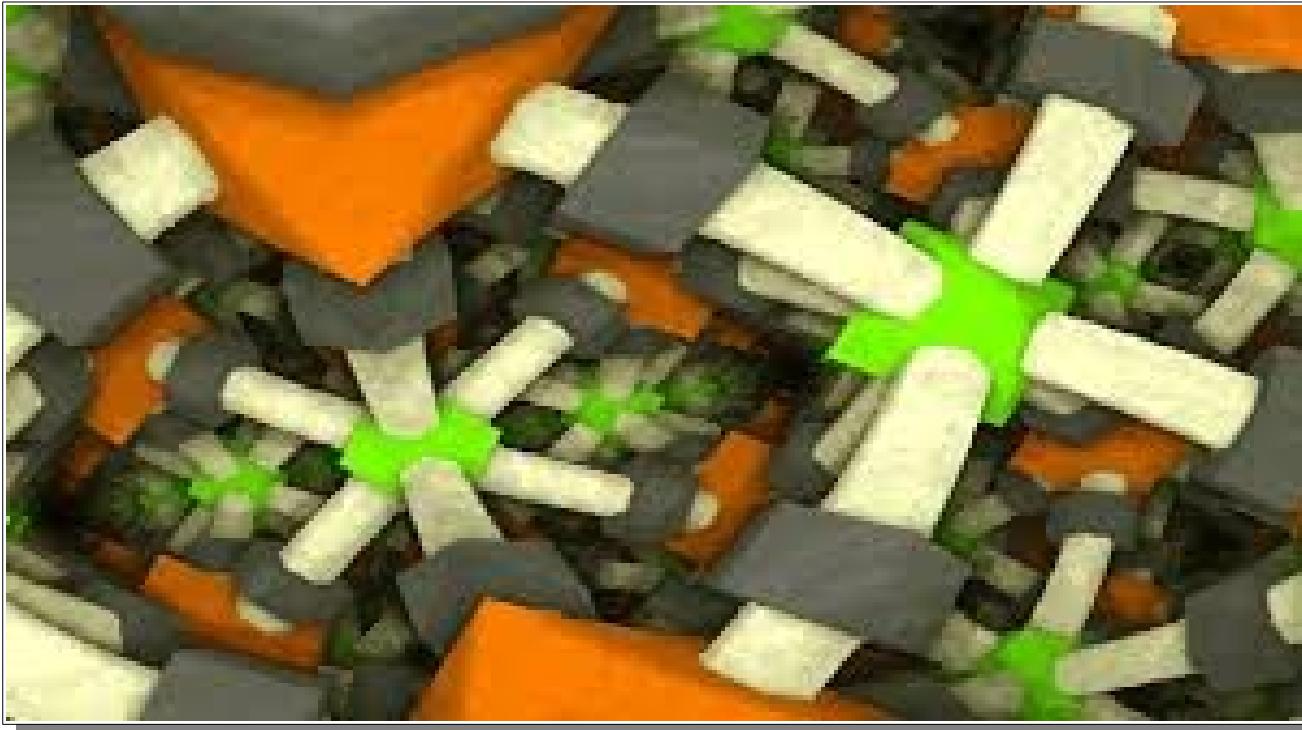


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256-byte demoscene: extremly strong competition

