AES 26TH INTERNATIONAL CONFERENCE

Denver, USA, July 7–9, 2005

Audio Forensics in the Digital Age

An analog cassette tape mysteriously appears in the incoming mail of a major newspaper. The tape is purportedly from an answering machine, and the accompanying note claims that it is an original tape containing an extortion attempt by a local business owner who is now running for governor. If the tape is authentic it would be a huge scoop for the newspaper, undoubtedly end the candidate's campaign, and possibly lead to criminal charges against him. On the other hand, if the tape is a fake it could be merely a cynical attempt by the candidate's adversaries to discredit him, and the newspaper would look foolish to have published it.

To the editor's ear the tape sounds like it might be authentic and would lend credence to the rumored extortion scheme. So what can the newspaper editor do? How can the authenticity of the tape be evaluated?

Don't worry, this is a fictional situation. But it might easily be entitled "All in a day's work for the forensic audio expert."

The AES 26th International Conference, *Forensic Audio in the Digital Age*, brought what was recently an obscure and arcane audio engineering subspecialty into a technical field of increasing importance. Based on the enthusiasm of the attendees and the influential role that AES members play in this field, audio forensics will be a hot topic for future conferences as well.

Denver, the Mile High City, was a gracious and welcoming host for more than 50 individuals with backgrounds as remarkable as they were varied. Members of the legal profession, university researchers, audio recording experts, software developers, and even sworn law-enforcement officers came together to share their insights, experience, and opinions about where the field of forensic audio has been, where it is today, and where it needs to go in the future.

Roy Pritts, conference chair, Richard Sanders and Tom Owen, papers cochairs, Wanda Newman, facilities chair, and the rest of the committee began planning the conference several years ago. The care and dedication with which they guided the planning process was clearly evident in the impeccable technical program and local arrangements.

The Adams Mark Hotel, located in downtown Denver, a few blocks from the Colorado State Capitol building and adjacent to Denver's 16th Street pedestrian mall, served as the conference headquarters. The program provided numerous opportunities for the attendees to share their expertise and to learn from each other. A full slate of technical papers and expert panels was scheduled each day while still leaving time for breaks and informal discussions, group lunches, a Western barbecue dinner on Friday evening, and a scenic tour up and over the Continental Divide just west of Denver on Sunday. Many of the attendees were also presenters, giving the conference a truly collegial workshop quality that can be difficult to achieve in larger settings.

TUTORIAL DAY

Recognizing that forensic audio concepts are not yet widely taught in audio engineering programs, the conference organizers provided several venues for the attendees to learn the terms, processing methods, and current issues for forensic audio practitioners. In fact, the entire day on Thursday was devoted to a fascinating tutorial on forensic audio, held at a University of Colorado at Denver building located near the city's trendy Larimer Square and adjacent to the Denver Center for Performing Arts. Glimpses of snow on the 14,000-foot summits of Longs Peak to the northwest, Mount Evans to the west, and Pikes Peak to the southwest all looked especially tantalizing as the temperatures in downtown Denver approached the 100 degree Fahrenheit mark. Fortunately, the meeting room was comfortably air conditioned and the attendees quickly settled in with coffee, juice, and pastries.

The tutorial began with a welcome by Roy Pritts, who introduced the local organizing committee including volunteers from the AES Colorado Section (students and professionals).

Tom Owen and Rich Sanders presented an introduction and history of forensic audio. Owen traced the use of forensic voice identification all the way back to the 1860s when a witness identified a particular dog bark in a court case. But it was not until the 1930s and 1940s that audio recordings were more commonly encountered in surveillance and criminal investigation. Spectrographic analysis for voice identification began to gain legal admissibility in the late 1950s, but Owen emphasized that the U.S. courts have treated voice identification somewhat irregularly over the years.

