Humdrum Analysis Tools I

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Musical Data Representations

- Notation
- Performance
- Analysis
Musical Data Representations

- Performance
- MIDI
- Notation
- SCORE
- Humdrum Analysis
Musical Data Representations

Notation
- SCORE
- MuseData (i-files/mpg files)

Performance
- MIDI
- MuseData (stage1)

Analysis
- Humdrum
- MuseData (stage2)
Musical Data Representations

- Performance
  - MIDI
  - MuseData (stage1)

- Notation
  - MUSICXML
  - lilypond
  - MuseData (i-files/mpg files)
  - MuseData (stage2)
  - Guido
  - Humdrum Analysis

- SCORE

Graph illustrates the relationships and conversions between various musical data representations.
Unix shell

- Humdrum Toolkit designed for use in a unix shell (terminal)
  

**Linux:** should be easy to find a terminal

**OS X:** /Applications/Utility/Terminal.app

**Windows:** not a unix system, so install unix emulator:
  * [http://www.cygwin.com](http://www.cygwin.com)
  * or install your favorite Linux OS in VirtualBox ([http://www.virtualbox.org](http://www.virtualbox.org))

- Some learning resources for terminal:
  -- Humdrum User’s Guide (see Documentation slide)
  -- [http://www.ee.surrey.ac.uk/Teaching/Unix](http://www.ee.surrey.ac.uk/Teaching/Unix)
  -- [http://community.linuxmint.com/tutorial/view/454](http://community.linuxmint.com/tutorial/view/454)
  -- [http://macdevcenter.com/pub/a/mac/2001/12/14/terminal_one.html](http://macdevcenter.com/pub/a/mac/2001/12/14/terminal_one.html)
  -- [http://www.youtube.com/watch?v=PYW7UG5VRgw](http://www.youtube.com/watch?v=PYW7UG5VRgw) (starting at 3:20)
Humdrum Processing Software

• Humdrum Toolkit:
  http://wiki.humdrum.org/wiki/downloads
  https://github.com/kroger/humdrum

• Humdrum Extras:
  https://github.com/craigsapp/humextra

• Humextra online (no software installation required):
  https://extras.humdrum.org/online

• Music21 (Humdrum data import only into Python):
  https://github.com/cuthbertLab/music21
Humdrum File Syntax Coloring

https://github.com/kroger/humdrum/tree/master/editors (emacs, vi)
http://www.ccarh.org/software/humdrum/vi/syntax (vi)
Humdrum documentation

- Links to scans and HTML files for the User and Reference Guides are listed on http://humdrum.ccarh.org

- Main webpage for the Humdrum Toolkit:
  http://www.humdrum.org/Humdrum

- Humdrum Wiki:
  http://wiki.humdrum.org

- Humdrum Extras documentation:
  http://extras.humdrum.org/man

- Humdrum Users’ Group (**HUG):
  https://groups.google.com/forum/?fromgroups#!forum/starstarhug
humdrum

- humdrum is a command which validates the Humdrum file format structure of a file.

**humdrum file.krn**

```plaintext
*kern 1c *
```

humdrum: ERROR 17: First exclusive interpretation record contains a non-exclusive interpretation in line 1, file file.krn.

```plaintext
*kern 1c ==
```

humdrum: ERROR 14: All spines have not been properly terminated in line 4, file file.krn.

```plaintext
! comment **kern 1c *
```

humdrum: ERROR 9: Local comment precedes first exclusive interpretation record in line 1, file file.krn.
proof

• proof is a command which validates the content of **kern data (more specific than humdrum command which validates structure)

```
**kern
*clefG2
*k[f#]
*M4/4
*MM120
=1-
1g
=2
2f#
=3
[1a
==
_*
```

**proof file.krn**

proof: Warning: Possible change of meter in measure 2, line 10
proof: Warning: Possible change of meter in measure 3, line 12
proof: Error: Incorrect tie specification in spine 1, line 11 "1a"

