata as a routine part of normal validation and consistency checks.

James H. Jones, Jr., of George Mason University, Fairfax, Virginia, presented the final technical paper of the conference, entitled "Deleted Audio File Decay on a Digital Voice Recorder." Jones worked with MP3 files recorded with a portable voice recorder and then "deleted." Jones explained that most digital storage systems delete a file simply by removing its allocation from the file directory table, while the actual contents of all of the storage sectors remains intact until something new is recorded over the prior information. A forensic examiner may be called upon to try to retrieve and reconstruct audio information from these unallocated (deleted) files. Jones found in his experiments that fragments of deleted MP3 audio files persisted in the storage memory even after multiple re-recordings, and that the fragments were often usefully decoded, revealing intelligible audio. The results have importance for forensic reconstruction, as well as those concerned about security and privacy.

Kyung Wha Kim receives one of the three iZotope Rx 6 licenses raffled to delegates at the conference.

Conference Best Paper Award

Subsequent to the conference, Platinum Sponsor CEDAR Audio selected a winning paper based upon their review of the conference proceedings. The paper receiving the award was "Increasing the Temporal Resolution of ENF Analysis via Harmonic Distortion," authored by Luca Cuccovillo and Patrick Aichroth of the Fraunhofer Institute. The winning paper is included as part of the conference proceedings, available in the AES online digital library.

AES AUDIO FORENSICS: FINDING SIGNAL IN THE NOISE

The AES 2017 Audio Forensics Conference maintained the tradition established by the five prior AES forensics conferences, providing an important mix of current research, practical workshops, open questions, and educational content. AES remains the leading professional group in the field of forensic audio analysis and interpretation.

Conference chairs Dan Rappaport and Jeff Smith graciously concluded the conference, thanking the volunteer conference committee and all of the conference delegates for sharing their research work and expertise.

As the delegates said farewell to colleagues and friends, it was clear that all were looking forward to hearing plans for the next AES conference on forensic audio.

Editor's note: the papers presented at this conference can be obtained from http://www.aes.org/publications/conferences/