AES 33rd INTERNATIONAL CONFERENCE

Denver, Colorado
June 5–7, 2008

The audio forensics community eagerly returned to Denver in June for another successful AES conference. The AES 33rd International Conference, *Audio Forensics—Theory and Practice*, picked up where the successful 26th Conference left off in 2005. With 2008 marking the 60th anniversary of the Audio Engineering Society, the 33rd Conference was but the latest example of the key role AES plays in bringing together laboratory research and practical know-how to serve the audio engineering profession.

Audio Forensics—Theory and Practice

Rich Sanders
conference chair

Eddy Brixen and Durand Begault
papers cochairs

Clockwise from top left, Tom Owen, Gordon Reid, and Greg Stutchman presented tutorials.

Planning for the 33rd Conference began almost immediately following the 26th Conference. Rich Sanders, conference chair, worked with Durand Begault and Eddy Brixen, papers cochairs, Wanda Newman, and the late Roy Pritts, who passed away in 2007, to arrange an excellent technical program that would once again attract audio forensic experts, researchers, and students from around the world. The exceptional quality of the local arrangements showed clearly how much hard work and planning had gone in to the conference preparation. The Denver Sheraton Hotel, situated adjacent to the downtown area of the Mile High City, hosted the meeting in comfort and style. Volunteers from the local AES Colorado Section and AES Student Section at the University of Colorado-Denver were particularly helpful in handling the registration tables and technical arrangements.

As in 2005, the program included a tutorial session day followed by two days of technical papers and panels. Attendees also enjoyed the friendly "workshop" ambience of the conference through discussions during breaks and group meals, a western barbecue dinner on Friday evening, and a bus tour to Colorado Springs and Pikes Peak on Sunday.

TUTORIAL DAY

The conference opened on Thursday afternoon, June 5, with the special tutorial sessions. In his introductory remarks Rich Sanders noted that more than 50 individuals had signed up for the tutorial sessions and more than half of the conference attendees were from outside the United States, providing a truly international basis for the discussion. The strength and enthusiasm of the AES forensics contingent was clearly evident among the assembled group.

The tutorial presentations included an overview of audio authenticity procedures by Tom Owen of Owl Investigations. Owen showed several interesting video sequences demonstrating how to receive and inspect audio tapes, verify track configuration, and obtain erase and record head signatures using ferrofluid for magnetic development.

Gordon Reid of CEDAR Audio gave a comprehensive tutorial on noise reduction and audio enhancement for forensic purposes. He presented many interesting examples of declicking, debuzzing, and adaptive digital filtering for both narrowband and broadband noise reduction. Reid emphasized the importance of having multiple audio recording microphones and channels, if possible, so that more sophisticated noise-cancellation algorithms can be brought to bear on the problem.

Durand Begault of the Audio Forensic Center, Charles M. Salter Associates, and Eddy Brixen of EBB-consult, teamed up with Fausto "Tito" Poza, Poza Consulting Systems, to discuss the history and prospects of forensic voice identification. Poza was unable to attend the conference in person, but fortunately he was able to link in via a live interactive audio-video conference feed. The tutorial discussion began with a review of the original cases conducted in the 1960s and 1970s by Lawrence Kersta, Oscar Tosi, Ernest Nash, and others, who were proponents of spectrographic voice identification. The accuracy and reliability of forensic voice identification has been in dispute since that time. The tutorial concluded with several recommendations on how to deal with the admissibility questions that come up in legal proceedings.

To round out the tutorial sessions, the conference organizers invited Gregg Stutchman of Stutchman Forensic Laboratory to give a presentation on photogrammetry for forensic investigations. Although image analysis lies outside the traditional realm of audio forensics, Stutchman's tutorial emphasized the importance of crossdisciplinary knowledge when dealing with complicated forensic cases. He included a number of interesting case studies to illustrate the applications of photogrammetric analysis.

The light rain that had greeted the tutorial participants in the morning gave way to beautiful late afternoon skies as the sun set over the mountains to the west of the city. The attendees enjoyed a social hour with hors d'oeuvres and beverages prior to making plans for an evening exploring Denver.

TECHNICAL PROGRAM

Papers cochairs Durand Begault and Eddy Brixen assembled a fascinating and informative slate of papers ranging from new and innovative techniques such as electrical network frequency authentication and magneto-resistive field mapping of recorded signals, to methods for enhancement and interpretation of forensic audio material.