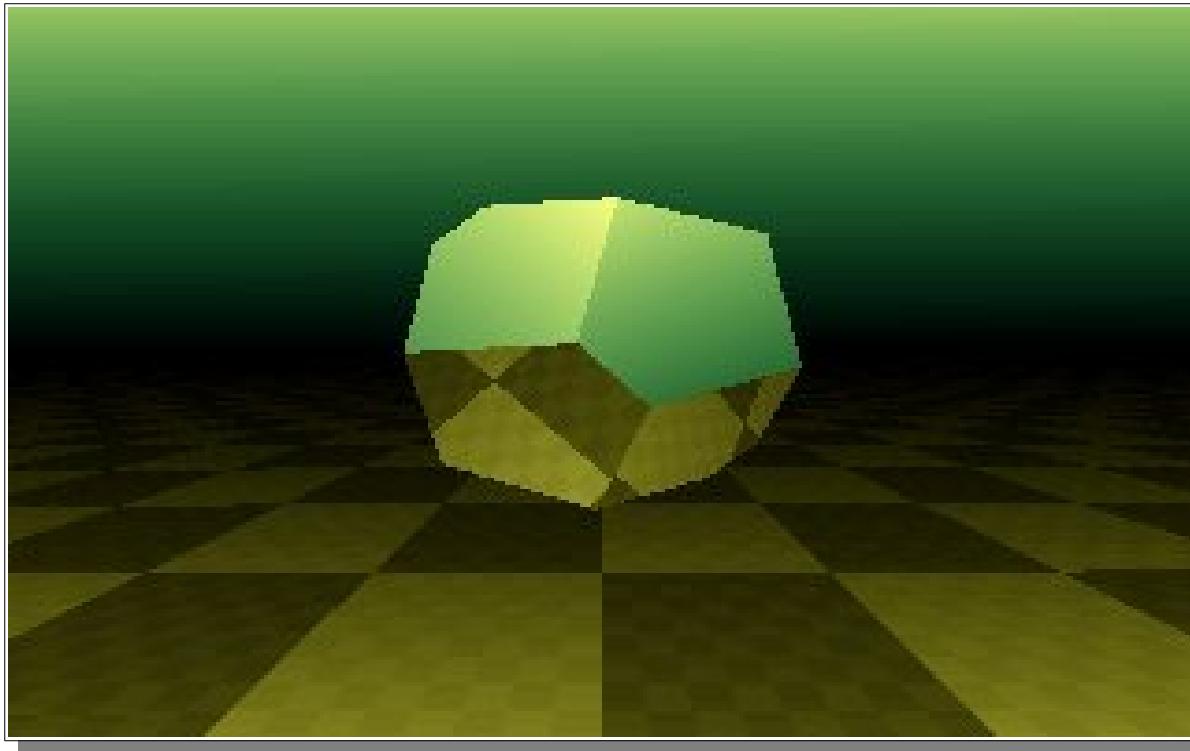


256-byte demoscene: extremly strong competition



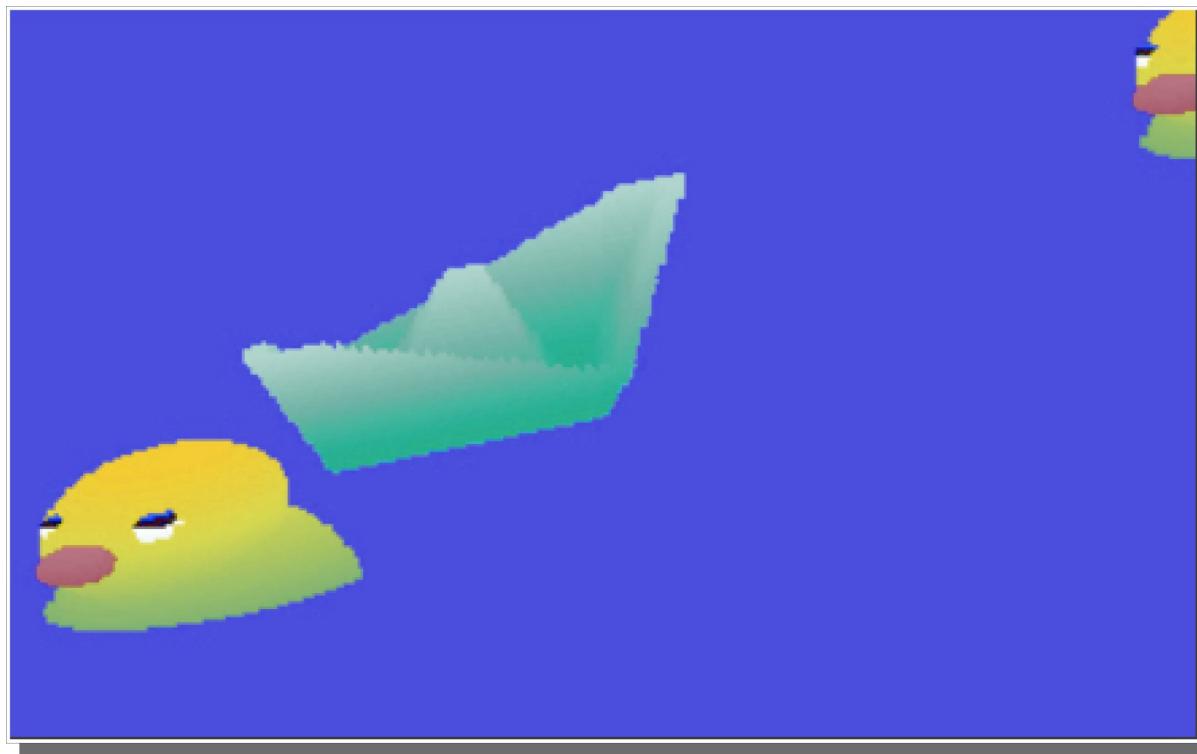
Řrřola: Puls

256-byte demoscene: extremly strong competition



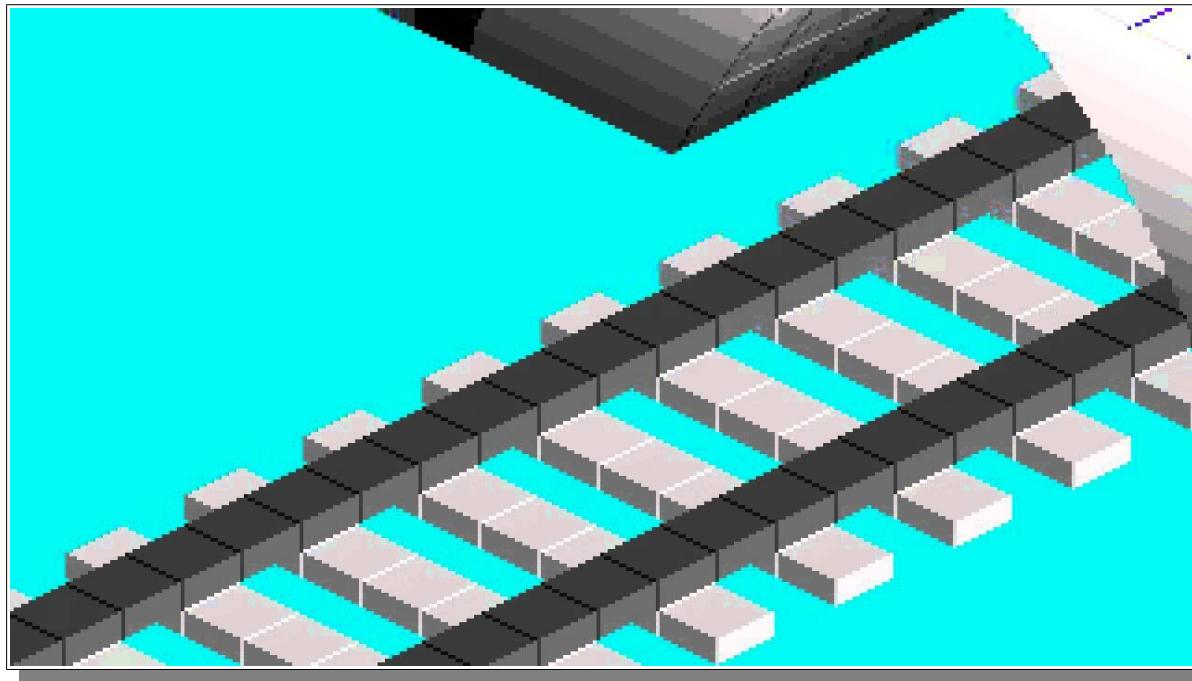
Řrřola: Pyrit

256-byte demoscene: extremly strong competition



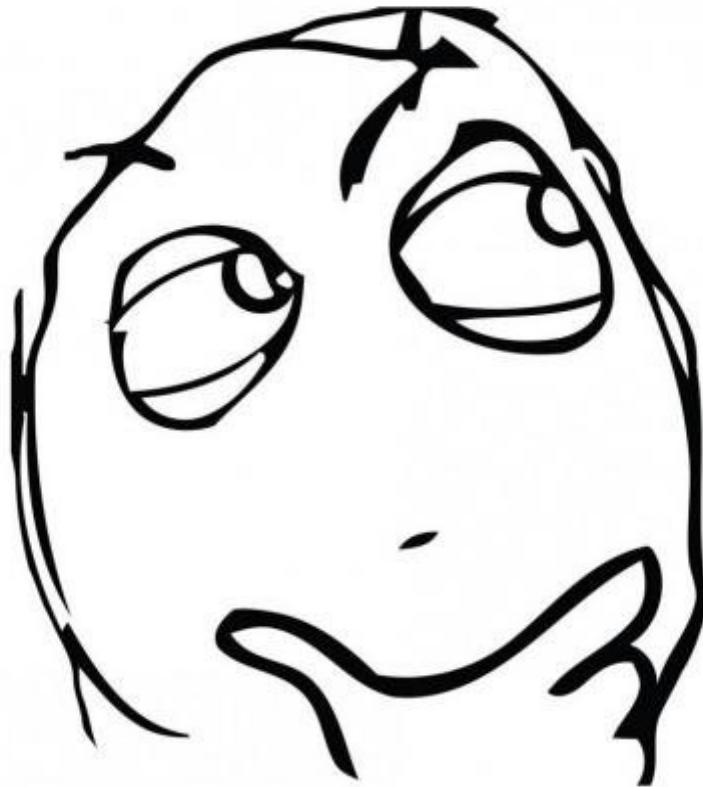
Digimind: Pool Patrol

256-byte demoscene: extremly strong competition



Digimind: Immediate Railways

256-byte demoscene: extremly strong competition

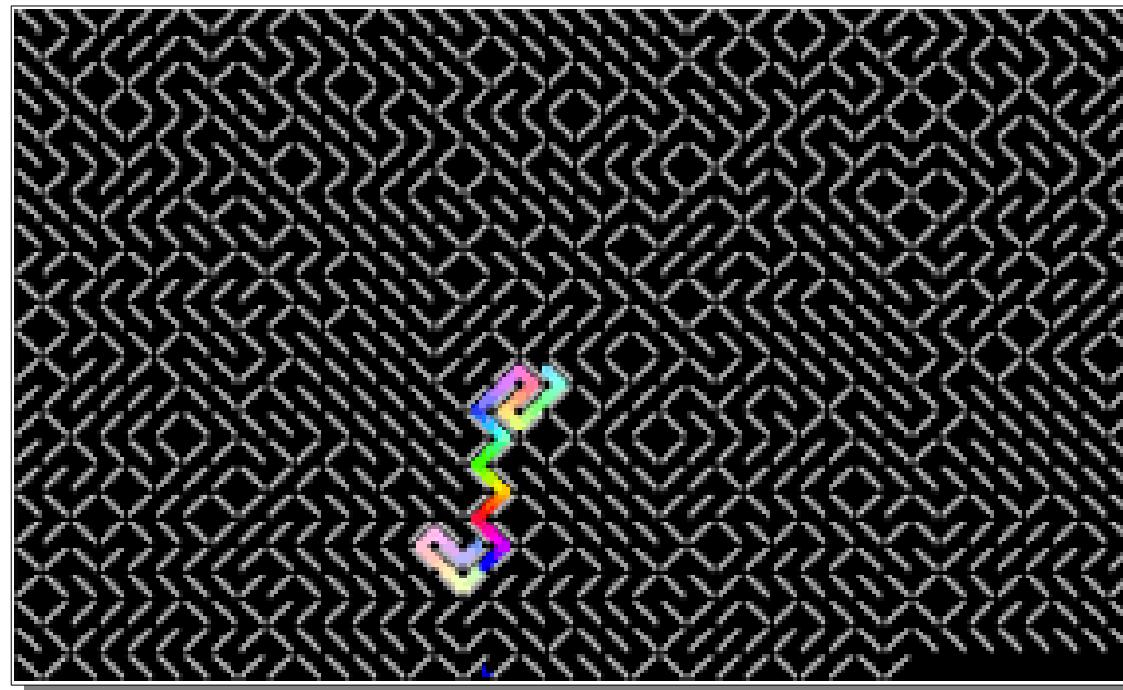


How to shine out of crowd?

256-byte demoscene: how to beat competition?

Fun

(if you are not a hardcore sizecoder)



ern0: Maze Solver

256-byte demoscene: how to beat competition?

Image processing



TomCat: She – Weak Signal

256-byte demoscene: how to beat competition?

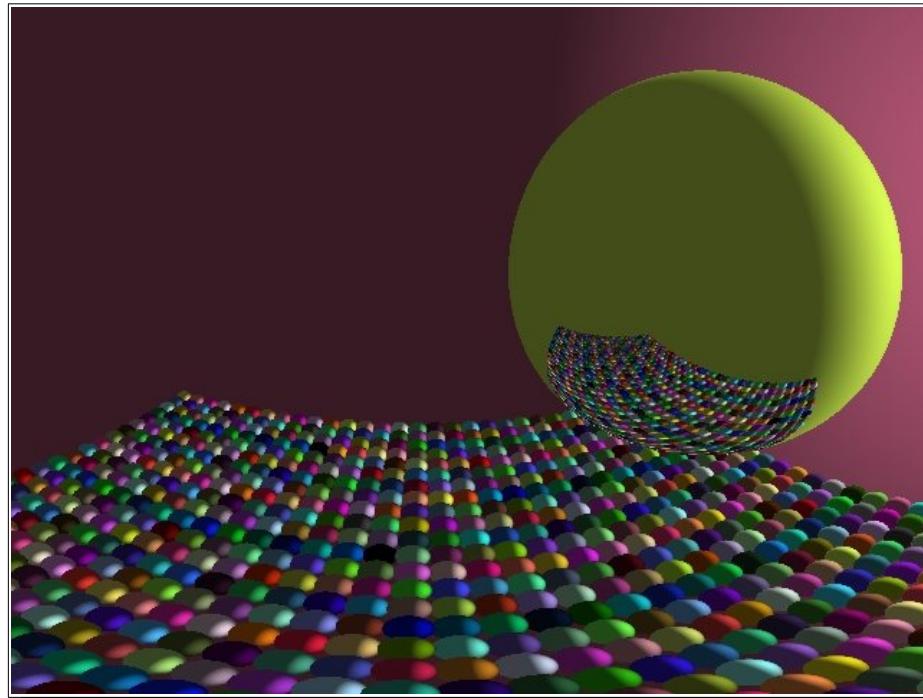
Image processing + fun



TomCat: Be Happy!

256-byte demoscene: how to beat competition?

Raytracing



TomCat: Colorful

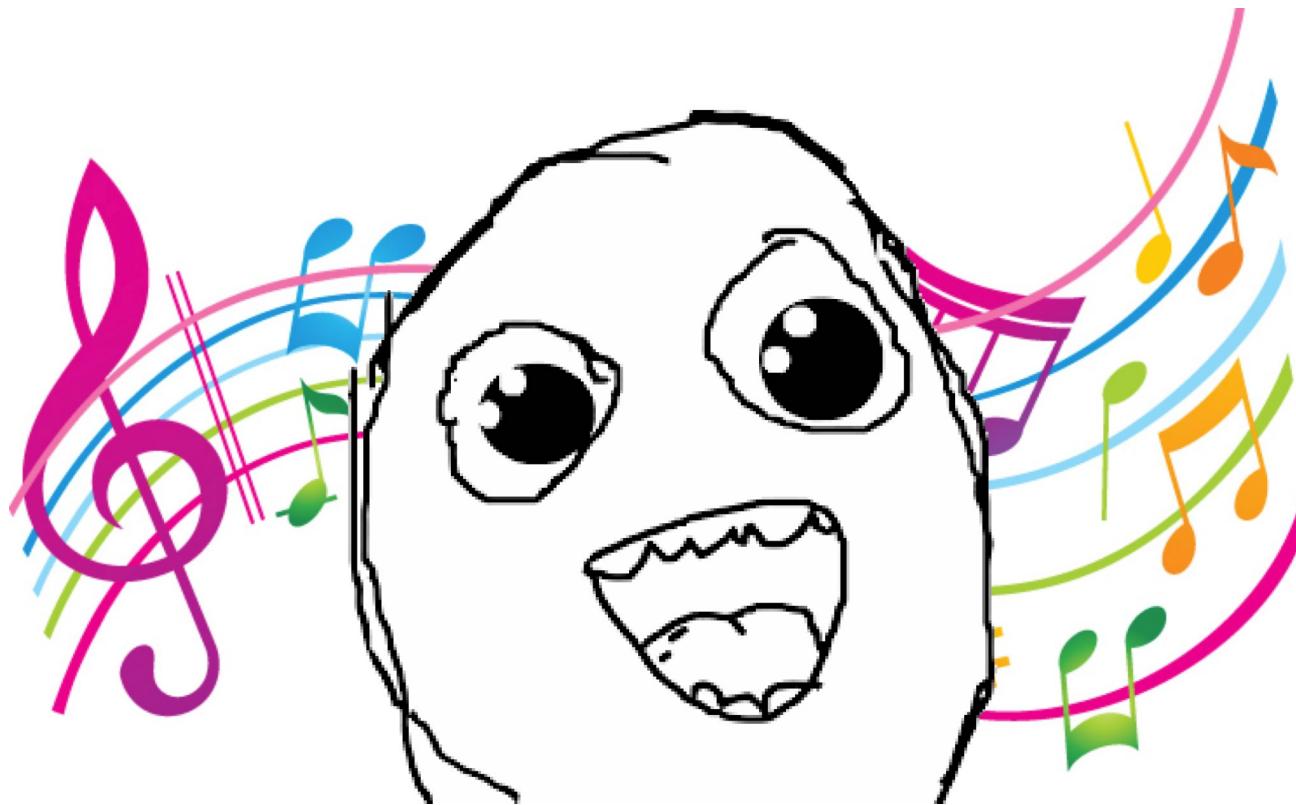
256-byte demoscene: how to beat competition?

Raytracing + fun



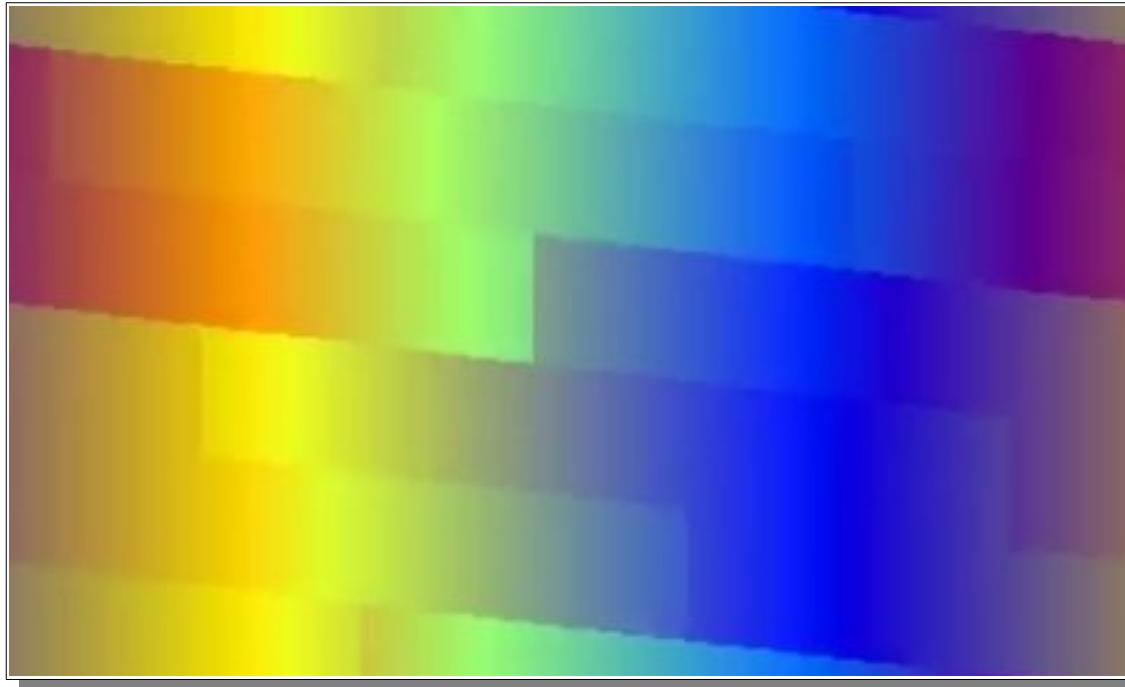
TomCat: Pokeball

256-byte demoscene: how to beat competition?



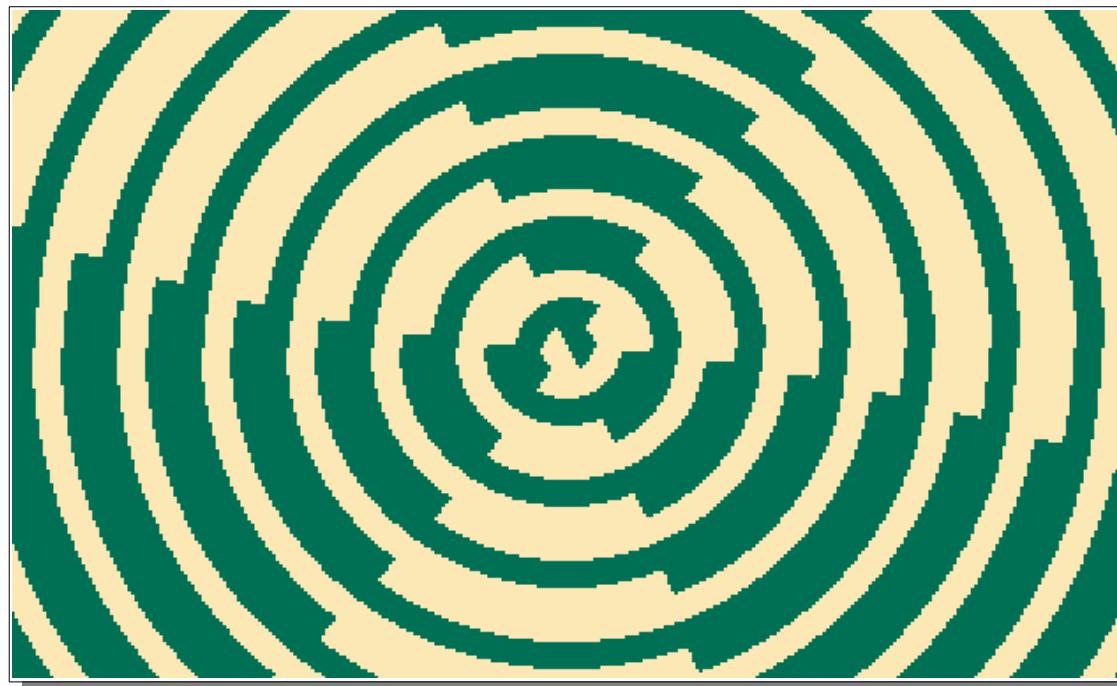
Music! Add music in 256-byte intros!

256 byte intro with music



*TomCat: 2(56)unlimited
(bytebeat music by ern0)*

256 byte intro with music



TomCat: No Sleep!
(buzzer music by ern0)

256 byte intro with music

Everyone loves it!



