





5th Open Workshop of MUSICNETWORK: Integration of Music in Multimedia Applications
 4-5, July, 2005, Universität für Musik und darstellende Kunst Wien, Austria
 July 5, 2005, Imaging and Interactivity Session 2, Room 1, 12:00PM-12:30PM

A Second Report on the User Experiments in the Distributed Immersive Performance Project

E.Chew, R.Zimmermann, A.A.Sawchuk, C.Papadopoulos, C.Kyriakakis, C.Tanoue, D.Desai, M.Pawar, R.Sinha, W.Meyer




Integrated Media Systems Center, a National Science Foundation Engineering Research Center
 University of Southern California Viterbi School of Engineering




OVERVIEW

The **Distributed Immersive Performance (DIP)** project explores one of the most challenging goals of networked media technology: creating a seamless environment for **remote and synchronous musical collaboration**.





It is an ideal **testbed** for human needs and requirements in collaborative environments such as collaborative problem solving, remote surgery, and games.





DIP PROJECT PERSONNEL

Viterbi School of Engineering / Integrated Media Systems Center
 Elaine Chew, Human Performance Engineering RAD
 Alexander Sawchuk, IMSC Assistant Director
 Roger Zimmermann, Media Immersion Environment RAD
 Christos Kyriakakis, Christos Papadopoulos, Alexandre François







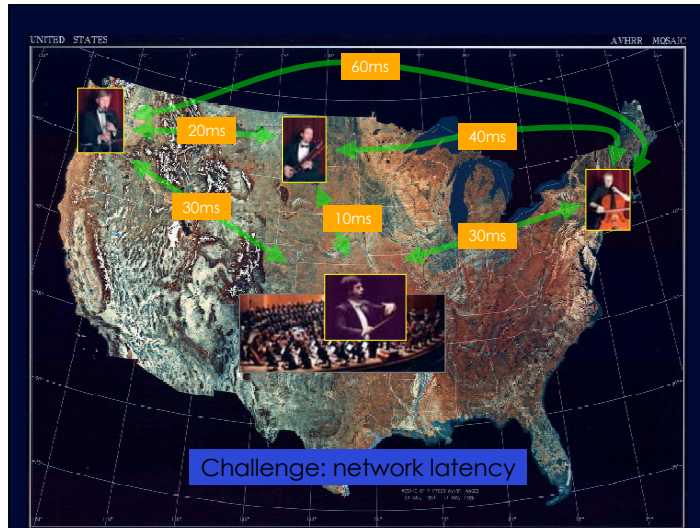
Thornton School of Music
 Vely Stoyanova, Ilia Tosheff, Dennis Thurmond, Ron Leonard

IMSC and School of Cinema-TV
 Seth Scafani, Allan Weber, Will Meyer, Victor Lacour

Other Research Personnel: Graduate Students and Postdocs
 Music - Carley Tanoue, Anja Volk, Hui-Yun (Frances) Kao
 Tech - Dwipal Desai, Moses Pawar, Kanika Malhotra, Rishi Sinha, Shiva Sundaram



EXISTENCE PROOF

USC Viterbi School of Engineering

- * Key observations:
 - Network latency maps to audio delay on stage
 - Visual delay is zero
- * Challenges include:
 - technical: lowering latency, maintain constant delays
 - human: effects on interaction, improvements possible?

CAN MORE DELAY BE BETTER?

RELATED WORK

USC Viterbi School of Engineering

- 1993 - USC Information Sciences Institute (ISI): distributed trio
- 1998 - "Melange a trois" (audio only) Warsaw, Helsinki, Oslo
- 2002 - CCRMA's Network Jam (a/v unsynch): Stanford, McGill
- 2002 (Dec) - USC IMSC Distributed Duet (audio only): PHE, EEB
- 2003 (Jun) - USC IMSC Duet w Audience (a/v unsynch): PHE, RMH
- 2003 - UC Santa Barbara, Santa Barbara College
- 2003 - Gigapop Ritual (improv): Princeton, McGill
- 2004 (Mar) - USC IMSC DIP Experiment Set A & B
- 2004 (Jun) - CCRMA (audio only): CA, Sweden
- 2004 (Jul) - USC IMSC DIP Experiment Set C & D
- 2004 (Aug) - ICHIM Network Concert: Berlin, Paris
- 2004 (Sep) - One-way live streaming of quartet performance, Texas Austin
- 2005 (May) - NIME AB_Time (improv): Vancouver, Troy, Marselles

