Music Informatics

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Today

- Segmentation and grouping ctd
- A more direct representation of the musical surface
- GTTM grouping rules implemented

Music Representation again

So far we have considered two different sorts of representation:

- acoustic signal: digitised version of audio signal
- MIDI and similar: a procedural language for operating certain forms of music-producing devices.

The first is accurate, very low level account of the sound phenomenon; the latter describes what should happen (procedure), rather than directly describing aspects of musical structure.

Declarative Description Languages

Alternative representations aim to describe musical structures directly in terms of their structure.

In programming languages, we distinguish between **procedural** languages (java, C, C++), and **declarative** languages (eg LISP, haskell, Prolog) – this is a related distinction, and a good analogy to musical representation.

Let's consider what a representation closer to these declarative languages for music where the musical surface is as in GTTM.

There are now similar so-called **description logic** languages associated with semantic web ideas:

`http://tinyurl.com/ygtgyoz`

this is closer to database languages than what we look at now.

Representing notes

A starting point is to consider a note defined in terms of:
– Pitch
– Onset-time
– Duration
– Articulation
– Dynamics

There are already options here

- can articulation (staccato, slur, etc.) be assigned to an individual note?
- what units for pitch, duration etc.?

Operations on pitch & time

Whatever representation is used of pitch and time, we need to be able to compute some functions and relations. For example, for time:

```
get_length/3

% get_length(Time1, Time2, Length)

  holds if Length is the duration between
  the times Time1, Time2.
```

Since this can be used in different ways, this also computes the time `Time2` given `Time1` and `Length`. Also need to compare times and durations for size.
A similar ability is needed for pitch.

Prolog version

Take notes to correspond to events, with predicate `event/5`:

```
event(Identifier, Pitch, Onset_time, Duration,
                  Articulation)
```

Identifier is of the form eN where N is an integer.

Pitch is a list [Name, Accidental, Octave],

Name is one of {c d e f g a b}

Accidental is one of {bb b = # x}

Onset_time is a rational number of crotchets from start

Duration is a rational number of crotchets

Articulation is a list eg. [sl, accent]

Score or acoustic analysis?

This representation is clearly borrowed from WTM **scores**, where we give ourselves at the start start times in terms of an underlying metrical grid, and not elapsed times; it also builds in the analysis of tonal music which distinguishes between $g\sharp, b\flat$.

However, for the same reason, this does give us something closer to the basics of the musical structures involved in WTM.

Combining notes

How to represent that some bunch of notes is considered to fit together on some musical criterion? Use Prolog predicate `constituent/4`:

```
    constituent(Identifier, Property, Definition,
                          Particles)
```

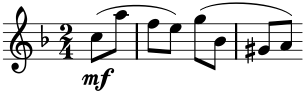
where

Identifier	is of the form cN where N is an integer.
Property	is a logical specification of the structural properties of the constituent
Definition	is a attached property attached by user/system
Particles	is list of note-events making up a constituent.

Dynamics

Dynamics can then be represented using constituents where *Property* = *dynamic* and *Definition* is one of {pp, p, mp, mf, f, ff, crescendo, diminuendo}.
For monophonic music, connected sequence of notes is a stream:
Property = *stream*,
and *Definition* relates the stream of notes to a particular piece.

Example first bar:



Example

```
event(e000, [c,=,1], 0/1, 1/2, [sl]).
event(e001, [a,=,1], 1/2, 1/2, [sl]).
event(e002, [f,=,1], 1/1, 1/2, [sl]).
event(e003, [e,=,1], 3/2, 1/4, [sl]).
event(e004, [g,=,1], 2/1, 1/2, [sl]).
event(e005, [b,b,0], 5/2, 1/2, [sl]).
event(e006, [g,#,0], 3/1, 1/2, [sl]).
event(e007, [a,=,0], 7/2, 1/4, [sl]).
event(e008, [g,=,0], 8/2, 1/2, [sl]).
event(e009, [d,=,1], 9/2, 1/4, [sl]).
...
constituent(c00, stream, mozart1, [e000, e001, e002, e003, ...
constituent(c01, dynamic, mf, [e000, e001, e002, e003,...
```

Interlude: reading logic programming programs

We will see some very simple Logic Programming rules. These can be understood as logical statements telling us when certain statements will be true (given other statements).

For example:

```
uncle(X,Y) :- brother(X,Z), parent(Z,Y).
```

says that

> **if** *X is brother of Z*, **and** *Z is parent of Y*,
> **then** *X is uncle of Y*

Here X,Y,Z are variables. A query with variables, if successful, returns values for any variables in the query that ensure the query is true.

