National Academy of Engineering
2010 U.S. Frontiers of Engineering
IBM Learning Center, Armonk, NY • September 24, 2010

De-mystifying Music and Its Performance

Elaine Chew

University of Southern California
Viterbi School of Engineering
Epstein Department of Industrial and Systems Engineering
Hsieh Department of Electrical Engineering
Thornton School of Music

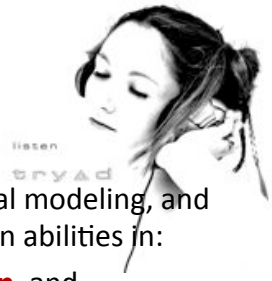
MuCoaCo

Systematic study, computational modeling, and scientific explanations of human abilities in:

music perception and cognition, and

music making (music performance, improvisation, and composition)

MuCoaCo



Systematic study, computational modeling, and scientific explanations of human abilities in:

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MuSA.RT

MuCoaCo

Systematic study, computational modeling, and scientific explanations of human abilities in:

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Hélène Grimaud

ESP
Open Courseware
DIP

MuCoaCo

Systematic study, computational modeling, and scientific explanations of human abilities in:

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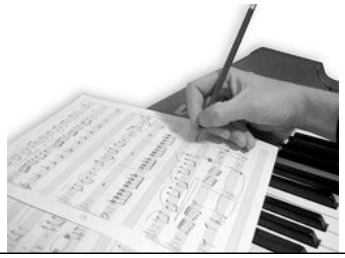


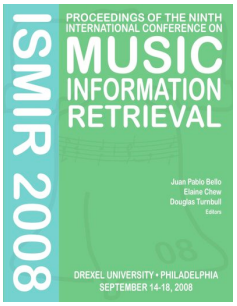
MIMI

Music Information Retrieval

9th International Conference on Music Information Retrieval

Sep 14-18, 2008

Philadelphia, PA



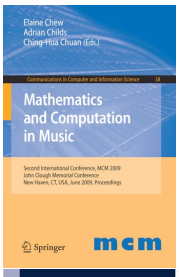
Dan Ellis and Youngmoo Kim, General Chairs

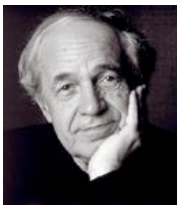
www.ismir.net • ismir2008.ismir.net

Mathematics and Computation in Music

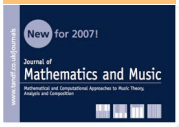
smcm-net.info
mcm2009.info
mcm2011.info

2nd Biennial Meeting, June 19-22, 2009, Yale University, New Haven, CT



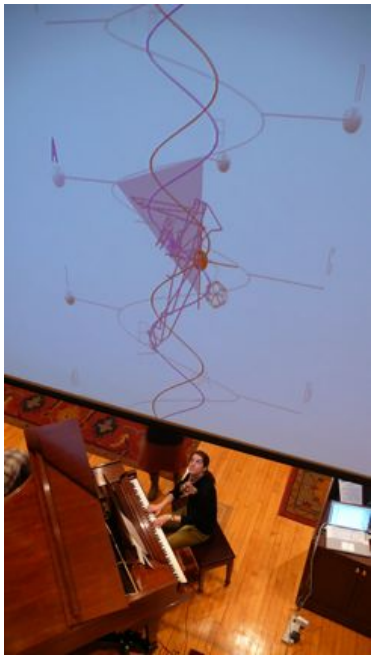


Pierre Boulez



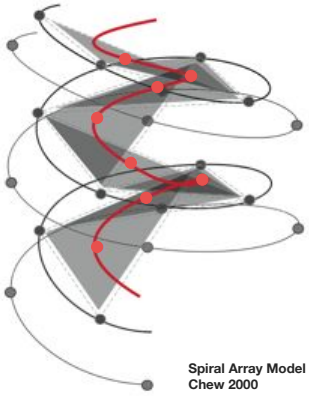
3rd Biennial Meeting, June 15-17, 2011, IRCAM, France

MuSA.RT



MuSA.RT

Interactive tonal analysis and visualization



Algorithms

Key finding (Chew 2000, 2001)

Segmentation (Chew 2002, 2004)

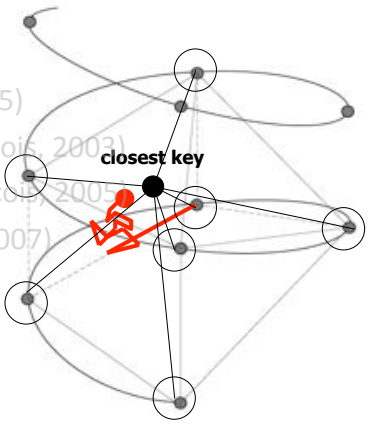
Pitch spelling (Chew & Chen 2003, 2005)

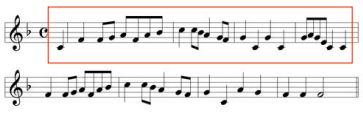
Interactive visualization (Chew & François, 2003)

Real-time tonal analysis (Chew & François, 2005)

Visualizing humor (Chew & François, 2007)

Pedal effects (Chew & François, 2008)





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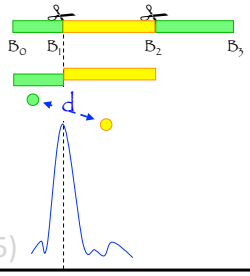