TIMELINE

USC Viterbi School of Engineering

- 2002**
 - Jun - Remote Media Immersion (RMI) Initial Demonstration
 - Oct - Internet2 Meeting: Large Room RMI Demonstration
 - Dec - **DIP v.0: Distributed Duet (audio only)**
- 2003**
 - Jan - Recording from Streams
 - Jan - Remote Master Class with New World Symphony
 - Jun - **DIP v.1: Duet with Audience (audio/video unsynch)**
- 2004**
 - Jan - Two-Way Live HD Streaming: L.A., Hawaii, Miami Experiments
 - Feb-Apr - **DIP v.2: Two-Way Baseline User Studies**
 - A: first time players perform under delayed conditions
 - B: player 1 and player 2 swap parts (symmetry test)
 - C: players practice to compensate for delay
 - D: players perform with both partner and self delayed
 - May -
 - Jun -
 - Sep - One-Way Live HD Streaming on Internet2: Austin, Texas
- 2005**
 - Jan-Jun - Developing objective measures of performance parameters for analyzing MIDI data
 - Developing HYDRA architecture for better query and retrieval



DIP v.0: Distributed Duet (Dec 2002)



Elaine Chew on keyboard in **Powell Hall** with 1-channel audio playback



Wilson Hsieh and viola in the **Electrical Engineering Bldg** with 10.2-channel Immersive audio


TECHNOLOGY:
10.2-channel immersive audio technology by Kyriakakis & Holman
Low-latency multichannel audio streaming software by Papadopoulos & Sinha
Actual delay controlled using Protocols console

EXPERIMENT
Varying audio delay: 0ms to >300ms
Pieces: Hindemith's *Sonata No.4* and Piazzolla's *Le Grand Tango*



WHAT WE LEARNED:
Latency tolerance dependent on

- tempo and onset synchronization: Hindemith *Sonata No.4* (mv1 vs final mv)
- timbre of instrument: Piazzolla's *Le Grand Tango* (accordion 25ms vs piano 100ms)

 Sense of acoustic presence made more "natural" by 10.2-channel audio
 Perspective differences require recording of experience at both sites

Remote Master Class (Jan 2003)






Ron Leonard cellist of the LA Philharmonic at USC


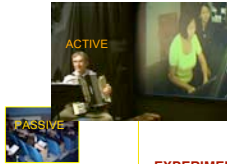
Student at the New World Symphony in **Miami Beach**

TECHNOLOGY
10.2 immersive audio by Kyriakakis and Holman
Off-the-shelf video software/hardware (Star Valley MPEG2 codecs), large delays


RESULT
Teacher reports improved presence with immersive audio:
"student was really there"

DIP v.1 - Duet with Audience (Jun 2003)

Dennis Thurmond in **Powell Hall** with audience, 10.2 immersive audio and Large screen HD image





Elaine Chew in **Ramo Hall** earphone and video monitor


TECHNOLOGY
Video: NTSC resolution, 31 Mb/s DV, software decode, **one-way latency: 110ms + <5ms** (compression + network)
Audio: uncompressed, 16 or more channels at 1 Mb/s each, **one-way latency: <10ms + <5 ms** (processing + network) by Papadopoulos & Sinha

EXPERIMENT
Piazzolla's *Le Grand Tango* (~120bpm)
Granularity of events is at 16th-note level, i.e. IOI = 125ms
Even 60ms RT delay could be debilitating. **VIDEO (DIP v.1)**

WHAT WE LEARNED
Video delay made it unusable as source of cues for synchronization. Audio (<<50ms RT delay) was used.
Musicians compensated for delay by anticipating each other's actions and scaling back on spontaneity (low risk performance). Some artistic licence was exercised to "make ends meet."
Co-location of audience with one musician caused imbalance in control. No matter what happened, performer at the audience site had to make the final performance "work".