Create universal bytebeat tool



Create universal bytebeat tool

- Bytebeat player & editor

TomCat



Create universal bytebeat tool

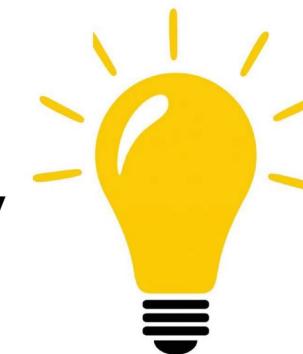
- Bytebeat player & editor

TomCat



- Formula compiler for assembly

ern0



Create universal bytebeat tool

- Bytebeat player & editor
TomCat
- Formula compiler for assembly
ern0



Create universal bytebeat tool

- Bytebeat player & editor

TomCat



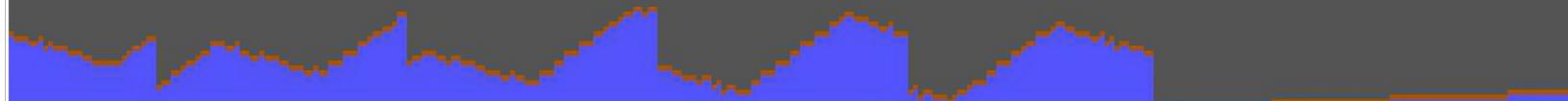
- Formula compiler for assembly

ern0



Bytebeat Editor (TomCat)

```
BYTEBEAT by TomCat/Abaddon 7 24632
freq:18939 zoom:1 out:7 vol:11173
Kick drum no:CMP1Z skip:TSTONZ
rate:16383 len:24576 vol:64
Hihat no:CMP3B skip:TST96NZ
rate:63 ien:22 rnd:99 vol:64 fade:1
Instrument1 no:CMP1B wave:sawtooth
idx:0 mask:15 len:8 tune:4 fade:1
Instrument2 no:CMP5B wave:triangle
idx:16 mask:31 len:4 tune:16 fade:1
Arpeggio no:CMP4B
idx:48 mask:7 rate:4 len:4 vol:31
```



```
9405450574B445B425B4744525059474
4 405A405743474 4 405A405743474
0525352535052505 4 405A405743474
042474 4043474 4 3 3 3 3 3 3 3 3 3
```

Bytebeat Editor (TomCat)

Features:

- realtime feedback

The screenshot shows the Bytebeat Editor interface. At the top, there is a text area containing the configuration for a bytebeat piece. Below this is a waveform visualization consisting of several blue triangles on a grey background. At the bottom, there is a hex dump of the bytebeat data.

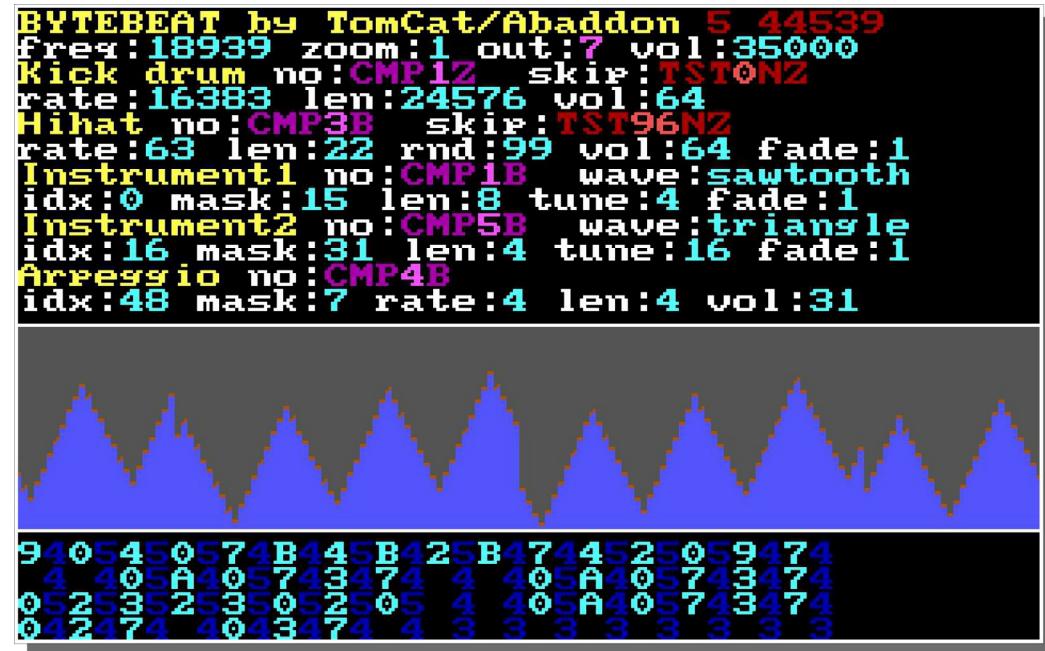
```
BYTEBEAT by TomCat/Abaddon 2 12981
freq:18939 zoom:1 out:7 vol:35000
Kick drum no:CMP1Z skip:TSTONZ
rate:16383 len:24576 vol:64
Hihat no:CMP3B skip:TST96NZ
rate:63 len:22 rnd:99 vol:64 fade:1
Instrument1 no:CMP1B wave:sawtooth
idx:0 mask:15 len:8 tune:4 fade:1
Instrument2 no:CMP5B wave:triangle
idx:16 mask:31 len:4 tune:16 fade:1
Arpeggio no:CMP4B
idx:48 mask:7 rate:4 len:4 vol:31
```

```
9405450574B445B425B4744525059474
4 405A405743474 4 405A405743474
0525352535052505 4 405A405743474
042474 4043474 4 3 3 3 3 3 3 3 3
```

Bytebeat Editor (TomCat)

Features:

- realtime feedback
- graphical sound wave



Bytebeat Editor (TomCat)

Features:

- realtime feedback
- graphical sound wave
- save/restore modified code

The screenshot shows the Bytebeat Editor interface. At the top, there is a text-based configuration section with various parameters for different instruments. Below this is a graphical sound wave visualization showing a repeating pattern of blue and grey triangles. At the bottom, there is a hex dump of the modified code.

```
BYTEBEAT by TomCat/Abaddon 2 12981
freq:18939 zoom:1 out:7 vol:35000
Kick drum no:CMP1Z skip:TSTONZ
rate:16383 len:24576 vol:64
Hihat no:CMP3B skip:TST96NZ
rate:63 len:22 rnd:99 vol:64 fade:1
Instrument1 no:CMP1B wave:sawtooth
idx:0 mask:15 len:8 tune:4 fade:1
Instrument2 no:CMP5B wave:triangle
idx:16 mask:31 len:4 tune:16 fade:1
Arpeggio no:CMP4B
idx:48 mask:7 rate:4 len:4 vol:31
```

```
9405450574B445B425B4744525059474
4 405A405743474 4 405A405743474
0525352535052505 4 405A405743474
042474 4043474 4 3 3 3 3 3 3 3 3
```

Bytebeat Editor (TomCat)

Features:

- realtime feedback
- graphical sound wave
- save/restore modified code

Issues:

- more than 70 hotkeys

BYTHEBEAT by TomCat/Abaddon 5 44539
freq:18939 zoom:1 out:7 vol:35000
Kick drum no:CMP1Z skip:TSTONZ
rate:16383 len:24576 vol:64
Hihat no:CMP3B skip:TST96NZ
rate:63 len:22 rnd:99 vol:64 fade:1
Instrument1 no:CMP1B wave:sawtooth
idx:0 mask:15 len:8 tune:4 fade:1
Instrument2 no:CMP5B wave:triangle
idx:16 mask:31 len:4 tune:16 fade:1
Arpeggio no:CMP4B
idx:48 mask:7 rate:4 len:4 vol:31

9405450574B445B425B4744525059474
4 405A405743474 4 405A405743474
0525352535052505 4 405A405743474
042474 4043474 4 3 3 3 3 3 3 3 3

Bytebeat Editor (TomCat)

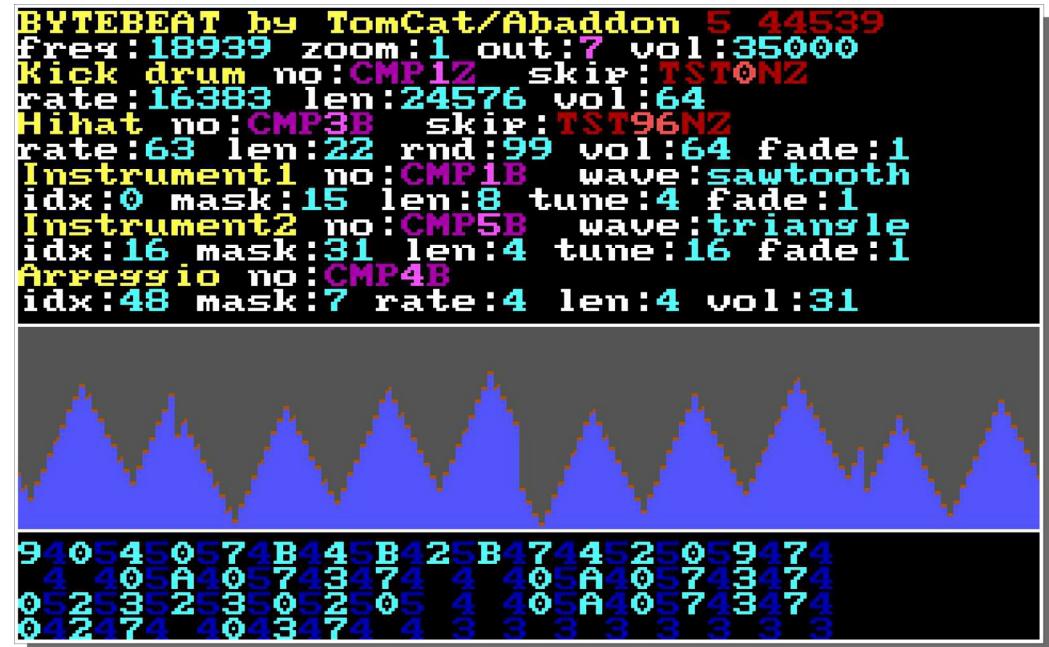
Features:

- realtime feedback
- graphical sound wave
- save/restore modified code



Issues:

- more than 70 hotkeys



Bytebeat Editor (TomCat)

Features:

- realtime feedback
- graphical sound wave
- save/restore modified code

Issues:

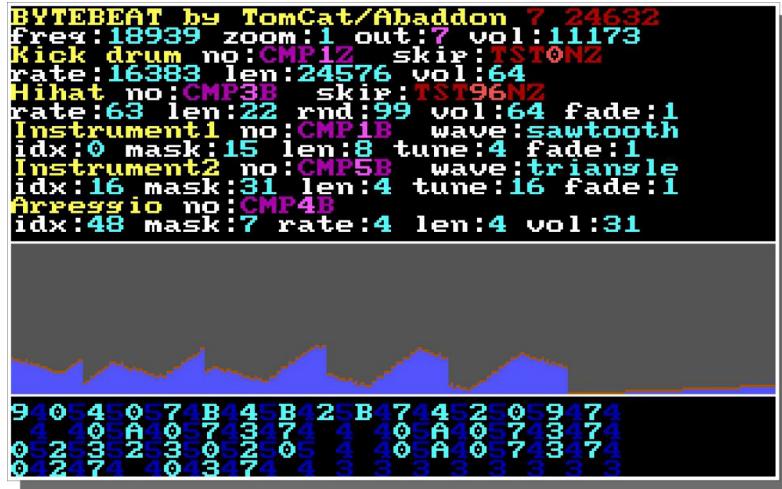
- more than 70 hotkeys
- needs some x86 coder knowledge
e.g. you can set any flag for a conditional jump

The screenshot shows the Bytebeat Editor interface. At the top, there is assembly-like code for a song titled 'BYTEBEAT by TomCat/Abaddon 2 12981'. The code includes parameters for various instruments like Kick, Drum, Hihat, and Arpeggio. Below the code is a waveform visualization consisting of several blue triangles on a grey background. At the bottom, there is a memory dump showing a sequence of bytes.

```
BYTEBEAT by TomCat/Abaddon 2 12981
freq:18939 zoom:1 out:7 vol:35000
Kick drum no:CMP1Z skip:TSTONZ
rate:16383 len:24576 vol:64
Hihat no:CMP3B skip:TST96NZ
rate:63 len:22 rnd:99 vol:64 fade:1
Instrument1 no:CMP1B wave:sawtooth
idx:0 mask:15 len:8 tune:4 fade:1
Instrument2 no:CMP5B wave:triangle
idx:16 mask:31 len:4 tune:16 fade:1
Arpeggio no:CMP4B
idx:48 mask:7 rate:4 len:4 vol:31
```

```
9405450574B445B425B4744525059474
4405A4057434744405A405743474
05253525350525054405A405743474
042474404347443333333333333333
```

Bytebeat Editor (TomCat)



Verdict:

- too complex, especially for musicians #UX

Bytebeat Editor (TomCat)



Verdict:

- too complex, especially for musicians #UX
- does not provide enough freedom

Bytebeat Editor (TomCat)



A screenshot of the Bytebeat Editor interface. On the left, there is a text editor window displaying assembly-like code for a Bytebeat track. On the right, there is a waveform visualization and a hex dump of the track's data.

```
BYTEBEAT by TomCat/Abaddon 7 24632
freq:18939 zoom:1 out:7 vol:11173
Kick drum no:CMP1Z skip:TST0NZ
rate:16383 len:24576 vol:64
Hihat no:CMP3B skip:TST96NZ
rate:63 len:22 rnd:99 vol:64 fade:1
Instrument1 no:CMP1B wave:sawtooth
idx:0 mask:15 len:8 tune:4 fade:1
Instrument2 no:CMP5B wave:triangle
idx:16 mask:31 len:4 tune:16 fade:1
Arpeggio no:CMP4B
idx:48 mask:7 rate:4 len:4 vol:31
```

9405450574B445B425B474452:0
4405A4057434744405A40574
0029352935092509400A40074
04217440134744333333333333

Verdict:

- Too Complex, especially for music fans
- UX does not provide enough freedom



Assemblyzator (ern0)

Transform bytebeat formula to assembly code...

Assemblyzator (ern0)

Transform bytebeat formula to assembly code
using a modern C compiler!

