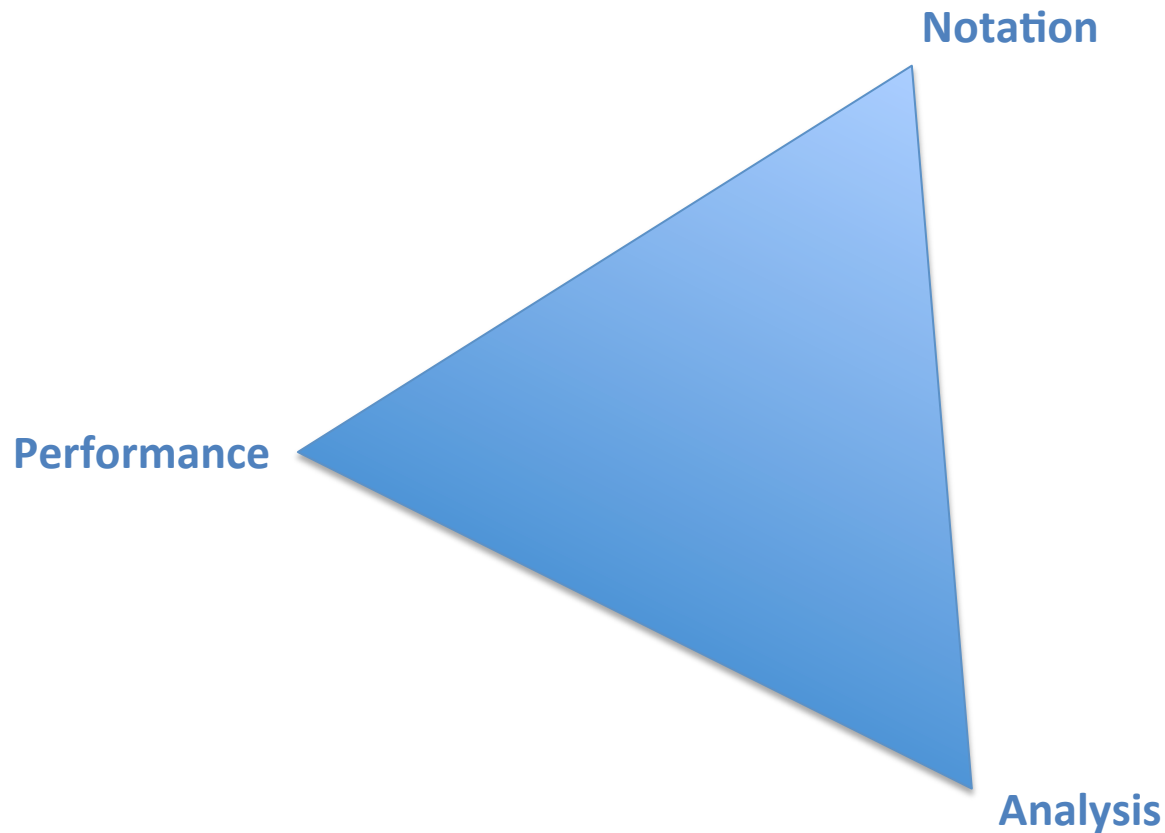


# Humdrum Analysis Tools I

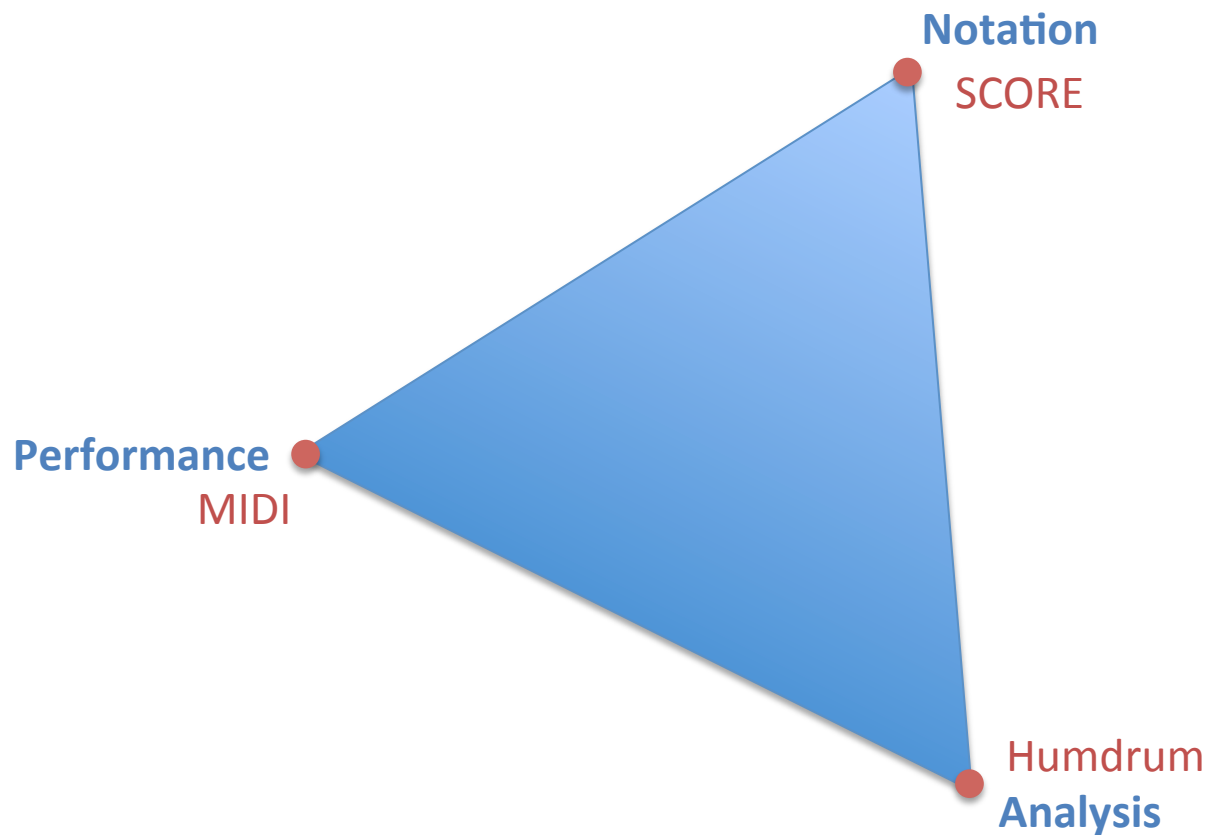
[craig@ccrma.stanford.edu](mailto:craig@ccrma.stanford.edu)