OBJECTIVE OF USER EXPERIMENTS



To measure and document *qualitatively and quantitatively* the effects of delay and other variables

On immersion, usability, and quality in the Distributed Immersive Performance scenario

A: first time players perform under delayed conditions
B: player 1 and player 2 swap parts (symmetry test)
C: players practice to compensate for delay
D: players perform with both partner and self delayed





TOSHEFF PIANO DUO

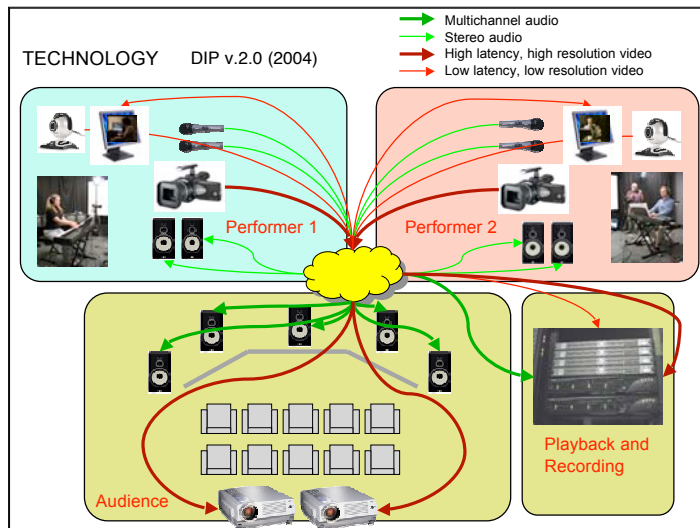
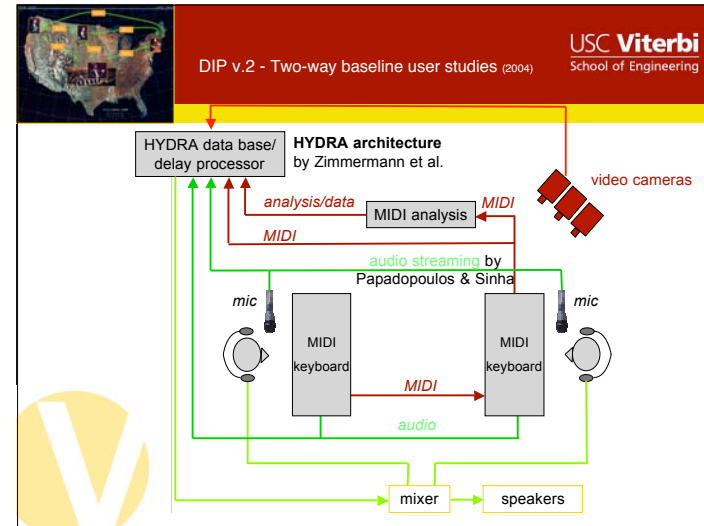

Tosheffpianoduo.com

Vely Stoyanova and Ilia Tosheff (piano duo since 1997)

The first piano duo to audition and be admitted to the USC Thornton School of Music as a team
Pioneers in the *Protégé Program* (Chris Sampson, Associate Dean for New Initiatives, USC Thornton School of Music)

Described by critics and press as
 "...brilliant concert artists..."
 "...captivating stage presence..."
 "...fascinating temperament..."
 "...charm and spontaneity that grabs the audience..."

THE GRAND PRIZE - Tokyo, Japan • THE GRAND PRIZE - Dobrich, Bulgaria • FIRST PRIZE - Rome, Italy • FIRST PRIZE - Rome, Italy • FIRST PRIZE - Sofia, Bulgaria • WINNERS - Zaragoza, Spain • WINNERS - Michigan, USA • WINNERS - Miami, USA • WINNERS - Los Angeles, USA • MUSICIAN OF THE YEAR in Bulgaria • PREMIO "Zinetti" - Verona, Italy • PREMIO "V.Bellini" - Caltanissetta, Italy • PRIZE - Groningen, Holland • PRIZE - Sofia, Bulgaria

POULENC's SONATA FOR PIANO 4-HANDS

EXPERIMENTS

Poulenc Sonata for Piano Four-Hands


- Prelude (tempo = 132 bpm)
- Rustique (tempo = 46 bpm)
- Finale (tempo = 160 bpm)

Questions:

- How would you rate the ease of ensemble playing?
- How would you rate the ease of creating a musical interpretation?
- How would you rate the ease of adapting to this condition?

Debriefing, observations

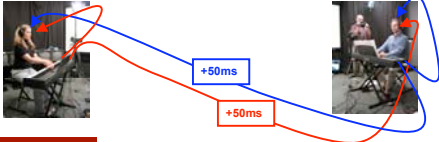
Quantitative measures of musical synchronization (Chew et al.)