A significant milestone in public awareness of audio forensics occurred when Judge John Sirica ordered the Nixon

Roy Pritts, conference chair

Theresa Leonard, AES president

Rich Sanders, papers cochair

administration to turn over audio tapes recorded in the White House. The now infamous 18-minute gap in a tape of a conversation from June 1972 between Nixon and his Chief of Staff H.R. Haldeman led to great interest by the press and the public, and the subsequent court-ordered investigation into the authenticity of the tape. The cause of the gap brought audio forensic science to the forefront for the first time.

Owen gave a brief description of how forensic audio examiners use the magnetic development technique to visualize the latent magnetic field pattern present on an analog tape. A special fluid containing ferromagnetic particles is spread in a thin layer on the tape itself. As the fluid evaporates the magnetic particles align themselves with the underlying magnetic domains of the tape, thereby leaving a visible pattern that the examiner can observe using a microscope. Each tape recorder shows a recognizable start/stop/erase magnetic pattern, or signature, that can be identified and sometimes even traced to a specific recorder. He mentioned that while magnetic development is a useful way to detect tape erasures and other features that might lead to the conclusion that a tape had been altered, the issue of authenticity will continue to grow as more and more recordings are made directly into solid-state digital form with flash memory devices and tapeless digital answering machines.

Rich Sanders defined audio forensics as "the study and examination of audio, recorded or otherwise, as it pertains to finding a truth." He presented several examples of how audio recordings enter the realm of forensic science—and emphasized that "reality is not like what is portrayed in the movies and on television." The key forensic aspects have to do with establishing tape authenticity, enhancing noisy or degraded recordings, preparing transcripts of taped conversations, comparing a speech sample from a suspect with an unknown voice in a recording, and other special investigations such as gunshot recordings and analysis of audio flight data and voice recorders.

In the second section of the tutorial Tom Owen described the methodology he recommends for all types of forensic audio (and video) evaluation. Owen's twelve-step procedure covers proper handling of the physical evidence, calibration of the test system, and a systematic sequence of steps for evaluating the audio material. The final step for the examiner is to produce a formal written report according to the requirements of Federal Civil Rule 26. Rule 26 requires the expert to present the basis and reasons for any conclusions, the data used to reach the conclusions, and the qualifications and experience of the expert.

The tutorial next turned to the subject of audio enhancement. Gordon Reid of CEDAR Forensic, Cambridge, U.K., described and demonstrated several remarkable methods for noise reduction in forensic recordings. Reid introduced the topic by explaining the need for noise reduction to gain increased speech intelligibility for transcripts and critical listening. He went on to explain the desirability of enhanced recordings for use in jury proceedings, since it is likely that the jury members will be untrained listeners.

The recommended enhancement procedure utilizes fixed filters to reduce tonal noise and more sophisticated adaptive filters to deal with nonstationary and broadband noise contamination. Because there are so many types and combinations of noise sources, Reid emphasized that a skilled engineer will need a variety of enhancement tools since a single, simple technique is unlikely to be sufficient. He also cautioned the attendees that future digital processing and enhancement techniques might allow unscrupulous individuals to create or manipulate audio recordings in a manner that might be difficult or impossible to detect using the latent magnetic imaging techniques used with analog magnetic tape.

Rich Sanders presented the concluding tutorial session describing the aural spectrographic method of voice identification. As the name implies, this well-established procedure involves two parts: an aural comparison (listening) by the examiner and a visual comparison of the speech spectrograms. The typical goal of the procedure is to form an opinion as to whether an unknown voice in the forensic recording was uttered by a particular suspect. Sanders explained that a set of key words and phrases are selected from the forensic recording, and then the suspect is recorded saying the same key words and phrases in a manner as close as possible to the unknown speech. These "exemplar" recordings are ideally performed using the same type of equipment used to obtain the original forensic recording of the unknown talker. The examiner must then compare the unknown and exemplar recordings for perceived pitch, dialect/accent, rate of utterance, peculiar mannerisms, pathological conditions, syllable ➥

coupling, and so on.

