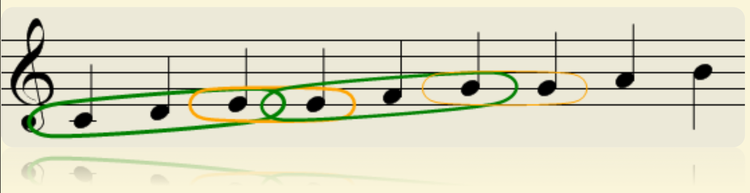

Modeling Real-Time Listening and Analogy-Making

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Abstract

What happens when people listen to music? What sorts of mental structures are formed? How do we make sense of a melody as its notes fly by in rapid succession? Can we model the experience of listening to music in real time? I have developed a computer model of human real-time melody perception called Musicat, whose architecture was informed by these sorts of questions.

Musicat "listens" to monophonic Western tonal melodies one note at a time (presented not as audio recordings, but rather in a symbolic form much like sheet music) and generates an internal representation of the musical structures it "hears". These structures include groups of adjacent notes, meta-groups comprised of smaller groups, expectations for upcoming structures, and, most importantly, similarities (analogies) between musical groups (and meta-groups) of various sizes.

Model Overview

High-level View:

1. Input:
   - Western tonal music (simple folk songs)
   - Symbolic representation of melody and bass line
   - Notes presented as simulated time moves forward
2. Model generates internal groupings and analogies between groups as time progresses
3. Representations include expectations

More-Detailed View:

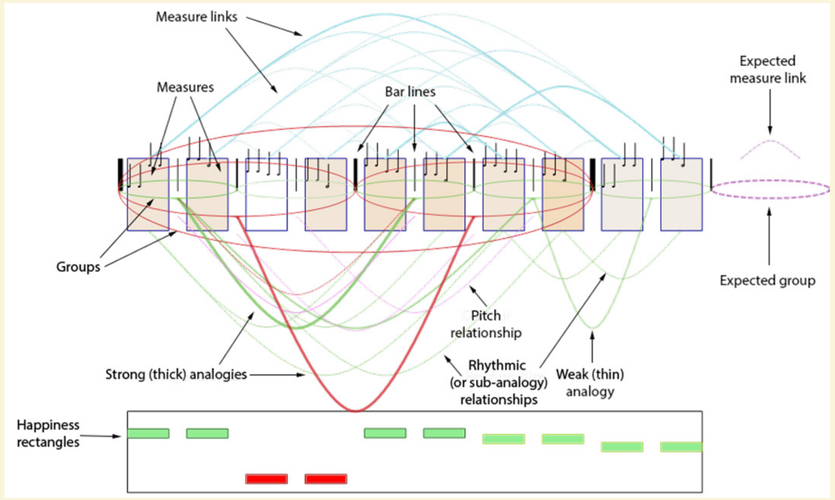
1. A **melody note** is presented to the system in symbolic form. The notes are **stored in the *Workspace***.
2. Many ***codelets*** (see below) **are run** to process the music currently in the Workspace. The number of codelets that are run depends on the **duration of the current melody note, in order to simulate** real-time listening.
3. The codelets create "**mental structures"** in the Workspace**,** such as **groups**, groups of groups (etc.), **analogies** between groups, and **expectations** of future notes and future groups.
4. The analogies forming in the Workspace **spawn new codelets** which, when run, will try to **create new higher-level perceptual structures**.
5. When enough simulated time has passed (measured in number of codelets run), move on to the next note and start processing in a similar fashion.

