Using `textmidicgm`

The MIDI-to-textmidi translator

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1 Overview

The `textmidicgm` program generates works of music in textmidi language, which can be converted by `textmidi` into standard MIDI file formats. Using `textmidicgm`, it is possible to generate pieces of music in a text file using textmidi language, which can in turn be converted by `textmidi` into a standard MIDI file . The resulting text files can be edited in text editors, processed with text tools, and enriched using a macro processor such as m4. (The C preprocessor uses the pound sign (#), which is a sharp sign in textmidi language.)

textmidicgm chooses pitches as MIDI key numbers from an even distribution of a random variable, and similarly for MIDI velocities and rhythmic durations. In addition, the current ranges of key, velocity and duration are modulated as sinusoids of any period but typically 2 to 5 minutes, which control, roughly, the mean and range for each, and the number of voices playing. A MIDI-key-based scale is specified in the input file formats, along with a pulse, which can force a pseudo-metrical feel on the music. If pulse is zero, then the rhythm will be more fluid or conversational. It is also possible to force a random-walk melody rather than use white-random key numbers. The text file specification implements this original scheme. The text file specification is deprecated and may lose support.

The XML file format implements this scheme with a few added features, such as parallel-tracking voices, setting the probabilities of a random walk moving up,down or repeating the key number; amplitudes and offsets for the form sinusoids.

Aside from a few simple added features, the compositional engine of `textmidicgm` is described in AlgoRhythms: Real-Time Algorithmic Composition for a Microcomputer, by Thomas E. Janzen, pp. 109-210, Readings in Computer-Generated Music, Denis Baggi, ed. AlgoRhythms 1.0 and 2.0 were released as open-source software on the Commodore Amiga and distributed at least on "Fred Fish" disks starting in 1990. AlgoRhythms 3.0 was probably not released; it combined MIDI and Amiga Audio voices.

`textmidicgm` writes computer-generated music using evenly-distributed random numbers controlled by sinusoidal waveforms that (usually slowly) change the character of the music. `textmidicgm` does not make use of AI (Artificial Intelligence). It does not train on other pre-existing music or other material. The mathematics it references is limited to simple population statistics (although the mean is imprecisely used) and trigonometric functions, because that's all the math I knew in 1976, when I conceived this approach to form (and prior to my engineering education). The specific key (note) numbers, durations and velocities (loudnesses) are derived from flat, evenly-distributed random numbers, because that is what I explored in about 1980 on a Radio Shack TRS80. Any resemblance to previously-existing music is purely coincidental. `textmidicgm` writes multiple monophonic lines (one line per track) and does not model themes, motifs, melodies, harmony or harmonic movement (with the exception of allowing parallel follower voices), nor a grammar of note movement or harmonic movement.

`textmidicgm` always generates one voice per track, in textmidi LAZY mode.

The textmidi language is described in the info page for `textmidi`.

1.1 What is textmidicgm?

The program `textmidicgm` generates a work of music basically using evenly-distributed ("white") random numbers to select of MIDI keynumbers, MIDI velocities, and durations. The output file is a text file in textmidi language.

Unlike the original AlgoRhythms program, which had a real-time GUI and permitted changes to a Form while playing, `textmidicgm` is a "batch" program which reads and writes files, but does not record or play over a MIDI interface.

The rationale for `textmidicgm` comprises several incentives:

- The use of simple statistical distributions as a source of musical choices has not been fully exploited. Iannis Xenakis's Akrata used a Gaussian density distribution, and LeJaren Hiller started with random notes before moving on to Markov chains, but further experimentation might have been productive before proceeding to advanced and exotic techniques. `textmidicgm` provides a tool for continued exploration of evenly-distributed random notes etc.
- The use of sinusoids to modulate the ranges of key number, loudness (dynamics), duration and number of voices explores an approach to musical form as the modulation of the character of the musical texture. This approach to musical form was used in Thomas E. Janzen's hand-composed piano works *Animations* (1977) and *Lucy's Dance* (1982). It is perfectly fine to experimental with very short periods, say 0.1 seconds, and very long ones, such as 1000000000.0 seconds (which produces a static performance).
- Just as human auditors in a Turing Test can be forgiving of computer and human entrants, those who listen to the music from `textmidicgm` can sometimes embue the music with meaning that depends on their imaginations and not on how the music was generated.
- `textmidicgm` is not, by itself, intended to imitate any known style of music. The presumption is Bach wrote all the Bach music that is needed, and bad jazz players in the 1950's made all the bad jazz that is needed. `textmidicgm` makes its own music.
- `textmidicgm` is a medium. When an artist uses a graphite pencil, they do not expect to produce a full-color image with painterly marks. A musician using `textmidicgm` doesn't expect to produce a movement in sonata form, or a Country song.
- `textmidicgm` exploits the conveniences of the MIDI interface definitions of key number, velocity, and duration. This off-loads `textmidicgm` from concerns with DSP and instrument sound generation.

1.2 History

`textmidicgm` enlarges on the approach developed in 1989 as "AlgoRhythms" for the Commodore Amiga (running AmigaDOS) and improved a couple years later. The compositional engine was adapted in 2004 for linux and to produce text-based textmidi files. Improvements in 2020 and 2021 added minor features.

`textmdicgm` is a command-line batch program and not an interactive graphical program as AlgoRhythms was.

