# Sonification, Emotion and Music

Strategies for Continuous Auditory Display of Arousal and Valence

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Music Technology

January 23, 2003



> http://www.sonifyer.org http://www.auditory-seismology.org

### Sonification of Tohoku Earthquake



Motion of earth's surface sped up (12 hour = 30 sec)

Sonification

http://sonification.de/handbook/, Chapter 2 Theory of Sonification, Walker, Ness.

Edited by Thomas Hermann, Andy Hunt, John G. Neuhoff

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### Some Applications

#### Data Exploration



#### Process Monitoring



#### Assistive Technology



#### Art/Outreach







# Sonification and Music

### How do they typically interact?

- 1. Sonifications in concert setting/installations
- 2. Aesthetics

- But what about music-related data?
  - Sonification of Expressive Movement
  - Sonification of Music

Winters, R. M., Savard, A., Verfaille, V., & Wanderley, M. M. (2012). A sonification tool for the analysis of large databases of expressive gesture. International Journal of Multimedia and Its Applications, 4(6), 13-26.

### Sonification of Expressive Gesture

Dr. Petri Toiviainen, http://vimeo.com/42395861



• Sound displays extra-musical content (embodiment, interpretation)





### Sonification of Music







Bach's

Chorales

Monteverdi's Madrigals









Sound displays non-obvious musical structure

### Summary



- Sonification benefits from relationship with music
  - 1. Display extra-musical content (Embodiment)
  - 2. Explore and search for musical structure
  - 3. Borrow structural/acoustic cues to display emotion

### New Work: Emotion



- How can we use sound to
  - Display emotional information?
  - Mediate the communication or expression of emotion?
- Sonification Goals:
  - Motivate
  - Determine best mappings
  - Evaluate the model

# Motivation: Affective Computing

- Why display or communicate emotion?
  - 1. Fundamental component of A.C.
  - 2. Real-time emotion recognition
- Why use sound?
  - 1. Display information that is not visually obvious
  - 2. Can be used when verbal or visual attention is occupied
  - 3. Results contribute to theoretical/experimental research



### Applications

- Display of emotions in therapy
- Analysis of models for affect
- Affective diary
- Remote affective monitoring
- How is my machine feeling?

# Determine best strategies

	Ecological Sound	Music
Mechanisms	More biological	More psychological
Time scale	Shorter	Longer
Emotion Distribution	Limited/Full	Limited/Full
Induced or perceived?	More Induced	More perceived

### Environmental Sounds

#### Emoacoustics

- ``We don't hear signals, we hear events"
- Four-layer typology
  - Physical Determinants
  - Psychological Determinants
  - Spatial Determinants
  - Cross-modal and other determinants

Tajadura-Jimenez, A., & Vastfjall, D. (2008). Auditory-induced emotion: A neglected channel forcommunication in human-computer interaction. In C. Peter & R. Beale (Eds.), Affect and emotion in HCI (p. 63-74). Berlin, Germany: Springer-Verlag.

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### Physical Determinants

### How annoying or unpleasant?

- Traditional
- Experiments with simple tones, sound quality
- Sharpness, roughness, loudness, tonality, spectral flux

### Applications:

Sound design, product sound quality....





### Psychological Determinants

- Subjective Meaning/Interpretation
- International Affective Digital Sounds (IADS)
- Self-representational sounds
- Not useful for continuous display
- Useful for Human-Machine Interfaces
  - Earcons
  - Auditory Icons
  - Warning, information sounds











### **Spatial Determinants**

- Emotion and "Presence"
  - "Presence is the perceptual illusion of non-mediation"
- Speed, proximity, location, approaching, spaciousness
- Intensity, reverberation, 3D sound
- Applications:
  - Virtual Reality
  - Computer Games
  - Architectural and Virtual Acoustics

### Cross-modal and others

- Emotion priming
- Interactions with Vision
- Attention
- Interaction



Juslin, P. N., & Sloboda, J. A. (2010). Introduction: Aims, organization, and terminology. In P. N. Juslin & J. A. Sloboda (Eds.), Handbook of music and emotion: Theory, research, applications. Oxford University Press.

### Music and Musical Emotion

- What is a musical emotion?
  "Emotion that is somehow induced by music"
- Important questions for sonification:
  - 1. What are the underlying mechanisms?
  - 2. What are the structural and acoustic elicitors?





Juslin, P. N., & Vastfjall, D. (2008). Emotional responses to music: The need to consider underlying mechanisms. Behavioral and Brain Sciences, 31(5), 559-621.

# Underlying Mechanisms

- Juslin produces 6, only two are useful:
  - 1. "Brain-stem reflexes"
  - 2. Emotional Contagion
- Characteristics:
  - 1. Low cultural impact
  - 2. Low volitional influence
  - 3. Medium dependence on musical structure

### Structural and Acoustic Elicitors

- Intervals
- Mode
- Rhythm
- Tempo
- Melody
- Amplitude Envelope
- Articulation
- Harmony
- Loudness

- Melodic Range
- Melodic Direction
- Pitch Contour
- Melodic Motion
- Pauses/Rests
- Pitch Level
- Pitch Variation
- Tonality
- Musical Form

Which should be used?

Gabrielsson, A., & Lindstrom, E. (2010). The role of structure in the musical expression of emotions. In P. N. Juslin & J. Sloboda (Eds.), Handbook of music and emotion: Theory, research, applications (p. 367-400). New York, NY: Oxford University Press.

# Listening Approach

- Emotional measurements correlated with
  - Real music
  - Specifically composed music
  - Synthesized tone sequences
- Perceived/induced emotion is measured
- Most salient/clear cut:
  - Tempo, loudness, timbre, pitch height, mode



CIRMMT Audience Response System

Coutinho, E., & Cangelosi, A. (2011). Musical emotions: Predicting second-by-second subjective feelings of emotion from low-level psychoacoustic features and physiological measurements. *Emotion*, 11(4), 921-937.

### Machine Approach

- Use data features, machine learning to determine the important factors
- Important features are:
  - Roughness, Notes/second, attack time, peak sound level
  - Pitch level, sharpness



Bresin, R., & Friberg, A. (2011). Emotion rendering in music: Range and characteristic values of seven musical variables. *Cortex*, *47*, 1068-81.

### Interaction Approach

- Have people convey emotion directly using controller
- Participants take an active role in emotional communication
- Restricting number of parameters offers control
  - Ranges of musical parameters determined



### Summary

- Inducing Auditory Emotions can be done through
  - Environmental sounds
  - Music
- Best strategies for sonification are based upon
  - Physical determinants
  - Emotional contagion
- Specific structural/acoustic cues identified

### Demo

- Tempo
- Loudness
- Mode
- Sensory Dissonance
- Articulation
- Timbre
- Bimodal Interaction

### Next steps: Evaluation

### Accuracy

- Can it be used when verbal/visual attention is already occupied?
- □ Is it an intuitive/likeable display?

### Saturday: Music Hack Day

#### Goals:

- Map T-stick to parameters of the model
- Add new features
- Do informal user testing







### Acknowledgements

- Marcelo M. Wanderley
- Ian Hattwick
- Stephen McAdams
- Emotional Imaging Inc.,
- NSERC Engage Grant

### Thank you!

Questions? 

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