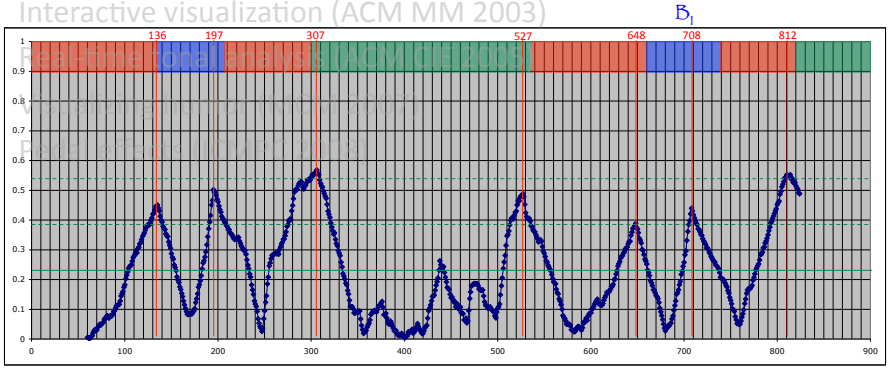

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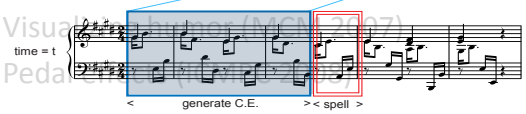
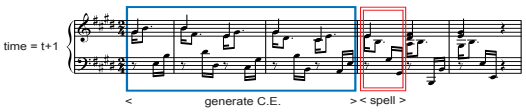
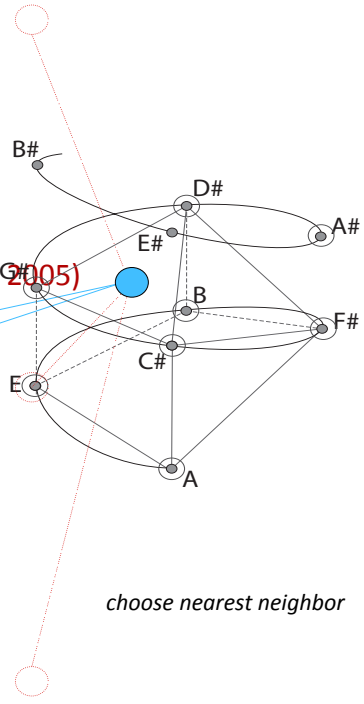
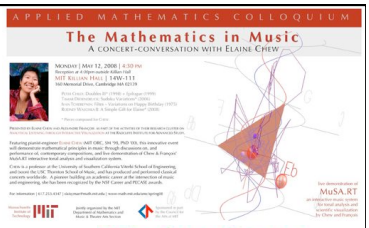






choose nearest neighbor

Algorithms



Technology Review PUBLISHED BY MIT

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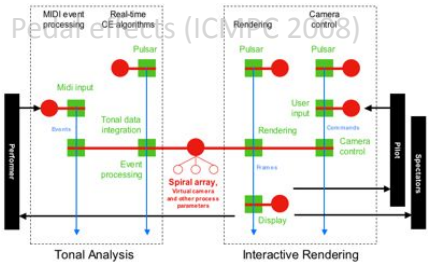
Pedal effects (ICMPC 2008)

LA Concert Rehearsal Jan 2007



Algorithms

ACM CIE Special issue on Tonal visualization

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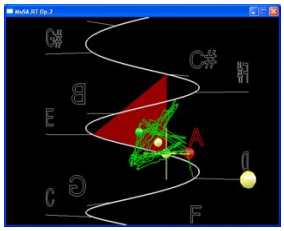
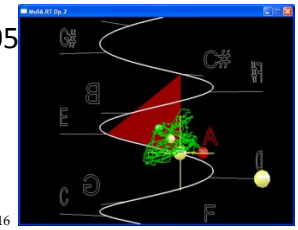
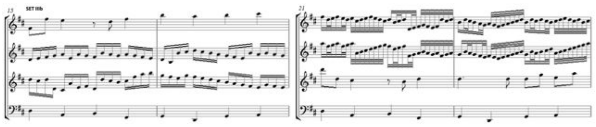
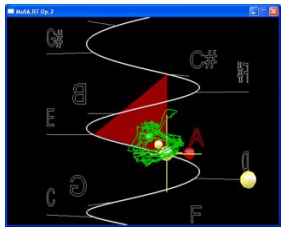
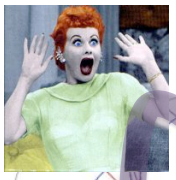








Algorithms



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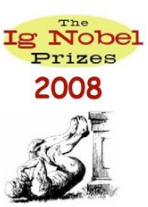

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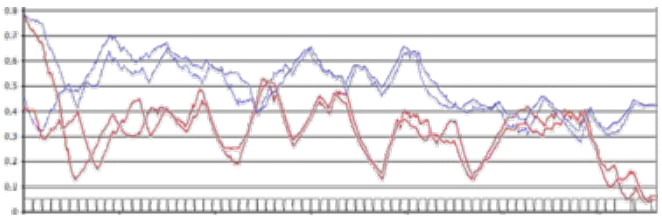
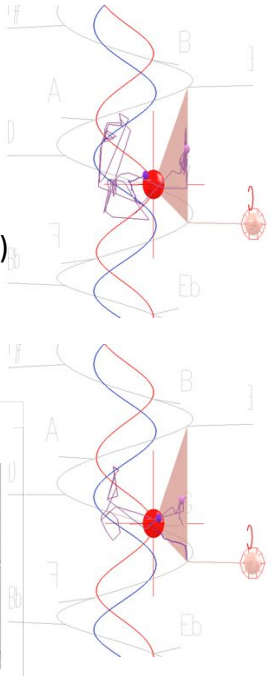