Electrical Network Frequency and Authentication

The first conference paper session commenced on Friday morning with a sequence of papers on electrical network frequency (ENF) for authenticating forensic recordings. The ENF concept, first proposed by Catalin Grigoras in 2003, is based on detecting the tell-tale crosstalk ("hum") of the AC electrical power network in an audio recording. The ➥

SORRY MEANS NOTHING

APx525 audio analyzer

There are no excuses for inaccurate results. Which is why the Audio Precision engineers build analyzers that produce unflinchingly credible data that people trust. In a demanding industry, using Audio Precision analyzers means never having to say you're sorry.

Read the Intolerance Manifesto at **http://ap.com/intolerance**

Audio precision®

Authors

Among the authors presenting papers were, clockwise from top left, Alan Cooper, Charles Van Winkle, Rob Maher, David Pappas, Polina Zubova, David Hallimore, Michael Piper, and Kent Gibson.

ENF, nominally 60 Hz in many countries including the United States, or 50 Hz in much of Europe and Asia, actually varies from time to time up to +/- 0.5 Hz due to the unpredictable short-term mismatch between the power generation on the grid and the system load. At any given point in time the ENF is consistent over the entire geographic region tied into the synchronous AC power distribution grid. So if a database of known ENF information is available, the characteristic frequency fluctuations extracted from the power hum in an audio recording can be compared to the database reference in order to estimate the particular date and time of the recording.

In the first presentation Eddy Brixen described an experiment to determine the susceptibility of common forensic audio recording devices to ENF pickup. Brixen discussed several measurements of the power system magnetic field in a variety of common locations for forensic audio recordings, such as a residential street and a restaurant. He then created a comparable controlled magnetic field using a length of wire with adjustable current, and measured the magnetic field pickup in several battery-powered audio recorders equipped with electret condenser microphones and one unit equipped with a dynamic (moving-coil) microphone. Brixen found that the units with electret mics demonstrated no measurable ENF signal, leading to his conclusion that audio forensic examiners should not assume that all audio recordings will yield useful ENF information for authentication.

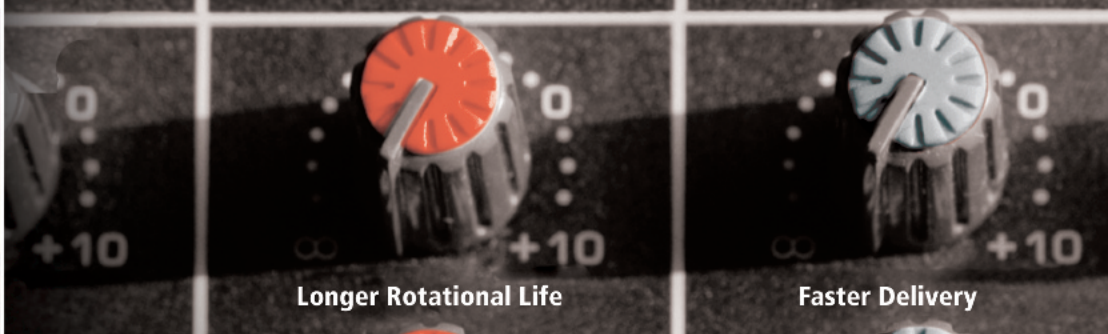
Alan Cooper of the London Metropolitan Police presented his work on automatic extraction and matching of ENF data. Cooper's technique involves monitoring the electrical network frequency with a full-wave rectified power signal, using the higher harmonics to help refine the frequency estimate. A short-time Fourier transform (STFT) is used to process the audio evidentiary recording, seeking a spectral magnitude peak in the 49.5 to 50.5 Hz range, using parabolic interpolation of the STFT magnitude to refine the estimate. Cooper's software then automatically compares the powerline reference data to the pattern extracted from the audio recording by crosscorrelation. The time shift corresponding to the minimum squared discrepancy between the reference and the extracted pattern is deemed to be the estimated alignment. Cooper showed several examples of the processing for relatively long and short recordings.