6 March 2014

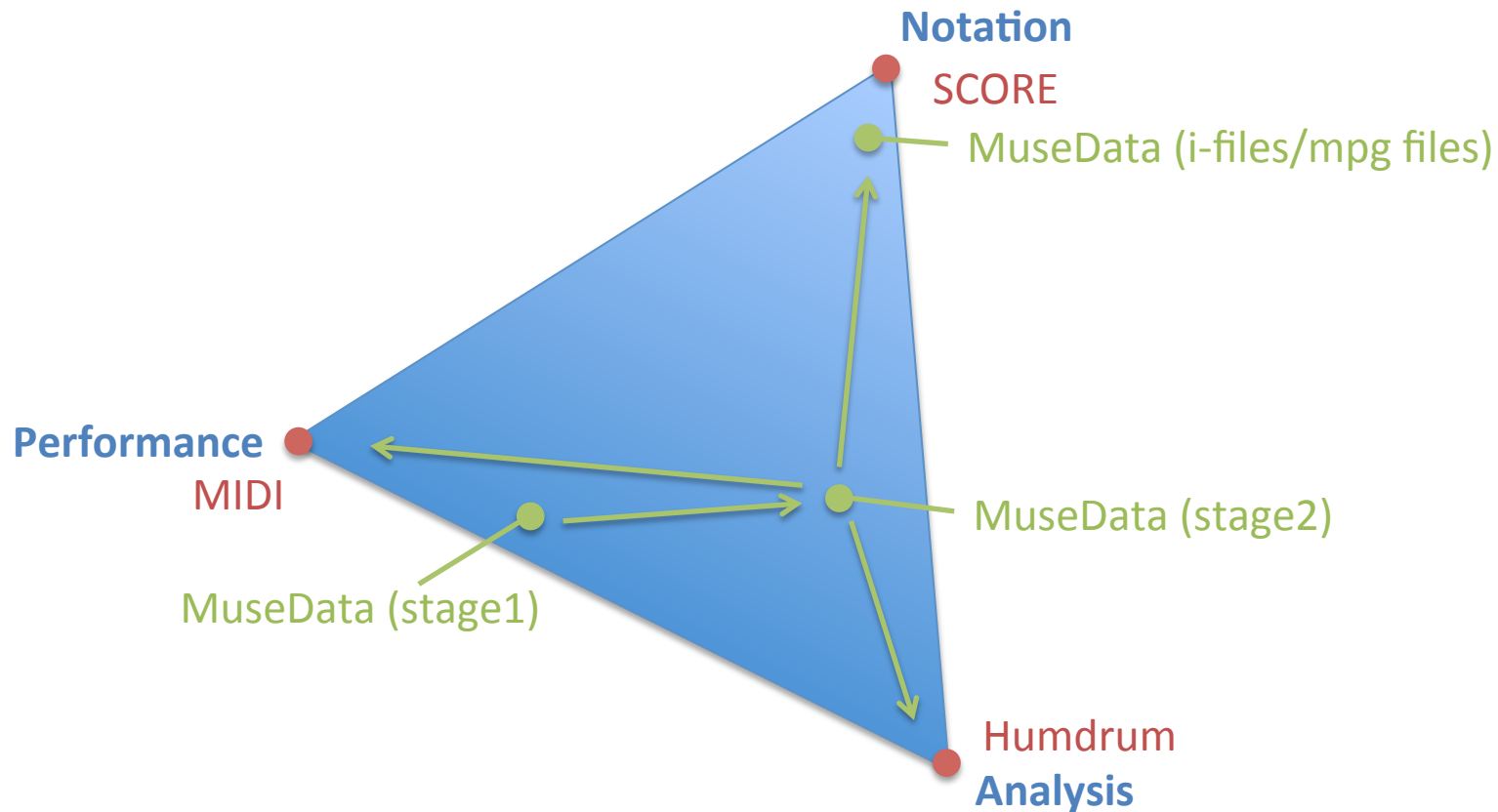
# Musical Data Representations



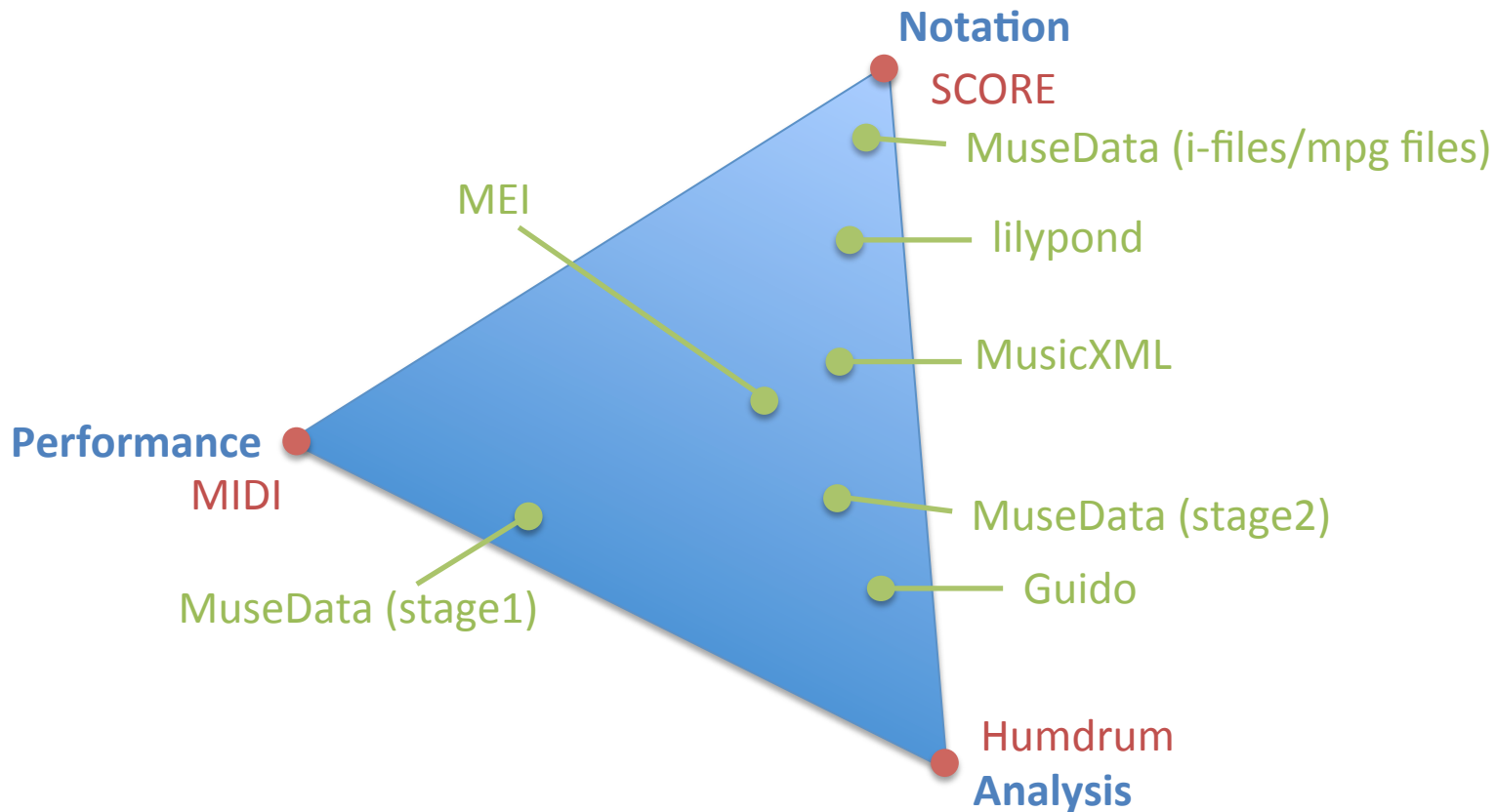
# Musical Data Representations



# Musical Data Representations



# Musical Data Representations



# Unix shell

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

[http://en.wikipedia.org/wiki/Unix\\_shell](http://en.wikipedia.org/wiki/Unix_shell)

**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>

\* or install your favorite Linux OS in VirtualBox (<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://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> (starting at 3:20)

# Humdrum Processing Software

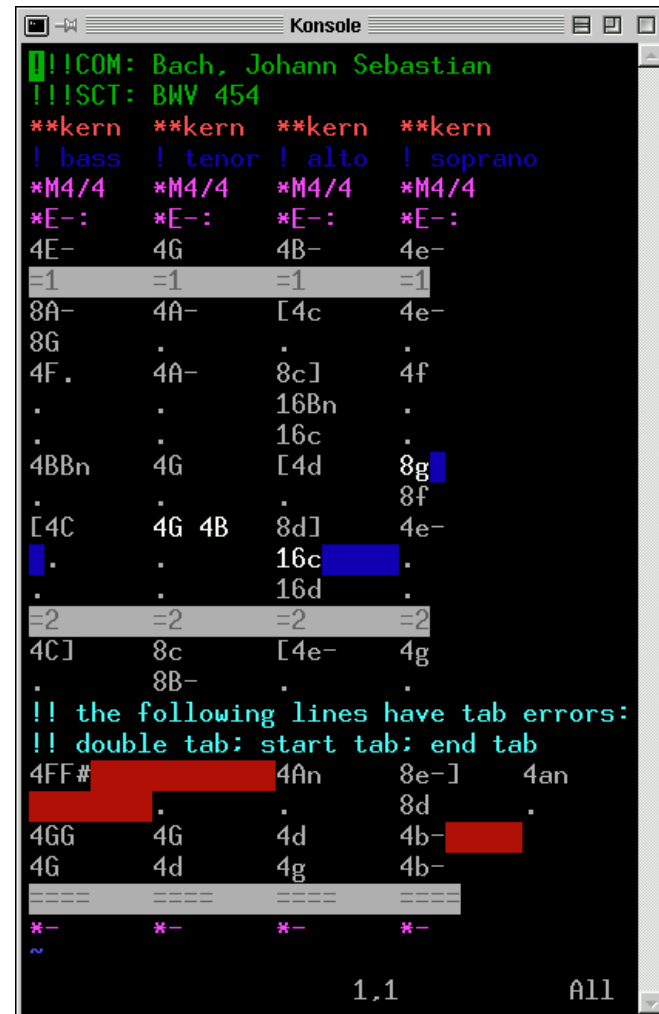