Goldberg Variation 8

Zenph Studios

Re-creations of historic performances

Goldberg Variation 15

Zenph Studios

Re-creations of historic performances

ESP

ESP

A literal take on the driving metaphor for expressive performance

Research Outcomes

THE CHRONICLE of Higher Education
ACM TechNews
scotsman.com
boingboing

Design and Implementation (NIME 2005)

Tempo Smoothness (ACE 2006)

Roadmaps as Interpretations (AMC MM 2006)

Designed using François' SAI software architecture style and MFSM middleware

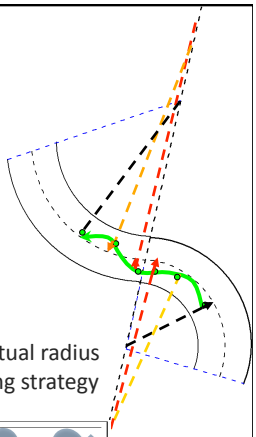
Research Outcomes

Design and Implementation (NIME 2005)

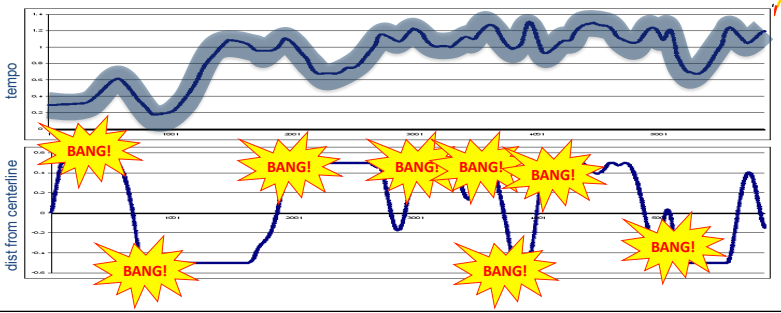
Tempo Smoothness (ACE 2006)

Roadmaps as Interpretations (AMC MM 2006)

Demo won Bronze Prize



virtual radius mapping strategy



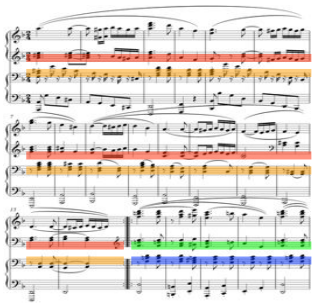
Research Outcomes

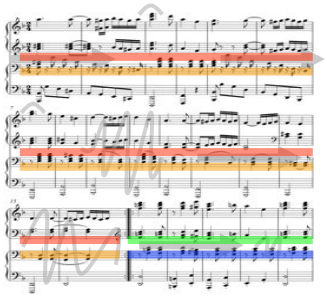
Design and Implementation (NIME 2005)

Tempo Smoothness (ACE 2006)

Roadmaps as Interpretations (AMC MM 2006)

Brahms Hungarian Dance No. 2: symmetric phrasing vs. gestural interpretation





Open Courseware

course announcement

ISE 575 EE 675b CSCI 575b **Topics in Engineering Approaches to Music Cognition**

Musical Prosody and Interpretation

Spring 2010

Daniel J. Epstein Department of Industrial and Systems Engineering
University of Southern California Viterbi School of Engineering

Instructor:
Elaine Chew
echew@usc.edu
GER-241, (213) 8.212.414

Tuesdays, 10am-1pm
PHE 223

www-scf.usc.edu/~ise575/d

Pre-requisites:
Graduate standing in engineering or by instructor's consent.
Programming experience (C++ or Java) and/or formal music knowledge.

This course explores the role of musical prosody in conveying diverse interpretations in musical performance. Performers manipulate musical parameters such as tempo, loudness, and articulation, so as to focus attention and facilitate parsing of musical features, and to create emotional affect. The class covers computational techniques for measuring prosodic cues such as timing and loudness (and time permitting, timbre) in music, the resulting accents and phrases, and how they map to perceived prominence and grouping. The class emphasizes learning by example, and learning by doing. The expected work includes reading of contemporary scientific literature on the topic, writing, presentation, discussion, and a final project.

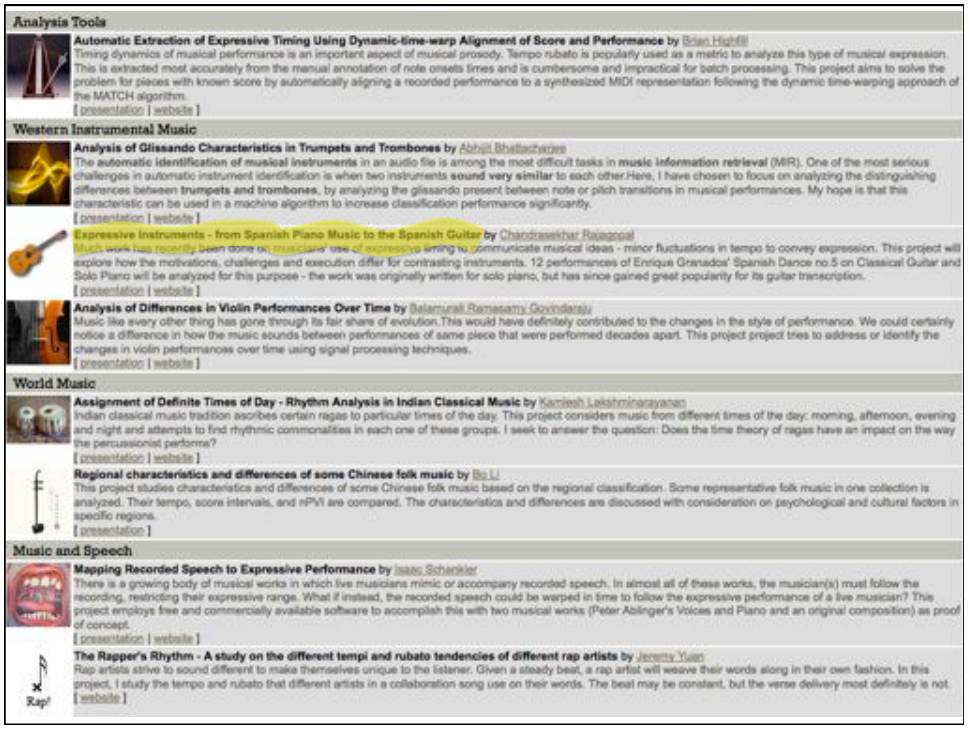
ISE575b CSCI575b EE675b Topics in Engineering Approaches to Music Cognition