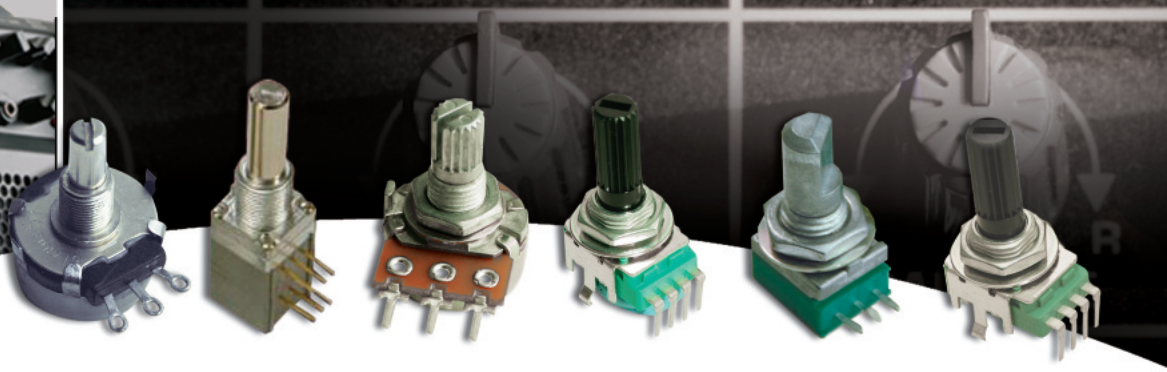
In the third ENF paper, Rich Sanders, in his role as director of the National Center for Media Forensics (NCMF) at the University of Colorado-Denver, reported on an experiment to verify intra-grid ENF consistency within the three major grids of the U.S. power system (east, west, and Texas). Sanders enlisted help to obtain ENF measurements simultaneously in three cities within each grid and found that the ENF measurements were in good agreement, as expected, within each grid, while the ENF measurements from different grids appeared to be uncorrelated.

Speaker ID and Speech Transcription

The second group of technical papers dealt with speaker identification and speech transcription. The first paper, authored by Jeff Smith and Rich Sanders of NCMF-Den- ➥

Better Panel Pots Across The Board





Shorter lead-times plus longer life adds up to a better price

With superior quality, outstanding customer service, 2-4 week lead-times (standard and specials) and 4-8 week lead-times (custom tooled products), double the rotational life and aggressive pricing, BI Technologies delivers the panel pot you want—without the wait. No availability issues, no quality issues, no hassles—choose BI Technologies for your next design.

TT electronics

BI Technologies

To order samples or our new sample kit go to www.bitechnologies.com.
BI Technologies, we're making it easy to do business.

ab | Bi technologies | IRC | OPTEK | Welwyn

TT electronics Components Division manufactures a comprehensive range of electronic components, hybrids, sensors and assemblies.

Exhibitors giving demos included IAS Forensics, CEDAR Ltd., Speech Technology Center, Digital Audio Corp., Sennheiser and Klein-Hummel, and the National Center for Media Forensics.

ver, reported on recent experiments with the authors' method known as Speaker Identification by Numerical Imprint (SIDNI). The test subjects were instructed to speak a short sentence several times, using the same pace and inflection for each utterance. The SIDNI technique extracts a set of 20 speech characteristics such as average fundamental frequency, spectral density in specific bands, and duration. The vector of extracted values, known as the Unique Numeric Code, is then compared to a database of codes calculated from other talkers. Smith and Sanders found that well over 90% correct matches could be obtained in their experiment with male talkers, but female comparisons yielded worse performance. The authors plan to expand the scope of their study to include a wider variety of test conditions and real-world scenarios.

Next, Durand Begault (in person) and Fausto Poza (via phone link from California) described their investigation into the role of forensic transcription of recorded dialog in court proceedings. A key question illuminated by Begault and Poza has to do with the impact of the examiner's interpretation of recorded speech that is noisy, distorted, or otherwise difficult to understand. For example, if the examiner states an interpretation of the marginally intelligible utterance, is there any scientific basis that would conclusively support that interpretation? The concern is that a transcript may bias the trier of fact (judge or jury) to "hear" what the transcript states, rather than coming to an independent conclusion. Begault and Poza concluded that a scientific basis for transcription does not currently exist, and therefore at the very least the examiner should use a methodology that properly accounts for the relative ease and difficulty in understanding different portions of the recorded evidence.