• -w option suppresses warnings and only lists errors.

```
proof –w file.krn
```

proof: Error: Incorrect tie specification in spine 1, line 11 "1a"

http://humdrum.org/Humdrum/commands/proof.html
census

- census is a command which gives basic counting statistics on a Humdrum file
- -k option can be added to include **kern data counting.

```plaintext
**kern
*M3/4
=1-
2c
[4d
=2
4d]
4e
4r
==
*-
```

**census file.krn**

**HUMDRUM DATA**

- Number of data tokens: 8
- Number of null tokens: 0
- Number of multiple-stops: 0
- Number of data records: 8
- Number of comments: 0
- Number of interpretations: 3
- Number of records: 11

**KERN DATA**

- Number of note-heads: 4
- Number of notes: 3
- Longest note: 2
- Shortest note: 4
- Highest note: e
- Lowest note: c
- Number of rests: 1
- Maximum number of voices: 1
- Number of single barlines: 2
- Number of double barlines: 1
humcat

- The humcat command can be used to download data from KernScores.

- All Humdrum Extras have built-in downloading capability (except when compiled natively for Windows) from the web, KernScores (http://kern.humdrum.org), and the Josquin Research Project (http://josquin.stanford.edu).

```
humcat h://371chorales/chor001.krn | less
```

```plaintext
!!!COM: Bach, Johann Sebastian
!!!CDT: 1685/02/21/-1750/07/28/
!!!OTL@DE: Aus meines Herzens Grunde
!!!OTL@EN: From the Depths of My Heart
!!!SCT: BWV 269
!!!PC#: 1
!!!AGN: chorale
**kern
*ICvox
*Ibass
*I"Bass
*>[A,A,B]
*>norep[A,B]
*>[A]
*k[f#]
*G:
*M3/4
*MM100
4GG
=1
4G
4E
* clefF4
*k[f#]
2G
8cL
8BJ
4F#
```

```plaintext
4A
4d
4d
4d
4dd
```
humcat (2)

• The humcat command can be used to download and pipe data to standard Humdrum Toolkit commands:

```
humcat h://371chorales/chor001.krn | census -k
```

**HUMDRUM DATA**

- Number of data tokens: 412
- Number of null tokens: 91
- Number of multiple-stops: 0
- Number of data records: 103
- Number of comments: 16
- Number of interpretations: 14
- Number of records: 133

**KERN DATA**

- Number of note-heads: 229
- Number of notes: 223
- Longest note: 2.
- Shortest note: 8
- Highest note: dd
- Lowest note: F F#
- Number of rests: 0
- Maximum number of voices: 4
- Number of single barlines: 22
- Number of double barlines: 1
humcat (3)

• humcat can also be used to stream multiple files from KernScores:

```
humcat -s h://371chorales | census -k
```

HUMDRUM DATA

Number of data tokens: 143760
Number of null tokens: 34224
Number of multiple-stops: 0
Number of data records: 35940
Number of comments: 5996
Number of interpretations: 4770
Number of records: 46706

KERN DATA

Number of note-heads: 86109
Number of notes: 84666
Longest note: 0
Shortest note: 32
Highest note: aa
Lowest note: CC
Number of rests: 783
Maximum number of voices: 4
Number of single barlines: 5291
Number of double barlines: 370

• For lots of data, better to download files for local use:

```
humcat -s h://371chorales | humsplit
census –k chor*.krn
```
thru/thrux

• thru can be used to generate performance sequence from score sequence

**kern
*->[A,A,B]
clefG2
*M2/4
*k[
=1-
*->A
c
=2:|!
*->B
d
==
*-

**kern
*thru
clefG2
*M2/4
*k[
=1-
*->A
c
=2:|!
*->A
c
=2:|!
*->B
d
==
*-

thru file.krn
thru/thrux (2)