Assemblyzator (ern0)

Transform bytebeat formula to assembly code using a modern C compiler!

```
int main() {
    int result = 0;

    for (int i = 0; i < 100; i++) {
        for (int j = 0; j < 100; j++) {
            result += i * j;
        }
    }

    return result;
}
```

```
b8 e4 e0 75 01
5c3
```

```
main:
    mov     eax,0x175e0e4
    ret
```

Assemblyzator (ern0)

Transform bytebeat formula to assembly code using a modern C compiler!

```
int main() {  
    int result = 0;  
  
    for (int i = 0; i < 100; i++) {  
        for (int j = 0; j < 100; j++) {  
            result += i * j;  
        }  
    }  
  
    return result;  
}
```

```
b8 e4 e0 75 01  
5c3
```

```
main:  
    mov     eax, 0x175e0e4  
    ret
```

Very optimized!
Such compiler!



Assemblyzator (ern0)

Transform bytebeat formula to assembly code using a modern C compiler!

int main() {
 int result = 0;

 for (int i = 0; i < 100; i++) {
 for (int j = 0; j < 100; j++) {
 result += i * j;
 }
 }

 return result;
}

b8 00 00 00 01
5c3
 mov eax, 0x175e0e4
 ret

~~Vc, optimized!
such compiler!~~



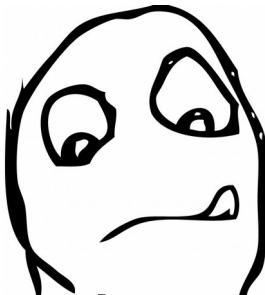
No modern compiler exists for **16-bit** target.

Assemblyzator (ern0)

Let's write a compiler thing!

Assemblylyzator (ern0)

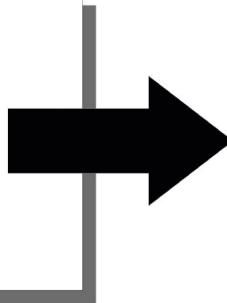
Let's write a compiler thing!



Split complex bytebeat formula
to series of simple formulas,
which is close to assembly

Assemblyzator (ern0)

```
((t<<1) ^ ((t<<1) +  
(t>>7) &t>>12)) |  
t>>(4- (1^7&(t>>19)))  
| t>>7
```



```
var3 = t << 1  
var7 = t >> 7  
var5 = var3 + var7  
var6 = t >> 12  
var4 = var5 & var6  
var1 = var3 ^ var4  
var12 = t >> 19  
var11 = 7 & var12  
var10 = 1 ^ var11  
var9 = -var10  
var9 = var9 + 4  
var8 = t >> var9  
var2 = var8 | var7  
result = var1 | var2
```

Assemblyzator (ern0)

Features:

- split formula

Assemblyzator (ern0)

Features:

- split formula
- handle num arrays

Assemblyzator (ern0)

Features:

- split formula
- handle num arrays
- handle string arrays

Assemblyzator (ern0)

Features:

- split formula
- handle num arrays
- handle string arrays
- remove duplications

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Features:

- split formula
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- handle string arrays
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Design Flaws:

- 3-op ($A = B \text{ op } C$)
8086 assembly instructions are 2-operand

Assemblyzator (ern0)

Features:

- split formula
- handle num arrays
- handle string arrays
- remove duplications

Design Flaws:

- 3-op ($A = B \text{ op } C$)
8086 assembly instructions are 2-operand
- can't handle cond. op.
 $A = (B \text{ op } C ? D : E)$
improperly designed Abstract Syntax Tree

Assemblyzator (ern0)

Features:

- split formula
- handle num arrays
- handle string arrays
- remove duplications

Design Flaws:

- 3-op ($A = B \text{ op } C$)
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- can't handle cond. op.
 $A = (B \text{ op } C ? D : E)$
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Verdict:

- nice try, but does not help much

Assemblyzator (ern0)

Features:

- split formula
- handle num arrays
- handle string arrays
- remove duplications

Design Flaws:

- 3-op ($A = B \text{ op } C$)
8086 assembly instructions are 2-operand
- can't handle cond. op.
 $A = (B \text{ op } C ? D : E)$
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Verdict:

- nice try, but does not help much
- writing a compiler is not as easy as it looks first

Assemblyzator (ern0)

Features:

- split formula
- handle num arrays
- handle string arrays
- remove duplications

Verdict:

- nice try, but it does not help much
- writing a compiler is not as easy as it looks first

Design Flaws:

- 3-op ($A = B \text{ op } C$)
8086 assembly instructions are 2-operand
can't handle cond. op.
(A op, B ? C : D)
improperly designed Abstract Syntax Tree



[TomCat] *Instead of creating universal tools,
we should choose one song and
optimize for it*

[ern0] *Right, I'll pick a song*



Some hours later...

[ern0] *I got the perfect one.*

Making of **549NOTES.COM**

the 256-byte intro for PC-DOS which plays 549 notes

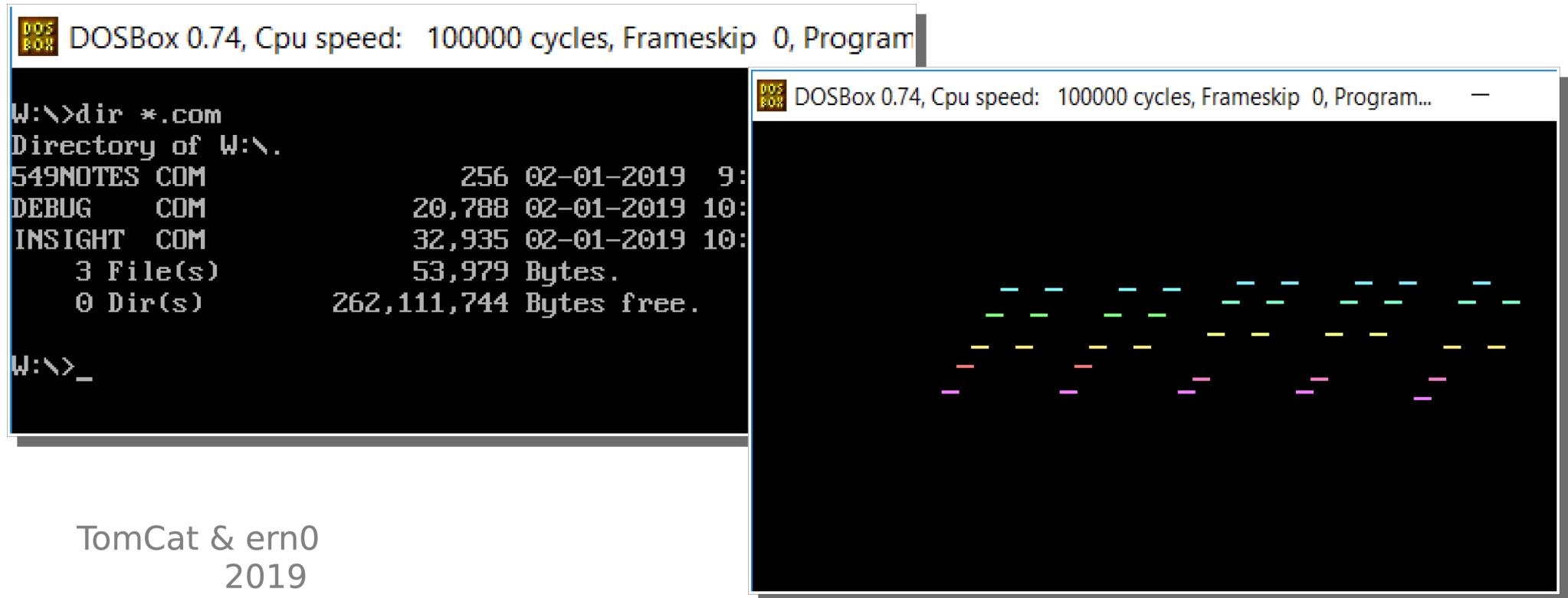


Table Of Contents

I. Song ★★★★☆

II. Data ★★★★★☆

III. Code ★★★★★★

I. Song

Prelude I

In C major

BWV 846

Johann Sebastian Bach (1685 - 1750)

Piano

This system shows the beginning of the prelude. The treble staff consists of eighth-note pairs followed by a rest. The bass staff consists of quarter notes with fermatas. The key signature is C major.

This system continues the pattern established in the first system. The treble staff has eighth-note pairs followed by rests. The bass staff has quarter notes with fermatas. A sharp sign appears in the key signature, indicating a temporary change to G major.

J. S. Bach: Prelude I. in C Major (BWV 846)

1. Popular, well-known piece

J. S. Bach: Prelude I. in C Major (BWV 846)

1. Popular, well-known piece
2. Written for piano: optimal for MIDI...

J. S. Bach: Prelude I. in C Major (BWV 846)

- Piano (patch 1) is the default instrument on all channels for all General MIDI instruments

J. S. Bach: Prelude I. in C Major (BWV 846)

- Piano (patch 1) is the default instrument on all channels for all General MIDI instruments

*Switch sound card
to MIDI mode:*

```
mov    al,3fH
mov    dx,331H
out    dx,al
```

J. S. Bach: Prelude I. in C Major (BWV 846)

- Piano (patch 1) is the default instrument on all channels for all General MIDI instruments
- Chord breaks: no „key up” message needed

*Switch sound card
to MIDI mode:*

```
mov    al,3fH
mov    dx,331H
out    dx,al
```

J. S. Bach: Prelude I. in C Major (BWV 846)

- Piano (patch 1) is the default instrument on all channels for all General MIDI instruments
- Chord breaks: no „key up” message needed

Switch sound card to MIDI mode:

```
mov    al,3fH  
mov    dx,331H  
out    dx,al
```

Play a note:

```
dec    dx  
mov    al,90H ; key down, ch=1  
out    dx,al  
lodsb          ; pitch  
out    dx,al  
mov    al,7fH ; velocity=127  
out    dx,al
```

J. S. Bach: Prelude I. in C Major (BWV 846)

- Piano (patch 1) is the default instrument on all channels for all General MIDI instruments
- Chord breaks: “key up” message needed

Switch sound card to MIDI mode:

```
mov al,3fH  
mov dx,331H  
out dx,al
```



```
90H ; key down, ch=1  
al  
; pitch  
al  
al  
al  
mov al,7fH ; velocity=127  
out dx,al
```

J. S. Bach: Prelude I. in C Major (BWV 846)

1. Popular, well-known piece
2. Written for piano: optimal for MIDI
3. Simple rhythm, only a few tempo changes...

J. S. Bach: Prelude I. in C Major (BWV 846)

Tempo changes:

- slow down around the end

J. S. Bach: Prelude I. in C Major (BWV 846)

Tempo changes:

- slow down around the end
- set minimal pause for the last 5-note chord

J. S. Bach: Prelude I. in C Major (BWV 846)

1. Popular, well-known piece
2. Written for piano: optimal for MIDI
3. Simple rhythm, only a few tempo changes
4. Contains repeating patterns...

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 1/2:

Piano

The musical score consists of two staves for piano. The top staff is in common time (4/4) and the bottom staff is also in common time (4/4). Both staves feature repeating patterns of eighth-note pairs and sixteenth-note pairs, with bass notes providing harmonic support. The music is divided into measures by vertical bar lines.

J. S. Bach: Prelude I. in C Major (BWV 846)

Repeating patterns 1/2:

Piano

4

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 1/2:

Piano

16 → 8 notes

16 → 8 notes

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 2/2:

Piano

The musical score consists of two staves for piano. The top staff is in common time (4/4) and the bottom staff is also in common time (4/4). Both staves feature a repeating pattern of eighth-note pairs followed by a sixteenth-note pair, with a bass note on the first beat of each measure. The pattern repeats four times in the top staff and five times in the bottom staff.

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 2/2:

Piano

The image displays two staves of a musical score for piano, labeled "Piano" on the left. The top staff is in common time (indicated by a "4") and the bottom staff is in common time (indicated by a "4"). Both staves feature a treble clef on the top line and a bass clef on the bottom line. The music consists of eighth-note patterns. In the first measure, the right hand has a pattern of eighth notes (purple shading) followed by a sixteenth-note rest. The left hand provides harmonic support with sustained notes and sixteenth-note patterns. This pattern repeats three more times. In the fifth measure, there is a transition where the right hand's pattern changes to a series of eighth notes (green shading), while the left hand continues its support. The pattern then repeats once more. The bottom staff follows a similar sequence, starting with a different right-hand pattern (blue shading) and transitioning to a new pattern (red shading) after the fourth measure. The left hand maintains a steady harmonic foundation throughout both staves.

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 2/2:

Piano

A musical score for the piano. The top staff is in common time (4/4) and the bottom staff is also in common time (4/4). The music features a repeating eighth-note pattern. The first four measures are highlighted with purple shading, and the last three measures are highlighted with green shading. The bass line consists of sustained notes with short vertical stems.

8 → 5 notes

A musical score for the piano. The top staff is in common time (4/4) and the bottom staff is also in common time (4/4). The music features a repeating eighth-note pattern. The first four measures are highlighted with blue shading, and the last three measures are highlighted with red shading. The bass line consists of sustained notes with short vertical stems.

