

LilyPond

Automated music formatting and The Art of Shipping



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“But that’s been done before, no?”

Handwritten musical score for bass clef, measures 12-27. The score is in 2/4 time and features a key signature of one flat (B-flat). It includes various musical notations such as slurs, accents, and dynamic markings.

Measure 12: tr

Measure 18

Measure 23: tr

Measure 27

(Finale 2003)

Gold standard

Hand *engraved* scores (early 20th century)



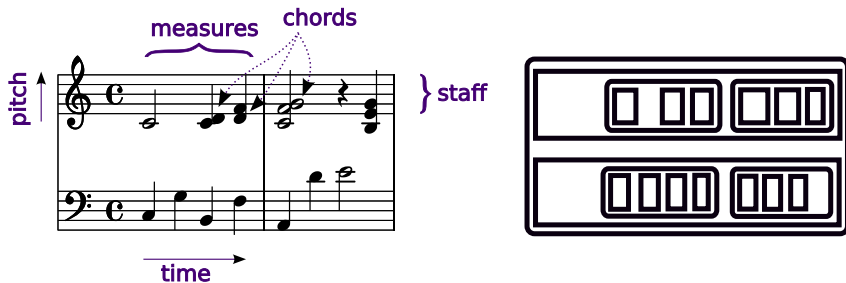
Beautiful music typography

- *A thing of beauty is a joy forever*
- Ease of reading
- Better performance

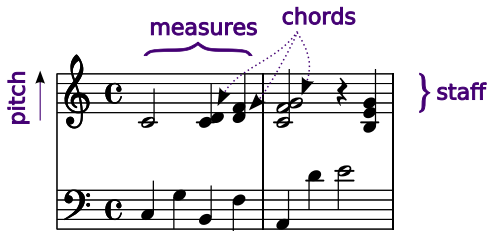
Automated music typography

- Problem statement
- Design overview
- Examples of *engraving*
- Implementation
 - Typography algorithms
 - Formatting architecture
- Zen and the Art of Shipping Software
- Conclusions

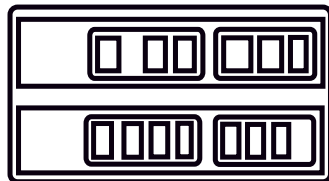
Modeling notation



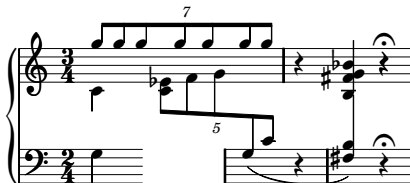
Modeling notation



A musical score in treble and bass clefs with a common time signature. A purple bracket labeled "measures" spans the first two measures. A purple bracket labeled "chords" points to the chordal structures in the second and third measures. A purple arrow labeled "pitch" points upwards on the left. A purple bracket labeled "staff" encompasses the entire musical notation.



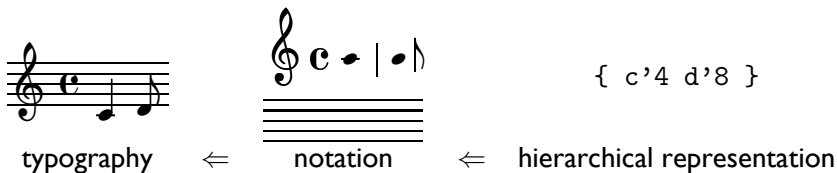
time →



A musical score in treble and bass clefs with a 3/4 time signature. A bracket labeled "7" is above the first measure of the treble staff. A bracket labeled "5" is below the first measure of the bass staff. The notation is more complex than the first example, with many notes and rests.

Simple hierarchy does not work for complex notation

Divide and conquer

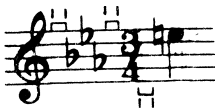


- 1 Typography: **where** to put symbols
- 2 Notation: **what** symbols for which music
- 3 Music representation: how to **encode** music
- 4 Program architecture: glue together everything

Typography

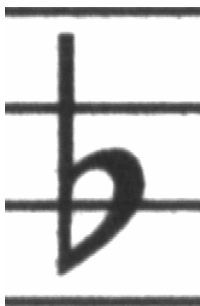
Music engraving: create pleasing look

- Visual: distance and blackness
- A craft: learned in practice
- No literature



Font

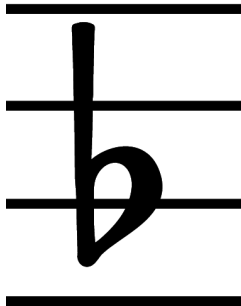
- Heavy look, matching line thickness
- Rounded shapes
- No prescribed rules, so imitate.