The visual spectrographic analysis uses the same unknown and exemplar recordings but the comparison is done using spectrograms. Sanders described how the examiner must look for details such as mean excitation frequency, formant trajectories, alignment and timing of fricative and plosive sounds, and other features that can be observed visually in the spectrographic record. He urged the audience to recognize the importance of training and "being conservative" when performing such subjective comparisons.

Tutorials presenters: from left, Rich Sanders, Gordon Reid, and Tom Owen.

According to Sanders, the examiner must come to one of seven possible conclusions after the aural spectrographic analysis of the unknown and exemplar recordings: positively the same, probably the same, possibly the same, inconclusive, possibly not the same, probably not the same, or positively not the same.

Friday morning authors: from left Andrew Harper, Tomislav Grubesa, Sanja Grubesa, Durand Begault, Ester Spence, Jeff Smith, Rebecca Wright, and Bradd Fanberg.

TECHNICAL PRESENTATIONS

The main technical sessions of the 26th Conference began Friday morning in the conference facilities of the Adams Mark hotel. Roy Pritts introduced AES President Theresa Leonard, who officially opened the Conference and thanked the committee for "making history" by organizing the first AES event devoted specifically to audio forensic science and engineering.

Rich Sanders and Tom Owen organized the paper sessions and workshop panels into three key areas: voice identification, signal enhancement, and authentication. With additional papers on audio forensic gunshot investigation, a review of the legal standards of admissibility for audio evidence, and the role of audio watermarking technology in authenticating digital recordings, the conference papers covered a comprehensive range of forensic audio topics.

Friday afternoon authors and workshop panelists: from left, Eddy Brixen, Rich Sanders, Chris Musialik, Mike McDermott, Tom Owen, Durand Begault, and Andrzej Czyzewski.

VOICE IDENTIFICATION ISSUES

As explained in the tutorial, forensic voice identification is used to determine scientifically whether the speech present in an audio recording is probably, possibly, or probably not a match to the speech of a particular known or suspected individual. The first paper in this session, "Voice Identification and Elimination Using Aural-Spectrographic Protocols," coauthored by consultant Tito Poza and Durand Begault of Charles M. Salter Associates and presented by Begault, considered the possible role of the examiner's bias—presumably unintentional, but unavoidable—that could limit the objective reliability of the voice-identification report. Begault explained that in the common aural spectrographic procedure an experienced examiner must make the determination regarding the likelihood that a particular unknown speech sample was produced by the same talker as a known exemplar. Begault suggested that the examiner's task should be viewed as a classical detection problem: What is the probability that the known and unknown speech samples are from the same talker versus from two different talkers. In a controlled experiment the examiner would like to achieve one of two possible outcomes: a correct decision, such as declaring a match when the two samples did, in fact, come from the same talker (a hit) or declining a match when the samples are from different talkers (a correct rejection). However, the examiner might also incorrectly declare that the unknown and the known samples match (a false alarm) or incorrectly determine that they do not match despite coming from the same talker (a miss). Begault referred to a large study conducted in the early 1970s by Oscar Tosi in which the false identification rate for skilled examiners was 6.4 percent and the false elimination rate was 11.8 percent. Since the uncertainty of correct detection or rejection is unavoidable, at least the examiner bias should be reduced as much as possible. Begault suggested that a stronger procedure involving a sequential "line-up" with similar-sounding subjects—more like an identification line-up for eyewitness identification—would make for a stronger case in court. In any event, Poza and Begault's recommendation was to reduce the chance of false identification, perhaps at the expense of more false eliminations, so that the examiner's role in forensic testimony gains greater acceptance.

Saturday morning authors and workshop panelists: from left, Wes Dooley, Rob Maher, Chris Musialik, Andrzej Czyzewski, Durand Begault, and Gordon Reid.

Saturday afternoon authors and workshop panelists: from left, Adam Olson, Wes Dooley, Daniel Stocker, Chris Musialik, Tom Owen, Durand Begault, Mike McDermott, and Jose Quinones.