2 Invoking textmidicgm

2.1 Options

```
textmidicgm −f|−−form
 text_form_file_glob...|
−x|−−xmlform xml_form_file_glob...
[−u|−−update]
[−r|−−random]
[−a|−−answer]
[−i|−−instruments {piano | chromaticpercussion | organ | guitar | bass | strings | en-
semble | brass
| reed | pipe | synthlead | synthpad | syntheffects | ethnic | percussive | soundeffects
| all | melodic | idiophone...}]
[−o|−−textmidi output textmidi file] [−g|−−gnuplot]
[−c|−−clampscale]
[−z|−−arrangements {rotateright | rotateleft | reverse
| previouspermutation | nextpermutation | swappairs | shuffle | skip | heaps }
[−t|−−maxeventspertrack {integer}
[−y|−−arrangementsperiod {time in seconds}
[−e|−−rhythmexpression rational|simplecontinuedfraction
[−h|−−help] [−V|−−version] [−v|−−verbose]
[−k|−−stacktracks]
```

−f, −−form *text_form_file*
: The input file: a text file in the format used in the original 1990 version, probably. Use of this file format is deprecated.

−x, −−xmlform *xml_form_file_glob...*
: The input file: an XML file supporting more features. If −−random is specified, the form's output file. This file name when used for input may be used to glob several files. Globbing filenames uses wildcards such as an asterisk to mean either nothing or any of something; A question mark is a placeholder for one mandatory character; character sets are groups with square brackets. Globbing is supported by the C standard library and POSIX.2. Each resolved filename is processed in turn; the name_ field is used to form an output file name. If −−stacktracks is specified, then each resolved form file's results are appended to the output file without FILEHEADER lines. The FILEHEADER may show an incorrect number of total tracks, but that is allowed because textmidi ignores the number of tracks given in the FILEHEADER line.

−r, −−update
: Update a version 0 XML form file to version 2. Has no effect on version 2 files. for

```
textmidicgm --xmlformfile symphony.xml --update
```

produces an updated version of symphony.xml called update_symphony.xml that is in the current format of an XML form file.

−r, −−random
: Make a random form, write it to the base filename given, adding ".xml" and exit.

- The name is taken from the argument provided to the −−random argument.

- The duration is 30 minutes.
- min_note_len to [0.03125. . . 0.03125 + random[0. . . 1.0)]
- max_note_len_ = min_note_len_ + random[0. . . 1.0) * 2
- The pulse is random in (0.0. . . 16.0).
- The melody probabilities are set to rest 1/8 of the time on average; the probabilities of walking down and repeating the same pitch are random; the walking up probability is set to be equal to the down probability so that the voice doesn't wander off to one end of its range.
- The form sines are all set with offsets and gains such that that the sines vary in (0.0. . . 1.0).
- The form sines period is random from 1 to 6 minutes and the phase is random in the range $(-\pi \ldots +\pi)$.
- The scale is randomly selected from diatonic, minor, whole, diminished, pentatonic (think Debussy), tritone (C, D, E, F, F#, G#, A#, B), chromatic, on any chromatic step. The scales themselve cover the full range of MIDI key numbers.
- The number of voices is random in (1. . . 24). MIDI channels (1. . . 16) are used sequentially save channel 10, which General MIDI assigns to idiophones; if idiophones are selected with −−instruments idiophone then channel 10 is used for an idiophone channel. Idiophones are not used unless specified by use of option −−instruments idiophone, along with other instrument groups if desired.
- Each voice is set to use a random MIDI channel from (1. . . 16), exclusive of 10. If the idiophone program is selected then the channel for a voice is set to 10.
- A voice is randomly selected to walk or skip.
- The General MIDI program is selected depending on the instruments selected with −−instruments. The voices' ranges are limited by the characteristic range of the instruments selected, using http://en.wikipedia.org to look up the actual instruments.
- The pan is set to spread the channels across the audio field from left to right, starting from the center. Idiophones on channel 10 are always centered. We don't want other channels to be pushed over to one side. There are one more stereo zones than the number of channels. For example: If there is one MIDI channel, there will be two zones, one on the left and one on the right, and the channel is centered:

```
(---------|---------)
L---------C---------R
          ^
```

  Two voices have 3 zones:

```
(------|------|-----)
L---------C---------R
       ^      ^
```

  3 voices have 4 zones:

```
(---|-----|-----|---)
```

```
L---------C---------R
    ^     ^     ^
```

- Set each voice's follower status:
- Random follow flag and leader voice.
- If the leader is a follower, then set the voice to lead. If the leader voice is a leader, then set this voice
  - Random interval type
  - random delay to something less than a whole note.
  - randomly set whether to invert the voice
  - randomly set whether to make the voice retrograde
- Set high and low pitches to match plausible values for the General MIDI instruments
- Clamp the scale to not exceed the instruments as a whole ensemble.
- Set the arrangement definition to have
  - a randomly selected permutation algorithm and
  - a random period in [0.0..30].

After the random form file has been written it may be edited, then used as an input to the −−xmlform option.

`−i, −−instruments {piano chromaticpercussion organ guitar bass strings ensemble brass reed pipe synthlead synthpad syntheffects ethnic percussive soundeffects all melodic idiophone...}`

Select the groups of General MIDI instruments (patches) to use. The selections may be repeated to affect their probability of being selected. For example, "strings strings piano" will create a complement in the form file that is twice as likely to have strings as pianos. Note that idiophones appear on channel 10, as per the MIDI 1.1 spec, and the range of scale used will be limited to the range given in the MIDI spec for idiophones, and will also be limited to the scale used. The default is all non-idiophones.

`−o, −−textmidi textmidi_output_file`

The output file, in textmidi text language.

`−g, −−gnuplot`

Output a file of gnuplot data.