Henle (2001)



Bärenreiter (1950)



Feta (LilyPond v2.0)

Spacing

Create illusion of evenness:

Regular spacing:



Optical correction:



Algorithms for aesthetics



- Literature: rule of thumb
- Rule of thumb: cover all cases?
- Case analysis: unwieldy
- Must derive rules from examples

Scoring

- Define ugliness of a configuration
- Try every configuration
- Select least ugly one

variance=15.39 TOTAL=15.39 idx=0



slope=2.00, L edge=1.71, R edge=9.37 TOTAL=13.08 idx=13



slope=2.00, R edge=10.04 TOTAL=12.04 idx=4



Score based formatting

- Beam: stem lengths, slope
- Ties: collisions, notehead/tie distance
- Line breaking
- Page breaking



Pro/Con

- + declarative programming
- expensive
- ? how to define ugliness?

Program architecture

- Music typography is visual
- Impossible to automate for all cases
- Allow manual override for users
- Need flexible program architecture:

“Any sufficiently complicated C or Fortran program contains an ad hoc informally-specified bug-ridden slow implementation of half of Common Lisp.”

(Phil Greenspun’s 10th rule of programming.)

Software duct-tape

Put real LISP interpreter (GUILE Scheme) in C++.

Symbols represented by “Layout objects”, containing variables

- Style: default values

```
'(RepeatSlash  
  . ((stencil .  
        ,Percent_repeat_item_interface::beat_slash)  
      (thickness . 0.48)  
      (slope . 1.7)))
```



- Function value: callback
- Tweak: override defaults

Benchmarking output

LilyPond 1.4



Bärenreiter



LilyPond 2.7.29



LilyPond today

- 9.5 years old; 9.5 man-years
- 10,000 downloads/month. 20,000 to 100,000 users?
- Most frequent comments: “Thank you,” “Beautiful output.”
- Focus on engraving is unique.
- Support through *LilyPond Software Design*

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(March '06)	Total	Linux %	Windows %	MacOS X %
Website	26,389	21	67	11
Downloads	12,966	11	67	22

- Non-technical program: non-technical users

Ship early, ship often

Why binaries?

- Get rid of install/compile questions
- Limit version support burden
- Quality control
- Expand user base
- Condition for paid support

First attempts

- Build LilyPond + dependencies (± 20)
- Existing solutions: fink, mknetrel, autopackage, etc.

Problems

- Duplication of effort
- Unreliable & unpredictable
- Need native machine

Enter **GUB**, *Grand Unified Builder*

- Mini package manager/distribution builder
- Cross-compiling: no native machine required
- Assemble into single installer
- Python based: No More Shell Scripts!
- Python class = package build spec
- Share code for platforms via inheritance
- Bugfix rollout: 25 min (6 platforms, Celeron 2GHz).

Build your own binaries

Lessons

- Long feedback cycle
- Cross-building: libtool Shiatsu and autoconf Voodoo
- Unix relocation: not there yet.
- Windows32 sucks.

Future

- automated release testing?
- continuous building/testing?
- use for other packages too?

Conclusions

- Music typography: subtle and difficult, but fun
- Computer engraving
 - score based aesthetics
 - flexible program architecture
 - benchmarking: compare with real engraving
- End-user software: ship early, ship often
<http://lilypond.org/~hanwen/gub/>
- Visit us, <http://lilypond.org/>

Duplicate classical typography

5

sie-gend durch die Nacht. Schön-er Tag, du bist er - wacht. Mit ge-
das be - weg - te Herz, sanft, wie ein ge - lieb - ter Schmerz. Dürft ich

cresc. *f*

Detailed description: This system shows the first four measures of a musical piece. The vocal line is in treble clef with a soprano range. The piano accompaniment consists of a right hand with a flowing sixteenth-note pattern and a left hand with a steady eighth-note bass line. Dynamic markings include 'cresc.' and 'f'.

sie - gend durch die Nacht. Schön-er Tag, du bist er - wacht. Mit ge-
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cresc. *f*

Detailed description: This system is an exact duplicate of the first system, showing the same musical notation and lyrics.