- Humdrum Toolkit:  
<http://wiki.humdrum.org/wiki/downloads>  
<https://github.com/kroger/humdrum>
- Humdrum Extras:  
<https://github.com/craigsapp/humextra>
- Humextra online (no software installation required):  
<https://extras.humdrum.org/online>
- Music21 (Humdrum data import only into Python):  
<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)

```
!!COM: Bach, Johann Sebastian
!!SCT: BWV 454
**kern **kern **kern **kern
! bass ! tenor ! alto ! soprano
*M4/4 *M4/4 *M4/4 *M4/4
*E-: *E-: *E-: *E-:
4E- 4G 4B- 4e-
=1 =1 =1 =1
8A- 4A- [4c 4e-
8G . . .
4F 4A- 8c] 4f
. . 16Bn .
. . 16c .
4BBn 4G [4d 8g
. . . 8f
[4C 4G 4B 8d] 4e-
. . 16c .
. . 16d .
=2 =2 =2 =2
4C] 8c [4e- 4g
. 8B- . .
!! the following lines have tab errors:
!! double tab; start tab; end tab
4FF# 4An 8e-] 4an
. . 8d .
4GG 4G 4d 4b-
4G 4d 4g 4b-
=====
*_ *_ *_ *_
```



```
Konsole
!!COM: Bach, Johann Sebastian
!!SCT: BWV 454
**kern **kern **kern **kern
! bass ! tenor ! alto ! soprano
*M4/4 *M4/4 *M4/4 *M4/4
*E-: *E-: *E-: *E-:
4E- 4G 4B- 4e-
=1 =1 =1 =1
8A- 4A- [4c 4e-
8G . . .
4F . 4A- 8c] 4f
. . 16Bn .
. . 16c .
4BBn 4G [4d 8g
. . . 8f
[4C 4G 4B 8d] 4e-
. . 16c .
. . 16d .
=2 =2 =2 =2
4C] 8c [4e- 4g
. 8B- . .
!! the following lines have tab errors:
!! double tab; start tab; end tab
4FF# 4An 8e-] 4an
. . 8d .
4GG 4G 4d 4b-
4G 4d 4g 4b-
=====
*_ *_ *_ *_
1,1 All
```