`−c, −−clampscale`

Trims the scale to remove low notes below the lowest low pitch in the voices, and to remove high notes above the highest high pitch in the voices. The scale will still cover the union of ranges of all of the voices. The purpose of this is to avoid an effect in which the pitch curve is, say, low, and the voice just bangs away at the voice's lowest note for a long time without moving at all until such time as the pitch curve starts to edge up above that low pitch for the voice. Because it is not a per-voice adjustment it is not a complete solution, but is coherent with the original technique. This option does not assume an rising-ordered scale.

`-z, --arrangements rotateright | rotateleft | reverse | previouspermutation | nextpermutation | swappairs | shuffle | skip | heaps`

Periodically reorder the voice priority for the purposes of applying the texture curve, which determines how large a portion of the complement (the ensemble) is playing. Without this feature, when the texture curve was thin, and a solo instrument played, it would always be the same voice and instrument playing. By re-ordering the voices now and then, a different voice can be the soloist at those times. For example, if arrangementsperiod is set to the same duration as the texture period, then each time the texture permits only one track to play, a different voice and instrument will play the solo. This has no effect on which voice follows another; those remain as they were at the start. The algorithms are based (with the exception of swappairs) on C++ standard library algorithms for containers. For example, if a form has four voices and use apply --arrangements rotateright and --arrangementsperiod 15, then every 15 seconds the voice orders will be

```
0 1 2 3
3 0 1 2
2 3 0 1
1 2 3 0
...
```

In this example, the solo would be from voice 0 for 15 seconds, then from voice 1 for 15 seconds, then from voice 2, then voice 1. During a time when only 2 voices are playing, first voices 0 and 1 would play, then in the next 15 seconeds voice 3 and 0 would play, and so on. This might be different from what it did before April 2023 (I'm not sure), but is probably more intuitive than before.

'`identity`'

The identity arrangement never changes the voice priority. If '`--arrangementsperiod 15`' the voice arrangements will just remain the same:

```
00:00 0 1 2 3
00:15 0 1 2 3
00:30 0 1 2 3
...
```

'`rotateright`'

Rotate right pushes the voices down in priority and brings the last voice to the top. The new top voice plays the solo when the texture curve is thin. If '`--arrangementsperiod 15`' the voice arrangements will change every 15 seconds and be:

```
00:00 0 1 2 3
00:15 3 0 1 2
00:30 2 3 0 1
00:45 1 2 3 0
01:00 0 1 2 3
01:15 3 0 1 2
```

'`rotateleft`'

Rotate left pulls the voices up in priority and pushes the top voice to the last position.

```
0 1 2 3
```

```
1 2 3 0
2 3 0 1
3 0 1 2
0 1 2 3
1 2 3 0
```

'`reverse`' Reverse the order of voices. The last voice becomes first in priority, and vis versa. Alternate periods produce the same priority order.

```
0 1 2 3
3 2 1 0
0 1 2 3
```

'`previouspermutation`'
Find and apply the previous permutation of the voice in terms of the integer priority, where 0 is the highest and plays the solo when the texture curve is thinest. These are lexicographically sorted descending permutations.

```
0 1 2 3
3 2 1 0
3 2 0 1
3 1 2 0
3 1 0 2
3 0 2 1
3 0 1 2
2 3 1 0
2 3 0 1
2 1 3 0
2 1 0 3
2 0 3 1
2 0 1 3
1 3 2 0
1 3 0 2
1 2 3 0
1 2 0 3
1 0 3 2
1 0 2 3
0 3 2 1
0 3 1 2
0 2 3 1
0 2 1 3
0 1 3 2
```

'`nextpermutation`'
Permute the voices in terms of the integer priority to the next permutation. These are lexicographically sorted ascending permutations.

```
0 1 2 3
0 1 3 2
0 2 1 3
0 2 3 1
0 3 1 2
0 3 2 1
1 0 2 3
1 0 3 2
1 2 0 3
1 2 3 0
```

```
1 3 0 2
1 3 2 0
2 0 1 3
2 0 3 1
2 1 0 3
2 1 3 0
2 3 0 1
2 3 1 0
3 0 1 2
3 0 2 1
3 1 0 2
3 1 2 0
3 2 0 1
3 2 1 0
```

'`swappairs`'
: Swap neighboring voices. Every other swap gets the same priority order.

```
0 1 2 3
1 0 3 2
0 1 2 3
```

'`shuffle`'
: Randomly shuffle the voices each scramble period. There's no guarantee of producing all permutations.

```
0 1 2 3
3 0 1 2
3 0 1 2
3 0 2 1
3 0 2 1
0 2 1 3
0 1 3 2
2 1 0 3
3 1 2 0
3 0 2 1
```

'`skip`'
: Shifts the first, third, fifth, etc. voices to the right and the second, fourth, sixth, tracks to the left.

```
0 1 2 3 4
1 0 3 2 4
1 3 0 4 2
3 1 4 0 2
3 4 1 2 0
4 3 2 1 0
4 2 3 0 1
2 4 0 3 1
2 0 4 1 3
0 2 1 4 3
```

For an even number of voices it's a little more nuanced.

```
0 1 2 3
1 0 3 2
2 3 0 1
3 2 1 0
0 1 2 3
1 0 3 2
2 3 0 1
3 2 1 0
0 1 2 3
```

```
1 0 3 2
```

'heaps' Applies Heap's Algorithm to scramble voices in such a way that only 2 voices swap in each successive permutation.

```
0 1 2 3
1 0 2 3
2 0 1 3
0 2 1 3
1 2 0 3
2 1 0 3
3 1 0 2
1 3 0 2
0 3 1 2
3 0 1 2
1 0 3 2
0 1 3 2
0 2 3 1
2 0 3 1
3 0 2 1
0 3 2 1
2 3 0 1
3 2 0 1
3 2 1 0
2 3 1 0
1 3 2 0
3 1 2 0
2 1 3 0
1 2 3 0
```

−y, −−arrangementsperiod time_in_seconds
: The time period in seconds at which to apply the track scramble algorithm. The default is 1000 minutes.

