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# Respecting Expressivity under Global Musical Tempo Transformations

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## Overview of the talk:

- Global Musical Tempo Transformations
- Case Based Reasoning
- Tempo Transformations Using CBR
- Results
- Conclusions
- Future Work

## Global Musical Tempo Transformations

Why not uniform time stretching?

- Timing of notes w.r.t. beat may have to change
- Expressive phenomena such as ornamentations and consolidations of notes may change as a function of tempo

## Onset deviations at different tempos (BodyAndSoul-A1)



## How to obtain an expressivity that is suitable for a particular tempo?

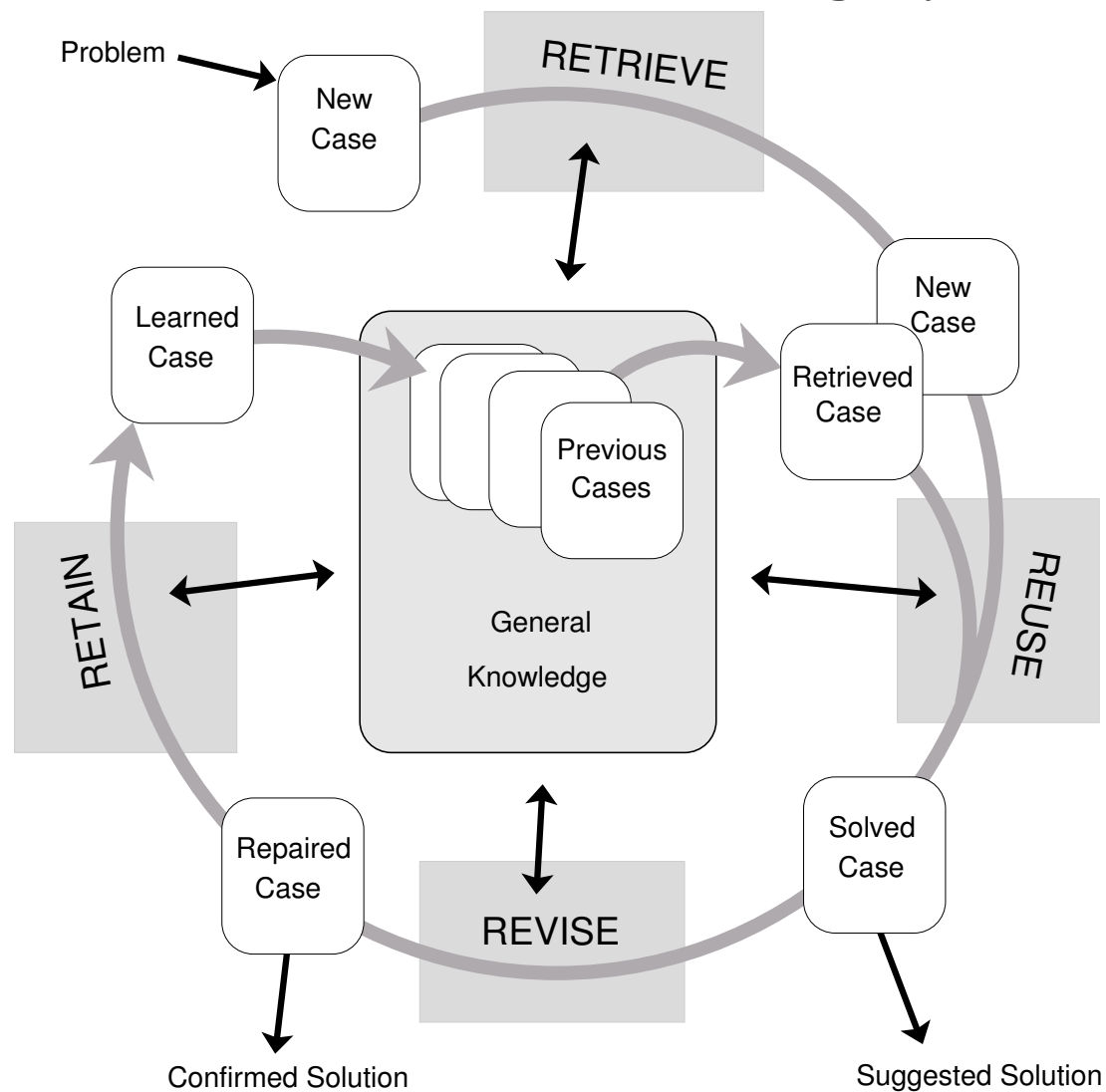
General approaches to expressive performance generation:

- Let a music expert formulate rules for music performance (e.g. Friberg 1991)
- Try to derive performance rules automatically from examples (e.g. Widmer, 2002)
- Build models of expressive music performance aspects (e.g. Todd, 1985)

## An alternative approach: Case Based Reasoning

- Solve problems based on past solutions to similar problems
- Lazy learning: learning/generalizing takes place at the moment of problem solving, not at the time of presenting past experience

## The CBR Problem Solving Cycle



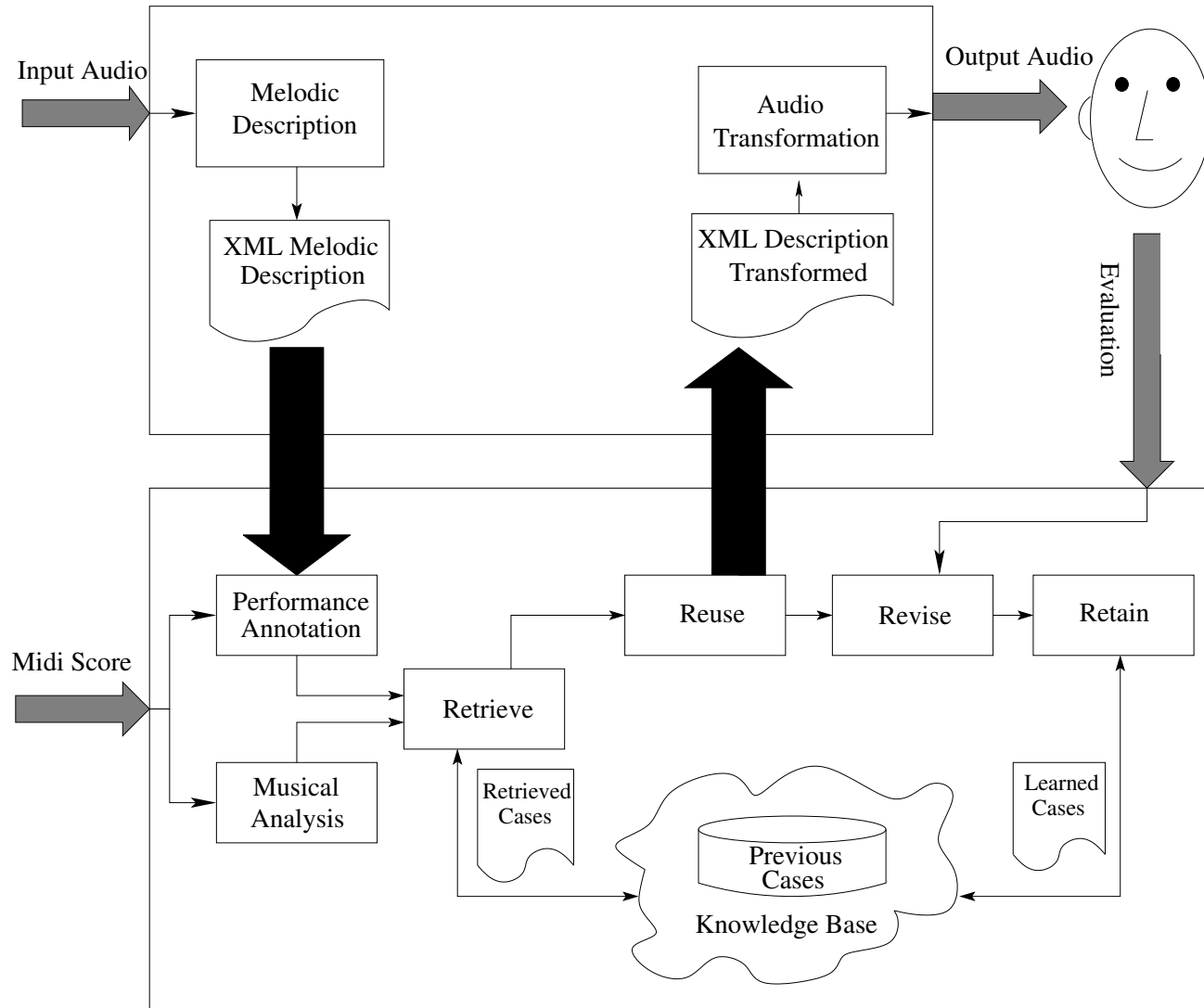
## Why Case Based Reasoning?