# 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**

```
*kern  
1c  
*_
```

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

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

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

```
! 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"
```

# census

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

```
**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**

```

!!!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          **kern          **kern          **kern
*ICvox          *ICvox          *ICvox          *ICvox
*Ibass          *Itenor         *Ialto          *Isoprn
*I"Bass        *I"Tenor       *I"Alto        *I"Soprano
*>[A,A,B]      *>[A,A,B]      *>[A,A,B]      *>[A,A,B]
*>norep[A,B]  *>norep[A,B]  *>norep[A,B]  *>norep[A,B]
*>A            *>A            *>A            *>A
*clefF4        *clefGv2       *clefG2        *clefG2
*k[f#]         *k[f#]         *k[f#]         *k[f#]
*G:            *G:            *G:            *G:
*M3/4          *M3/4          *M3/4          *M3/4
*MM100        *MM100        *MM100        *MM100
4GG           4B             4d             4g
=1            =1             =1             =1
4G            4B             4d             2g
4E            8cL           4e             .
.             8BJ           .              .
4F#          4A             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:                FF#
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
2c
=2: | !
*>B
2d
==
*_

```

**thru file.krn**

```

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

```



# thru/thrux (2)

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

```

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

```

**thru -v norep file.krn**

```

**kern
*thru
*k[ ]
=1-
*>A
2c
=2
*>A2
2e
=4
*>B
2d
==
*_

```

# thru and census

census with repeated sections

thru \*.krn | census -k

## HUMDRUM DATA

Number of data tokens:	168723
Number of null tokens:	39889
Number of multiple-stops:	0
Number of data records:	42189
Number of comments:	5627
Number of interpretations:	6027
Number of records:	53843

## KERN DATA

Number of note-heads:	101015
Number of notes:	<b>99393</b>
Longest note:	0
Shortest note:	32
Highest note:	aa
Lowest note:	CC
Number of rests:	889
Maximum number of voices:	4
Number of single barlines:	6365
Number of double barlines:	372

census without repeats

thru -v norep \*.krn | census -k

## HUMDRUM DATA

Number of data tokens:	143755
Number of null tokens:	34224
Number of multiple-stops:	0
Number of data records:	35944
Number of comments:	5626
Number of interpretations:	4784
Number of records:	46354

## KERN DATA

Number of note-heads:	86104
Number of notes:	<b>84661</b>
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:	5293
Number of double barlines:	371

# for-loops in bash shell

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

```
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)

```
for i in *.krn
do
  echo $i `census -k $i | grep "Number of notes"`
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
chor252.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 5<sup>th</sup> field on line

# transpose

```
transpose -b 6
```

```
transpose -d 1 -c 2
```

```
**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
*_
```

```
transpose -k f#
```

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

# key/keycor

**kern	key file.krn
c	keycor file.krn
d	transpose -b 23 file.krn   key
e	
f	transpose -b 18 file.krn   key
g	
a	
b	keycor h://wtc/wtc1p01.krn
cc	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.