−t, −−maxeventspertrack integer_events
: Puts a limit on the number of MIDI events generated for a single track, in order to avoid generating over-large files. The default is 100,000 events.

−e, −−rhythmexpression rational|simplecontinuedfraction
: Used with –**lazy**, selects either a rational or simple continued fraction expression of rhythm. The default is a rational-like musical rhythm. Note that `textmidicgm` uses −e while both `miditext` and `smustextmidi` use −r. See textmidi.pdf for details of the syntax of simple continued fractions.

−v, −−verbose
: Write some informative messages to the screen. Errors are printed regardless.

−V, −−version
: Print the version of `textmidicgm`.

−h, −−help
: Print the options summary.

−k|−−stacktracks
: The −−**stacktracks** options cause all of the form file names resolved from the list and globbing to have their resulting textmidi output to be added to one output file. The output file name may be specified with the −−**textmidi** option, otherwise it will be taken from the name field of the first form file.

Note that the XML file produced can be edited to reflect your interests; you will learn what XML and boost serialization can accept for edits.

2.2 Invocation Examples

The following command will read the XML form file graduallyitsmorning.xml and generate the textmidi text file graduallyitsmorning.txt:

```
textmidicgm --xmlform graduallyitsmorning.mid --textmidi graduallyitsmorning.txt
```

The following generates a randomized form file for generation in another step, and then converted into a MIDI file:

```
textmidicgm --random --xmlform newpiece.xml
textmidicgm --xmlform newpiece.xml --textmidi newpiece.txt
textmidi --textmidi newpiece.txt --midi newpiece.mid
```

The following example generates a data file that can be plotted as a statistical plot with error bars:

```
textmidicgm --xmlform newpiece.xml --textmidi newpiece.txt --gnuplot
```

The gnuplot data file will be named from the name inside the XML form file, with ".plot" appended.

3 The Model of Musical Form

The `textmidicgm` program models musical form as a musical character that is modulated by sinusoids. This was explored in a traditionally-composed work in 1976/1977, and again in 1982. It was automated by the AlgoRhythms program distributed as open-source software for the Commodore Amiga , which was described in a paper listed in the Bibliography.

Note that a hard limit of 100,000 note events has been added to avoid filling a disk because selections produce notes of short length with a static rhythm mean.

`textmidicgm` does not model musical melody, meter, harmony, or traditional forms such as sonata form.

Musical character is described as the following intantaneous statistical quantities:

- Pitch
  - Mean: The mean, or average, pitch (actually the mean MIDI key number);
    - period: in seconds
    - phase: in radians (sorry). Note that one full circle is two pi radians (about 6.28). Ninety degrees is $\pi/2$, about 1.5707 radians, and so on. Phase may be negative, so the full range could be represented from about -3.14159 to +3.14159.
  - Range: The range of key numbers from which one is selected. A narrow range will select a narrow range around the value of the mean.
    - period: in seconds
    - phase: in radians
- Dynamic
  - Mean: The mean MIDI key velocity, or loudness.
    - period: in seconds
    - phase: in radians
  - Range: The range of velocity from which one is selected for the note event.
    - period: in seconds
    - phase: in radians
- Duration
  - Mean: The mean duration of individual notes from the overall range given separately. Note that the pulse setting in the form file specifies a minimum duration that supersedes the minimum duration given in the form file. A pulse of, for example, a fifth of a second or so tends to make the music bounce a bit, as though it had a time signature, although `textmidicgm` does not specify a time signature or other way to group rhythmic values.
    - period: in seconds
    - phase: in radians
  - Range: The range of duration from which one is selected; this range is a subset of the overall range, which is given separately.
    - period: in seconds
    - phase: in radians

- Texture (number of voices)
  - Range: The number of voices playing polyphonically.
    - period: in seconds
    - phase: in radians

These quantities can be modulated over time so that the character of the music varies. Edgard Vare'se explored using statistcal functions to modulate musical character. `textmidicgm` uses sinusoids, typically with periods of one to a few minutes. Periods that are very long relative to the length of the piece produce static pieces that in which the musical character does not change, which has its own fascination. Because the seven sinusoids can each have a unique phase and period, the exact character of the music might not repeat at all for long pieces.

In addition to this approach to musical form, `textmidicgm` specifies a musical work as having:

- name: the name of the piece;
- len: a length in seconds for the entire piece;
- min_note_len: the global mininum length of a note in seconds;
- max_note_len: the global maximum length of a note in seconds;
- scale: the full scale in MIDI key numbers;
- pulse: which forces notes to start together on a number of pulses per second;
- melody_probabilities: the cumulative probabilities of a walking-mode melody taking a step up, down, or repeating the last key number;
- pitch_form: as described above;
- rhythm_form: as described above;
- dynamic_form: as described above;
- texture_form: as described above;
- a number of voices, each of which has the following attributes:
  - low_pitch: a pitch below which the voice is tacet;
  - high_pitch: a pitch above which the voice is tacet;
  - channel: the MIDI voice channel;
  - walking: the probability that a voice is in walking mode, randomized note to note. A zero makes the voices always random key (or somewhat jumpy); a 1.0 makes the voice walk in the scale. A value between 0.0 and 1.0 is the probability that the voice will be walking, note event to note event; if not walking, leap randomly.
  - program: in the XML form file, a MIDI program, mapped by General MIDI to an instrument sound;
  - pan: a left-right stereo pan value;
  - in the XML file each voice can be defined as a follower by:
    - follow: 0 to be a unique melody; 1 to follow another voice
    - leader: the leader voice to follow (with voices numbered 0...). The leader may be a higher-numbered voice.
    - interval_type: a scaler or chromatic interval;

- interval: the interval, from -128 to + 128;
- delay: a rational musical rhythm value to delay after the leader;
- inversion: 0 to not invert the melody; 1 to invert;
- retrograde: 0 to copy the leader forwards; 1 to copy it in reverse time.