Slur/rest rule

GPR 2a (Proximity) Given notes n_1, n_2, n_3, n_4, the boundary $n_2 - n_3$ may be heard as a group boundary if

1. (Slur/Rest) the interval of time from the end of n_2 to the beginning of n_3 is greater than that from the end of n_1 to the beginning of n_2 and that from end of n_3 to beginning of n_4

```
grouping_rule(rule_2a, Ev1, Ev2, Ev3, Ev4):-
        get_transition_dur(Ev1, Ev2, Dur1), % dur from end of
                                            % Ev1 to start Ev2
        get_transition_dur(Ev2, Ev3, Dur2),
        get_transition_dur(Ev3, Ev4, Dur3),
        gtdur(Dur2, Dur1),
        gtdur(Dur2, Dur3).
```

Attack point rule

GPR 2b (Proximity) Given notes n_1, n_2, n_3, n_4, the boundary $n_2 - n_3$ may be heard as a group boundary if

1. (Attack-Point) the interval of time between attack points of n_2 and n_3 is greater than that between the attack points of n_1 and n_2 and that between the attack points of n_3 and n_4.

```
grouping_rule(rule_2b, Ev1, Ev2, Ev3, Ev4):-
        get_attackpt_dur(Ev1, Ev2, Dur1),
        get_attackpt_dur(Ev2, Ev3, Dur2),
        get_attackpt_dur(Ev3, Ev4, Dur3),
        gtdur(Dur2, Dur1),
        gtdur(Dur2, Dur3).
```

Change rule

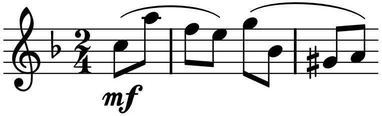
GPR 3a (Change) Given sequence of notes n_1, n_2, n_3, n_4, $n_2 - n_3$ can be heard as a boundary if

1. (Register) $n_2 - n_3$ is a larger pitch interval than both $n_1 - n_2$ and $n_3 - n_4$

```
grouping_rule(rule_3a, Ev1, Ev2, Ev3, Ev4):-
        get_abs_pitch_int(Ev1, Ev2, Int1),
        get_abs_pitch_int(Ev2, Ev3, Int2),
        get_abs_pitch_int(Ev3, Ev4, Int3),
        gtint(Int2, Int1),
        gtint(Int2, Int3).
```

Applying 2a, 3a

These two rules apply to our small example:



Rule 2a allows a boundary after the 4th note;
rule 3a allows a boundary after the 5th note.

Change in duration

Here implement a simplified version of the rule.

GPR 3d (Change) Given sequence of notes n_1, n_2, n_3, n_4, $n_2 - n_3$ can be heard as a boundary if

1. (Duration) $n_2 - n_3$ involves a larger change in duration than both $n_1 - n_2$ and $n_3 - n_4$,

```
grouping_rule(rule_3d, Ev1, Ev2, Ev3, Ev4):-
        get_length(Ev1, Ev2, L1),
        get_length(Ev2, Ev3, L2),
        get_length(Ev3, Ev4, L3),
        get_length(Ev4, _, L4), !,
        \+ eqdur(L2, L3),
        eqdur(L1, L2), eqdur(L3, L4).
```

Parallel rule

GPR 6 (Parallelism) *Where two or more segments of the music can be construed as parallel, they preferably form parallel parts of groups.*

This is more complex. Need to decide

- what counts as parallel
- how to search for parallel instances

eg, only look for patterns of 4 consecutive notes for match;
if match is found, try to extend to longer match.
Start with first four notes; then try notes 2–5, etc.

Forms of parallelism

Some notions of parallelism:

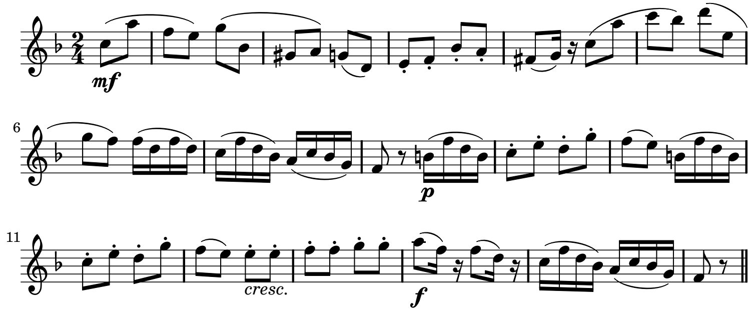
- Identity; corresponding notes same pitch and duration
- Long identity; identity, except first note differs in duration
- Transpose; shifted by constant pitch interval, durations same
- Loose Transpose; shifted by constant pitch interval, ignore durations
- Tonal transpose (using note names without accidentals)