An issue for forensic speech examination is the acceptability of digital and analog spectrograms. Analog spectrograms are widely accepted by judges across the U.S., but digital spectrograms for voice identification may not be accepted in all jurisdictions. Andrew Harper, Esther Spence, and Kevin Garland of the University of Colorado at Denver conducted a comparison of the conventional analog spectrogram produced by a Voice Identification, Inc., Series 700 Analog Spectrograph and two software packages that include spectrographic output. They chose a set of three example sentences and recorded examples spoken individually by a panel of male and female talkers. The comparisons showed significant discrepancies between the analog system and the digital results, especially in the case of female talkers. The results also raised the question of how to scale the contrast and gray scale for the digital systems, since there is no standard spectrographic display at present. Several questions from the audience asked about the integrity of the system transfer functions and whether the differences might be attributable to electrical differences. It was clear that further research on this topic will be needed.

A second investigation by University of Colorado at Denver students Jeff Smith, Bradd Fanberg, and Rebecca Wright, dealt with the question of how much the spectrogram is altered by deliberate vocal changes. Can an uncooperative subject cause a mismatch, or would even a minor nasal infection significantly alter the spectrogram? The researchers obtained a large set of recordings in which the subjects were asked to speak normally, with a pinched nose, in a high register, and to try to mimic an example recording. Each recording was processed with linear predictive coding (LPC) to derive speech formant frequencies and statistics. Differences were generally aurally distinguishable and many of the alterations were clear in the spectrograms. For the "mimic" recordings even the best mimics were aurally distinguishable, but the formant analyses were sometimes close enough that the LPC analysis could lead to confusion. The authors concluded that although the changes due to speech alterations may be slight, examiners need to consider the chance of misidentification.

The next paper on voice identification described a method for speaker recognition using a combination of signal processing strategies. The presenter, Tomislav Grubesa, noted that any automatic speaker identification system requires great care in selecting the criteria, training set, and other optimal choices. The authors' proposed technique used a neural network acting on signal subbands obtained from a wavelet analysis. They calculate a weighted sum of the matching decisions for each subband, and then use the combined decisions to form the overall assessment. The results showed that the method was reasonably effective in the context of the testing procedure.

As mentioned during the tutorial session, one of the issues for modern forensic audio is the frequent use of digital speech coding in telephony systems and for data compression in small recording devices. Eddy Brixen of EBB-consult, Smørum, Denmark, and Durand Begault investigated the question of whether spectrographic analysis of G.723-encoded speech (6.3 kbps) by the proprietary Sony LPEC (Long Term Predicted Excitation) at approximately 16k bps and 10 kbps would reveal significant differences compared to spectrograms obtained from linear PCM recordings of the same speech material. Although they observed minor differences in the spectrograms, Brixen and Begault expressed confidence that the essential features required for spectrographic analysis, such as fundamental frequency, formant frequencies, and formant trajectories, were clearly comparable among the linear PCM and the speech codecs. They cautioned, however, that an examiner must be careful if attempting to perform aural comparisons among the various codecs due to the differing frequency bandwidths.

VOICE IDENTIFICATION PANEL

The excellent slate of papers during the Friday morning sessions set the stage for a panel discussion on "Voice ID in the 21st Century." The panel included Eddy Brixen, Durand Begault, Tom Owen, and Michael McDermott. Rich Sanders served as moderator.

Attorney Mike McDermott, president of Frank McDermott, Inc., opened the panel with several comments on how voice identification is used and viewed by the courts. He expressed his opinion that most studies showing only 50 percent accuracy in aural spectrographic analysis are based on unskilled users. Better accuracy is attained if a skilled examiner employs good methodology with proper signal quality. McDermott stated that voice-identification results are sometimes ruled inadmissible if a savvy attorney on the opposing side does a good job by raising doubts about the examiner's methodology, the reliability of the software used (alluding to things like possible computer viruses), and pointing to scientific studies indicating poor objective results for voice identification in general.