Raw Data

| <i>part</i> | <i>effective notes</i> | <i>raw data</i> |
|----------------------|------------------------|-----------------|
| <i>repeating</i> | 512 | 160 |
| <i>non-repeating</i> | 32 | 32 |
| <i>final chord</i> | 5 | 5 |
| <i>total</i> | 549 | 197 |

II. Data

Data overview

```
"c-3","e-3","g-3","c-4","e-4",
"c-3","d-3","a-3","d-4","f-4",
"h-2","d-3","g-3","d-4","f-4",
"c-3","e-3","g-3","c-4","e-4",
"c-3","e-3","a-3","e-4","a-4",
"c-3","d-3","f#3","a-3","d-4",
"h-2","d-3","g-3","d-4","g-4",
"h-2","c-3","e-3","g-3","c-4",
"a-2","c-3","e-3","g-3","c-4",
"d-2","a-2","d-3","f#3","c-4",
"g-2","h-2","d-3","g-3","h-3",
"g-2","a#2","e-3","g-3","c#4",
"f-2","a-2","d-3","a-3","d-4",
"f-2","g#2","d-3","f-3","h-3",
"e-2","g-2","c-3","g-3","c-4",
"e-2","f-2","a-2","c-3","f-3",
"d-2","f-2","a-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"c-2","e-2","g-2","c-3","e-3",
"c-2","g-2","a#2","c-3","e-3",
"f-1","f-2","a-2","c-3","e-3",
"f#1","c-2","a-2","c-3","e-3",
"g#1","f-2","h-2","c-3","d-3",
"g-1","f-2","g-2","h-2","d-3",
"g-1","e-2","g-2","c-3","e-3",
"g-1","d-2","g-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"g-1","d#2","a-2","c-3","f#3",
"g-1","e-2","g-2","c-3","g-3",
"g-1","d-2","g-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"c-1","c-2","g-2","a#2","e-3"
```

Part 1:

Data overview

```
"c-3","e-3","g-3","c-4","e-4",
"c-3","d-3","a-3","d-4","f-4",
"h-2","d-3","g-3","d-4","f-4",
"c-3","e-3","g-3","c-4","e-4",
"c-3","e-3","a-3","e-4","a-4",
"c-3","d-3","f#3","a-3","d-4",
"h-2","d-3","g-3","d-4","g-4",
"h-2","c-3","e-3","g-3","c-4",
"a-2","c-3","e-3","g-3","c-4",
"d-2","a-2","d-3","f#3","c-4",
"g-2","h-2","d-3","g-3","h-3",
"g-2","a#2","e-3","g-3","c#4",
"f-2","a-2","d-3","a-3","d-4",
"f-2","g#2","d-3","f-3","h-3",
"e-2","g-2","c-3","g-3","c-4",
"e-2","f-2","a-2","c-3","f-3",
"d-2","f-2","a-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"c-2","e-2","g-2","c-3","e-3",
"c-2","g-2","a#2","c-3","e-3",
"f-1","f-2","a-2","c-3","e-3",
"f#1","c-2","a-2","c-3","e-3",
"g#1","f-2","h-2","c-3","d-3",
"g-1","f-2","g-2","h-2","d-3",
"g-1","e-2","g-2","c-3","e-3",
"g-1","d-2","g-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"g-1","d#2","a-2","c-3","f#3",
"g-1","e-2","g-2","c-3","g-3",
"g-1","d-2","g-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"c-1","c-2","g-2","a#2","e-3"
```

Part 1:

- 32 lines x 5 notes

Data overview

```
"c-3","e-3","g-3","c-4","e-4",
"c-3","d-3","a-3","d-4","f-4",
"h-2","d-3","g-3","d-4","f-4",
"c-3","e-3","g-3","c-4","e-4",
"c-3","e-3","a-3","e-4","a-4",
"c-3","d-3","f#3","a-3","d-4",
"h-2","d-3","g-3","d-4","g-4",
"h-2","c-3","e-3","g-3","c-4",
"a-2","c-3","e-3","g-3","c-4",
"d-2","a-2","d-3","f#3","c-4",
"g-2","h-2","d-3","g-3","h-3",
"g-2","a#2","e-3","g-3","c#4",
"f-2","a-2","d-3","a-3","d-4",
"f-2","g#2","d-3","f-3","h-3",
"e-2","g-2","c-3","g-3","c-4",
"e-2","f-2","a-2","c-3","f-3",
"d-2","f-2","a-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"c-2","e-2","g-2","c-3","e-3",
"c-2","g-2","a#2","c-3","e-3",
"f-1","f-2","a-2","c-3","e-3",
"f#1","c-2","a-2","c-3","e-3",
"g#1","f-2","h-2","c-3","d-3",
"g-1","f-2","g-2","h-2","d-3",
"g-1","e-2","g-2","c-3","e-3",
"g-1","d-2","g-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"g-1","d#2","a-2","c-3","f#3",
"g-1","e-2","g-2","c-3","g-3",
"g-1","d-2","g-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"c-1","c-2","g-2","a#2","e-3"
```

Part 1:

- 32 lines x 5 notes
- last 3 notes are repeated

Data overview

```
"c-3", "e-3", "g-3", "c-4", "e-4",
"c-3", "d-3", "a-3", "d-4", "f-4",
"h-2", "d-3", "g-3", "d-4", "f-4",
"c-3", "e-3", "g-3", "c-4", "e-4",
"c-3", "e-3", "a-3", "e-4", "a-4",
"c-3", "d-3", "f#3", "a-3", "d-4",
"h-2", "d-3", "g-3", "d-4", "g-4",
"h-2", "c-3", "e-3", "g-3", "c-4",
"a-2", "c-3", "e-3", "g-3", "c-4",
"d-2", "a-2", "d-3", "f#3", "c-4",
"g-2", "h-2", "d-3", "g-3", "h-3",
"g-2", "a#2", "e-3", "g-3", "c#4",
"f-2", "a-2", "d-3", "a-3", "d-4",
"f-2", "g#2", "d-3", "f-3", "h-3",
"e-2", "g-2", "c-3", "g-3", "c-4",
"e-2", "f-2", "a-2", "c-3", "f-3",
"d-2", "f-2", "a-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"c-2", "e-2", "g-2", "c-3", "e-3",
"c-2", "g-2", "a#2", "c-3", "e-3",
"f-1", "f-2", "a-2", "c-3", "e-3",
"f#1", "c-2", "a-2", "c-3", "e-3",
"g#1", "f-2", "h-2", "c-3", "d-3",
"g-1", "f-2", "g-2", "h-2", "d-3",
"g-1", "e-2", "g-2", "c-3", "e-3",
"g-1", "d-2", "g-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"g-1", "d#2", "a-2", "c-3", "f#3",
"g-1", "e-2", "g-2", "c-3", "g-3",
"g-1", "d-2", "g-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"c-1", "c-2", "g-2", "a#2", "e-3"
```

Part 1:

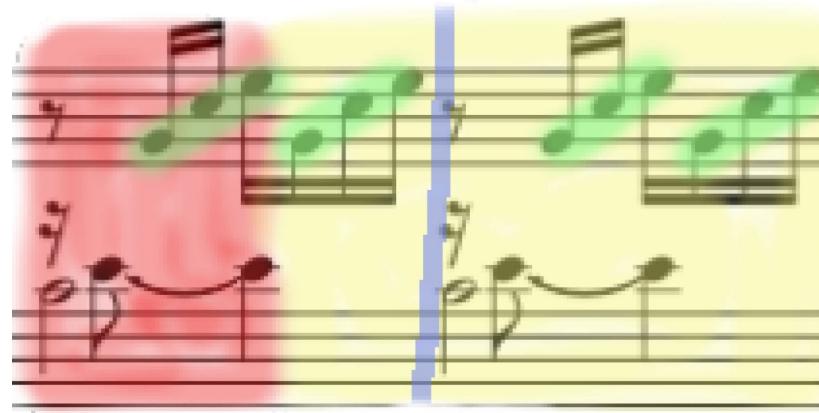
- 32 lines x 5 notes
- last 3 notes are repeated
- (8-note) lines are repeated

Data overview

```
"c-3", "e-3", "g-3", "c-4", "e-4",
"c-3", "d-3", "a-3", "d-4", "f-4",
"h-2", "d-3", "g-3", "d-4", "f-4",
"c-3", "e-3", "g-3", "c-4", "e-4",
"c-3", "e-3", "a-3", "e-4", "a-4",
"c-3", "d-3", "f#3", "a-3", "d-4",
"h-2", "d-3", "g-3", "d-4", "g-4",
"h-2", "c-3", "e-3", "g-3", "c-4",
"a-2", "c-3", "e-3", "g-3", "c-4",
"d-2", "a-2", "d-3", "f#3", "c-4",
"g-2", "h-2", "d-3", "g-3", "h-3",
"g-2", "a#2", "e-3", "g-3", "c#4",
"f-2", "a-2", "d-3", "a-3", "d-4",
"f-2", "g#2", "d-3", "f-3", "h-3",
"e-2", "g-2", "c-3", "g-3", "c-4",
"e-2", "f-2", "a-2", "c-3", "f-3",
"d-2", "f-2", "a-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"c-2", "e-2", "g-2", "c-3", "e-3",
"c-2", "g-2", "a#2", "c-3", "e-3",
"f-1", "f-2", "a-2", "c-3", "e-3",
"f#1", "c-2", "a-2", "c-3", "e-3",
"g#1", "f-2", "h-2", "c-3", "d-3",
"g-1", "f-2", "g-2", "h-2", "d-3",
"g-1", "e-2", "g-2", "c-3", "e-3",
"g-1", "d-2", "g-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"g-1", "d#2", "a-2", "c-3", "f#3",
"g-1", "e-2", "g-2", "c-3", "g-3",
"g-1", "d-2", "g-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"c-1", "c-2", "g-2", "a#2", "e-3"
```

Part 1:

- 32 lines x 5 notes
- last 3 notes are repeated
- (8-note) lines are repeated



Data overview

```
"c-3","e-3","g-3","c-4","e-4",
"c-3","d-3","a-3","d-4","f-4",
"h-2","d-3","g-3","d-4","f-4",
"c-3","e-3","g-3","c-4","e-4",
"c-3","e-3","a-3","e-4","a-4",
"c-3","d-3","f#3","a-3","d-4",
"h-2","d-3","g-3","d-4","g-4",
"h-2","c-3","e-3","g-3","c-4",
"a-2","c-3","e-3","g-3","c-4",
"d-2","a-2","d-3","f#3","c-4",
"g-2","h-2","d-3","g-3","h-3",
"g-2","a#2","e-3","g-3","c#4",
"f-2","a-2","d-3","a-3","d-4",
"f-2","g#2","d-3","f-3","h-3",
"e-2","g-2","c-3","g-3","c-4",
"e-2","f-2","a-2","c-3","f-3",
"d-2","f-2","a-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"c-2","e-2","g-2","c-3","e-3",
"c-2","g-2","a#2","c-3","e-3",
"f-1","f-2","a-2","c-3","e-3",
"f#1","c-2","a-2","c-3","e-3",
"g#1","f-2","h-2","c-3","d-3",
"g-1","f-2","g-2","h-2","d-3",
"g-1","e-2","g-2","c-3","e-3",
"g-1","d-2","g-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"g-1","d#2","a-2","c-3","f#3",
"g-1","e-2","g-2","c-3","g-3",
"g-1","d-2","g-2","c-3","f-3",
"g-1","d-2","g-2","h-2","f-3",
"c-1","c-2","g-2","a#2","e-3"
```

Part 1:

- 32 lines x 5 notes
- last 3 notes are repeated
- (8-note) lines are repeated

```
"c-1","c-2","f-2","a-2","c-3","f-3","c-3","a-2",
"c-3","a-2","f-2","a-2","f-2","d-2","f-2","d-2",
"c-1","h-1","g-3","h-3","d-4","f-4","d-4","h-3",
"d-4","h-3","g-3","h-3","d-3","f-3","e-3","d-3"
```

Part 2:

- 32 notes
- no tricks

Data overview

```
"c-3", "e-3", "g-3", "c-4", "e-4",
"c-3", "d-3", "a-3", "d-4", "f-4",

```

```
"c-3", "e-3", "a-3", "e-4", "a-4",
"c-3", "d-3", "f#3", "a-3", "d-4",

```

```
"a-2", "c-3", "e-3", "g-3", "c-4",
"d-2", "a-2", "d-3", "f#3", "c-4",
"g-2", "h-2", "d-3", "g-3", "h-3",
"g-2", "a#2", "e-3", "g-3", "c#4",
```

```
"f-2", "a-2", "d-3", "a-3", "d-4",
"f-2", "g#2", "d-3", "f-3", "h-3",
"e-2", "g-2", "c-3", "g-3", "c-4",
"e-2", "f-2", "a-2", "c-3", "f-3",
```

```
"d-2", "f-2", "a-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"c-2", "e-2", "g-2", "c-3", "e-3",
"c-2", "g-2", "a#2", "c-3", "e-3",
```

```
"f-1", "f-2", "a-2", "c-3", "e-3",
"f#1", "c-2", "a-2", "c-3", "e-3",
"g#1", "f-2", "h-2", "c-3", "d-3",
"g-1", "f-2", "g-2", "h-2", "d-3",
```

```
"g-1", "e-2", "g-2", "c-3", "e-3",
"g-1", "d-2", "g-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"g-1", "d#2", "a-2", "c-3", "f#3",
```

```
"g-1", "e-2", "g-2", "c-3", "g-3",
"g-1", "d-2", "g-2", "c-3", "f-3",
"g-1", "d-2", "g-2", "h-2", "f-3",
"c-1", "c-2", "g-2", "a#2", "e-3"
```

Part 1:

- 32 lines x 5 notes
- last 3 notes are repeated
- (8-note) lines are repeated

```
"c-1", "c-2", "f-2", "a-2", "c-3", "f-3", "c-3", "a-2",
"c-3", "a-2", "f-2", "a-2", "f-2", "d-2", "f-2", "d-2",
"c-1", "h-1", "g-3", "h-3", "d-4", "f-4", "d-4", "h-3",
"d-4", "h-3", "g-3", "h-3", "d-3", "f-3", "e-3", "d-3"
```

Part 2:

- 32 notes
- no tricks

```
"c-1", "c-2", "e-3", "g-3", "c-4"
```

Part3:

- 5 notes
- no tricks

Histogram of raw (31 values, 197 notes)

| | | | | | | | | |
|----------|----|-------|--|---|-----|--------|----|-------|
| ; c-1:36 | 4 | #### | | ; | 1. | c-3:60 | 23 | ##### |
| ; f-1:41 | 1 | # | | ; | 2. | g-2:55 | 14 | ##### |
| ; f#1:42 | 1 | # | | ; | 3. | e-3:64 | 14 | ##### |
| ; g-1:43 | 9 | ##### | | ; | 4. | g-3:67 | 13 | ##### |
| ; g#1:44 | 1 | # | | ; | 5. | d-3:62 | 12 | ##### |
| ; h-1:47 | 1 | # | | ; | 6. | a-2:57 | 12 | ##### |
| ; c-2:48 | 6 | ##### | | ; | 7. | f-2:53 | 11 | ##### |
| ; d-2:50 | 9 | ##### | | ; | 8. | f-3:65 | 10 | ##### |
| ; d#2:51 | 1 | # | | ; | 9. | h-2:59 | 9 | ##### |
| ; e-2:52 | 5 | #### | | ; | 10. | g-1:43 | 9 | ##### |
| ; f-2:53 | 11 | ##### | | ; | 11. | d-2:50 | 9 | ##### |
| ; g-2:55 | 14 | ##### | | ; | 12. | d-4:74 | 8 | ##### |
| ; g#2:56 | 1 | # | | ; | 13. | c-4:72 | 7 | ##### |
| ; a-2:57 | 12 | ##### | | ; | 14. | h-3:71 | 6 | ##### |
| ; a#2:58 | 3 | ## | | ; | 15. | c-2:48 | 6 | ##### |
| ; h-2:59 | 9 | ##### | | ; | 16. | e-2:52 | 5 | ##### |
| ; c-3:60 | 23 | ##### | | ; | 17. | c-1:36 | 4 | ##### |
| ; d-3:62 | 12 | ##### | | ; | 18. | a-3:69 | 4 | ##### |
| ; e-3:64 | 14 | ##### | | ; | 19. | f-4:77 | 3 | ### |
| ; f-3:65 | 10 | ##### | | ; | 20. | f#3:66 | 3 | ### |
| ; f#3:66 | 3 | ## | | ; | 21. | e-4:76 | 3 | ### |
| ; g-3:67 | 13 | ##### | | ; | 22. | a#2:58 | 3 | ### |
| ; a-3:69 | 4 | ## | | ; | 23. | h-1:47 | 1 | # |
| ; h-3:71 | 6 | ## | | ; | 24. | g-4:79 | 1 | # |
| ; c-4:72 | 7 | ## | | ; | 25. | g#2:56 | 1 | # |
| ; c#4:73 | 1 | # | | ; | 26. | g#1:44 | 1 | # |
| ; d-4:74 | 8 | ## | | ; | 27. | f-1:41 | 1 | # |
| ; e-4:76 | 3 | ## | | ; | 28. | f#1:42 | 1 | # |
| ; f-4:77 | 3 | ## | | ; | 29. | d#2:51 | 1 | # |
| ; g-4:79 | 1 | # | | ; | 30. | c#4:73 | 1 | # |
| ; a-4:81 | 1 | # | | ; | 31. | a-4:81 | 1 | # |

Histogram of raw (31 values, 197 notes)

| | | | | | | |
|----------|----|-------|--|--------------|----|-------|
| ; c-1:36 | 4 | #### | | ; 1. c-3:60 | 23 | ##### |
| ; f-1:41 | 1 | # | | ; 2. g-2:55 | 14 | ##### |
| ; f#1:42 | 1 | # | | ; 3. e-3:64 | 14 | ##### |
| ; g-1:43 | 9 | ##### | | ; 4. g-3:67 | 13 | ##### |
| ; g#1:44 | 1 | # | | ; 5. d-3:62 | 12 | ##### |
| ; h-1:47 | 1 | # | | ; 6. g-2:53 | 11 | ##### |
| ; c-2:48 | 6 | ##### | | ; 7. f-2:53 | 11 | ##### |
| ; d-2:50 | 9 | ##### | | ; 8. f-3:65 | 10 | ##### |
| ; d#2:51 | 1 | # | | ; 9. h-2:59 | 9 | ##### |
| ; e-2:52 | 5 | ##### | | ; 10. g-1:42 | 8 | ##### |
| ; f-2:53 | 11 | ##### | | ; 11. d-2:51 | 8 | ##### |
| ; g-2:55 | 14 | ##### | | ; 12. d-4:74 | 8 | ##### |
| ; g#2:56 | 1 | # | | ; 13. c-4:72 | 7 | ##### |
| ; a-2:57 | 12 | ##### | | ; 14. h-3:71 | 6 | ##### |
| ; a#2:58 | 3 | ## | | ; 15. c-2:48 | 6 | ##### |
| ; h-2:59 | 9 | ##### | | ; 16. e-2:52 | 5 | ##### |
| ; c-3:60 | 23 | ##### | | ; 17. c-1:36 | 4 | ##### |
| ; d-3:62 | 12 | ##### | | ; 18. a-3:69 | 4 | ##### |
| ; e-3:64 | 14 | ##### | | ; 19. f-4:77 | 3 | ### |
| ; f-3:65 | 10 | ##### | | ; 20. f#3:66 | 3 | ### |
| ; f#3:66 | 3 | ## | | ; 21. e-4:76 | 3 | ### |
| ; g-3:67 | 13 | ##### | | ; 22. a#2:58 | 3 | ### |
| ; a-3:69 | 4 | ## | | ; 23. h-1:47 | 1 | # |
| ; h-3:71 | 6 | ## | | ; 24. g-4:79 | 1 | # |
| ; c-4:72 | 7 | ## | | ; 25. g#2:56 | 1 | # |
| ; c#4:73 | 1 | # | | ; 26. g#1:44 | 1 | # |
| ; d-4:74 | 8 | ## | | ; 27. f-1:41 | 1 | # |
| ; e-4:76 | 3 | ## | | ; 28. f#1:42 | 1 | # |
| ; f-4:77 | 3 | ## | | ; 29. d#2:51 | 1 | # |
| ; g-4:79 | 1 | # | | ; 30. c#4:73 | 1 | # |
| ; a-4:81 | 1 | # | | ; 31. a-4:81 | 1 | # |

notes: 5 bit x 197 = 124 byte
table: 31 byte
total: 155 byte

Histogram of raw (31 values, 197 notes)

| | | | | | | |
|----------|----|-------|--|--------------|----|-------|
| ; c-1:36 | 4 | #### | | ; 1. c-3:60 | 23 | ##### |
| ; f-1:41 | 1 | # | | ; 2. g-2:55 | 14 | ##### |
| ; f#1:42 | 1 | # | | ; 3. e-3:64 | 14 | ##### |
| ; g-1:43 | 9 | ##### | | ; 4. g-3:67 | 13 | ##### |
| ; g#1:44 | 1 | # | | ; 5. d-3:62 | 12 | ##### |
| ; h-1:47 | 1 | # | | ; 6. a-2:53 | 12 | ##### |
| ; c-2:48 | 6 | #### | | ; 7. f-2:53 | 11 | ##### |
| ; d-2:50 | 9 | #### | | ; 8. f-3:65 | 10 | ##### |
| ; d#2:51 | 1 | # | | ; 9. h-2:59 | 9 | ##### |
| ; e-2:52 | 5 | ## | | ; 10. g-1:43 | 9 | ##### |
| ; f-2:53 | 11 | + | | ; 11. d-2:50 | 9 | ##### |
| ; g-2:55 | 14 | ##### | | ; 12. d-4:74 | 8 | ##### |
| ; g#2:56 | 1 | # | | ; 13. c-4:72 | 7 | ##### |
| ; a-2:57 | 12 | ##### | | ; 14. h-3:71 | 6 | ##### |
| ; a#2:58 | 3 | ## | | ; 15. c-2:48 | 6 | ##### |
| ; h-2:59 | 9 | ##### | | ; 16. e-2:52 | 5 | ##### |
| ; c-3:60 | 23 | ##### | | ; 17. c-1:36 | 4 | ##### |
| ; d-3:62 | 12 | ##### | | ; 18. a-3:69 | 4 | ##### |
| ; e-3:64 | 14 | ##### | | ; 19. f-4:77 | 3 | ##### |
| ; f-3:65 | 10 | ##### | | ; 20. f#3:66 | 3 | ##### |
| ; f#3:66 | 3 | ## | | ; 21. e-4:76 | 3 | ##### |
| ; g-3:67 | 13 | ##### | | ; 22. a#2:58 | 3 | ##### |
| ; a-3:69 | 4 | ## | | ; 23. h-1:47 | 1 | # |
| ; h-3:71 | 6 | ## | | ; 24. g-4:79 | 1 | # |
| ; c-4:72 | 7 | ## | | ; 25. g#2:56 | 1 | # |
| ; c#4:73 | 1 | # | | ; 26. g#1:44 | 1 | # |
| ; d-4:74 | 8 | ## | | ; 27. f-1:41 | 1 | # |
| ; e-4:76 | 3 | ## | | ; 28. f#1:42 | 1 | # |
| ; f-4:77 | 3 | ## | | ; 29. d#2:51 | 1 | # |
| ; g-4:79 | 1 | # | | ; 30. c#4:73 | 1 | # |
| ; a-4:81 | 1 | # | | ; 31. a-4:81 | 1 | # |

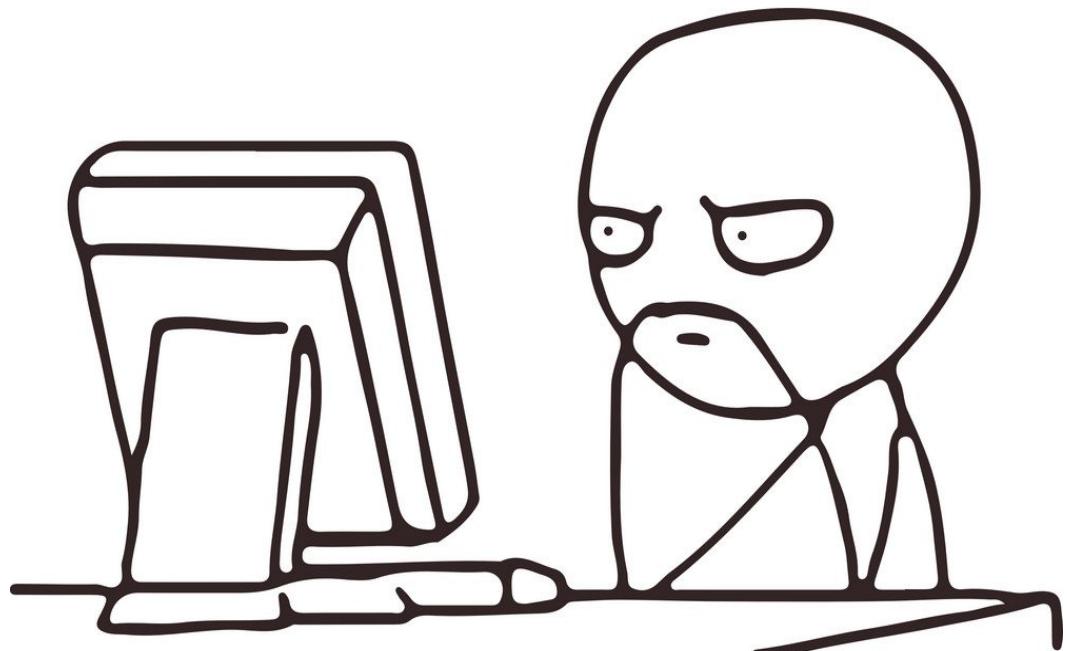
note range: 36 .. 81: 45 values

values: 6 bit x 197 = 148 byte

Think Diff

```
; c-3:60  e-3:64  g-3:67  c-4:72  e-4:76  (...)  
; c-3:60  d-3:62  a-3:69  d-4:74  f-4:77  (...)  
; h-2:59  d-3:62  g-3:67  d-4:74  f-4:77  (...)  
; c-3:60  e-3:64  g-3:67  c-4:72  e-4:76  (...)  
; c-3:60  e-3:64  a-3:69  e-4:76  a-4:81  (...)  
; c-3:60  d-3:62  f#3:66  a-3:69  d-4:74  (...)  
; h-2:59  d-3:62  g-3:67  d-4:74  g-4:79  (...)  
; h-2:59  c-3:60  e-3:64  g-3:67  c-4:72  (...)  
; a-2:57  c-3:60  e-3:64  g-3:67  c-4:72  (...)  
; d-2:50  a-2:57  d-3:62  f#3:66  c-4:72  (...)  
; g-2:55  h-2:59  d-3:62  g-3:67  h-3:71  (...)  
; g-2:55  a#2:58  e-3:64  g-3:67  c#4:73  (...)  
; f-2:53  a-2:57  d-3:62  a-3:69  d-4:74  (...)  
; f-2:53  g#2:56  d-3:62  f-3:65  h-3:71  (...)  
; e-2:52  g-2:55  c-3:60  g-3:67  c-4:72  (...)  
; e-2:52  f-2:53  a-2:57  c-3:60  f-3:65  (...)  
; d-2:50  f-2:53  a-2:57  c-3:60  f-3:65  (...)  
; g-1:43  d-2:50  g-2:55  h-2:59  f-3:65  (...)  
; c-2:48  e-2:52  g-2:55  c-3:60  e-3:64  (...)  
; c-2:48  g-2:55  a#2:58  c-3:60  e-3:64  (...)  
; f-1:41  f-2:53  a-2:57  c-3:60  e-3:64  (...)  
; f#1:42  c-2:48  a-2:57  c-3:60  e-3:64  (...)  
; g#1:44  f-2:53  h-2:59  c-3:60  d-3:62  (...)  
; g-1:43  f-2:53  g-2:55  h-2:59  d-3:62  (...)  
; g-1:43  e-2:52  g-2:55  c-3:60  e-3:64  (...)  
; g-1:43  d-2:50  g-2:55  c-3:60  f-3:65  (...)  
; g-1:43  d-2:50  g-2:55  h-2:59  f-3:65  (...)  
; g-1:43  d#2:51  a-2:57  c-3:60  f#3:66  (...)  
; g-1:43  e-2:52  g-2:55  c-3:60  g-3:67  (...)  
; g-1:43  d-2:50  g-2:55  c-3:60  f-3:65  (...)  
; g-1:43  d-2:50  g-2:55  h-2:59  f-3:65  (...)  
; c-1:36  c-2:48  g-2:55  a#2:58  e-3:64  (...)
```

```
; c-1:36  c-2:48  f-2:53  a-2:57  c-3:60  f-3:65  c-3:60  a-2:57  
; c-3:60  a-2:57  f-2:53  a-2:57  f-2:53  d-2:50  f-2:53  d-2:50  
; c-1:36  h-1:47  g-3:67  h-3:71  d-4:74  f-4:77  d-4:74  h-3:71  
; d-4:74  h-3:71  g-3:67  h-3:71  d-3:62  f-3:65  e-3:64  d-3:62  
; c-1:36  c-2:48  e-3:64  g-3:67  c-4:72
```