```

8F\ )
8E'\
8F'\J
(8G\L      2c\      [2ee\      [2eee\
8A-\ )
8G'\
8A-\'\J
=210      =210      =210      =210      =210      =210      =210
[1F       [1Bn [1|      2ee\      2eee\
.         .         .         .         .         .         .
=211      =211      =211      =211      =211      =211      =211
1F_       1B_ 1a-|    2dd\      2ddd\
.         .         .         .         .         .         .
=212      =212      =212      =212      =212      =212      =212
1F_       2B\ 2a|     2b\      2bb\
.         [2Bn\ [|    [2a-/    [2aa-\
=213      =213      =213      =213      =213      =213      =213
1F_       1B_ 1d_   4a-/     4aa-\
.         .         .         .         .         .         .
=214      =214      =214      =214      =214      =214      =214
4F\ ]     4B\ 4d|    4d/      4dd\
4r        2Bn/    4r       2bn\

```

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

```

# extract/extractx

- 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
```

```
**kern
*ICvox
*Ialto
*I"Alto
*>[A,A,B]
*>norep[A,B]
*>A
*clefG2
*k[#c#g#d#]
*E:
*M4/4
*met(c)
*MM100
=1-
2r
.
.
4r
8g#L
8g#J
=2
4a
8aL
8g#J
8g#L
16f#L
16eJJ
8f#L
8f#J
.
=3
```

- Use extractx if input data contains spine splits/joins ( $*^$ ,  $*_$ ).

# prange

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

```
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.

```
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/ridx

- 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
```

```
15      1
10      1.5
 1      1.75
11      2
 9      2.5
15      3
11      3.5
 1      3.75
13      4
12      4.5
 2      4.75
```

- 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
```

```
6 1 1-1
1 1 2-1
44 1 2-3
45 1 2-4
3 1 2-5
99 1 3-10
1182 1 3-11A
2380 1 3-11B
16 1 3-12
1 1 3-2A
3 1 3-2B
27 1 3-4A
4 1 3-6
82 1 3-7A
1 1 3-7B
16 1 3-8A
239 1 3-9
7 1 4-11A
1 1 4-11B
1 1 4-13A
103 1 4-14A
1 1 4-19A
2 1 4-19B
45 1 4-20
79 1 4-22A
13 1 4-23
242 1 4-26
136 1 4-27A
198 1 4-27B
32 1 4-28
1 1 4-29A
2 1.5 2-2
24 1.5 2-3
41 1.5 2-4
49 1.5 2-5
185 1.5 3-10
288 1.5 3-11A
350 1.5 3-11B
14 1.5 3-12
3 1.5 3-2B
26 1.5 3-4A
19 1.5 3-4B
4 1.5 3-5A
1 1.5 3-5B
3 1.5 3-6
130 1.5 3-7A
85 1.5 3-7B
28 1.5 3-8A
19 1.5 3-8B
146 1.5 3-9
17 1.5 4-10
18 1.5 4-11A
22 1.5 4-11B
1 1.5 4-12A
3 1.5 4-12B
7 1.5 4-13A
5 1.5 4-13B
91 1.5 4-14A
85 1.5 4-14B
5 1.5 4-16A
8 1.5 4-16B
1 1.5 4-17
5 1.5 4-18A
5 1.5 4-18B
15 1.5 4-19A
10 1.5 4-19B
195 1.5 4-20
8 1.5 4-21
148 1.5 4-22A
72 1.5 4-22B
142 1.5 4-23
7 1.5 4-24
203 1.5 4-26
86 1.5 4-27A
245 1.5 4-27B
28 1.5 4-28
6 1.5 4-29A
20 1.5 4-29B
1 1.5 4-7
1 1.5 4-8
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