Print music database

Automatically convert MIDI, MusicXML, ABC → SVG, PDF or
pixmap:

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop <http://give-lab.cs.uu.nl/cgi-bin/MIR/mir.cgi> Go Search Print

Home Bookmarks

Browse:

-100000 -10000 -1000 -100 -50 -7 +7 +50 +100 +1000 +10000 +100000 Jump ?

400000 [Freschi, Domenico 1625c-1710: Giulio Ces...](#) (850.024.922) *This music bitmap is being generated. To see it, please refresh the page after a while.*

400001 [Freschi, Domenico 1625c-1710: Giulio Ces...](#) (850.024.923)

400002 [Legrenzi, Giovanni 1626-1690: Anticco il...](#) (850.024.925)

400003 [Legrenzi, Giovanni 1626-1690: Anticco il...](#) (850.024.926)

400004 [Legrenzi, Giovanni 1626-1690: Anticco il...](#) (850.024.927)

400005 [Legrenzi, Giovanni 1626-1690: Anticco il...](#) (850.024.928)

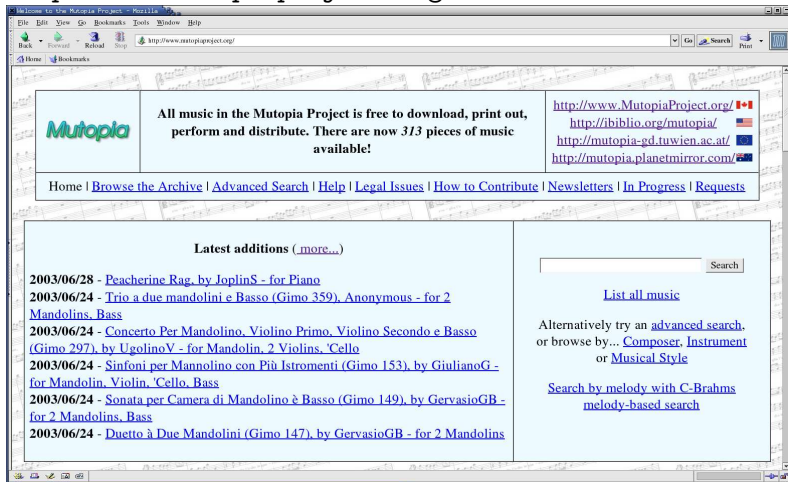
400006 [Legrenzi, Giovanni 1626-1690: Anticco il...](#) (850.024.929)

Query: ?

(RISM 2002 database)

Collect scores on-line

<http://www.mutopiaproject.org/>



The screenshot shows a Mozilla browser window displaying the Mutopia Project website. The page features a navigation menu, a list of latest additions, and a search box. The background of the page is a musical score.

Mutopia

All music in the Mutopia Project is free to download, print out, perform and distribute. There are now 313 pieces of music available!

<http://www.MutopiaProject.org/> | <http://biblio.org/mutopia/> | <http://mutopia-gd.tuwien.ac.at/> | <http://mutopia.planetmirror.com/>

Home | [Browse the Archive](#) | [Advanced Search](#) | [Help](#) | [Legal Issues](#) | [How to Contribute](#) | [Newsletters](#) | [In Progress](#) | [Requests](#)

Latest additions ([more...](#))

- 2003/06/28 - [Peacherine Rag, by JoplinS - for Piano](#)
- 2003/06/24 - [Trio a due mandolini e Basso \(Gimo 359\), Anonymous - for 2 Mandolins, Bass](#)
- 2003/06/24 - [Concerto Per Mandolino, Violino Primo, Violino Secondo e Basso \(Gimo 297\), by UgolinoV - for Mandolin, 2 Violins, 'Cello](#)
- 2003/06/24 - [Sinfoni per Mannolino con Più Istromenti \(Gimo 153\), by GiulianoG - for Mandolin, Violin, 'Cello, Bass](#)
- 2003/06/24 - [Sonata per Camera di Mandolino è Basso \(Gimo 149\), by GervasioGB - for 2 Mandolins, Bass](#)
- 2003/06/24 - [Duetto à Due Mandolini \(Gimo 147\), by GervasioGB - for 2 Mandolins](#)

Search

[List all music](#)

Alternatively try an [advanced search](#), or browse by... [Composer](#), [Instrument](#) or [Musical Style](#)

[Search by melody with C-Brahms melody-based search](#)

Approximately 5000 pages of music.