- Fit for problem domains where the knowledge used to provide solutions is hard to verbalize (it's implicit in the cases)
- Because lazy learners make many *local* approximations of the target function (instead of making one *global* approximation), it is more apt to learn complex target functions

Drawbacks:

- Need to specify retrieval and adaptation methods
- Due to laziness, work must be done at problem solving time (not good when there's memory/time constraints)

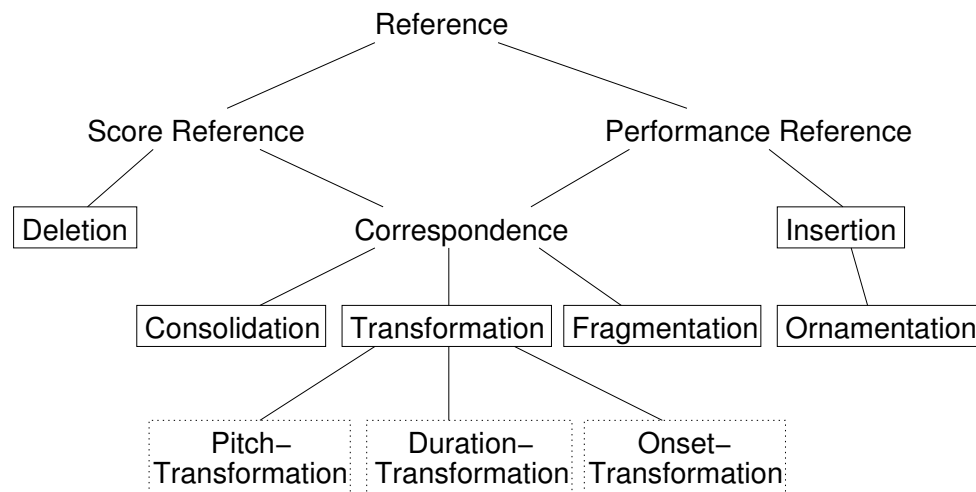
## A CBR Approach to Tempo Transformation



## Performance Annotation

Expressivity in jazz performances is more than timing/dynamics deviations. Also spontaneous note ornamentations, fragmentations etc occur.

To represent this, define a set of *Performance Events*:



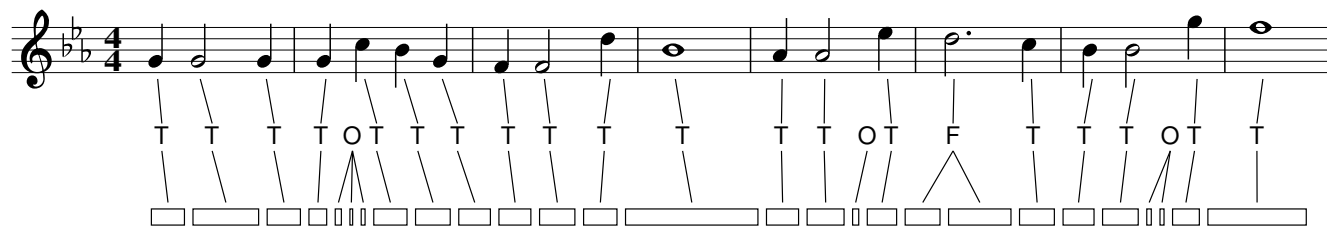
And use them as edit-operations to obtain an edit-distance alignment between score and performance

## Example


- Transformation-Event
  - Performance-Reference
  - Score-Reference
  - Onset-Deviation
  - Duration-Deviation
- Ornamentation-Event
  - Performance-Reference
  - Pitch-Interval
  - Duration-Interval