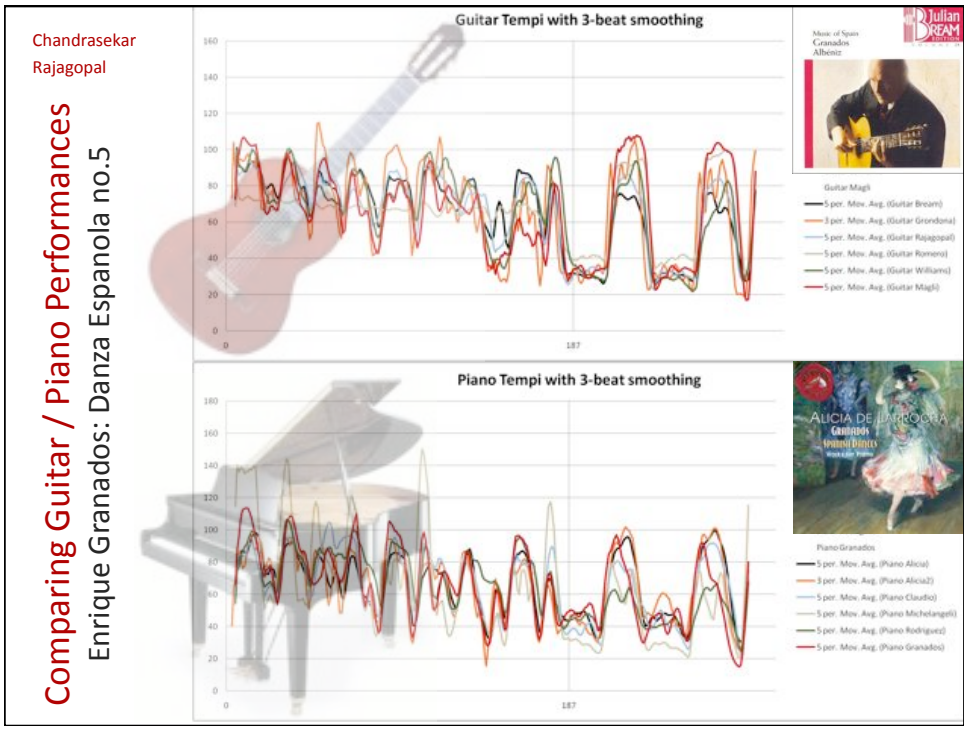
Musical Prosody and Interpretation

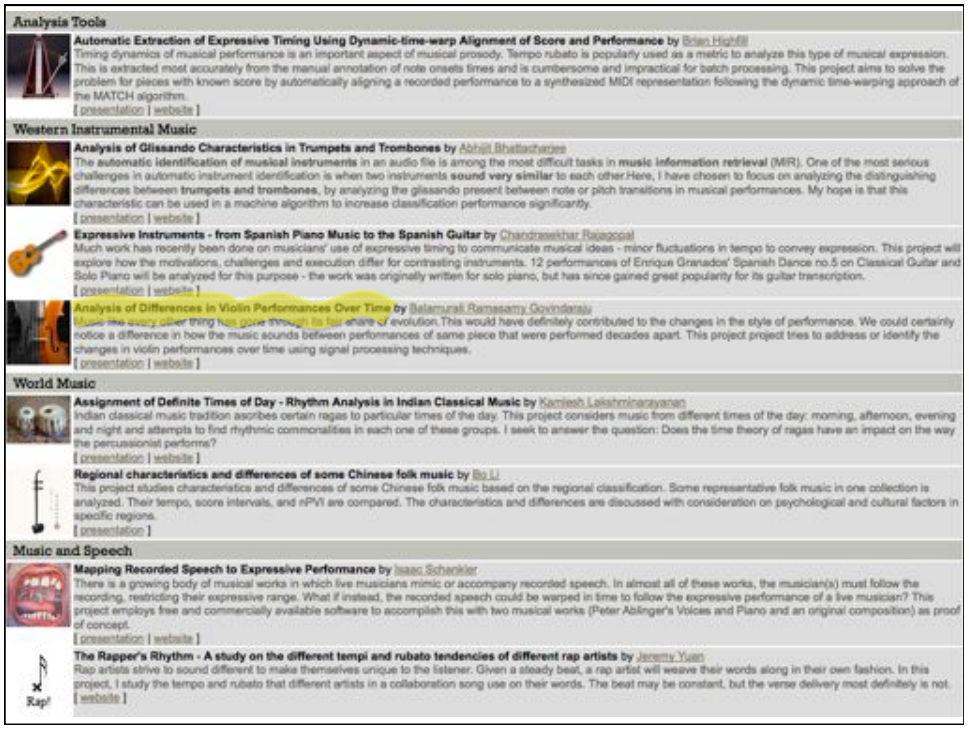
Spring 2010

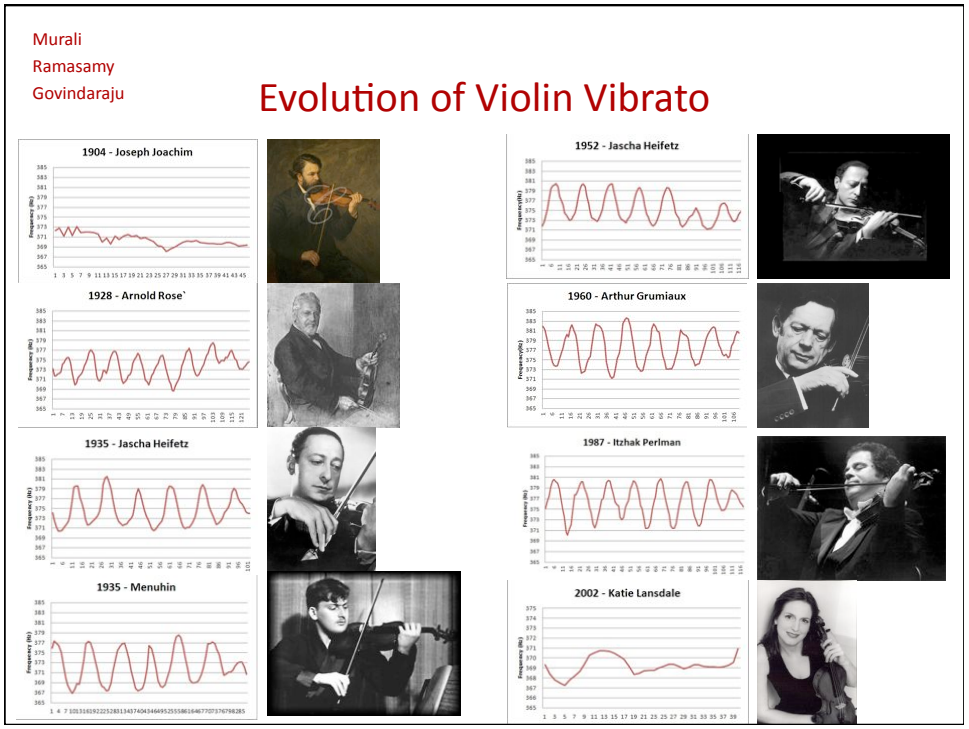
Daniel J. Epstein Department of Industrial and Systems Engineering
University of Southern California Andrew and Erna Viterbi School of Engineering

Introduction	
Week 1	Introduction to the course, and to concepts of beat, tempo, and loudness.
(Jan 12)	Listening examples include: Kreisler, Bach's Unaccompanied Violin Sonata, Glenn Gould's recordings of Bach's Goldberg Variations, Brahms' Hungarian Dances.
Week 2	Palmer, C., & Hutchins, S. (2006). What is musical prosody? In B. H. Ross (Ed.), Psychology of Learning and Motivation, 46: 245-278. [PDF] reports: [bhattacharjee, lakshminarayanan, rajagopal, schankler]
(Jan 19)	Homework 1B: Bring a piece of music that has variations in tempo or loudness to share with the class. Download and install QMUL's Sonic Visualiser.
Rhythm in Music and Speech	
Week 3	Patel, A.D., Iversen, J.R., & Rosenberg, J.C. (2006). Comparing the rhythm and melody of speech and music: The case of British English and French. Journal of the Acoustical Society of America, 119:3034-3047. [PDF] presentation: [balajee] reports: [bhattacharjee, lakshminarayanan, rajagopal, schankler]
(Jan 26)	Iversen, J.R., Patel, A.D., & Ohgushi, K. (2008). Perception of rhythmic grouping depends on auditory experience. Journal of the Acoustical Society of America, 124: 2263-2271. [PDF] presentation: [yuan] reports: [bhattacharjee, highfill]
	Patel, A.D. (2006). Musical rhythm, linguistic rhythm, and human evolution. Music Perception, 24:99-104. [PDF] presentation: [rajagopal] reports: [rajagopal]
(Jan 28)	Special Event: Attend the following talk by Aniruddh Patel to take place at 3:30pm in Doheny 240 - *Rhythm in Speech and Music*. Announcement: [PDF]
Beat and Tempo: Tracking and Analysis	
Week 4	Dixon, S. (2001). Automatic Extraction of Tempo and Beat from Expressive Performances. Journal of New Music Research, 30(1):39-58. [PDF] presentation: [bhattacharjee] reports: [bhattacharjee, rajagopal, ramasamy govindaraju, schankler]