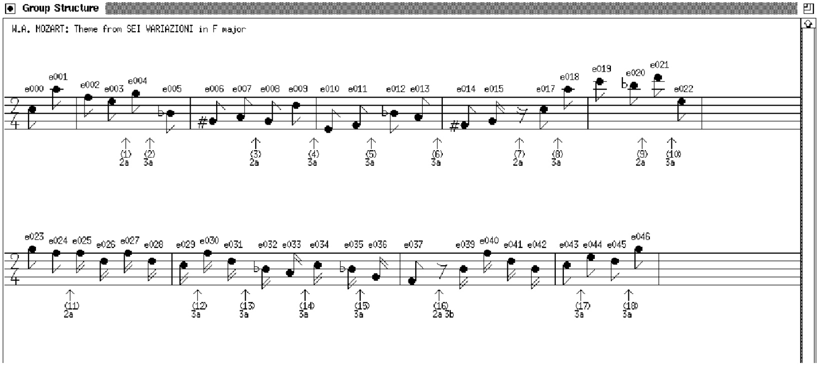
Each of these is easy to program;
There is a **lot** of choice as to what is put here.

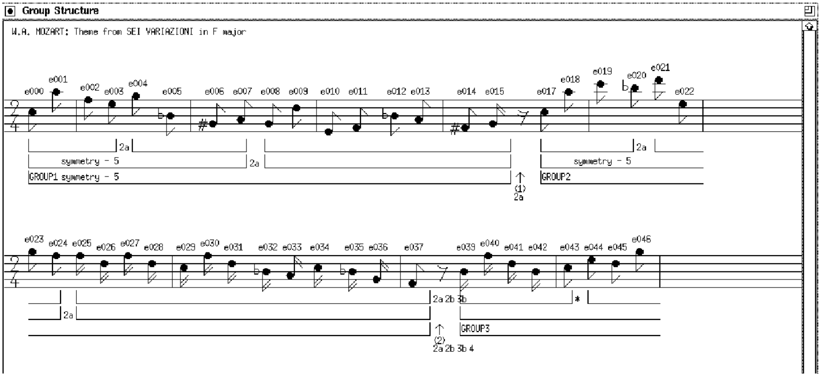
Using rules

At this point it is clear that rules 2 and 3 to start with generate more possible boundaries than make musical sense.
One possibility is to allow user to choose between groupings on the basis of evidence (eg how many rules apply), and use this to generate a grouping analysis.
Next images show initial applications of rules 2, 3; and a possible analysis using some of these with other rules (parallelism is rule 6).
The final analysis gives us a possible parsing of the musical surface into a parse tree, justified by the rules.

Given musical surface




Group Structure
W.A. MOZART: Theme from SEI VARIAZIONI in F major
e000 e001 e002 e003 e004 e005 e006 e007 e008 e009 e010 e011 e012 e013 e014 e015 e017 e018 e019 e020 e021 e022
(1) 2a (2) 3a (3) 2a (4) 3a (5) 3a (6) 3a (7) 2a (8) 3a (9) 2a (10) 3a
e023 e024 e025 e026 e027 e028 e029 e030 e031 e032 e033 e034 e035 e036 e037 e039 e040 e041 e042 e043 e044 e045 e046
(11) 2a (12) 3a (13) 3a (14) 3a (15) 3a (16) 2a 3b (17) 3a (18) 3a


Group Structure
W.A. MOZART: Theme from SEI VARIAZIONI in F major
e000
e001
e002
e003
e004
e005
e006
e007
e008
e009
e010
e011
e012
e013
e014
e015
e017
e018
e019
e020
e021
e022
2a
symmetry - 5
2a
GROUP1 symmetry - 5
(1)
2a
2a
symmetry - 5
GROUP2
e023
e024
e025
e026
e027
e028
e029
e030
e031
e032
e033
e034
e035
e036
e037
e039
e040
e041
e042
e043
e044
e045
e046
2a 2b 3b
*
2a
(2)
2a 2b 3b 4
GROUP3

Context-free grammar

The grouping rules are **not** context-free (because of, eg parallel rule). Intuitively, a context-free grammar allows us to recognise when we have an instance of a grammatical class (here, a chunk) by looking at some **consecutive** instances of other classes.

Given a context-free grammar, it is not necessary to look outside the chunk we are analysing, ie to look at the context. If we have such a grammar, the parsing task is relatively easy. The parallelism rule introduces long-range dependencies – in principle, the parallel occurrences can be arbitrarily far apart.
This is incompatible with a context-free grammar for grouping.

Summary

- declarative note-based representation
- implementing grouping rules
- how use in practice?