



IT TAKES TWO TO TANGO—IMSC researchers demonstrated their concept of how two musicians in different locations could play a tango together over the Internet. Dennis Thurmond, lecturer of keyboard studies, and Elaine Chew, assistant professor of industrial and systems engineering, performed in different campus buildings as they played an eight-minute adaptation of Astor Piazzolla's "Le Grand Tango" for a National Science Foundation site visit team in June.

Two musicians linked over the Internet for tango

They say it takes two to tango, and IMSC researchers recently added a new twist to the old adage—they used a tango to demonstrate their concept of how two musicians in different campus buildings could perform together over the Internet.

Elaine Chew, assistant professor of industrial and systems engineering, and Dennis Thurmond, lecturer of keyboard studies, played an adaptation of Astor Piazzolla's (1921-1992) "Le Grand Tango" over the Internet for a small group in IMSC's Powell Hall theater.

Their demonstration showed an early realization of an interactive Internet performance, with the musicians themselves compensating for Internet delay. The fast-paced tango was filled with syncopations (off-beats), which posed challenges for both the engineers and musicians.

Thurmond played the accordion in front of the audience in Powell, while Chew appeared on a large screen, playing the piano in Ramo Hall, a quarter mile away. To coordinate their playing, Thurmond watched her on the screen, and Chew watched him on a monitor. Since Chew needed to listen to both the sound of Thurmond's accordion and the sound of her own piano playing, she used a single earphone, allowing her to hear the piano with one ear and to hear the accordion with the earphone.

"By the time I heard the reaction to an action that I had initiated," Chew said, "many more notes had already been played. So I had to craft a musical interpretation and hold a steady pulse while keeping an ear out for delayed cues of possible ensemble issues at Powell."

She said that Thurmond had to anticipate her every move to make sure that the piece was synchronized to create a coherent performance. And, she pointed out, "a little creative license was taken once or twice" in the eight-minute performance "to ensure that all ends were met."

The occasion was a demonstration for a National Science Foundation (NSF) site visit team touring IMSC in June as part of the Center's annual evaluation by NSF.

The demonstration was part of IMSC's Distributed Immersive Performance (DIP) project, aimed at developing the technology for a concert with the conductor, musicians and audience in different physical locations, delivered in real-time over the Internet. Other phases of the five-year project will be a concert by a trio and then a concert involving a full orchestra.

Roger Zimmermann, research assistant professor of computer science and co-director of the project, said that playing together over the Internet is one of the most difficult problems to solve. He pointed out that the main concern is reducing the delay in the delivery of both audio and video to a tolerable level for each musician as he or she tries to follow the conductor and play along with the other musicians.

When a conductor is included in a later phase, the researchers will have the three goals of ensuring that concurrent, synchronized video of the conductor is transmitted to all players; synchronized video and audio are transmitted among the players; and delayed, synchronized video and audio are transmitted to the audience.

The researchers are taking a unique approach in considering the entire end-to-end process of acquisition, transmission and rendering as an integrated system that will be jointly optimized rather than presented as a set of individual pieces of technology.

In addition to investigating transmission delay, researchers will conduct research on numerous other issues, including data loss management; network error correction; precision timing, using highly accurate Global Positioning System (GPS) clocks; distributed event recording and recall; and evaluation of musician coordination.

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Prof. Shahabi awarded NSF Early Career grant . . .

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USC's Information Laboratory (<http://infolab.usc.edu>).

He is one of the co-authors of "Streaming Media Server Design," a new book published by IMSC Press that includes IMSC's major contributions to streaming media technology. (The other co-authors are Ali Dashti, an IMSC Ph.D. graduate and faculty member at the University of Kuwait; Seon Ho Kim, an IMSC Ph.D. graduate and faculty member at the University of Denver; and Roger Zimmermann, IMSC's Director of the Media Immersion Environment (MIE) research. Dashti is one of Prof. Shahabi's former students.)