(Feb 2)	Download Dixon's BeatRoot software (requires Java 1.5 or higher). Beat tracking examples.
	Dixon, S. & Widmer, G. MATCH: A Music Alignment Tool Chest. In Proceedings of the 6th Intl Conf on Music Information Retrieval, London, UK, 492-497. [PDF] presentation: [lakshminarayanan] reports: [bhattacharjee, highfill, rajagopal]
	Download Dixon's MATCH software (Java, any platform), or the Sonic Visualiser MATCH Vamp plugin.
Week 5	Timmers, R., Ashley, R, Desain, P, and Heijink, H. (2000). The influence of musical context on tempo rubato. Journal of New Music Research 29(2):131-158 [HTML]
(Feb 9)	Cammuri, A., Mazzarino, B., Ricchetti, M., Timmers, R., and Volpe, G. (2004). Multimodal Analysis of Expressive Gesture in Music and Dance Performances. In Gesture-Based Communication in Human-Computer Interaction, Springer Lecture Notes in Computer Science 2915. Read the Introduction (p.20-22), Section 4 (p.30-37) [PDF]
	Timmers, R. (2005). Predicting the similarity between expressive performances of music from measurements of tempo and dynamics. Journal of the Acoustical Society of America, 117(1): 391-399 [PDF] presentation: [schankler]
Tempo and Loudness: Visualization	
Week 6	Langner J. & Goebl W. (2003). Visualizing Expressive Performance in Tempo-Loudness Space. Computer Music Journal, 27(4): 69-83. [PDF] presentation: [yeh]
(Feb 16)	Goebl, W., Pampalk, E. & Widmer, G. (2004). "Exploring Expressive Performance Trajectories: Six Famous Pianists Play Chopin Pieces." In Proceedings of the 8th International Conference on Music Perception and Cognition. [PDF] presentation: [highfill]
Week 7	Grachten, M., Goebl, W., Flossmann, S., Widmer, W. (2009). Phase-plane Representation and Visualization of Gestural Structure in Expressive Timing. Journal of New Music Research, 38(2): 183-195. [PDF] presentation: [ ]
(Feb 23)	Sapp, C. S. (2007). Comparative Analysis of Multiple Musical Performances. In Proceedings of the 8th International Conference on Music Information Retrieval. [PDF]