Architecture

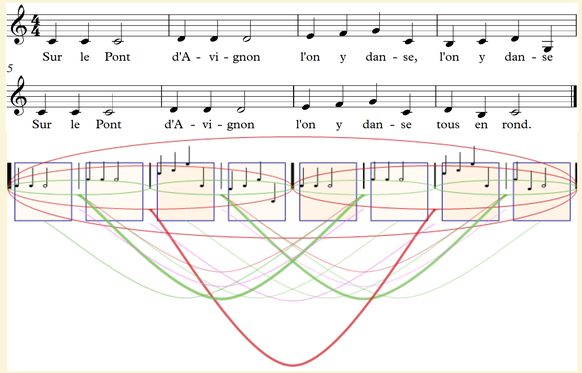
Coderack

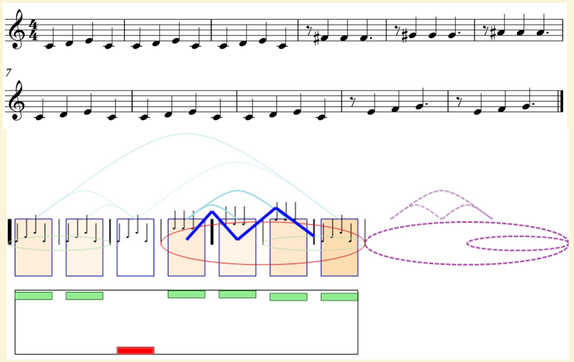
Codelet Name	Urgency
Measure Linker	14
Look for Relationship	35
Grouper	17
Group Breaker	7
Meta Grouper	7
Create Analogy	9
Suggest Parallel Analogy	9
Look for Contour Relationship	8
Look for Relationship	8
Proximity Grouper	9
Measure Hierarchy	8
Find Sequence	3
Extend Group Right	6

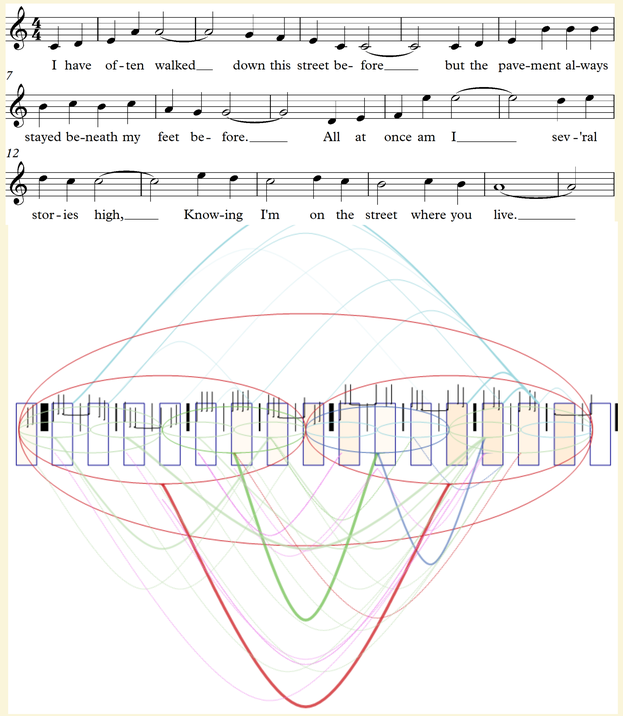
Workspace



Examples







Grouping

Groups of measures are formed stochastically, with group strength computed as the weighted sum of group reasons including the following:

- Interval Gaps
- Rhythm Gaps
- Perceived Accent
- Parallelism (analogy, at various hierarchical scales)
- Rhythmic similarity
- Contour Similarity

Analogy-Making

Analogies are formed stochastically between groups of measures, with analogy strength computed using a weighted sum of the following four factors:

1. Size of the analogy (20%)
2. Completeness of the mapping (35%)
3. Strength of component relationships (35%)
4. How long the analogy has survived in the Workspace (10%)

Results

An evaluation of the model on melodies from the Essen corpus shows that it forms grouping structures nearly as well as Temperley's CBMS system[1] (74% group accuracy, vs 76% for CBMS), even though Musicat is constrained to work in a cognitively-plausible quasi-realtime fashion. It also captures several previously unmodeled aspects of musical listening, such as analogy-making and hierarchical grouping in real time.

	Groups correct	Groups extra	Analogies correct	Analogies extra
Musicat: Simple Melodies	83%	14%	48%	66%
Musicat: Complex Melodies	68%	43%	27%	78%
Musicat: Simplified Essen sub-subset	**74%**	39%	n/a	n/a
CBMS: Essen subset	**76%**	25%	n/a	n/a

[1] Temperley, D. (2001). *The Cognition of Basic Musical Structures*. Cambridge, Mass.: MIT Press.

Future Work

- Improve knowledge about pitch, tonality, and tension
- Make program notice some superficial features more readily
- Allow program to "reset" after strong closure
- Restore motivic memory
- Generate note-level expectations

Acknowledgements

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