Tom Owen echoed Mike McDermott's sentiments regarding the importance of examiner experience and proper analysis procedures. Owen is beginning a study involving 300 recorded voices for analysis under controlled conditions in order to help address the issues of bias and variability.

Durand Begault advised the audience to be clear about the type of identification task being conducted, such as matching an utterance to a particular speaker in a closed group (it must be one of them) or attempting to match an unknown speaker to a large, open population (it might or might not be one of them). He went on to say that voice identification is a difficult and "fragile" task that is susceptible to signal quality issues, and unfortunately forensic recordings are often of poor quality.

Eddy Brixen commented on the importance of having a broad background in the audio field in order to be successful in forensic audio. He mentioned having encountered the attitude of nonexperts who say, "It's digital, so it must be good, so what is the problem?" His experience with professional audio recording makes him particularly aware of issues such as the deviation in speech characteristics due to microphone distance, orientation, and azimuth with respect to the talker's mouth.

Several questions were raised about future prospects for fully automated voice identification. The panel consensus was that unlike the essentially static nature of fingerprint and DNA evidence, speech is highly dynamic and variable even for the same speaker, indicating that the dream of "voiceprint" identification is still well out of reach.

SIGNAL-ENHANCEMENT TECHNIQUES FOR AUDIO FORENSICS

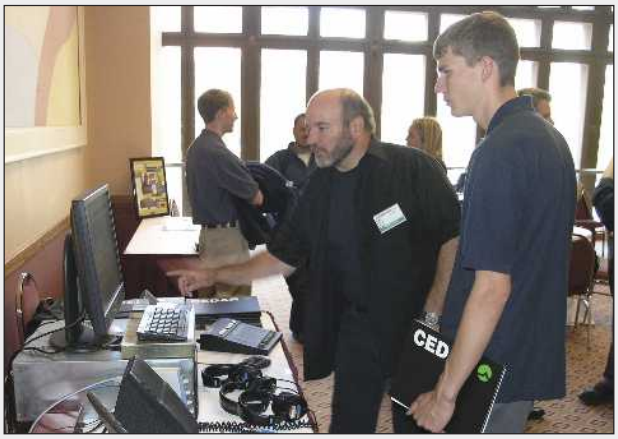
The second major focus of the 26th Conference was signal enhancement. Christoph Musialik of Algorithmix, GmbH, Waldshut-Tiengen, Germany, presented an excellent demonstration of signal-enhancement software using frequency-domain processing. His processing palette included click and pop removal, broadband noise reduction, and wow and flutter compensation. According to Musialik, the software has many useful automatic settings, but user-adjustable controls are provided to handle the large "gray zone" of nonstandard noise types. An intriguing set of features allow cut-and-paste editing and interpolation in the frequency vs. time domain.

Andrzej Czyzewski of Gdansk University of Technology, Poland, described several methods for detecting and removing parasitic frequency modulation (wow and flutter) in archival analog audio recordings on tape or mechanical disc. Among the difficulties to be overcome is how to separate the unwanted parasitic frequency modulation from normal frequency fluctuations such as musical vibrato. Czyzewski explained several methods for determining the pitch variation, including sinusoidal tracking (McAulay-Quatieri method), power cepstral smoothing, and pitch periodicity detection. He also described methods to track variations in the AC power hum present in the recording, and the high-frequency bias signal from the analog recording process.

Wes Dooley, top, and Bozena Kostek ask questions after a presentation. In addition to questions, Q&A time gives all attendees an opportunity to provide comments and feedback that make AES conferences interactive, educational events.

Conference committee: Wanda Newman, Ed Davidson, Duane Wise, Rich Sanders, Mike Perlmeter, Tom Owen, Dan Matthews, and Roy Pritts.

In addition to coordinating special events and meals, Wanda Newman (left), facilities chair, and Ann Sanders discuss registration and event issues.



