An Interactive Case-Based Reasoning Approach for Generating Expressive Music

Josep Lluís Arcos
Ramon López De Mántaras
Artificial Intelligence Institute of the Spanish Scientific Research Council (IIIA-CSIC)

Presented by Ching-Hua Chuan

Outline/Introduction

Interactive SaxEx
- SMS (Spectral Modeling and Synthesis)
- Noos
- Background Musical Knowledge
- Interactive Interface
- System Evaluation

SaxEx

Authors

Josep Lluís Arcos
- Postdoctoral researcher in IIIA-CSIC
- M.S. on musical creation and sound technology
- Ph.D. in CS

Ramon López De Mántaras
- Research professor in IIIA-CSIC
- M.Sc. In CS
- Ph.D in physics and CS.
**SaxEx - SMS**

SMS: Spectral Modeling and Synthesis

Pre-processor: spectral modeling
- Extracting high level parameters from real sound files.
- High level parameters: dynamics, rubato, vibrato, articulation.
- Based on decomposing a sound into sinusoids plus a spectral residual.

Post-processor: synthesis
- Transform the sound according to performance parameters.

---

**Noos**

Noos
- A reflective object-centered representation language designed to support knowledge modeling of problem solving and learning.
- Modeling a problem in Noos requires three types of knowledge: domain knowledge, problem solving knowledge, & metalevel knowledge.
- Domain knowledge: a set of concepts and their relations Musical ontology, such as notes, chords, structures, expressive parameters.
- Problem solving knowledge: specify the set of tasks to be solved Infer a sequence of expressive transformations for a given musical phrase. Decomposed into subtasks.
- Metalevel knowledge: Perspectives and preferences.

---

**SMS snapshot**

---

**Noos – metalevel**

- Perspectives
  - Describes declarative biases for case retrieval.
  - Two types of declarative biases:
    - assess similarities among score.
    - detect affective intention in performances and assess similarities among them.
- Preferences
  - A symbolic representation of relevance in comparing a given current problem with problems previously solved by the system.
  - Two kinds of preferences methods:
    1. preference construction method (increasing-preference, …).
    2. preference combination method (inversion, preference-union…).
- Episodic Memory
  - The collection of problems that the system has solved.
Background Musical Knowledge

- Narmour’s Implication/Realization (IR) Model
  - Proposes a theory of cognition of melodies based on eight basic structures.
- Lerdahl and Jackendoff’s Generative Theory of Tonal Music (GTTM)
  - Understand melodies based on a hierarchical structure of musical cognition.
  - Grouping structure – segmentation units
  - Metrical structure – rhythm hierarchy of the piece
  - Time-span reduction structure – relative structural importance of notes within the audible rhythmic units of a phrase
  - Prolongation reduction structure – tension-relaxation relationships among groups of notes.
- Jazz Theory
  - Chord progressions, tonal functionality of chords, the use of dominants.

Case Representation

- Score
  - Melody and harmony
- Musical Analysis
  - Implication-realization structure, metrical structure, time-span reduction structure, and prolongational reduction structure
- Performance Representation
  - Affective Regions
    - tender-aggressive, sad-joyful, calm-restless
  - Solution Description
    - dynamics, rubato, vibrato, articulation, attack
  - Note Expressivity Parameters
    - sound transformation operations
      (eg: delay-attack, increase-vibrato, legato-articulation)
**CBR Task**

- **Retrieve-CBR**
- **Retrieve**
- **Search**
- **Select**
- **Apply expressive transformations**
- **Propose expressive performance**
- **Memorize new solved case**

**Interactive**

**Reuse Criteria**

- The "**Majority Rule**" criterion
  - Values applied in the **majority** of the precedents
- The "**Strict Majority Rule**" criterion
  - Values applied in **at least half** of the precedents
- The "**Minority Rule**" criterion
  - Values applied in the **minority** of the precedents
- The "**Strict Minority Rule**" criterion
  - Values applied in **at most one** of the precedents
- The "**Continuity**" criterion
  - Gives priority to precedent notes in the **same sub phrase**
- The "**Non-Continuity**" criterion
  - Gives priority to precedents **not in the same** sub phrase
- The "**Random**" criterion

**Retrieval Perspectives**

- **Affective labels**
  - tender-aggressive, sad-joyful, calm-restless
- **Musical knowledge**
  - IR model
    - Role in IR structure, melodic direction, durational cumulation.
  - GTTM theory
    - Metrical strength, role in the Time-span reduction tree, role in the Prolongation reduction.
  - Jazz theory
    - Harmonic stability, note duration.

**Interacting with SaxEx-1**

- **New Problem**
  - **Problem Manager**
    - **Tender**
    - **Aggressive**
    - **Sad**
    - **Joyful**
    - **Calm**
    - **Restless**

- **Cas Ex**
  - **All of Me**
  - **Autumn Leaves**
  - **How High the Moon**
  - **Wish You Were Here**
  - **My Way**
  - **I'll Be Good for You**

- **CBR Method**
  - **Retrieve**
  - **Search**
  - **Select**
  - **Propose**
  - **Memorize**

- **Start**
Interacting with SaxEx-2

System Evaluation-1

Interacting with SaxEx-3

System Evaluation-2

Arcos & de Mantaras: An Interactive Case-Based Approach to Generating Expressive Performances

Presented by C.-H. Chuan
Conclusions

- SaxEx: a CBR system to generate expressive performance.
- Interactive version: educational tool, creative process.
- Some details to be improved:
  - Show the precedents selected for each note and the other among them.
  - Allow different reuse criteria for each expressive parameter.
  - Model the degree of the different expressive parameters by fuzzy sets.