4 The Original Text Form File

The original text form file was developed for the Amiga version of this music generator. It may now be slightly different from that for the Amiga, but probably it is identical to the form file for AlgoRhythms 2.0. The original text form file is now deprecated in favor of the XML form file.

Individual notes have key numbers, velocities (dynamics), and durations that are selected using evenly-distributed ("white"). At a given moment these values are selected from ranges of key number, velocity, and duration that are determined by sinusoidal curves defined in the form file. There are seven curves:

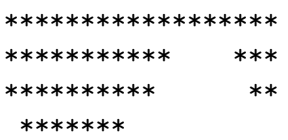
- Pitch
  - Mean Sinusoid: The peak of the sinusoid selects high pitches (MIDI key numbers); the low part selects low pitches.
  - Range Sinusoid: A narrow range will select a narrow range around the value of the mean sinusoid.
- Dynamic
  - Mean Sinusoid: The peak of the sinusoid selects high (loud) velocities; The low part selects softer dynamics.
  - Range Sinusoid
- Duration
  - Mean Sinusoid: The peak of the sinusoid selects long durations from the full duration range specified in the form file. The low part selects shorter durations. Note that the pulse setting in the form file specifies a minimum duration that supersedes the minimum duration given in the form file. A pulse of, for example, a fifth of a second or so tends to make the music bounce a bit, as though it had a time signature, although `textmidicgm` does not specify a time signature or other way to group rhythmic values.
  - Range Sinusoid
- Texture (number of voices)
  - Range Sinusoid The range sinusoid merely specifies how many voices will play, in the order of the voice list. At the peak of the texture sinusoid, all of the voices will play. At the low point, only one voice will play.

The range sinusoid is used to spread out the mean. The mean sinusoid:

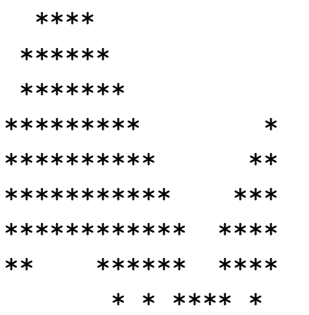
```
    **
  *    *
 *      *
         *       *
           *     *
             **
```

The range sinusoid: The lowest values of the range wave indicates a narrow range.

```
 *******
**********       **
***********     ***
```



The range sinusoid, by halves, added to and subtracted from the mean sinusoid:



Note that the range and mean sinusoids can have different periods and different phases so that they do not align like the example above. In addition, note that when the range goes beyond the actual limits of key number or dynamic, it is clipped, or truncated to the practical limit. Because the range sinusoid, which varies (0. . . 1), is defined as covering the full range, this happens any time that the added range exceeds the peak of the mean sinusoid, or below its minimum. Originally the form sinusoids had periods of about 1 to 4 minutes. To make a static, unchanging, form, use very long periods, such as millions of seconds.