During breaks attendees could check out a number of desktop demos. Norman Verrall demonstrates Cedar Audio products.

In a second paper, Czyzewski explained a sophisticated multichannel signal enhancement system developed for the Polish Air Force Academy at Deblin to assist with accident investigations and training. The system obtains and records cockpit voice communications simultaneously from several radio receiving stations, then synchronizes and level-matches each instance. The resulting multiple channels can be played back to a human listener via a multichannel loudspeaker system. Czyzewski and his colleagues have found that this multichannel approach with a human expert listener is quite reliable and useful. In addition to the playback system, it has a variety of on-line and off-line software processing tools for noise whitening, dynamic expansion, blind deconvolution, time-scale modification, and other enhancement procedures.

Rob Maher of Montana State University-Bozeman explained a processing framework for forensic audio signal enhancement using a time-frequency representation. Maher first presented the basic hierarchy of single-ended noise reduction techniques, including single-band and multiband noise gates, adaptive lowpass filters, and spectral subtraction. He then proposed a two-dimensional (frequency and amplitude vs. time) spectral filter viewpoint in which spectral components that remained consistent in frequency and amplitude over a short time span were attributed to the desired signal, while rapidly fluctuating components were presumed to be noise and removed. Maher emphasized an additional algorithm that identified spectral features that were likely to be fricative and plosive (noisy) speech components and retained them in the enhanced output signal. This feature was important to avoid having the initial and final consonants removed due to their noise-like appearance in the spectrum. Maher played several audio examples of the signals before and after the enhancement process.

SIGNAL-ENHANCEMENT PANEL

At the conclusion of the technical papers on enhancement, Rob Maher moderated a panel discussion about the current state-of-the-art for forensic audio processing and prospects for the future. The panelists included Gordon Reid, Chris Musialik, Durand Begault, Wes Dooley of Audio Engineering Associates, and Andrzej Czyzewski.

A wide variety of topics were presented. Gordon Reid addressed several audio-enhancement issues that could affect admissibility in court, such as the need for careful documentation of the enhancement process, its goals in the context of the legal proceedings, and always maintaining the original, unaltered recording for review and comparison. He also suggested that in surveillance situations the option of obtaining additional simultaneous recordings from spatially separated microphones should be explored.

Andrzej Czyzewski agreed that additional spatial diversity is potentially a big help in the enhancement process. Nevertheless, all the panelists recognized that in many forensic audio situations a single mono channel will be all the enhancement engineer has to work with. Czyzewski suggested that future work on human perception and pattern recognition may prove more fruitful than the current signal processing emphasis on statistical modeling.

Durand Begault felt that a goal-oriented approach to audio enhancement may be the most useful at present. For example, if the goal is to produce a certified transcript from a noisy recording, the enhancement processing should "starve" the spectral content such that only the speech elements essential for a human listener to transcribe the conversation should be maintained.

Chris Musialik stated the consensus opinion that there is no miracle recipe for signal enhancement, so one goal of the research community should be the development and implementation of better, more intuitive user interfaces to make ➥

careful listening by expert human examiners more effective and efficient. He also suggested that ongoing development of new non-Fourier-based transforms in the wider signal-processing community may prove interesting for forensic audio enhancement purposes.

In a departure from the research and development focus of the other panelists, Wes Dooley expressed several thoughts from the practitioner's point of view. He stated that working forensic audio examiners must have software and hardware tools that are affordable, intuitive enough to learn quickly, and designed for efficient use on a variety of projects. He also raised two important points for forensic examiners to consider: language skills and hearing acuity. He explained that transcribers must be knowledgeable in the verbal language on the forensic tape, including familiarity with foreign languages, slang expressions, nicknames, idioms, and so forth. Dooley also urged all examiners to have their hearing tested and to acknowledge honestly any significant limitations in their practice due to hearing impairments.