Think Diff

```
; c-3:60 e-3:64 g-3:67 c-4:72 e-4:76 (...)  
; c-3:60 d-3:62 a-3:69 d-4:74 f-4:77 (...)  
; h-2:59 d-3:62 g-3:67 d-4:74 f-4:77 (...)  
; c-3:60 e-3:64 g-3:67 c-4:72 e-4:76 (...)  
; a-3:60 e-3:64 a-3:69 e-4:76 a-4:81 (...)  
; c-3:60 d-3:62 f#3:66 a-3:69 d-4:74 (...)  
h-2:59 d-3:62 g-3:67 d-4:74 g-4:79 (...)  
h-2:59 c-3:60 e-3:64 g-3:67 c-4:72 (...)  
a-2:57 c-3:60 e-3:64 g-3:67 c-4:72 (...)  
d-2:50 a-2:57 d-3:62 f#3:66 c-4:72 (...)  
g-2:55 h-2:59 d-3:62 g-3:67 h-3:71 (...)  
g-2:55 a#2:58 e-3:64 g-3:67 c#4:73 (...)  
f-2:53 a-2:57 d-3:62 a-3:69 d-4:74 (...)  
e-2:53 g#2:56 d-3:62 a-3:69 d-4:71 (...)  
e-2:52 g-2:55 c-3:60 g-3:67 (...)  
e-2:52 f-2:53 a-2:57 c-3:60 (...)  
d-2:50 f-2:53 a-2:57 c-3:60 f-3:65 (...)  
g-1:43 d-2:50 g-2:55 h-2:59 f-3:65 (...)  
c-2:48 e-2:52 g-2:55 c-3:60 e-3:64 (...)  
c-2:48 g-2:55 a#2:58 c-3:60 e-3:64 (...)  
f-1:41 f-2:53 a-2:57 c-3:60 e-3:64 (...)  
f#1:42 c-2:48 a-2:57 c-3:60 e-3:64 (...)  
g#1:44 f-2:53 h-2:59 c-3:60 d-3:62 (...)  
g-1:43 f-2:53 g-2:55 h-2:59 d-3:62 (...)  
g-1:43 e-2:52 g-2:55 c-3:60 e-3:64 (...)  
g-1:43 d-2:50 g-2:55 c-3:60 f-3:65 (...)  
g-1:43 d-2:50 g-2:55 h-2:59 f-3:65 (...)  
g-1:43 d#2:51 a-2:57 c-3:60 f#3:66 (...)  
g-1:43 e-2:52 g-2:55 c-3:60 g-3:67 (...)  
g-1:43 d-2:50 g-2:55 c-3:60 f-3:65 (...)  
g-1:43 d-2:50 g-2:55 h-2:59 f-3:65 (...)  
c-1:36 c-2:48 g-2:55 a#2:58 e-3:64 (...)
```

```
; c-1:36 c-2:48 f-2:53 a-2:57 c-3:60 f-3:65 c-3:60 a-2:57  
; c-3:60 a-2:57 f-2:53 a-2:57 f-2:53 d-2:50 f-2:53 d-2:50  
; c-1:36 h-1:47 g-3:67 h-3:71 d-4:74 f-4:77 d-4:74 h-3:71  
; d-4:74 h-3:71 g-3:67 h-3:71 d-3:62 f-3:65 e-3:64 d-3:62  
; c-1:36 c-2:48 e-3:64 g-3:67 c-4:72
```

Focus on values of Part 1



Think Diff

| | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| c-3:60 | e-3:64 | g-3:67 | c-4:72 | e-4:76 | d-2:50 | f-2:53 | a-2:57 | c-3:60 | f-3:65 |
| c-3:60 | d-3:62 | a-3:69 | d-4:74 | f-4:77 | g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| h-2:59 | d-3:62 | g-3:67 | d-4:74 | f-4:77 | c-2:48 | e-2:52 | g-2:55 | c-3:60 | e-3:64 |
| c-3:60 | e-3:64 | g-3:67 | c-4:72 | e-4:76 | c-2:48 | g-2:55 | a#2:58 | c-3:60 | e-3:64 |
| c-3:60 | e-3:64 | a-3:69 | e-4:76 | a-4:81 | f-1:41 | f-2:53 | a-2:57 | c-3:60 | e-3:64 |
| c-3:60 | d-3:62 | f#3:66 | a-3:69 | d-4:74 | f#1:42 | c-2:48 | a-2:57 | c-3:60 | e-3:64 |
| h-2:59 | d-3:62 | g-3:67 | d-4:74 | g-4:79 | g#1:44 | f-2:53 | h-2:59 | c-3:60 | e-3:64 |
| h-2:59 | c-3:60 | e-3:64 | g-3:67 | c-4:72 | g-1:43 | f-2:53 | g-2:55 | h-2:59 | d-3:62 |
| a-2:57 | c-3:60 | e-3:64 | g-3:67 | c-4:72 | g-1:43 | e-2:52 | g-2:55 | c-3:60 | d-3:62 |
| d-2:50 | a-2:57 | d-3:62 | f#3:66 | c-4:72 | g-1:43 | d-2:50 | g-2:55 | c-3:60 | e-3:64 |
| g-2:55 | h-2:59 | d-3:62 | g-3:67 | h-3:71 | g-1:43 | d-2:50 | g-2:55 | c-3:60 | f-3:65 |
| g-2:55 | a#2:58 | e-3:64 | g-3:67 | c#4:73 | g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| f-2:53 | a-2:57 | d-3:62 | a-3:69 | d-4:74 | g-1:43 | d#2:51 | a-2:57 | c-3:60 | f#3:66 |
| f-2:53 | g#2:56 | d-3:62 | f-3:65 | h-3:71 | g-1:43 | e-2:52 | g-2:55 | c-3:60 | g-3:67 |
| e-2:52 | g-2:55 | c-3:60 | g-3:67 | c-4:72 | g-1:43 | d-2:50 | g-2:55 | c-3:60 | f-3:65 |
| e-2:52 | f-2:53 | a-2:57 | c-3:60 | f-3:65 | g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| | | | | | c-1:36 | c-2:48 | g-2:55 | a#2:58 | e-3:64 |

Think Diff

| | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| c-3:60 | e-3:64 | g-3:67 | c-4:72 | e-4:76 | d-2:50 | f-2:53 | a-2:57 | c-3:60 | f-3:65 |
| c-3:60 | d-3:62 | a-3:69 | d-4:74 | f-4:77 | g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| h-2:59 | d-3:62 | g-3:67 | d-4:74 | f-4:77 | c-2:48 | e-2:52 | g-2:55 | c-3:60 | e-3:64 |
| c-3:60 | e-3:64 | g-3:67 | c-4:72 | e-4:76 | c-2:48 | g-2:55 | a#2:58 | c-3:60 | e-3:64 |
| c-3:60 | e-3:64 | a-3:69 | e-4:76 | a-4:81 | f-1:41 | f-2:53 | a-2:57 | c-3:60 | e-3:64 |
| c-3:60 | d-3:62 | f#3:66 | a-3:69 | d-4:74 | f#1:42 | c-2:48 | a-2:57 | c-3:60 | e-3:64 |
| h-2:59 | d-3:62 | g-3:67 | d-4:74 | g-4:79 | g#1:44 | f-2:53 | h-2:59 | c-3:60 | d-3:62 |
| h-2:59 | c-3:60 | e-3:64 | g-3:67 | c-4:72 | g-1:43 | f-2:53 | g-2:55 | h-2:59 | d-3:62 |
| a-2:57 | c-3:60 | e-3:64 | g-3:67 | c-4:72 | g-1:43 | e-2:52 | g-2:55 | c-3:60 | e-3:64 |
| d-2:50 | a-2:57 | d-3:62 | f#3:66 | c-4:72 | g-1:43 | d-2:50 | g-2:55 | c-3:60 | f-3:65 |
| g-2:55 | h-2:59 | d-3:62 | g-3:67 | h-3:71 | g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| g-2:55 | a#2:58 | e-3:64 | g-3:67 | c#4:73 | g-1:43 | d#2:51 | a-2:57 | c-3:60 | f#3:66 |
| f-2:53 | a-2:57 | d-3:62 | a-3:69 | d-4:74 | g-1:43 | e-2:52 | g-2:55 | c-3:60 | g-3:67 |
| f-2:53 | g#2:56 | d-3:62 | f-3:65 | h-3:71 | g-1:43 | d-2:50 | g-2:55 | c-3:60 | f-3:65 |
| e-2:52 | g-2:55 | c-3:60 | g-3:67 | c-4:72 | g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| e-2:52 | f-2:53 | a-2:57 | c-3:60 | f-3:65 | c-1:36 | c-2:48 | g-2:55 | a#2:58 | e-3:64 |

Think Diff

| | | | | |
|--------|--------|--------|--------|--------|
| c-3:60 | e-3:64 | g-3:67 | c-4:72 | e-4:76 |
| c-3:60 | d-3:62 | a-3:69 | d-4:74 | f-4:77 |
| h-2:59 | d-3:62 | g-3:67 | d-4:74 | f-4:77 |
| c-3:60 | e-3:64 | g-3:67 | c-4:72 | e-4:76 |
| c-3:60 | e-3:64 | a-3:69 | e-4:76 | a-4:81 |
| c-3:60 | d-3:62 | f#3:66 | a-3:69 | d-4:74 |
| h-2:59 | d-3:62 | g-3:67 | d-4:74 | g-4:79 |
| h-2:59 | c-3:60 | e-3:64 | g-3:67 | c-4:72 |
| a-2:57 | c-3:60 | e-3:64 | g-3:67 | c-4:72 |
| d-2:50 | a-2:57 | d-3:62 | f#3:66 | c-4:72 |
| g-2:55 | h-2:59 | d-3:62 | g-3:67 | h-3:71 |
| g-2:55 | a#2:58 | e-3:64 | g-3:67 | c#4:73 |
| f-2:53 | a-2:57 | d-3:62 | a-3:69 | d-4:74 |
| f-2:53 | g#2:56 | d-3:62 | f-3:65 | h-3:71 |
| e-2:52 | g-2:55 | c-3:60 | g-3:67 | c-4:72 |
| e-2:52 | f-2:53 | a-2:57 | c-3:60 | f-3:65 |

| | | | | |
|--------|--------|--------|--------|--------|
| d-2:50 | f-2:53 | a-2:57 | c-3:60 | f-3:65 |
| g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| c-2:48 | e-2:52 | g-2:55 | c-3:60 | e-3:64 |
| c-2:48 | g-2:55 | a#2:58 | c-3:60 | e-3:64 |
| f-1:41 | f-2:53 | a-2:57 | c-3:60 | e-3:64 |
| f#1:42 | c-2:48 | a-2:57 | c-3:60 | e-3:64 |
| g#1:44 | f-2:53 | h-2:59 | c-3:60 | d-3:62 |
| g-1:43 | f-2:53 | g-2:55 | h-2:59 | d-3:62 |
| g-1:43 | e-2:52 | g-2:55 | c-3:60 | e-3:64 |
| g-1:43 | d-2:50 | g-2:55 | c-3:60 | f-3:65 |
| g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| g-1:43 | d#2:51 | a-2:57 | c-3:60 | f#3:66 |
| g-1:43 | e-2:52 | g-2:55 | c-3:60 | g-3:67 |
| g-1:43 | d-2:50 | g-2:55 | c-3:60 | f-3:65 |
| g-1:43 | d-2:50 | g-2:55 | h-2:59 | f-3:65 |
| c-1:36 | c-2:48 | g-2:55 | a#2:58 | e-3:64 |



The raw-diff-5 theory

Think Diff: why raw-diff-5?

Why raw?

Think Diff: why raw-diff-5?

Why raw?

- Two options:
 - raw MIDI notes or
 - indexed data

Think Diff: why raw-diff-5?

Why raw?

- Two options:
 - raw MIDI notes or
 - indexed data
- Dispersion: 31 values in range of 45

Think Diff: why raw-diff-5?

Why raw?

- Two options:
 - raw MIDI notes or
 - indexed data
- Dispersion: 31 values in range of 45
- Indexed requires extra 31-byte table

Think Diff: why raw-diff-5?

Why raw?

- Two options:
 - raw MIDI notes or
 - indexed data
- Dispersion: 31 values in range of 45
- Indexed requires extra 31-byte table
- Can't compress table, only data

Think Diff: why raw-diff-5?

Why diff-5?

Think Diff: why raw-diff-5?

Why diff-5?

- Part 1 contains chord breaks

Think Diff: why raw-diff-5?

Why diff-5?

- Part 1 contains chord breaks
- Chords are evolving slowly to next one

Think Diff: why raw-diff-5?

Why diff-5?

- Part 1 contains chord breaks
- Chords are evolving slowly to next one
- Slowness is emphasized by repeating all chord breaks twice (not stored)

Think Diff: why raw-diff-5?

Why diff-5?

- Part 1 contains chord breaks
- Chords are evolving slowly to next one
- Slowness is emphasized by repeating all chord breaks twice (not stored)
- Slow change means small diffs

Think Diff: why raw-diff-5?

Why diff-5?

- Part 1 contains chord breaks
- Chords are evolving slowly to next one
- Slowness is emphasized by repeating all chord breaks twice (not stored)
- Slow change means small diffs
- Chord breaks are 8 notes long

Think Diff: why raw-diff-5?

Why diff-5?

- Part 1 contains chord breaks
- Chords are evolving slowly to next one
- Slowness is emphasized by repeating all chord breaks twice (not stored)
- Slow change means small diffs
- Chord breaks are 8 notes long
- Which are stored in 5 bytes

Think Diff: why raw-diff-5?

Why diff-5?