- alternate thru sequences
- “norep” is a convention for the score without repeating sections

```plaintext
**kern
*>[A,A1,A,A2,B]
*>norep[A,A2,B]
*k[ ]
=1-
*>A
2c
=2
*>A1
2d
=3: |
*>A2
2e
=4
*>B
2d
==
*_
```

```plaintext
**kern
*thru
*thru
*k[ ]
=1-
*>A
2c
=2
*>A2
2e
=4
*>B
2d
==
*_
```
### thru and census

#### census with repeated sections

```bash
thru *.krn | census -k
```

**HUMDRUM DATA**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of data tokens:</td>
<td>168723</td>
</tr>
<tr>
<td>Number of null tokens:</td>
<td>39889</td>
</tr>
<tr>
<td>Number of multiple-stops:</td>
<td>0</td>
</tr>
<tr>
<td>Number of data records:</td>
<td>42189</td>
</tr>
<tr>
<td>Number of comments:</td>
<td>5627</td>
</tr>
<tr>
<td>Number of interpretations:</td>
<td>6027</td>
</tr>
<tr>
<td>Number of records:</td>
<td>53843</td>
</tr>
</tbody>
</table>

**KERN DATA**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of note-heads:</td>
<td>101015</td>
</tr>
<tr>
<td>Number of notes:</td>
<td><strong>99393</strong></td>
</tr>
<tr>
<td>Longest note:</td>
<td>0</td>
</tr>
<tr>
<td>Shortest note:</td>
<td>32</td>
</tr>
<tr>
<td>Highest note:</td>
<td>aa</td>
</tr>
<tr>
<td>Lowest note:</td>
<td>CC</td>
</tr>
<tr>
<td>Number of rests:</td>
<td>889</td>
</tr>
<tr>
<td>Maximum number of voices:</td>
<td>4</td>
</tr>
<tr>
<td>Number of single barlines:</td>
<td>6365</td>
</tr>
<tr>
<td>Number of double barlines:</td>
<td>372</td>
</tr>
</tbody>
</table>

#### census without repeats

```bash
thru -v norep *.krn | census -k
```

**HUMDRUM DATA**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of data tokens:</td>
<td>143755</td>
</tr>
<tr>
<td>Number of null tokens:</td>
<td>34224</td>
</tr>
<tr>
<td>Number of multiple-stops:</td>
<td>0</td>
</tr>
<tr>
<td>Number of data records:</td>
<td>35944</td>
</tr>
<tr>
<td>Number of comments:</td>
<td>5627</td>
</tr>
<tr>
<td>Number of interpretations:</td>
<td>4784</td>
</tr>
<tr>
<td>Number of records:</td>
<td>46354</td>
</tr>
</tbody>
</table>

**KERN DATA**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of note-heads:</td>
<td>86104</td>
</tr>
<tr>
<td>Number of notes:</td>
<td><strong>84661</strong></td>
</tr>
<tr>
<td>Longest note:</td>
<td>0</td>
</tr>
<tr>
<td>Shortest note:</td>
<td>32</td>
</tr>
<tr>
<td>Highest note:</td>
<td>aa</td>
</tr>
<tr>
<td>Lowest note:</td>
<td>CC</td>
</tr>
<tr>
<td>Number of rests:</td>
<td>783</td>
</tr>
<tr>
<td>Maximum number of voices:</td>
<td>4</td>
</tr>
<tr>
<td>Number of single barlines:</td>
<td>5293</td>
</tr>
<tr>
<td>Number of double barlines:</td>
<td>371</td>
</tr>
</tbody>
</table>
for-loops in bash shell

```bash
for i in *.krn
do
    echo $i `census -k $i | grep "Number of notes"
end
```

chor001.krn Number of notes: 223
chor002.krn Number of notes: 229
chor003.krn Number of notes: 196
chor004.krn Number of notes: 185
chor005.krn Number of notes: 330
chor006.krn Number of notes: 120
chor007.krn Number of notes: 346
chor008.krn Number of notes: 358
chor009.krn Number of notes: 238
...