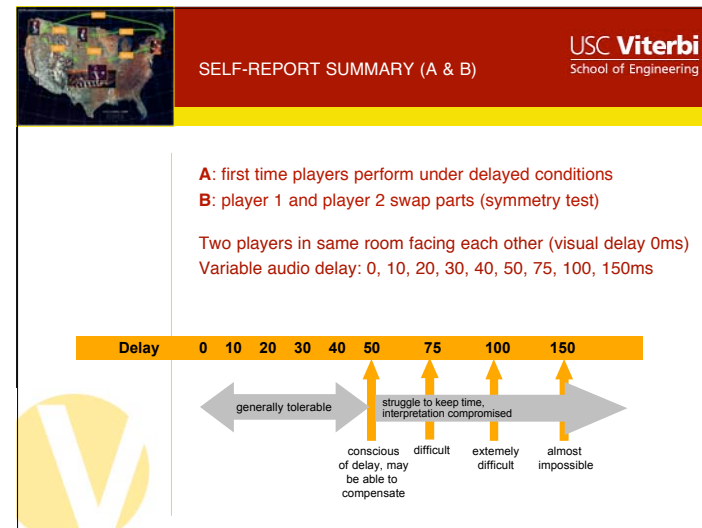
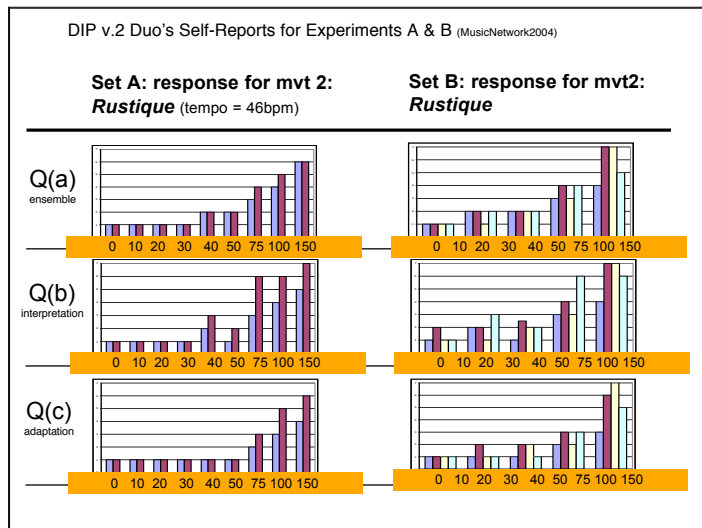
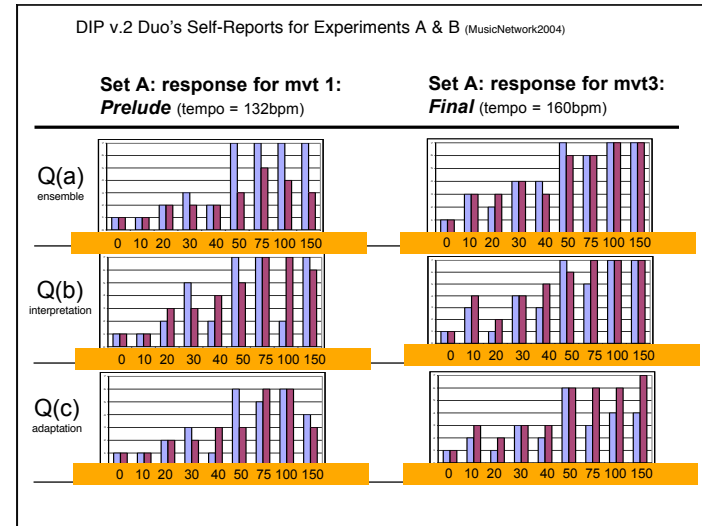
VIDEOS

A: first time players perform under delayed conditions
B: player 1 and player 2 swap parts (symmetry test)

Two players in same room facing each other (visual delay 0ms)
 Variable audio delay: 0, 10, 20, 30, 40, 50, 75, 100, 150ms



VIDEO (DELAYS)
 VIDEO (PERSPECTIVES)
 VIDEO (COMMENTS)



SELF-REPORT SUMMARY (A & B)

USC Viterbi School of Engineering

C: players practice to compensate for delay
D: players perform with both partner and self delayed

Two players in same room facing each other (visual delay 0ms)
 Variable audio delay **C:** 20 - 100ms
 Variable audio delay **D:** 40, 45, 50, 55, 60, 65, 70, 75ms