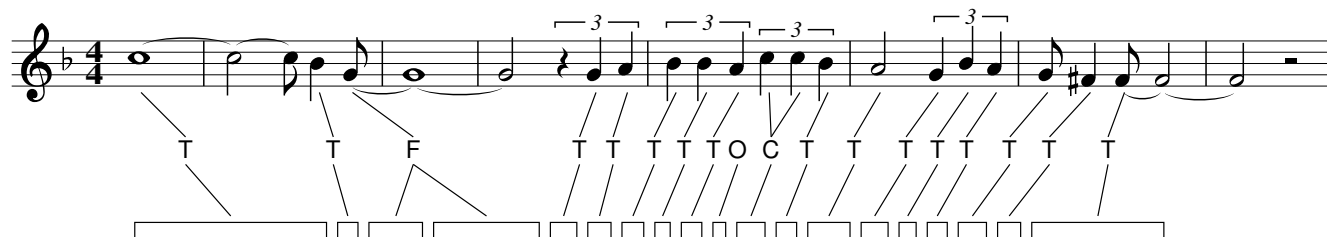
## Performance Annotation

- LikeSomeoneInLove-A (80 bpm) 



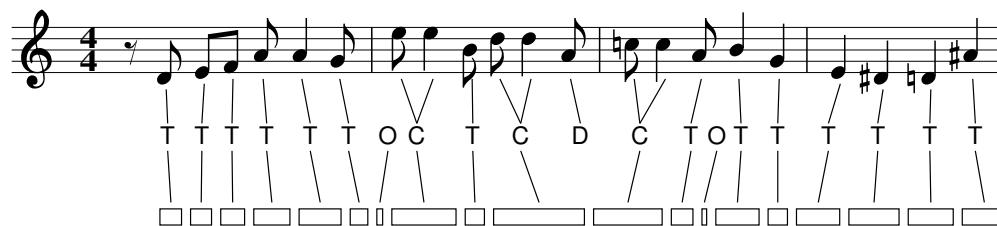
Musical notation for LikeSomeoneInLove-A (80 bpm) with performance annotations. The notation is in 4/4 time with a key signature of two flats. The melody consists of quarter and eighth notes. Below the staff, letters T, O, and F are placed above specific notes, with lines connecting them to a sequence of 16 rectangular boxes representing a performance timeline.

- OnceILoved-B1 (220 bpm) 



Musical notation for OnceILoved-B1 (220 bpm) with performance annotations. The notation is in 4/4 time with a key signature of two flats. It features triplet markings over groups of three notes. Below the staff, letters T and F are placed above notes, with lines connecting them to a sequence of 16 rectangular boxes representing a performance timeline.

- BodyAndSoul-B2 (65 bpm) 



Musical notation for BodyAndSoul-B2 (65 bpm) with performance annotations. The notation is in 4/4 time with a key signature of one flat. The melody includes eighth and quarter notes. Below the staff, letters T, O, C, D, and F are placed above notes, with lines connecting them to a sequence of 16 rectangular boxes representing a performance timeline.

## Music Analysis: The Implication/Realization Model (Narmour, 1990)

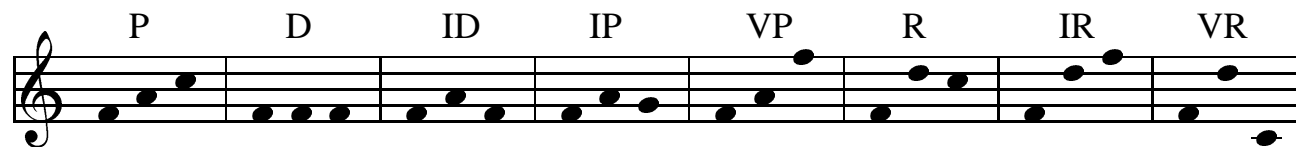
- Fundamental Idea: hearing a melody creates ‘instantaneous’ expectations of the continuation of the melody
- The I/R model tries to capture the pattern of fulfillment/violation of expectations created by the melodic surface

## The Implication/Realization Model

The listener's expectations are subject to *gestalt*-like principles, e.g.