The book spotlights Yima™, IMSC's streaming architecture, which handles multiple simultaneous high-bandwidth streams of images and sound, all synchronized to single-frame accuracy over the Internet. Yima™ is a key component of IMSC's Remote Media Immersion (RMI) technology, which is available for streaming movies, concerts and other entertainment over the Internet.

Prof. Shahabi was instrumental in developing Yima™ over the years. His pioneering paper in the area of continuous media servers was published in the early days of the field in 1993. His Ph.D. dissertation in 1996 was on the synchronization of multiple streams of continuous media. He developed a vision of a scalable and distributed streaming media server that would support both intra-stream and inter-stream synchronization. He gave the server the ancient Persian name of Yima™ as suggested by his colleague, Prof. Zimmermann. In Persian

mythology, Yima™ was the first man, the progenitor of the human race and the son of the sun. In 2000, Prof. Shahabi received a \$500,000 NSF Information Technology Research grant to pursue his vision. He said that now Yima™ has evolved into a workable end-to-end streaming architecture recognized by the research community as a second-generation continuous media server.

Since he envisions a future role for Yima™ as the main component in peer-to-peer (P2P) video/audio sharing architectures, his current research focuses on these P2P systems. (See page 4 for an article on P2P networking.)

Prof. Shahabi is on the editorial board of the Digital Symposium Collection (DiSC) of the Association for Computing Machinery's (ACM) Special Interest Group on Management of Data (SIGMOD) and the ACM Computers in Entertainment magazine.

He serves on numerous conference program committees, including committees for the International Conference on Multimedia and Expo (ICME) 2003 of the Institute of Electrical and Electronics Engineers (IEEE); and the ACM Conference on Information and Knowledge Management (CIKM) 2003. He also serves on the program committees for the flagship database conferences of IEEE and ACM—the IEEE International Conference on Data Engineering (ICDE) 2004; and ACM Special Interest Group on Management of Data (SIGMOD) 2004 conference.

He was the program committee chair of an ACM Web Information and Data Management (WIDM) 1999 workshop and the local chair of the ACM Special Interest Group on Metrics (SIGMETRICS) 2002 conference.

Community outreach . . .

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logic is a humanistic kind of logic in that everything is not just black and white as it is in the usual logic, but can also be different shades of gray. Evolutionary computing is a computer design system that bases mechanical designs on the evolution of natural, biological life forms.

"There's the hope that their research results might address some of IMSC's data classification problems involving human speech and emotions," Prof. Mendel said.

JRI's Web site is <http://www.jisan.org>.

Immersive performance . . .

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IMSC Deputy Director Alexander (Sandy) Sawchuk, professor of electrical engineering and the other co-director of the project, said the project is a test bed for cross-disciplinary investigation into psycho-acoustical, neurological and artistic issues. He pointed out that the project is the first step in meeting the overall goal of IMSC's entertainment vision project to create seamless distributed environments for highly realistic interaction among people in entertainment, online games, simulations, teleconferencing, social gatherings, performance events, and sports.

Peer-to-peer networking . . .

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niques to the development of an audio chat room capability, called YimaCast™, for the School of Engineering's Distance Education Network (DEN). Audio chat will supplement the traditional text chat rooms for professors and students. Students will be able to conduct on-line discussions among themselves and with teaching assistants and the professor. Prof. Zimmermann said plans call for launching the audio chat room sometime during the fall semester.

He said that the YimaCast™ system is being designed to meet the need to scale to the hundreds of on-campus and off-campus students enrolled in DEN classes and pointed out that traditional, centralized audio chat systems do not have this capability. Additionally, he said, the YimaCast™ system will be integrated seamlessly with USC's TOTALe online learning portal to allow access to all of the University's electronic classroom resources and assets.

Prof. Zimmermann also said the YimaCast™ system will allow students to search for previous discussion sequences of interest and replay them at a convenient time. Speech-to-text generation will produce a transcript of each session, and the sessions will be archived and available for retrieval.