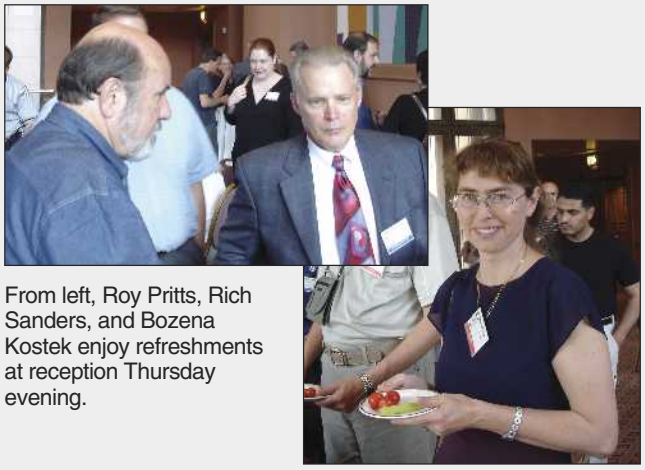
AUTHENTICATION TECHNIQUES

The ultimate role of forensic audio material is in a court of law providing evidence of truth for a judge and jury to consider. The essential ingredient is the authenticity of the material.

The use of multitrack playback equipment to analyze half-track or quarter-track magnetic tape was described by Durand Begault in a paper coauthored with Brian Brustad and Andrew Stanley. The technique uses the multiple playback heads to reveal the position and orientation of magnetic patterns on the tape without the need to use magnetic development fluid. The multiple playback heads span the width of the tape so that the edge effects and record/pause/erase signatures can be obtained. Although Begault mentioned several instances in which magnetic development still provides advantages, the use of multitrack playback equipment gives a quick and less cumbersome means to observe the tape's condition and authenticity.

The long and varied legal history of audio recording evidence was described in a paper entitled "Law and the Expert Witness—The Admissibility of Recorded Evidence," coauthored by Tom Owen, Jennifer Owen, and Jill Lindsay of Owl Investigations and Mike McDermott of Frank M. McDermott Ltd. Tom Owen explained that the use of scientific expert testimony in court dates back to the 1923 case *Frye v. United States*, in which the court held that a standard of "general acceptance" be applied to testimony involving any scientific principle or analysis methodology. A more recent ruling by the U.S. Supreme Court in *Daubert v. Merrell Dow Pharmaceuticals* (1993) superseded the *Frye* ruling, yet many states still use *Frye* as the standard for expert testimony. Mike McDermott explained the controlling case for audio authenticity, *United States v. McKeever* (1958), which established the Seven Tenants of Audio Authenticity, namely:

1. The recording device was capable of making the recording.
2. The operator was competent to make the recording.
3. The recording is judged to be authentic and correct.
4. No changes, additions, or deletions have been made.
5. The recording has been preserved in a reliable manner.
6. The speakers are identified.



From left, Roy Pritts, Rich Sanders, and Bozena Kostek enjoy refreshments at reception Thursday evening.

7. The conversation recorded was made voluntarily without threat or inducement.

The need to determine authenticity of digital audio material is becoming increasingly important as more and more forensic audio recordings are made directly in digital form. Two papers described the prospects for using audio watermarking technology to label and validate forensic audio data. The first presentation by Adam Olson and Jose Quinones of the University of Colorado at Denver described several potential watermarking applications using current commercial software-based codecs. The technology would allow a forensic audio recording to be flagged as authentic at the time of the original recording, but conventional watermarks would not protect the data against subsequent alteration. In fact, the deliberate robustness of the watermark technology would allow it to survive digital deletions, insertions, and mixing. Similarly, the second watermarking presentation by Daniel Stocker of NOA Audio Solutions, Vienna, Austria, stressed the potential strength of watermarking technology in providing a reliable ownership and tracking label embedded within the recording. Stocker's proprietary technique uses a secure public-key encoding procedure that achieves a data payload of 40 bits per second. He pointed out the advantages of the system, including its resilience to multiple embedding and observation attacks.