- A small interval implies another small interval in the same direction
- A large interval implies a small interval in the opposite direction

Based on fulfillment/violations of such principles, basic patterns can be identified:



## The Implication/Realization Model

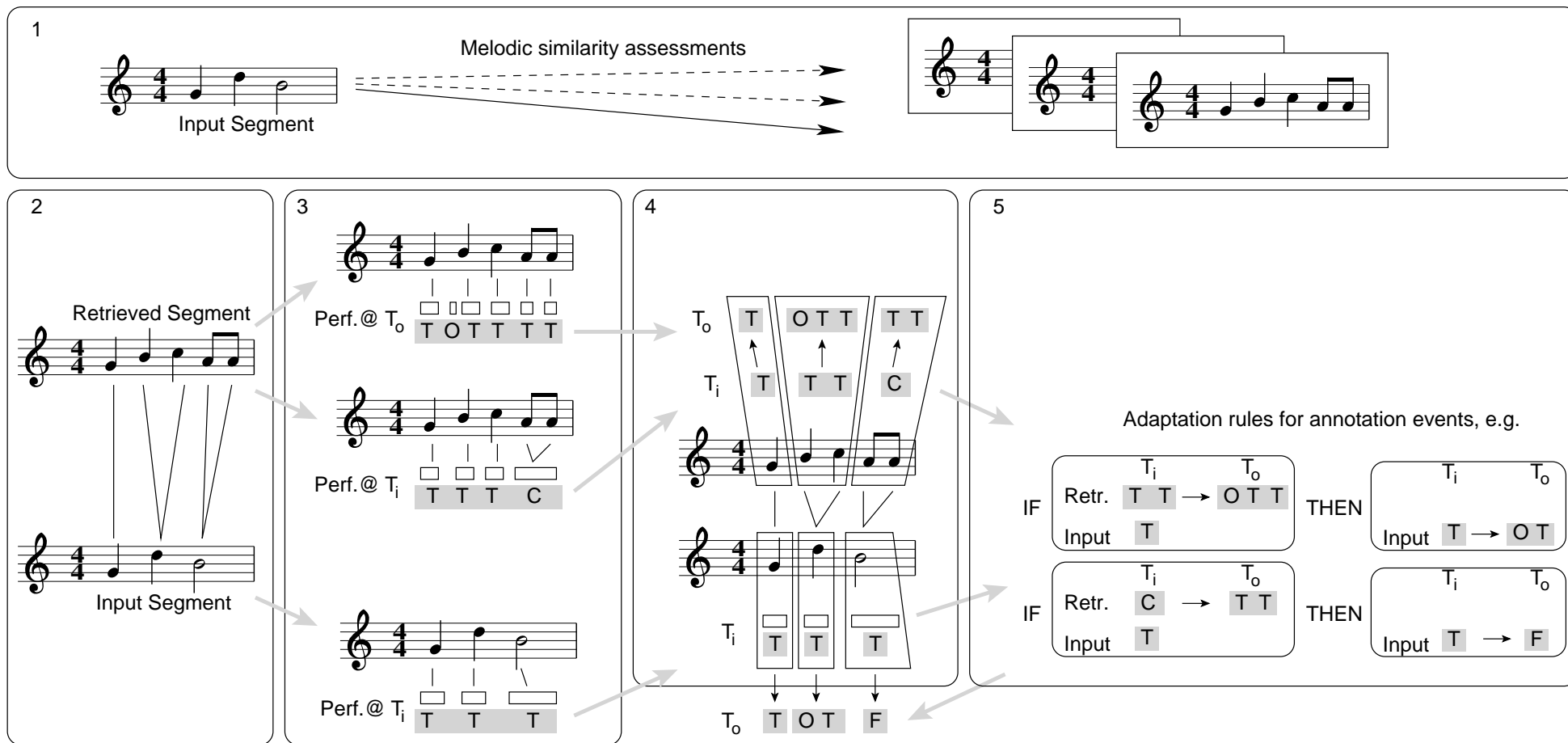
An I/R analysis of a melody consists of determining the patterns that constitute the melody, e.g.:

All Of Me

The image shows a musical staff in 4/4 time for the song 'All Of Me'. The melody is written in treble clef. The notes are: G4 (quarter), A4 (quarter), B4 (quarter), C5 (quarter), B4 (quarter), A4 (quarter), G4 (quarter), F#4 (quarter), E4 (quarter), D4 (half). A slur covers the first four notes (G4-A4-B4-C5), and another slur covers the last four notes (B4-A4-G4-F#4). A triplet bracket is over the notes B4, A4, and G4. Below the staff, brackets indicate patterns: 'P' under the first four notes, 'ID' under the triplet (B4-A4-G4), 'P' under the notes A4-G4-F#4, and 'P' under the final note D4.