Signal Analysis and Interpretation

The Friday afternoon sessions continued with several fascinating papers on audio signal interpretation. The lead-off paper, "Audio Analysis and Spectral Restoration Workflows using Adobe Audition," dealt with the suite of audio restoration and spectral processing tools available in the recently released Adobe Audition 3.0 software package. Charles Van Winkle of Adobe Systems demonstrated several interactive software elements for displaying, modifying, and listening to forensic audio material. Among the more intriguing features was the ability to alter the time-frequency representation using manipulations very much like those used in photographic image-processing packages.

Next, Rob Maher of Montana State University presented a paper, coauthored with his colleague Steven Shaw, concerning the characteristics and interpretation of audio recordings of gunshots. Maher summarized the basics of gunshot acoustical evidence, including the mechanical sounds of the firearm, the muzzle blast noise, and the acoustic shock wave of the projectile if the muzzle velocity of the ammunition exceeds the speed of sound. Examples of acoustical analyses of rifle shot recordings obtained within a few meters of the muzzle and also for hundreds of meters downrange demonstrated the authors' points regarding the direct sound of the shot and acoustic reflections and reverberation due to the surroundings.

Durand Begault returned to the lectern to present a paper with what is likely the most intriguing title of the entire conference, "Forensic Analysis of the Audibility of Female Screams." Begault described his experiments investigating the sound pressure level of screams and predictions of how far away the scream might be audible. He noted that the particular spectral and temporal features of screams make

them particularly distinctive and alarming to human listeners. His test subjects were able to produce screams with an average level of 113.8 dBA (LAFMAX) at a distance of 36 inches in a sound-deadened room. Testing by playback with a calibrated loudspeaker playback at a distance of 300 feet outdoors showed positive signal-to-noise ratios even with ambient background noise or with the receiver located inside a residential dwelling.

AES 33rd Conference Committee: from left, Tom St. James, Scott Bagus, Ann Sanders, Durand Begault, Rich Sanders, Duane Wise, Eddy Brixen, Wanda Newman, and Bradd Fanberg.

The next paper, "Magneto-Resistive Field Mapping of Analog Audio Tapes for Forensic Imaging," provided a captivating introduction to a new technique for studying the magnetic patterns stored on audio tape. David Pappas of the National Institute of Standards and Technology described his work with Kenneth Marr of the FBI Engineering Research Facility to use modern magnetic-head technology from the disk-drive industry to detect the tell-tale magnetic patterns on the tape. Unlike the ferrofluid technique most commonly used for magnetic development, the magneto-resistive field mapping (MRFM) system can scan the entire length of the tape continuously and even playback the stored audio by analyzing the magnetic image itself. The MRFM technique also provides exceptionally detailed imaging for forensic investigation of recording device peculiarities. The audio forensics community can expect to see and hear more about this fascinating technology in the future.

Concluding the Friday afternoon session, Kent Gibson of ForensicAudio.org described his extensive experience in obtaining surveillance recordings of two or more suspects who are deliberately placed together in a police vehicle or holding cell. Gibson emphasized the importance of audio enhancement software since the surveillance recordings are usually suboptimal acoustically, meaning that the suspects may whisper, lean away from the microphone position, or otherwise mask their speech with background noise. He also reinforced the importance of not doing anything in the enhancement process that could alter the meaning of what was present in the original recording.

THE HAL LEONARD RECORDING METHOD

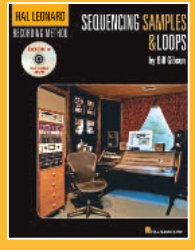
THE FIRST-EVER PROFESSIONAL RECORDING METHOD TO TAKE THE READER FROM THE BEGINNING OF THE SIGNAL PATH TO THE FINAL MASTER MIX

EACH OF THE SIX BOOKS has hundreds of pages of text, full-color photographs and illustrations, plus dozens of audio and video examples. The Hal Leonard Recording Method sets the bar for learning to record, and delivers the only complete multimedia method on the market teaching recording techniques.