Analysis Tools
Automatic Extraction of Expressive Timing Using Dynamic-time-warp Alignment of Score and Performance by Brian Highfill
Timing dynamics of musical performance is an important aspect of musical prosody. Tempo rubato is popularly used as a metric to analyze this type of musical expression. This is extracted most accurately from the manual annotation of note onsets times and is cumbersome and impractical for batch processing. This project aims to solve the problem for pieces with known score by automatically aligning a recorded performance to a synthesized MIDI representation following the dynamic time-warping approach of the MATCH algorithm.
[presentation | website]
Western Instrumental Music
Analysis of Glissando Characteristics in Trumpets and Trombones by Abhijit Bhattacharjee
The automatic identification of musical instruments in an audio file is among the most difficult tasks in music information retrieval (MIR). One of the most serious challenges in automatic instrument identification is when two instruments sound very similar to each other.Here, I have chosen to focus on analyzing the distinguishing differences between trumpets and trombones, by analyzing the glissando present between note or pitch transitions in musical performances. My hope is that this characteristic can be used in a machine algorithm to increase classification performance significantly.
[presentation | website]
Expressive Instruments - from Spanish Piano Music to the Spanish Guitar by Chandrasekhar Rajagopal
Much work has recently been done on musicians' use of expressive timing to communicate musical ideas - minor fluctuations in tempo to convey expression. This project will explore how the motivations, challenges and execution differ for contrasting instruments. 12 performances of Enrique Granados' Spanish Dance no.5 on Classical Guitar and Solo Piano will be analyzed for this purpose - the work was originally written for solo piano, but has since gained great popularity for its guitar transcription.
[presentation | website]
Analysis of Differences in Violin Performances Over Time by Balamurali Ramasamy Govindaraju
Music like every other thing has gone through its fair share of evolution.This would have definitely contributed to the changes in the style of performance. We could certainly notice a difference in how the music sounds between performances of same piece that were performed decades apart. This project project tries to address or identify the changes in violin performances over time using signal processing techniques.
[presentation | website]
World Music
Assignment of Definite Times of Day - Rhythm Analysis in Indian Classical Music by Kamlesh Lakshminarayanan
Indian classical music tradition ascribes certain ragas to particular times of the day. This project considers music from different times of the day: morning, afternoon, evening and night and attempts to find rhythmic commonalities in each one of these groups. I seek to answer the question: Does the time theory of ragas have an impact on the way the percussionist performs?
[presentation | website]
Regional characteristics and differences of some Chinese folk music by Bo Li
This project studies characteristics and differences of some Chinese folk music based on the regional classification. Some representative folk music in one collection is analyzed. Their tempo, score intervals, and nPVI are compared. The characteristics and differences are discussed with consideration on psychological and cultural factors in specific regions.
[presentation]
Music and Speech
Mapping Recorded Speech to Expressive Performance by Isaac Schankler
There is a growing body of musical works in which live musicians mimic or accompany recorded speech. In almost all of these works, the musician(s) must follow the recording, restricting their expressive range. What if instead, the recorded speech could be warped in time to follow the expressive performance of a live musician? This project employs free and commercially available software to accomplish this with two musical works (Peter Ablinger's Voices and Piano and an original composition) as proof of concept.
[presentation | website]
The Rapper's Rhythm - A study on the different tempi and rubato tendencies of different rap artists by Jeremy Yuan
Rap artists strive to sound different to make themselves unique to the listener. Given a steady beat, a rap artist will weave their words along in their own fashion. In this project, I study the tempo and rubato that different artists in a collaboration song use on their words. The beat may be constant, but the verse delivery most definitely is not.
[website]
Rap!


Chandrasekar Rajagopal
Comparing Guitar / Piano Performances
Enrique Granados: Danza Espanola no.5
Guitar Tempi with 3-beat smoothing
Piano Tempi with 3-beat smoothing
Julian Bream
Alicia de Larrocha