## CBR steps

1. Segment input performance
2. Segment-wise construction of output performance; For each segment:
  - (a) Retrieve most similar melodic segment from case base
  - (b) Align input segment and retrieved segment
  - (c) If possible, transfer Performance events for  $T_o$  to notes of input segment, through alignment

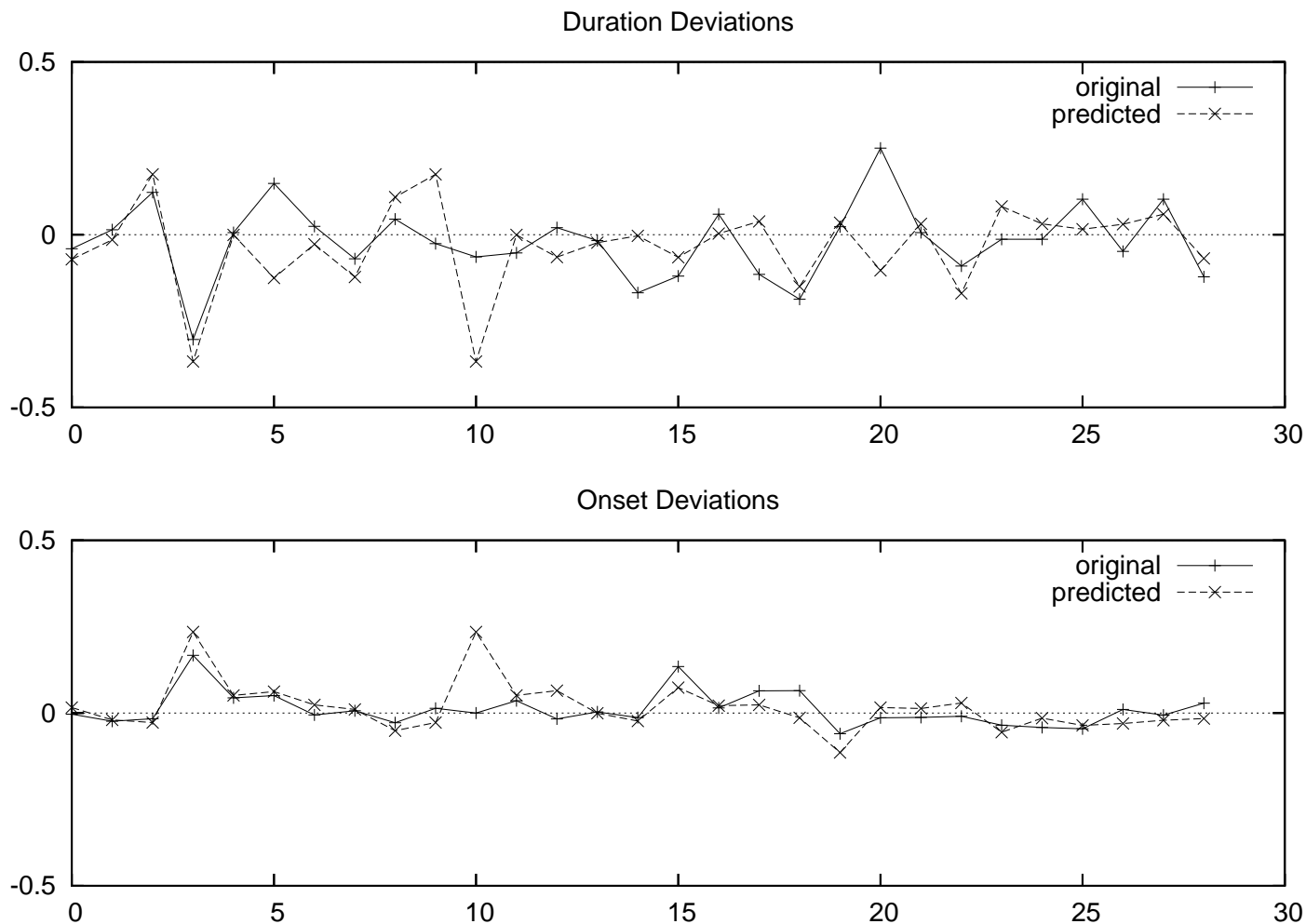


## Example transformation: OnceILoved-A1

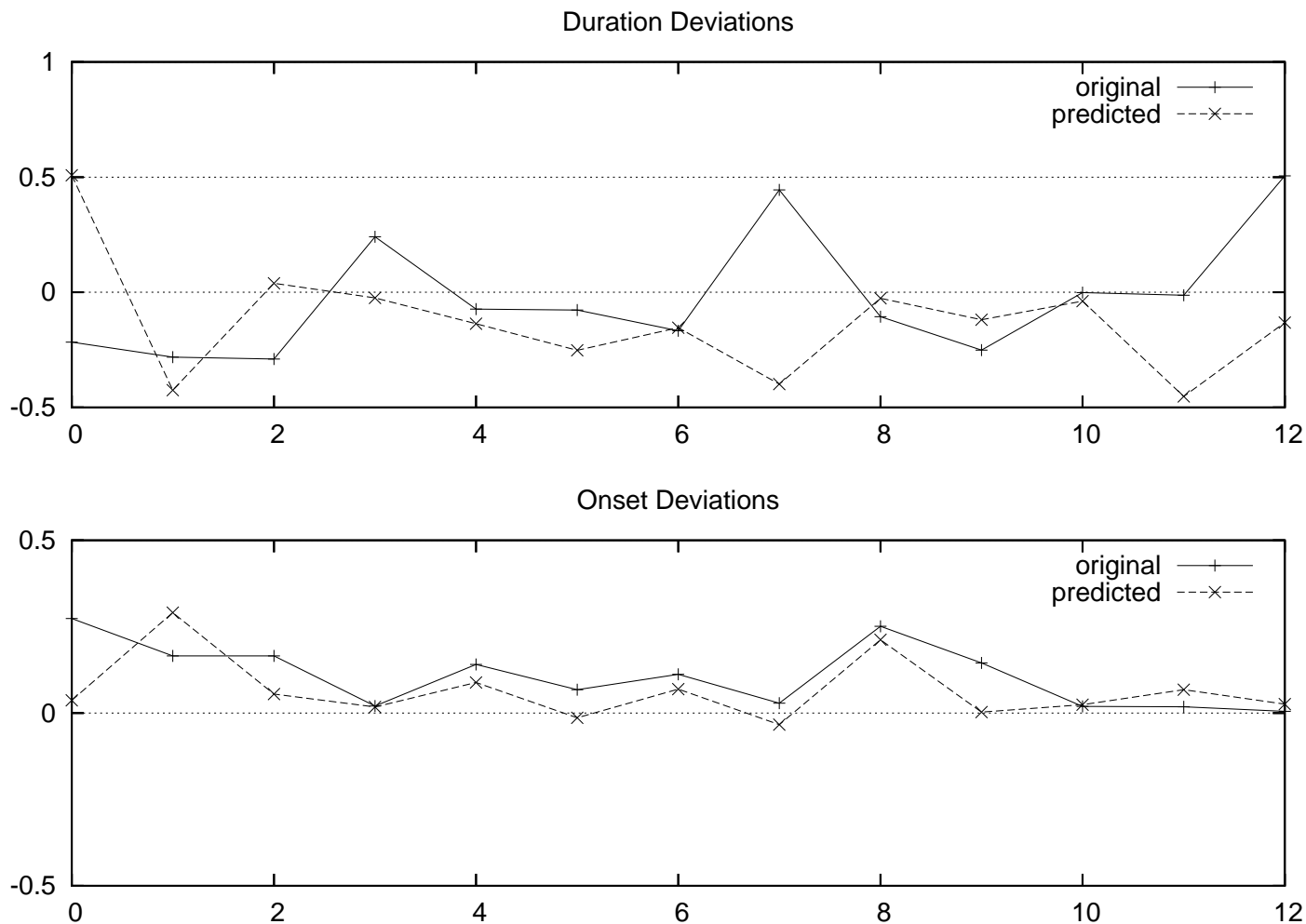


- Original (55 bpm) 
- Uniform Time Stretching (100 bpm) 
- Using CBR (100 bpm) 
- Original (100 bpm) 