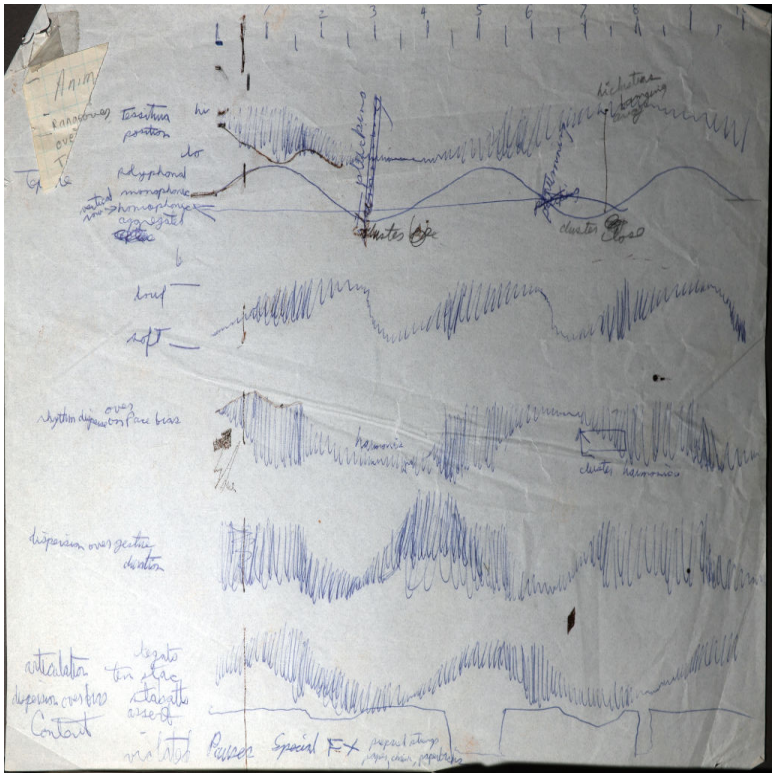


Figure 4.1: Animations (1976, conventionally composed) drawn plot

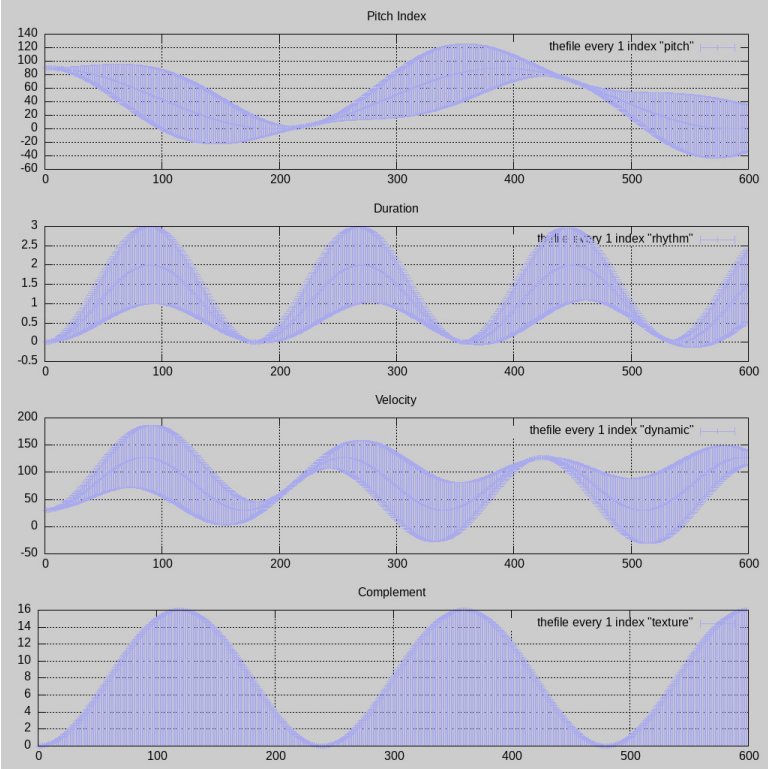


Figure 4.2: Animations (1977, conventionally composed) plot using textmidicgm.gnuplot.

```
[seconds duration of entire musical piece]
[minimum individual note length in seconds]
[maximum nindividual ote length in seconds]
[number of scale tones]
[scale MIDI key numbers (Middle C = 60)]
...
[number of voices]
[pulses per second]
[pitch period of mean]
[pitch phase of mean]
[pitch period of range]
[pitch phase of range]
[duration period of mean]
[duration phase of mean]
[duration period of range]
[duration phase of range]
[velocity period of mean]
[velocity phase of mean]
[velocity period of range]
[velocity phase of range]
[texture period of range]
[texture phase of range]
[voice 0 low pitch] [high pitch] [channel 0-15] [walking flag]
...
```

For example:

```
600.00
0.00
2.00
13
48
50
53
55
58
60
62
65
67
70
72
74
77
4
6
200.00
-1.57
200.00
-1.57
200.00
1.57
200.00
-1.57
200.00
-1.57
200.00
-1.57
200.00
-1.57
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  96  14  1
24  120  14  0
24  120  14  0
24  120  14  0
24  120  14  0
```

5 The XML Form File

The XML version of the form file is a boost serialization XML archive format. (Cf. https://boost.org). The format must be exactly as expected by boost serialization; for example, comments may not be added. On the other hand, the floating point values need not have all the trailing fractional zeroes that are written by boost serialization. Note that the <count> tag must have the correct length of the following data, for example for the scale length. If <count> is corrected afterward, then you may add or delete members of a container. The new format of XML Form file adds a number of items for specifying the form to the original text format:

- Melody Probabilities When using a random walk, the probability of walking up or down, or repeating the previous key number, or by implicaton, resting, can be specified. These probabilities are cumulative and act as thresholds.
  - Up: **up** is the probability of a walking voice either being silent, walking down or repeating the last note; if the random variable $\geq$ **up**, then it walks up the scale;
  - Same: **same** is the probability of a walking voice either being silent or walking down. If the random variable $\geq$ **same** and < **up**, then it repeats the last pitch.
  - Down: **down** is the probability of a walking voice being silent. If the random variable $\geq$ **down** but < **same**, then it walks down; otherwise it rests.
  - Rest: If the random variable < **down**, the walking voice rests.

  $down = probability(resting)$
  $same = probability(resting) + probability(walkingdown)$
  $up = probability(resting) + probability(walkingdown) + probability(repeatingthelastpitch)$

  Because the probabilities are cumulative, the following hold:
  $1.0 \geq up$
  $up \geq same$
  $same \geq down$
  $down \geq 0.0$
  To prevent voices from walking off to one end of their ranges, keep
  $up == down$.

  The original program, AlgoRhythms, did not provide for voices randomly resting; voices only rested because the current musical character's texture did not specify sufficient voices for a voice to play; the first voice always played and had no rests.
- sinusoid amplitude and offset The sinusoids can have specified amplitudes for a narrower range of change, and offsets that raise and lower the sinusoid. These features have not been thoroughly tested. Their defaults are both 0.5; this is how AlgoRhythms set them.
- MIDI Program Each voice has a program, which is a 1-based MIDI program. Refer to General MIDI for the instrument assignments to program numbers.
- Fuzzy Walking: In the XML file the walking value represents the probability that a voice will be in walking mode from note event to note event. It is a value from 0.0 to 1.0, inclusive. This is compatible with the boolean flag used before 2024, because the flag was stored as 0 or 1 in the XML file. A value of 0.0 means non-walking, and 1.0

means always walking. A value of 0.5 means that the voice will have a 50% chance of being in either walking or random mode. Other values between 0 and 1 may be used.