Analysis Tools
Automatic Extraction of Expressive Timing Using Dynamic-time-warp Alignment of Score and Performance by Brian Highfill
Timing dynamics of musical performance is an important aspect of musical prosody. Tempo rubato is popularly used as a metric to analyze this type of musical expression. This is extracted most accurately from the manual annotation of note onsets times and is cumbersome and impractical for batch processing. This project aims to solve the problem for pieces with known score by automatically aligning a recorded performance to a synthesized MIDI representation following the dynamic time-warping approach of the MATCH algorithm.
[presentation | website]
Western Instrumental Music
Analysis of Glissando Characteristics in Trumpets and Trombones by Abhijit Bhattacharjee
The automatic identification of musical instruments in an audio file is among the most difficult tasks in music information retrieval (MIR). One of the most serious challenges in automatic instrument identification is when two instruments sound very similar to each other.Here, I have chosen to focus on analyzing the distinguishing differences between trumpets and trombones, by analyzing the glissando present between note or pitch transitions in musical performances. My hope is that this characteristic can be used in a machine algorithm to increase classification performance significantly.
[presentation | website]
Expressive Instruments - from Spanish Piano Music to the Spanish Guitar by Chandrasekhar Rajagopal
Much work has recently been done on musicians' use of expressive timing to communicate musical ideas - minor fluctuations in tempo to convey expression. This project will explore how the motivations, challenges and execution differ for contrasting instruments. 12 performances of Enrique Granados' Spanish Dance no.5 on Classical Guitar and Solo Piano will be analyzed for this purpose - the work was originally written for solo piano, but has since gained great popularity for its guitar transcription.
[presentation | website]
Analysis of Differences in Violin Performances Over Time by Balamurali Ramasamy Govindaraju
Music like every other thing has gone through its fair share of evolution.This would have definitely contributed to the changes in the style of performance. We could certainly notice a difference in how the music sounds between performances of same piece that were performed decades apart. This project project tries to address or identify the changes in violin performances over time using signal processing techniques.
[presentation | website]
World Music
Assignment of Definite Times of Day - Rhythm Analysis in Indian Classical Music by Kamlesh Lakshminarayanan
Indian classical music tradition ascribes certain ragas to particular times of the day. This project considers music from different times of the day: morning, afternoon, evening and night and attempts to find rhythmic commonalities in each one of these groups. I seek to answer the question: Does the time theory of ragas have an impact on the way the percussionist performs?
[presentation | website]
Regional characteristics and differences of some Chinese folk music by Bo Li
This project studies characteristics and differences of some Chinese folk music based on the regional classification. Some representative folk music in one collection is analyzed. Their tempo, score intervals, and nPVI are compared. The characteristics and differences are discussed with consideration on psychological and cultural factors in specific regions.
[presentation]
Music and Speech
Mapping Recorded Speech to Expressive Performance by Isaac Schankler
There is a growing body of musical works in which live musicians mimic or accompany recorded speech. In almost all of these works, the musician(s) must follow the recording, restricting their expressive range. What if instead, the recorded speech could be warped in time to follow the expressive performance of a live musician? This project employs free and commercially available software to accomplish this with two musical works (Peter Ablinger's Voices and Piano and an original composition) as proof of concept.
[presentation | website]
The Rapper's Rhythm - A study on the different tempi and rubato tendencies of different rap artists by Jeremy Yuan
Rap artists strive to sound different to make themselves unique to the listener. Given a steady beat, a rap artist will weave their words along in their own fashion. In this project, I study the tempo and rubato that different artists in a collaboration song use on their words. The beat may be constant, but the verse delivery most definitely is not.
[website]
Rap!

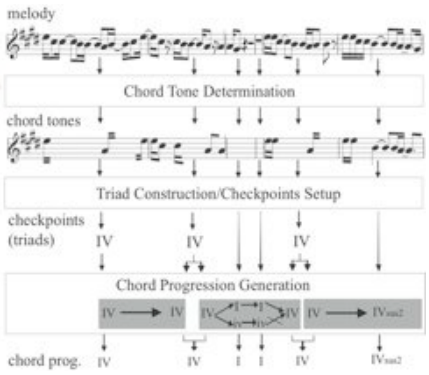

Murali
Ramasamy
Govindaraju
Evolution of Violin Vibrato
1904 - Joseph Joachim
1928 - Arnold Rose`
1935 - Jascha Heifetz
1935 - Menuhin
1952 - Jascha Heifetz
1960 - Arthur Grumiaux
1987 - Itzhak Perlman
2002 - Katie Lansdale