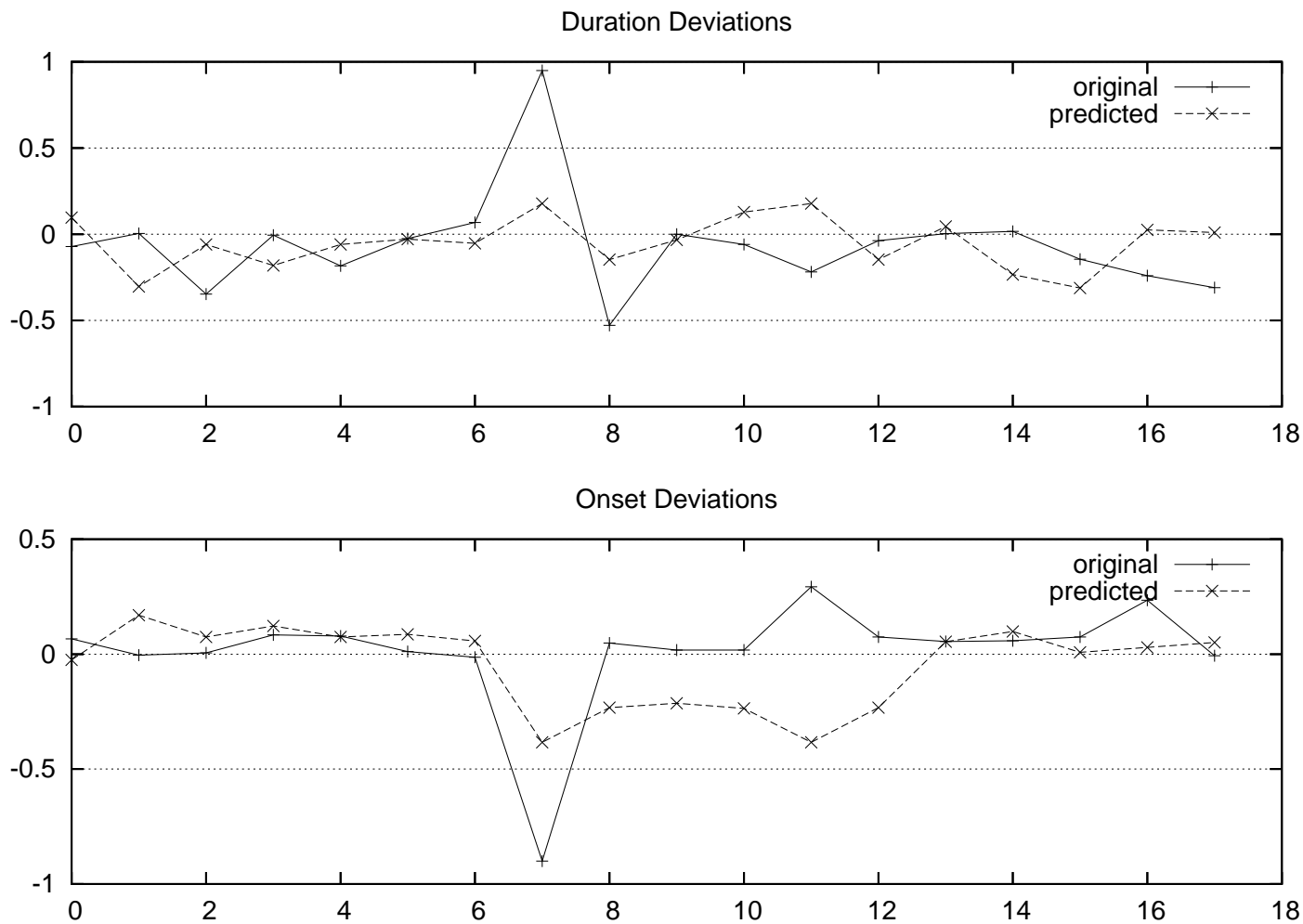
# BodyAndSoul-A1 50bpm



# BodyAndSoul-B1 60bpm



# LikeSomeoneInLove-A, 120bpm



	avg. onset error	avg. duration error
BodyAndSoul-B1-60	27	59
BodyAndSoul-A1-50	22	30
LikeSomeoneInLove-A-120	19	24

Table 1: Prediction errors, shown as percentages of the maximum deviation in the original performance

## Conclusions

- A system was presented for automatic global tempo transformations of monophonic jazz performances
- The system uses Case Based Reasoning as a technique for managing the changes to expressivity
- Expressivity is more than changing timing/dynamics

## Future Work

- Only preliminary results have been obtained (small Case Base).  
Need more testing
- Extend representation of expressivity to sub-note level (e.g. vibrato, attack, legato/staccato note transitions)
- Some kind of evaluation is needed (human evaluation, comparison to other approaches)