Delay: 0 10 20 30 40 50 75 100 150

Improvement possible with practice

conscious of delay, may be able to compensate

difficult

extremely difficult

almost impossible

EXPERIMENTS C & D

USC Viterbi School of Engineering

C: players practice to compensate for delay
D: players perform with both partner and self delayed

Two players in same room facing each other (visual delay 0ms)
 Variable audio delay **C:** 20 - 100ms
 Variable audio delay **D:** 40, 45, 50, 55, 60, 65, 70, 75ms

Delay: 0 10 20 30 40 50 75 100 150

FOCUS

FROM EXPERIMENTS C TO D

USC Viterbi School of Engineering

C: players practice to compensate for delay
D: players perform with both partner and self delayed

Two players in same room facing each other (visual delay 0ms)
 Variable audio delay **C:** 20 - 100ms
 Variable audio delay **D:** 40, 45, 50, 55, 60, 65, 70, 75ms

VIDEO (SETS C & D)

"Can we both hear what the audience is hearing?"

+50ms

+50ms

+50ms

SELF-REPORT SUMMARY (C & D)

USC Viterbi School of Engineering

C: players practice to compensate for delay
D: players perform with both partner and self delayed

Two players in same room facing each other (visual delay 0ms)
 Variable audio delay **C:** 20 - 100ms
 Variable audio delay **D:** 50, 55, 60, 65, 70, 75ms

CAN MORE DELAY BE BETTER?

SOMETIMES, UNDER THE RIGHT CONDITIONS


Delay: 0 10 20 30 40 50 65 75 100 150


C: Tolerable with practice

D: Tolerable with practice

NEXT: (paper under review)

- Corroborating self-reports with quantitative analysis of recorded data.
- Quantitative analysis of effects of delays on interpretation.







CONCLUSION

Vely: *Here, it's like we're on the same track ...*
 Ilia: *... we're on the same track, like in a real performance.*

IMPORTANT:




ACCESS TO PERFORMANCE: *to hear what the audience hears*
to be able to sense the feedback from actions at destination so as to plan and strategize towards performance goals



COMMON CLOCK: *to be on the same track*
to be able to share a common reality
to be able to sense a common reality
to be able to plan and strategize towards common goals

LESS IMPORTANT: immediate feedback of one's own actions

REALLY BAD: sensing two realities simultaneously, neither of which is the common one







IMPACT - APPLICATIONS



www.umd.edu



www.weichbiz.com

Musical Performance

- Better understand collaborative performance
- New modes of musical communication

Collaborative workspaces

- Video conferencing, remote collaborations (extending to asymmetric systems in which users do not have the same bandwidth, video resolution, delay, etc.)

Problem solving

- Remote assistance, crisis management, command and control, security

Training and simulation

- Distance education: lectures and workgroups
- Aware and immersive gaming

Distributed virtual entertainment and social events



www.generated.com



The New York Times
October 5, 2004
Broadway Pit Shrinks;
Drummer Is Sent to Room





REFERENCES/ACKNOWLEDGEMENTS

Some References

- Chew, E., Sawchuk, A.A., Zimmerman, R., the Tosheff Piano Duo (Stoyanova, V. and Tosheff, I.), Kyriakakis, C., Papadopoulos, C., Francois, A.R.J., Volk, A. (2004). "Distributed Immersive Performance". Proceedings of the 2004 Annual National Association of the Schools of Music (NASM) Meeting, San Diego, CA, November 22, 2004.
- Chew, Zimmermann, Sawchuk, Kyriakakis, Papadopoulos, Francois, Kim, Rizzo and Volk (2004). Musical Interaction at a Distance: Distributed Immersive Performance. In proceedings of the 4th Open Workshop of MUSICNETWORK: Integration of Music in Multimedia Applications, Barcelona, Spain.
- Sawchuk, Chew, Zimmermann, Papadopoulos and Kyriakakis (2003). From Remote Media Immersion to Distributed Immersive Performance. In Proceedings of the ACM SIGMM 2003 Workshop on Experiential Telepresence (ETP 2003), Berkeley, California.

Acknowledgements

- National Science Foundation Engineering Research Center Cooperative Agreement No. EEC-9529152
- National Science Foundation Major Research Instrumentation Equipment Grant No. 0321377



Any Opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect those of the National Science Foundation.