BOOK 1: MICROPHONES & MIXERS
Provides everything you need to know about how professional microphones work, which to choose and why, plus how to set them up for recordings.
00331773 Book/DVD Pack **$39.95**

BOOK 2: INSTRUMENT & VOCAL RECORDING
With illustrations, photographs, plus dozens of video and audio examples, you'll learn everything you need to know about capturing the best vocal and instrument tracks possible.
00331774 Book/DVD Pack **$39.95**

BOOK 3: RECORDING SOFTWARE & PLUG-INS
This book and DVD use detailed illustrations and screen shots, plus audio and video examples, to give you a comprehensive understanding of recording software and plug-ins.
00331775 Book/DVD Pack **$39.95**



BOOK 4: SEQUENCING SAMPLES & LOOPS
Learn to create amazing music productions using the latest sequencing techniques and pre-recorded loops. With illustrations, video and audio examples, you're on your way to rounding out your recording education.
00331776 Book/DVD Pack **$39.95**

BOOK 5: ENGINEERING & PRODUCING
Dives into what makes a producer great, how to inspire awesome performances from the musicians you record, tricks for selecting the best tracks from your sessions.
00331777 Book/DVD Pack **$39.95**

BOOK 6: MIXING & MASTERING
Detailed illustrations, photographs, plus audio and video examples on DVD make sure you understand everything you need to know to mix and master like the pros.
00331778 Book/DVD Pack **$39.95**

HAL LEONARD RECORDING METHOD – **COMPLETE SERIES**
The Hal Leonard Recording Method is now availabe as a complete six-book/six-DVD set!
00331966 Six Book/DVDs $199.99

MUSIC DISPATCH®
(800) 637-2852 WWW.MUSICDISPATCH.COM

AES is now a scitopia.org partner

We're one year old and growing

three hundred fifty years of content
three and a half million documents
twenty leaders in science & technology research
one gateway to it all

scitopia.org

Search **scitopia.org** to find quality content from leaders in science and technology research. Scitopia.org generates relevant and focused results – with no Internet noise. From peer-reviewed journal articles and technical conference papers to patents and more, **scitopia.org** is a researchers' heaven on earth.

search

scitopia.org

Integrating Trusted Science + Technology Research

Scitopia.org was founded by: Acoustical Society of America · American Geophysical Union · American Institute of Physics · American Physical Society · American Society of Civil Engineers · American Society of Mechanical Engineers · American Vacuum Society · ECS · IEEE · Institute of Aeronautics and Astronautics · Institute of Physics Publishing · Optical Society of America · Society of Automotive Engineers · Society for Industrial and Applied Mathematics · SPIE

New partners include: Audio Engineering Society · Institution of Mechanical Engineers · International Union of Crystallography · Royal Society of Chemistry

Winners of Enhancement Contest: Marisa Déry (second from left) and Eugene Landa (right) are flanked by Roger Furness (left), AES executive director, and Tom Owen, who contributed the $1000 for the cash prizes.

Measurement and Identification

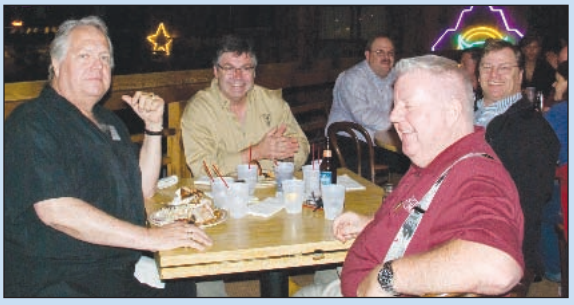
The Saturday technical sessions included two papers by students from the College of Arts and Media at the University of Colorado-Denver. The first paper, authored by students John Dinos and Randy Haines, dealt with an experiment to extract ENF information from audio recordings using the Diamond Cut Live 6 audio software. The results were not particularly satisfying, so the students are now working to determine if the test recordings happened to be hum-free, or if their procedures using narrowband filtering in the analysis software were ineffective. The second paper described an experiment conducted by students Adam Berrett, Tira Neal, and Chris Ochsner, to investigate the characteristic background noise and reverberation in several recording locations to see if sufficient information could be gleaned to recognize the individual venues. The students found that most of the venues contained subtle background tones and mechanical sounds that could be distinguishable for the purpose of forensic authentication.

Polina Zubova of the Speech Technology Center presented a paper coauthored with Serge Koval entitled "Speaker ID on Language Unknown to an Expert." Zubova explained the difficulties associated with attempting to identify a particular talker when the language being used is unfamiliar to the examiner. This particular situation is common in ethnic disputes and crimes in Russia. The Speech Technology Center's technique involves a set of objective measurements of speech formant frequencies, pitch periods, and other attributes that can be compared for similarity assessments. The challenge of making a fully automated or semi-automated analysis system is the next step for this research group.