**sort**

Identify the chorales with the most notes (excluding repeats)

```bash
for i in *.krn
done | sort -nrk5 | less
```

chor205.krn Number of notes: 957
chor132.krn Number of notes: 790
chor133.krn Number of notes: 600
chor197.krn Number of notes: 554
chor241.krn Number of notes: 517
chor215.krn Number of notes: 475
chor259.krn Number of notes: 471
chor091.krn Number of notes: 467
chor251.krn Number of notes: 458
chor214.krn Number of notes: 443
chor116.krn Number of notes: 429
chor069.krn Number of notes: 429
chor011.krn Number of notes: 414
chor277.krn Number of notes: 405
chor220.krn Number of notes: 380

sort options being used:
- `-n` == sort numerically
- `-r` == reverse order (largest first)
- `-k 5` == sort by 5th field on line
**kern
*k[
*C:
c
d
e
f
g
a
b
cc
*-

**kern
*Trd1c2
*k[f#c]
*D:
d
e
f#
g
a
b
cc#
dd
*-

**kern
*Trd3c6
*k[f#c#g#d#a#e#]
*F#:
f#
g#
a#
b
cc#
dd#
ee#
ff#
*-

transpose –b 6
transpose –d 1 –c 2

transpose –k f#
key/keycor

**kern

c
d
e
f
g
a
b
cc
*-

key file.krn
keycor file.krn

transpose –b 23 file.krn | key

transpose –b 18 file.krn | key

keycor h://wtc/wtc1p01.krn
keycor h://wtc/wtc1p02.krn
keycor h://wtc/wtc1p03.krn
keycor h://wtc/wtc1p04.krn
hum2mid

- Convert Humdrum file into a MIDI file.

```
hum2mid h://essen/asia/china/shanxi/shanx276.krn -o shanx276.mid
```

Some options:

- `-O` == create a Type-0 MIDI file
- `--autopan` == array parts in stereo field
- `--plus` == store pitch spellings using MIDI+ method

```
--temperament == see http://kern.ccarh.org/browse?l=temperament
```

http://extras.humdrum.org/man/hum2mid
myank

- “Measure Yank”: extracts selected measures from full score:

```
myank -m1-2 h://371chorales/chor032.krn
```

```
**kern  **kern  **kern  **kern
*clefF4 *clefGv2 *clefG2 *clefG2
*k[f#c#g#] *k[f#c#g#] *k[f#c#g#] *k[f#c#g#]
*A:     *A:     *A:     *A:     
*M4/4   *M4/4   *M4/4   *M4/4   
*met(c) *met(c) *met(c) *met(c) 
*MM100  *MM100  *MM100  *MM100 
=1-     =1-     =1-     =1-     
8AL     4c#     4a     4ee     
8BJ     .       .       .       
8c#L    4c#     4a     4ee     
8AJ     .       .       .       
8DL     4d      4a     4ff#     
8EJ     .       .       .       
8F#L    4d      4a     4ff#     
8DJ     .       .       .       
=2      =2      =2      =2      
2A;     2c#;   2a;    2ee;    
4r      4ry     4ry     4r      
4A      4f#     4a     4cc#     
=3      =3      =3      =3      
4G#     4e      4b     4dd     
4A      4e      4a     4cc#     
8EL     4e      4g#     4b     
8DJ     .       .       .       
8C#L    4e      4a     8cc#L    
8AAJ    .       .       8ddJ    
=       =       =       =       
*_-     *_-     *_-     *_-     
```
humplay

- Humplay will perform Humdrum files in real-time as it displays the file on screen.

- See http://extra.humdrum.org/man/humplay for real-time commands.