- Voice Pan: The pan value for a voice can be specified for the entire piece of music. A pan of -64 is all the way left, 63 is all the way right, and zero (0) is centered.
- Voice following: A voice may be specified as a follower of another voice. If <follow_> is 0, then the voice will be independent. If <follow_> is 1, then the voice will follow the voice given in the <leader> tag (voices count from zero (0)). The interval_type tag determines whether the voice follows in the scale (1) or chromatically (2). The tag <interval_> specifies how many scale steps or half-steps above (positive values) or below (negative values) the follower should be. The follower voice can be set as the inversion of the leader voice. The selection of scalar or chromatic following is obverved for the inversion.

  Lastly, the follower voice can be set as the retrograde (time-reversal) of the leader voice. The pitch_follower field is always a 1; all followers follow the pitch of the leader. If there is a following circle, the voices in the circle will not have any notes. A following circle is created by any of the following:

  - A voice follows itself.
  - A voice follows another voice, which in turn follows the first voice.
  - A chain of follows ultimately follow a member in the chain.

The current version's format is:

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<!DOCTYPE boost_serialization>
<boost_serialization signature="serialization::archive" version="18">
<xml_form class_id="0" tracking_level="0" version="3">
<name_>random</name_>
<copyright_>© 2024</copyright_>
<len_>1.80000000000000000e+03</len_>
<min_note_len_>0.00000000000000000e+00</min_note_len_>
<max_note_len_>2.00000000000000000e+00</max_note_len_>
<scale_ class_id="1" tracking_level="0" version="0">
<count>57</count>
<item_version>0</item_version>
<item>C0</item>
<item>Db0</item>
<item>E0</item>
<item>F0</item>
<item>G0</item>
<item>Ab0</item>
<item>Bb0</item>
<item>C1</item>
<item>Db1</item>
<item>E1</item>
<item>F1</item>
<item>G1</item>
<item>Ab1</item>
```

```
<item>Bb1</item>
<item>C2</item>
<item>Db2</item>
<item>E2</item>
<item>F2</item>
<item>G2</item>
<item>Ab2</item>
<item>Bb2</item>
<item>C3</item>
<item>Db3</item>
<item>E3</item>
<item>F3</item>
<item>G3</item>
<item>Ab3</item>
<item>Bb3</item>
<item>C4</item>
<item>Db4</item>
<item>E4</item>
<item>F4</item>
<item>G4</item>
<item>Ab4</item>
<item>Bb4</item>
<item>C5</item>
<item>Db5</item>
<item>E5</item>
<item>F5</item>
<item>G5</item>
<item>Ab5</item>
<item>Bb5</item>
<item>C6</item>
<item>Db6</item>
<item>E6</item>
<item>F6</item>
<item>G6</item>
<item>Ab6</item>
<item>Bb6</item>
<item>C7</item>
<item>Db7</item>
<item>E7</item>
<item>F7</item>
<item>G7</item>
<item>Ab7</item>
<item>Bb7</item>
<item>C8</item>
</scale_>
<pulse_>1.11191005625678478e+01</pulse_>
<melody_probabilities_ class_id="2" tracking_level="0" version="0">
```

```
<down_>1.25000000000000000e-01</down_>
<same_>4.12009462496464418e-01</same_>
<up_>7.12990537503535582e-01</up_>
</melody_probabilities_>
<pitch_form_ class_id="3" tracking_level="0" version="0">
<mean_sine_ class_id="4" tracking_level="0" version="0">
<period_>1.02425584134316992e+02</period_>
<phase_>-1.82253453478075400e+00</phase_>
<amplitude_>5.00000000000000000e-01</amplitude_>
<offset_>5.00000000000000000e-01</offset_>
</mean_sine_>
<range_sine_>
<period_>6.21093741597446325e+01</period_>
<phase_>-7.21610833281546404e-01</phase_>
<amplitude_>5.00000000000000000e-01</amplitude_>
<offset_>5.00000000000000000e-01</offset_>
</range_sine_>
</pitch_form_>
<rhythm_form_>
<mean_sine_>
<period_>2.46548001388247883e+02</period_>
<phase_>2.04461102007382189e+00</phase_>
<amplitude_>5.00000000000000000e-01</amplitude_>
<offset_>5.00000000000000000e-01</offset_>
</mean_sine_>
<range_sine_>
<period_>1.57452388934053829e+02</period_>
<phase_>-2.50927379969043862e+00</phase_>
<amplitude_>5.00000000000000000e-01</amplitude_>
<offset_>5.00000000000000000e-01</offset_>
</range_sine_>
</rhythm_form_>
<dynamic_form_>
<mean_sine_>
<period_>2.98937996187264332e+02</period_>
<phase_>-1.86851759827392172e+00</phase_>
<amplitude_>5.00000000000000000e-01</amplitude_>
<offset_>5.00000000000000000e-01</offset_>
</mean_sine_>
<range_sine_>
<period_>1.32768648088267241e+02</period_>
<phase_>1.11850231647852882e+00</phase_>
<amplitude_>5.00000000000000000e-01</amplitude_>
<offset_>5.00000000000000000e-01</offset_>
</range_sine_>
</dynamic_form_>
<texture_form_>
```

```
<period_>2.49044070569047960e+02</period_>
<phase_>-3.04239702993273964e+00</phase_>
<amplitude_>5.00000000000000000e-01</amplitude_>
<offset_>5.00000000000000000e-01</offset_>
</texture_form_>
<voices_ class_id="5" tracking_level="0" version="0">
<count>9</count>
<item_version>0</item_version>
<item class_id="6" tracking_level="0" version="0">
<low_pitch_>C0</low_pitch_>
<high_pitch_>C8</high_pitch_>
<channel_>13</channel_>
<walking_>6.17341310053484582e-01</walking_>
<program_>81</program_>
<pan_>20</pan_>
<follower_ class_id="7" tracking_level="0" version="2">
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_ class_id="8" tracking_level="0" version="0">
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
</item>
<item>
<low_pitch_>E1</low_pitch_>
<high_pitch_>G4</high_pitch_>
<channel_>16</channel_>
<walking_>2.80945818972443251e-01</walking_>
<program_>44</program_>
<pan_>41</pan_>
<follower_>
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_>
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
```