Another very practical contribution came from Michael Piper of the U.S. Secret Service and David Hallimore of the Houston Police Department. Both men are affiliated with the Audio Committee of the Scientific Working Group on Digital Evidence (SWGDE). SWGDE is a cooperative organization with members from local, state, federal, and international law enforcement and investigative agencies who share information and education in the field of digital forensics. Piper and Hallimore presented information about the SWGDE "Best Practices for Forensic Audio" document that provides agencies with recommendations for handling and examining forensic audio evidence.

SPECIAL PANEL ON HOW TO RUN AN AUDIO FORENSICS LABORATORY

The conference organizers presented a special session to discuss the ins and outs of running a forensic audio lab or forensic examination business. The panel—Tom Owen, Eddy Brixen, Alan Cooper, and Mike Piper—represented both private investigators and individuals working at government agencies. Each panel member provided interesting remarks and suggestions based on his many years of experience.



Attendees enjoyed the festivities at the banquet on Friday night at Denver's Stampede restaurant and nightclub.

The examiners in private practice almost always publish a rate sheet for their services, typically ranging from $200 to $400 per hour. Tom Owen recommended that private examiners operate in a completely business-like manner, and always "get the money up front" to avoid misunderstandings later.

Several panel members mentioned that they are increasingly encountering the "CSI effect," meaning that judges and juries have very high—and sometime unreasonable—expectations regarding the availability, quality, and reliability of forensic evidence based on what they see in the fictional U.S. television series "CSI: Crime Scene Investigation." The panel agreed that it is vitally important for the examiner to always be an advocate for the data, and not be an advocate for a particular party or client. The panel also emphasized the fundamental importance of preparing comprehensive written reports and taking sufficient time for thorough preparation before testifying in court.

ENHANCEMENT COMPETITION

At the conclusion of the conference, the organizing committee announced the results of a special audio enhancement competition. Rich Sanders and his student Brandon Anderson prepared several five-minute recordings to simulate typical surveillance tapes. Interested attendees were able to request copies of the recordings prior to the conference, perform enhancement procedures of their own choosing, and return their enhanced samples for judging. Tom Owen donated $1000 for the cash prizes. The runner-up award went to Marisa Déry, a media technician in the Audio Preservation Studio of the Loeb Music Library at Harvard University. Déry used Sound Cleaner software by SpeechPro, first emphasizing the unwanted noise and then inverting the settings to remove it. The overall enhancement award went to Eugene Landa and his team of four examiners from the Speech Technology Center. The award winners received appreciative applause from the audience for their excellent efforts and results.

EXHIBITORS

An added bonus for attendees was an elite group of commercial and educational exhibitors who participated in special demonstration sessions running throughout the conference schedule. Exhibitors included Jonathan Broyles of IAS Forensics (magnetic development systems), Gordon Reid of CEDAR Ltd. (noise-reduction and audio-enhancement products), Eugene Landa of the Speech Technology Center, (software for speech processing, noise reduction, and analysis), Donald Tunstall of Digital Audio Corporation (hardware and software for audio forensics), Robby Scharf and Mike Pappas of Sennheiser and Klein-Hummel (microphones and PA systems), and Rich Sanders of the National Center for Media Forensics (a new research and education facility hosted at the University of Colorado-Denver). The demonstration room was always packed with interested attendees during breaks in the technical program.

SOCIAL EVENTS

In addition to the exhibitor events, the conference organizers allowed many other opportunities for the attendees to get acquainted and share ideas. The collegial nature of the audio forensics profession helped newcomers contribute and participate, and the AES tradition of technical leadership made everyone feel right at home.

An evening of western barbecue was held at the Stampede, a giant country-and-western restaurant and night club located just a few minutes east of Denver in Aurora. The attendees were treated to barbecue chicken and ribs, baked beans, coleslaw, baked potatoes, salad, and a dessert of apple crisp and ice cream. While few of the conference attendees wore the traditional cowboy hats and boots sported by the crowd of regulars on the dance floor, the frontier spirit and dance music was contagious, nonetheless.