Ching-Hua Chuan

2010 best new investigator paper award

ASSA

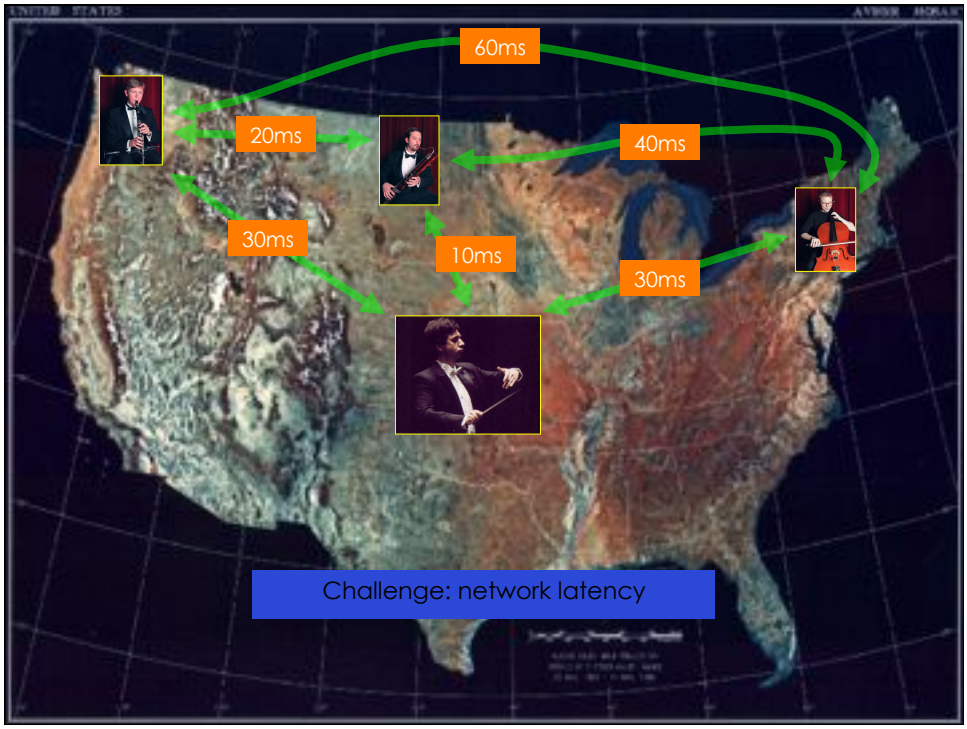
automatic style-specific accompaniment



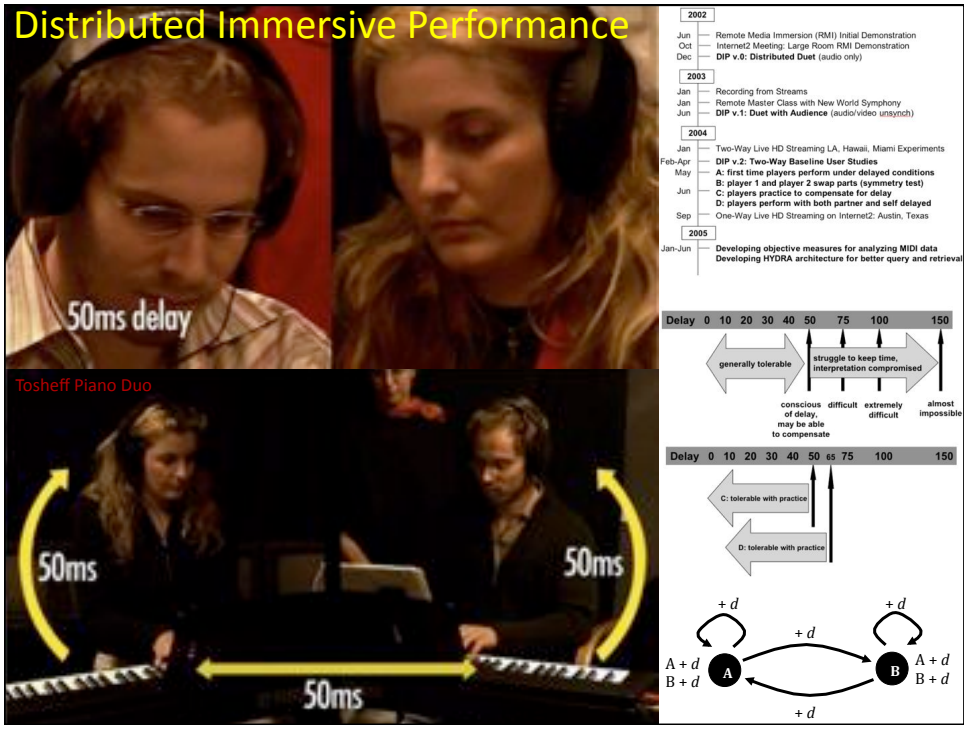
Melody to be harmonized	Radiohead's *Creep*	
Style learned from	Fiona Apple's *Never is a promise*	
Generated Accompaniment		

MSNBC FOX NEWS Channel USA TODAY The Daily Telegraph The WIRED

DIP

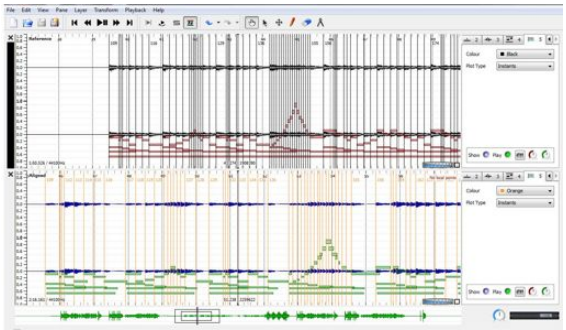

60ms
20ms
40ms
30ms
10ms
30ms
Challenge: network latency


Player 1
15m: 45ms
15m: 45ms
Conductor
Player 2
10m: 30ms



DIP: Evaluation of Ensemble Coordination

- Distributed Immersive Performance (ETP 2003)
- Auditory delay of other's playing to self (MusicNetwork 2004)
- Auditory delay of own playing to self (NASM 2004, MusicNetwork 2005)
- Segmental tempo analysis (SMC 2005)
- Automatic alignment of duet performances (ISMIR 2010)
- Evaluation of ensemble coordination



Katie Wolf

MIMI

MIMI

Multimodal Interaction in Musical Improvisation

Mimi's international debut at MCM 2007 at the Berlin Musical Instrument Museum on the historic Seiler piano

Analyzing Musical Creation

Mimi & Isaac Schankler
People Inside Electronics Concert

Boston Court Performing Arts Center
Pasadena, California, June 5, 2010

collaborators

Colleagues

Alexandre François, Alexander Sawchuk, Roger Zimmermann, Christos Papadopoulos, Christos Kyriakakis, Anja Volk

Students

Yun-Ching Chen, Ching-Hua Chuan, Brian Highfill, Jie Liu, Chandrasekar Rajagopal, Murali Ramasamy Govindaraju, Carley Tanoue, Katie Wolf, Aaron Yang

Artists

Isaac Schankler, Dennis Thurmond, Tosheff Piano Duo

links

music computation and cognition lab (research and projects)
www-rcf.usc.edu/~mucoaco

topics in engineering approaches to music cognition (open courseware)
www-scf.usc.edu/~ise575

publications
www-rcf.usc.edu/~echew/bibliography