

## An Interactive Case-Based Reasoning Approach for Generating Expressive Music

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## Outline/Introduction

Inexpressive phrase (Score, MIDI, Audio)

Interactive SaxEx

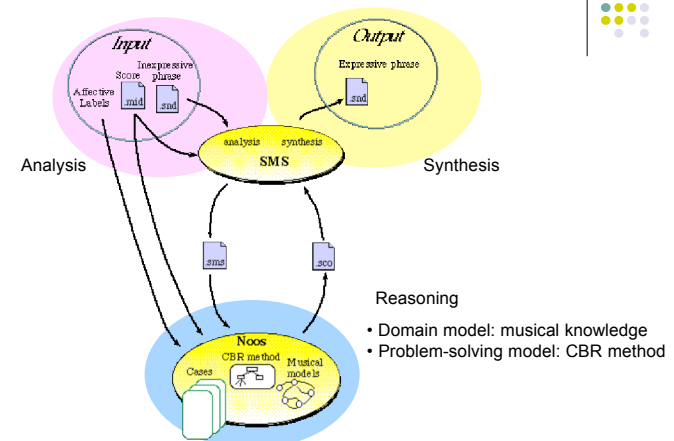


- SMS (Spectral Modeling and Synthesis)
- Noos
- Background Musical Knowledge
- Interactive Interface
- System Evaluation

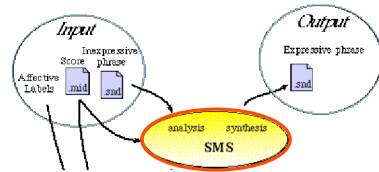
Expressive phrase (Audio)



## SaxEx



## 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.

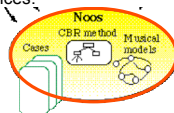
## SMS snapshot



## 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.



## Noos – metalevel

- Perspectives
  - Describes **declarative biases for case retrieval**.
  - Two types of declarative biases:
    1. assess similarities among score.
    2. 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.

## Background Musical Knowledge - Example



All Over Me

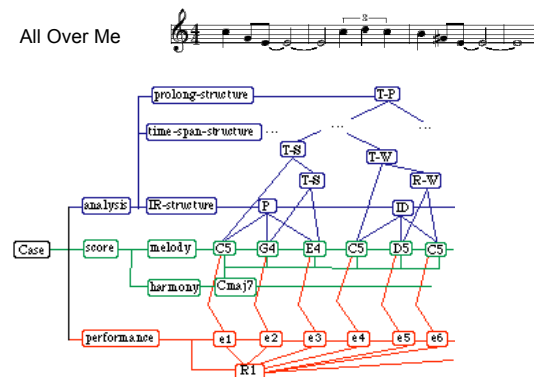
The diagram shows a musical score for 'All Over Me' with two models overlaid. The GTTM model (Time-span reduction) is shown as a series of vertical lines of varying heights, indicating the relative structural importance of notes. The IR model is shown as a series of brackets labeled P, ID, P, P, representing the Implication/Realization structure. Below the score, the 'Eight basic structures of IR Model' are listed: P, D, IP, IP, VP, R, IR, VR.

## Case Representation

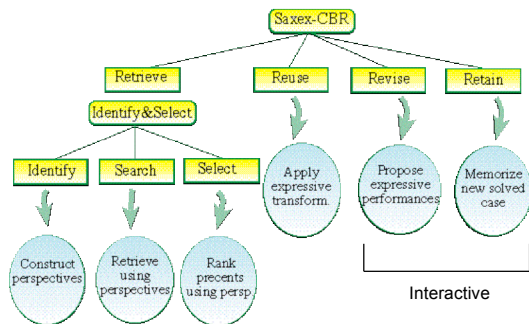


- Score
  - Melody and harmony
- Musical Analysis
  - Implication-realization structure, metrical structure, time-span reduction structure, and prolongational reduction structure
- Performance Representation
  - Affective Regions
    - tender-aggressive, sad-joyful, calm-restless
  - Solution Description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

## Case Representation Example



## CBR Task



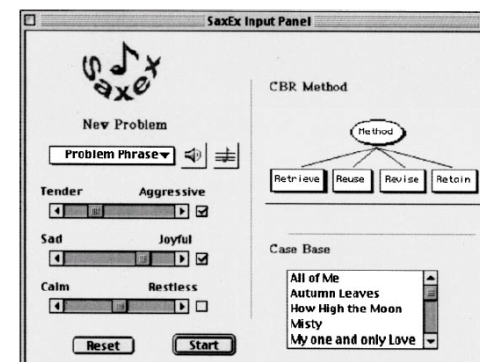
## Retrieval Perspectives

- 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.*

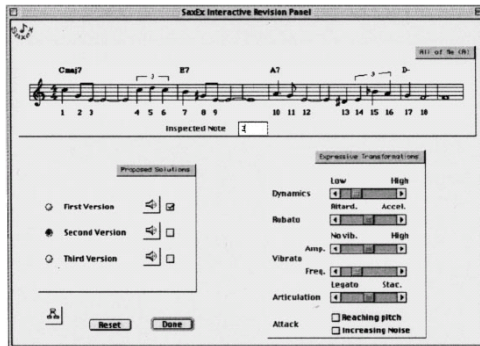
## Reuse Criteria

- 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

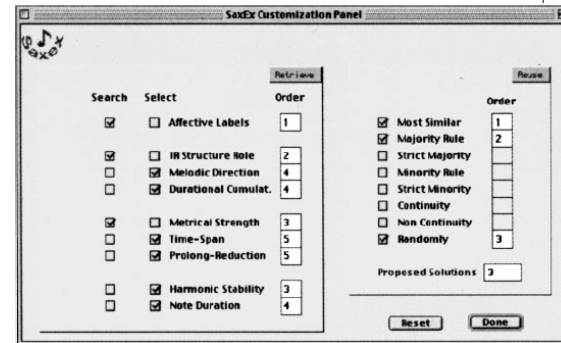
## Interacting with SaxEx-1



## Interacting with SaxEx-2



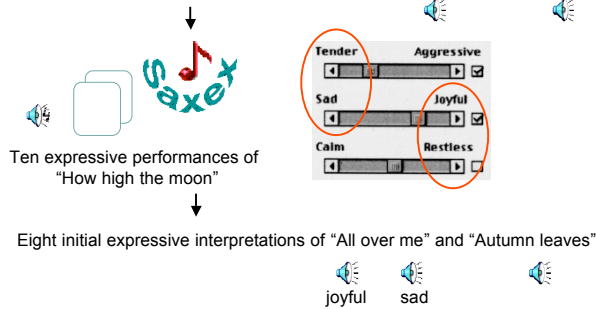
## Interacting with SaxEx-3



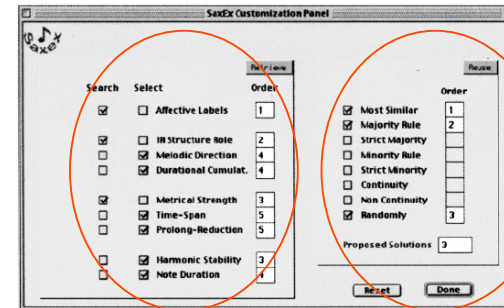
## System Evaluation-1



Two phrases of "All over me", "Autumn leaves"



## System Evaluation-2



Another 8 interpretations

Another 8 interpretations

## 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.