The organizing committee also arranged for an optional bus trip on Sunday from Denver a few miles south to Colorado Springs, home of both the U.S. Air Force Academy and world famous Pike's Peak (14,110 feet). In 1893, Katharine Lee Bates penned the words to the song "America the Beautiful" based in part on the stunning view of the Rocky Mountains and eastern plains of Colorado from the summit of Pike's Peak. We don't know if the visit inspired the AES 33rd Conference attendees to write poetry or music to commemorate the event, but they undoubtedly found the view to be as moving and inspiring as Bates did more than 100 years ago!

AES AUDIO FORENSICS ON THE RISE

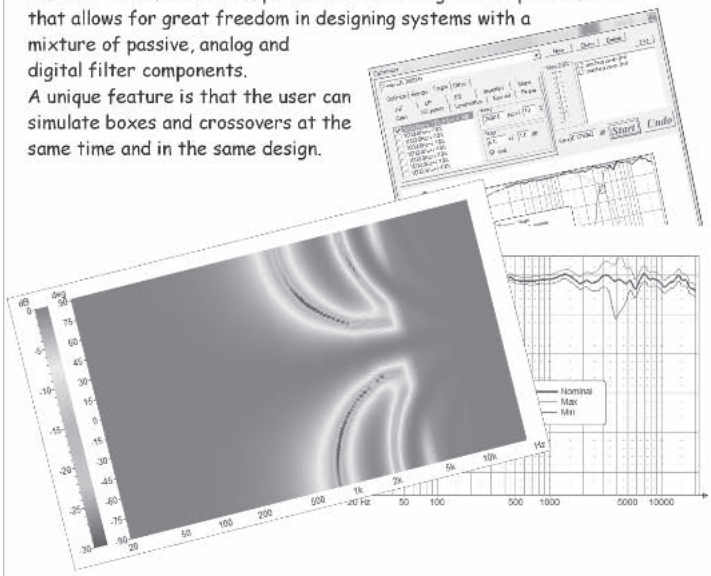
The AES 33rd Conference was a resounding success. The attendees once again expressed a strong vote for scheduling another AES conference on forensic audio in the next few years to keep up-to-date on new techniques and challenges. It is an exciting time to be involved in audio forensic examinations, and AES is clearly in the forefront of this increasingly important field of research.

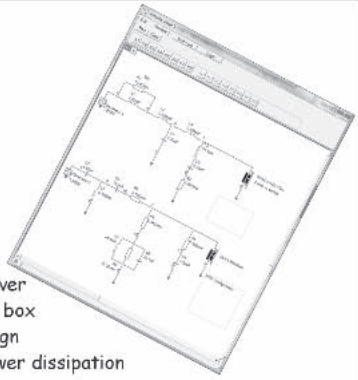
Editor's note: The CD-ROM of conference papers can be purchased at <www.aes.org/publications/conf.cfm>.

LspCAD 6

Loudspeaker modelling software

LspCAD 6 is a loudspeaker design software intended for the simulation of loudspeaker crossovers and boxes. The user interface is a simple and intiutive drag and drop interface that allows for great freedom in designing systems with a mixture of passive, analog and digital filter components. A unique feature is that the user can simulate boxes and crossovers at the same time and in the same design.





Features

- Mix passive and active (analog and digital) crossover components + loudspeaker box modelling in the same design
- Passive components with power dissipation computation for resistors
- Tolerance analysis on passive components
- Active analog filter components using OP amplifiers
- Digital filters, using adder/delay elements or models of commercial crossovers from Behringer, dbxPro or XTA
- Fast prototyping analog and digital filter blocks such as HP/LP, notch, allpass, Matlab polynomials, BiQuad and more...
- Grouping of components, makes it easier to manage evaluation of e.g different crossover frequencies
- Templates with many ready to use component blocks such as active filters and closed/bassreflex boxes
- Thermal and nonlinear modelling
- Imports T/S parameters from Klippel, Praxis and CLIO
- Powerful optimizer with limits on component values. Additional constraints on e.g crossover frequency and total impedance can be applied
- Polar maps, off axis modelling either from piston model or imported polar measurements
- Crossover emulator, makes it possible to evaluate crossovers without actually building them

Visit http://www.ijdata.com for additional info, a fully functional demo and a list of distributors.