Try:

humplay h://beethoven/sonatas/sonata08-2.krn
humplay h://musedata/haydn/sym/sym101-1.krn
humplay h://wtc/wtc2/p18.krn
humplay h://371chorales/chor268.krn
• Use the extract program to pull out a particular part from a full score:

```
humcat h://371chorales/chor043.krn | extract -f2
extractx -s2 h://371chorales/chor043.krn
extractx -g alto h://371chorales/chor043.krn
```

• Use extractx if input data contains spine splits/joins (*^, *v).
prange

- Generate pitch histograms of input data (like census –k but more detail)

```plaintext
extractx -g alto h://371chorales/chor043.krn | prange

**keyno **kern **count
59 B 3
61 c# 1
63 e- 5
64 e 10
66 f# 19
68 g# 13
69 a 3
70 b- 1

!*-*-*-**
!!tessitura: 11 semitones
!!mean: 65.6 (f#)
!!median: 66 (f#)
```
**Metric Position**

- The beat command can be used to identify the beat number in measure for each data line.
- -a option used to append analysis data to input score.

```plaintext
beat -a h:\371chorales/chor200.krn

**kern** | **kern** | **kern** | **kern** | **beat**
---|---|---|---|---
=1− | =1− | =1− | =1− | =1−
4c | 4e | 4g | 4cc | 1
4B | 4d | [4g | 4g | 2
4A | 4c | 8gL] | 4a | 3
. | . | 8f#J | . | 3.5
8GL | 4d | 4g | 4b | 4
8FJ | . | . | . | 4.5
=2 | =2 | =2 | =2 | =2
4E | 8cL | 4.g | 2cc | 1
. | 8B–J | . | . | 1.5
4F | 4A | . | . | 2
. | . | [8fnX | . | 2.5
4C; | 4G; | 8fL] | 4cc; | 3
. | . | 8e;J | . | 3.5
8cL | 4c | [4e | 4g | 4
8B–J | . | . | . | 4.5
=3 | =3 | =3 | =3 | 3
```
Rid program removed various categories of Humdrum file structure:
- G == remove global comments (and reference records)
- L == remove local comments
- I == remove interpretations (and spine manipulators)
- M == remove measure lines (ridx only)
- d == remove null token data lines

```
beat h://371chorales/chor200.krn | ridx -GLIMd
```

1
2
3
3.5
4
4.5
1
1.5
2
2.5
3
3.5
4
...

**uniq -c**

```
beat h://371chorales/chor200.krn | ridx -GLIMd | sort -nr | uniq -c
```

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>1.5</td>
</tr>
<tr>
<td>1</td>
<td>1.75</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>2.5</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>3.5</td>
</tr>
<tr>
<td>1</td>
<td>3.75</td>
</tr>
<tr>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>4.5</td>
</tr>
<tr>
<td>2</td>
<td>4.75</td>
</tr>
</tbody>
</table>

- 15 times an event on beat 1 (could be tied note or rest)
- 10 times an event on beat 1.5
- Type “man uniq” to see the manual page for the uniq command.
Sonority analysis

humcat –s h://371chorales | humsplit
for i in chor*.krn
do
  beat -a $i | tntype -a | extract -f 4,5
done | rid –GLId | grep –v = | sort -n | uniq –c | less

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
<td>1-1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2-1</td>
</tr>
<tr>
<td>44</td>
<td>1</td>
<td>2-3</td>
</tr>
<tr>
<td>45</td>
<td>1</td>
<td>2-4</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>2-5</td>
</tr>
<tr>
<td>99</td>
<td>1</td>
<td>3-10</td>
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<td>1182</td>
<td>1</td>
<td>3-11A</td>
</tr>
<tr>
<td>2380</td>
<td>1</td>
<td>3-11B</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>3-12</td>
</tr>
<tr>
<td>11</td>
<td>3-2A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>3-2B</td>
</tr>
<tr>
<td>27</td>
<td>1</td>
<td>3-4A</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>3-6</td>
</tr>
<tr>
<td>82</td>
<td>1</td>
<td>3-7A</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>3-7B</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>3-8A</td>
</tr>
<tr>
<td>239</td>
<td>1</td>
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<td>7</td>
<td>1</td>
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</tr>
<tr>
<td>103</td>
<td>1</td>
<td>4-14A</td>
</tr>
<tr>
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<td>1</td>
<td>4-19A</td>
</tr>
<tr>
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<td>4-22A</td>
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