```
</item>
<item>
<low_pitch_>E1</low_pitch_>
<high_pitch_>D6</high_pitch_>
<channel_>2</channel_>
<walking_>1.78122971305915118e-01</walking_>
<program_>22</program_>
<pan_>-43</pan_>
<follower_>
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_>
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
</item>
<item>
<low_pitch_>F1</low_pitch_>
<high_pitch_>F6</high_pitch_>
<channel_>5</channel_>
<walking_>6.67719786543500615e-01</walking_>
<program_>8</program_>
<pan_>-22</pan_>
<follower_>
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_>
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
</item>
<item>
<low_pitch_>F1</low_pitch_>
<high_pitch_>F6</high_pitch_>
<channel_>12</channel_>
<walking_>9.16052290796560253e-01</walking_>
<program_>8</program_>
```

```
<pan_>-1</pan_>
<follower_>
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_>
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
</item>
<item>
<low_pitch_>E1</low_pitch_>
<high_pitch_>G4</high_pitch_>
<channel_>16</channel_>
<walking_>9.02619110837619476e-01</walking_>
<program_>44</program_>
<pan_>41</pan_>
<follower_>
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_>
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
</item>
<item>
<low_pitch_>F1</low_pitch_>
<high_pitch_>F6</high_pitch_>
<channel_>12</channel_>
<walking_>8.68743255236859302e-02</walking_>
<program_>8</program_>
<pan_>-1</pan_>
<follower_>
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_>
```

```
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
</item>
<item>
<low_pitch_>C0</low_pitch_>
<high_pitch_>C8</high_pitch_>
<channel_>13</channel_>
<walking_>8.12108137049251222e-01</walking_>
<program_>81</program_>
<pan_>20</pan_>
<follower_>
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_>
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
</item>
<item>
<low_pitch_>F1</low_pitch_>
<high_pitch_>F6</high_pitch_>
<channel_>12</channel_>
<walking_>2.39896215303452925e-01</walking_>
<program_>8</program_>
<pan_>-1</pan_>
<follower_>
<follow_>0</follow_>
<leader_>2147483647</leader_>
<interval_type_>0</interval_type_>
<interval_>0</interval_>
<delay_>
<numerator_>0</numerator_>
<denominator_>1</denominator_>
</delay_>
<inversion_>0</inversion_>
<retrograde_>0</retrograde_>
</follower_>
</item>
```

```
</voices_>
<arrangement_definition_ class_id="9" tracking_level="0" version="0">
<algorithm_>1</algorithm_>
<period_>1.0000000000000000e+05</period_>
</arrangement_definition_>
</xml_form>
</boost_serialization>
```

Notes on XML tag versions:

- xml_form version 0: no copyright tag, no arrangement lock, and no follower for each voice tag.
- xml_form version 2 : adds an arrangement block at the bottom.
- xml_form version 2, follower_ version 2 : options for delay/inversion/retrograde.
- xml_form version 3, follower_ version 2 : adds copyright_ tag.

6 The textmidi File

The output of `textmidicgm` is a textmidi text file with tracks in LAZY mode. It can be converted into a standard MIDI file by using the `textmidi` program. While a text file, the textmidi output can be edited in text editors and processed by other text tools. For example, assignments of MIDI channels and instrument programs can be changed.

7 The Gnuplot File

The −−gnuplot option will cause a gnuplot data file to be written with the name in the xml form file with ".plot" appended. A gnuplot file that can read the file is shown below.

```
#
# RUN WITH by specifying the data file output by textmidicgm:
# /usr/bin/gnuplot -e "thefile='tjcgm.txt'" textmidicgm.gnuplot > name.jpg
#
# AlgoRhythms 3.0 colors
#wavecolor = "green"
#textcolor = "white"
#backgroundcolor = "0x9932CC"
## AlgoRhythms 1.0 colors
wavecolor = "0xAAAAEE"
textcolor = "black"
backgroundcolor = "0xCCCCCC"
set title "textmidicgm" textcolor rgb textcolor
set terminal jpeg background rgb backgroundcolor size 1024,1024
set grid xtics linetype rgb textcolor
set grid ytics linetype rgb textcolor
set border  linetype rgb textcolor
set xtics textcolor rgb textcolor
set ytics textcolor rgb textcolor
set size 1.0,0.5
set multiplot layout 4,1
set size 1.0,0.25
set autoscale y
set title "Pitch Index" textcolor rgb textcolor
plot [] [] thefile every 1 index "pitch" with yerrorbars linecolor rgb wavecolor
set autoscale y
set title "Duration" textcolor rgb textcolor
plot [] [] thefile every 1 index "rhythm" with yerrorbars linecolor rgb wavecolor
set autoscale y
set title "Velocity" textcolor rgb textcolor
plot [] [] thefile every 1 index "dynamic" with yerrorbars linecolor rgb wavecolor
set autoscale y
set title "Complement" textcolor rgb textcolor
plot [] [] thefile every 1 index "texture" with yerrorbars linecolor rgb wavecolor

unset multiplot
```

8 Installation

This program was prepared for builds using GNU autoconf tools. Unpack the archive. Move to the directory created for the program. Run the configure script and run make.

```
./configure
make
```

Make yourself superuser (root), or use sudo to run install targets:

```
make install
make install-info
```

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