Another intriguing area of forensic audio is the analysis of recorded gunshots. The ubiquitous Durand Begault was called

During tour of Phoenix Gold Mine in Idaho Springs, attendees posed for a group photo.

upon to present a survey paper on forensic gunshot investigations authored by his colleagues, John Freytag and Brian Brustad, who were unfortunately unable to attend the conference. Investigation of recorded gunshots is an important area of forensic studies. Audio recordings containing gunshot evidence can be used to corroborate or refute witness testimony regarding the timeline of events, the distance and orientation of the firearm, and, if multiple simultaneous recordings from different locations are available, the location of the shooter. Begault also explained that contrary to popular belief it is seldom possible to determine the type of weapon based solely on audio recordings because the very brief duration of the shock wave (a few microseconds) provides very little signature information within the typical audio bandwidth limitations and sample rates; most of the recording consists of echoes and reverberation from the surrounding environment.

AES TECHNICAL COMMITTEE ON FORENSIC AUDIO

As part of the 26th Conference program, the AES Standards Working Group SC-03-12 on forensic audio held an open task group meeting to discuss the development of standards and the opportunities for professional involvement in the field. The standards group is working on two initiatives, one in the area of a standard methodology for analog tape authenticity determination and a second project on proper techniques for managing audio material before, during, and after forensic examination. The cochairs of the working group, Tom Owen, Eddy Brixen, and Mike McDermott, were all in attendance at the conference, and invited all interested AES members to consider joining in the standards effort. Wes Dooley, a member of the working group, discussed recommended practices for forensic audio data collection and handling, and invited comments from the audience.

It was also announced that a new AES Technical Committee on Forensic Audio is being formed. The Technical Committee will serve as a forum for timely discussion of forensic audio issues and trends and as the organizing force for forensic-related workshops, paper sessions, and tutorials to be held at future AES conventions.

SOCIAL EVENTS

Eager to avoid an "all work and no play" reputation, the conference organizers provided great opportunities to relax and enjoy Colorado's Western hospitality. A low-key social mixer and cocktail party was held on Thursday evening shortly after the conclusion of the tutorial day. The attendees quickly made new acquaintances and renewed long-term friendships over an ample selection of hors d'oeuvres and beverages. Conversation topics ranged from tutorial follow-up questions, to discussions of the latest audio processing software, to deliberations over where to go for local entertainment that evening.

On Friday evening the attendees were treated to an evening of Western barbecue food and dancing at the Stampede, a legendary (and cavernous) restaurant and bar. On Sunday the organizing committee also arranged for an optional Rocky ➥

On Friday night, conference attendees spent the evening at the Stampede, Denver's emporium of country music, line dancing, and Western cooking. Among those enjoying the "down home" atmosphere were, from left, Gordon Reid, Norman Verrall, Paul Botley, Alan Cooper, Robin How, Ryan Johnson, Jill Lindsay, Jennifer Owen, Eddy Brixen, and Tom Owen.

Mountains bus trip that included a tour of an old gold mine in Idaho Springs, a ride on a narrow-gauge railroad, lunch in historic Georgetown, a stop at the Continental Divide at Loveland Pass (11,990 ft.), and a stop for some outlet shopping before returning to Denver.

During closing statements, Rich Sanders expressed appreciation and thanks to the attendees and the presenters for making the 26th Conference such a wonderful learning experience. Roger Furness, AES executive director asked for a show of hands of those who would like to see another AES conference on forensic audio in the next few years; the response was a unanimous and enthusiastic yes. Audio forensics is viewed as a possible growth area as the public demands greater security from terrorists and other criminal organizations. Several educational institutions (including the University of Colorado at Denver) are establishing teaching and research centers focusing specifically on forensic studies. These trends, coupled with the availability of miniaturized recording devices and inexpensive high-performance computer workstations, appear to support the notion that another AES conference devoted to this topic will soon be in the planning stages.