- Part 1 contains chord breaks
- Chords are evolving slowly to next one
- Slowness is emphasized by repeating all chord breaks twice (not stored)
- Slow change means small diffs
- Chord breaks are 8 notes long
- Which are stored in 5 bytes
- Diff-5 is diff to previous line

Think Diff: raw-diff-5 data overview

Added diff values in dump:

| | | | | |
|------------|------------|------------|------------|------------|
| c-3:60:/00 | e-3:64:/00 | g-3:67:/00 | c-4:72:/00 | e-4:76:/00 |
| c-3:60:=00 | d-3:62:-02 | a-3:69:+02 | d-4:74:+02 | f-4:77:+01 |
| h-2:59:-01 | d-3:62:=00 | g-3:67:-02 | d-4:74:=00 | f-4:77:=00 |
| (. . .) | | | | |

Think Diff: raw-diff-5 data overview

| | | | | | | | | | | | |
|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|--|--|
| c-3:60:/00 | e-3:64:/00 | g-3:67:/00 | c-4:72:/00 | e-4:76:/00 | | | | | | | |
| c-3:60:=00 | d-3:62:-02 | a-3:69:+02 | d-4:74:+02 | f-4:77:+01 | | | | | | | |
| h-2:59:-01 | d-3:62:=00 | g-3:67:-02 | d-4:74:=00 | f-4:77:=00 | d-2:50:-02 | f-2:53:=00 | a-2:57:=00 | c-3:60:=00 | f-3:65:=00 | | |
| c-3:60:+01 | e-3:64:+02 | g-3:67:=00 | c-4:72:-02 | e-4:76:-01 | g-1:43:-07 | d-2:50:-03 | g-2:55:-02 | h-2:59:-01 | f-3:65:=00 | | |
| c-3:60:=00 | e-3:64:=00 | a-3:69:+02 | e-4:76:+04 | a-4:81:+05 | c-2:48:+05 | e-2:52:+02 | g-2:55:=00 | c-3:60:+01 | e-3:64:-01 | | |
| c-3:60:=00 | d-3:62:-02 | f#3:66:-03 | a-3:69:-07 | d-4:74:-07 | c-2:48:=00 | g-2:55:+03 | a#2:58:+03 | c-3:60:=00 | e-3:64:=00 | | |
| h-2:59:-01 | d-3:62:=00 | g-3:67:+01 | d-4:74:+05 | g-4:79:+05 | f-1:41:-07 | f-2:53:-02 | a-2:57:-01 | c-3:60:=00 | e-3:64:=00 | | |
| h-2:59:=00 | c-3:60:-02 | e-3:64:-03 | g-3:67:-07 | c-4:72:-07 | f#1:42:+01 | c-2:48:-05 | a-2:57:=00 | c-3:60:=00 | e-3:64:=00 | | |
| a-2:57:-02 | c-3:60:=00 | e-3:64:=00 | g-3:67:=00 | c-4:72:=00 | g#1:44:+02 | f-2:53:+05 | h-2:59:+02 | c-3:60:=00 | d-3:62:-02 | | |
| d-2:50:-07 | a-2:57:-03 | d-3:62:-02 | f#3:66:-01 | c-4:72:=00 | g-1:43:-01 | f-2:53:=00 | g-2:55:-04 | h-2:59:-01 | d-3:62:=00 | | |
| g-2:55:+05 | h-2:59:+02 | d-3:62:=00 | g-3:67:+01 | h-3:71:-01 | g-1:43:=00 | e-2:52:-01 | g-2:55:=00 | c-3:60:+01 | e-3:64:+02 | | |
| g-2:55:=00 | a#2:58:-01 | e-3:64:+02 | g-3:67:=00 | c#4:73:+02 | g-1:43:=00 | d-2:50:-02 | g-2:55:=00 | c-3:60:=00 | f-3:65:+01 | | |
| f-2:53:-02 | a-2:57:-01 | d-3:62:-02 | a-3:69:+02 | d-4:74:+01 | g-1:43:=00 | d-2:50:=00 | g-2:55:=00 | h-2:59:-01 | f-3:65:=00 | | |
| f-2:53:=00 | g#2:56:-01 | d-3:62:=00 | f-3:65:-04 | h-3:71:-03 | g-1:43:=00 | d#2:51:+01 | a-2:57:+02 | c-3:60:+01 | f#3:66:+01 | | |
| e-2:52:-01 | g-2:55:-01 | c-3:60:-02 | g-3:67:+02 | c-4:72:+01 | g-1:43:=00 | e-2:52:+01 | g-2:55:-02 | c-3:60:=00 | g-3:67:+01 | | |
| e-2:52:=00 | f-2:53:-02 | a-2:57:-03 | c-3:60:-07 | f-3:65:-07 | g-1:43:=00 | d-2:50:-02 | g-2:55:=00 | c-3:60:=00 | f-3:65:-02 | | |
| | | | | | g-1:43:=00 | d-2:50:=00 | g-2:55:=00 | h-2:59:-01 | f-3:65:=00 | | |
| | | | | | c-1:36:-07 | c-2:48:-02 | g-2:55:=00 | a#2:58:-01 | e-3:64:-01 | | |

| | | | | | | | | | | | |
|------------|------------|------------|------------|------------|------------|------------|------------|--|--|--|--|
| c-1:36:=00 | c-2:48:=00 | f-2:53:-02 | a-2:57:-01 | c-3:60:-04 | f-3:65:+29 | c-3:60:+12 | a-2:57:+04 | | | | |
| c-3:60:+03 | a-2:57:-03 | f-2:53:-12 | a-2:57:-03 | f-2:53:-04 | d-2:50:-10 | f-2:53:-04 | d-2:50:-03 | | | | |
| c-1:36:-21 | h-1:47:-06 | g-3:67:+17 | h-3:71:+18 | d-4:74:+24 | f-4:77:+41 | d-4:74:+27 | h-3:71:+04 | | | | |
| d-4:74:+03 | h-3:71:-03 | g-3:67:-10 | h-3:71:-03 | d-3:62:-09 | f-3:65:-09 | e-3:64:-07 | d-3:62:-05 | | | | |

c-1:36:-35 c-2:48:-14 e-3:64:-01 g-3:67:+03 c-4:72:+10

Think Diff: raw-diff-5 data overview

| | | | | |
|------------|------------|------------|------------|------------|
| c-3:60:/00 | e-3:64:/00 | g-3:67:/00 | c-4:72:/00 | e-4:76:/00 |
| c-3:60:=00 | d-3:62:-02 | a-3:69:+02 | d-4:74:+02 | f-4:77:+01 |
| h-2:59:-01 | d-3:62:=00 | g-3:67:-02 | d-4:74:=00 | f-4:77:=00 |
| c-3:60:+01 | e-3:64:+02 | g-3:67:=00 | c-4:72:-02 | e-4:76:-01 |
| c-3:60:=00 | e-3:64:=00 | a-3:69:+02 | e-4:76:+04 | a-4:81:+05 |
| c-3:60:=00 | d-3:62:-02 | f#3:66:-03 | a-3:69:-07 | d-4:74:-07 |
| h-2:59:-01 | d-3:62:=00 | g-3:67:+01 | d-4:74:+05 | g-4:79:+05 |
| h-2:59:=00 | c-3:60:-02 | e-3:64:-03 | g-3:67:-07 | c-4:72:-07 |
| a-2:57:-02 | c-3:60:=00 | e-3:64:=00 | g-3:67:=00 | c-4:72:=00 |
| d-2:50:-07 | a-2:57:-03 | d-3:62:-02 | f#3:66:-01 | c-4:72:=00 |
| g-2:55:+05 | h-2:59:+02 | d-3:62:=00 | g-3:67:+01 | h-3:71:-01 |
| g-2:55:=00 | a#2:58:-01 | e-3:64:+02 | g-3:67:=00 | c#4:73:+02 |
| f-2:53:-02 | a-2:57:-01 | d-3:62:-02 | a-3:69:+02 | d-4:74:+01 |
| f-2:53:=00 | g#2:56:-01 | d-3:62:=00 | f-3:65:-04 | h-3:71:-03 |
| e-2:52:-01 | g-2:55:-01 | c-3:60:-02 | g-3:67:+02 | c-4:72:+01 |
| e-2:52:=00 | f-2:53:-02 | a-2:57:-03 | c-3:60:-07 | f-3:65:-07 |

| | | | | |
|------------|------------|------------|------------|------------|
| d-2:50:-02 | f-2:53:=00 | a-2:57:=00 | c-3:60:=00 | f-3:65:=00 |
| g-1:43:-07 | d-2:50:-03 | g-2:55:-02 | h-2:59:-01 | f-3:65:=00 |
| c-2:48:+05 | e-2:52:+02 | g-2:55:=00 | c-3:60:+01 | e-3:64:-01 |
| c-2:48:=00 | g-2:55:+03 | a#2:58:+03 | c-3:60:=00 | e-3:64:=00 |
| f-1:41:-07 | f-2:53:-02 | a-2:57:-01 | c-3:60:=00 | e-3:64:=00 |
| f#1:42:+01 | c-2:48:-05 | a-2:57:=00 | c-3:60:=00 | e-3:64:=00 |
| g#1:44:+02 | f-2:53:+05 | h-2:59:+02 | c-3:60:=00 | d-3:62:-02 |
| g-1:43:-01 | f-2:53:=00 | g-2:55:-04 | h-2:59:-01 | d-3:62:=00 |
| g-1:43:=00 | e-2:52:-01 | g-2:55:=00 | c-3:60:+01 | e-3:64:+02 |
| g-1:43:=00 | d-2:50:-02 | g-2:55:=00 | c-3:60:=00 | f-3:65:+01 |
| g-1:43:=00 | d-2:50:=00 | g-2:55:=00 | h-2:59:-01 | f-3:65:=00 |
| g-1:43:=00 | d#2:51:+01 | a-2:57:+02 | c-3:60:+01 | f#3:66:+01 |
| g-1:43:=00 | e-2:52:+01 | g-2:55:-02 | c-3:60:=00 | g-3:67:+01 |
| g-1:43:=00 | d-2:50:-02 | g-2:55:=00 | c-3:60:=00 | f-3:65:-02 |
| g-1:43:=00 | d-2:50:=00 | g-2:55:=00 | h-2:59:-01 | f-3:65:=00 |
| c-1:36:-07 | c-2:48:-02 | g-2:55:=00 | a#2:58:-01 | e-3:64:-01 |

| | | | | | | | |
|------------|------------|------------|------------|------------|------------|------------|------------|
| c-1:36:=00 | c-2:48:=00 | f-2:53:-02 | a-2:57:-01 | c-3:60:-04 | f-3:65:+29 | c-3:60:+12 | a-2:57:+04 |
| c-3:60:+03 | a-2:57:-03 | f-2:53:+12 | a-2:57:-03 | f-2:53:-04 | d-2:50:-10 | f-2:53:-04 | d-2:50:-03 |
| c-1:36:-21 | h-1:47:-06 | g-3:67:+17 | h-3:71:+18 | d-4:74:+24 | f-4:77:+41 | d-4:74:+27 | h-3:71:+04 |
| d-4:74:+03 | h-3:71:-03 | g-3:67:-10 | h-3:71:-03 | d-3:62:-09 | f-3:65:-09 | e-3:64:-07 | d-3:62:-05 |

c-1:36:**-35** c-2:48:**-14** e-3:64:-01 g-3:67:+03 c-4:72:+10

Think Diff: raw-diff-5 data overview

```
c-3:60:/00 e-3:64:/00 g-3:67:/00 c-4:72:/00 e-4:76:/00
c-3:60:=00 d-3:62:-02 a-3:69:+02 d-4:74:+02 f-4:77:+01
h-2:59:-01 d-3:62:=00 g-3:67:-02 d-4:74:=00 f-4:77:=00
c-3:60:+01 e-3:64:+02 g-3:67:+00 c-4:72:-02 e-4:76:-01
c-3:60:=00 e-3:64:=00 a-3:69:+02 e-4:76:+04 a-4:81:+05
c-3:60:=00 d-3:62:-02 f#3:66:-03 a-3:69:-07 d-4:74:-07
h-2:59:-01 d-3:62:=00 g-3:67:+01 d-4:74:+05 g-4:79:+05
h-2:59:=00 c-3:60:-02 e-3:64:-03 g-3:67:-07 c-4:72:-07
a-2:57:-02 c-3:60:=00 e-3:64:=00 g-3:67:=00 c-4:72:=00
d-2:50:-07 a-2:57:-03 d-3:62:-02 f#3:66:-01 c-4:72:=00
g-2:55:+05 h-2:59:+02 d-3:62:=00 g-3:67:+01 h-3:71:-01
g-2:55:+00 a#2:58:-01 e-3:64:+02 g-3:67:=00 c#4:73:+02
f-2:53:-02 a-2:57:-01 d-3:62:-02 a-3:69:+02 d-4:74:+01
f-2:53:=00 g#2:56:-01 d-3:62:=00 f-3:65:-04 h-3:71:-03
e-2:52:-01 g-2:55:-01 c-3:60:-02 g-3:67:+02 c-4:72:+01
e-2:52:=00 f-2:53:-02 a-2:57:-03 c-3:60:-07 f-3:65:-07
```

| | | | | |
|------------|------------|------------|------------|------------|
| d-2:50:-02 | f-2:53:=00 | a-2:57:=00 | c-3:60:=00 | f-3:65:=00 |
| g-1:43:-07 | d-2:50:-03 | g-2:55:-02 | h-2:59:-01 | f-3:65:=00 |
| c-2:48:+05 | e-2:52:+02 | g-2:55:=00 | c-3:60:+01 | e-3:64:-01 |
| c-2:48:=00 | g-2:55:+03 | a#2:58:+03 | c-3:60:=00 | e-3:64:=00 |
| f-1:41:-07 | f-2:53:-02 | a-2:57:-01 | c-3:60:=00 | e-3:64:=00 |
| f#1:42:+01 | c-2:48:-05 | a-2:57:=00 | c-3:60:=00 | e-3:64:=00 |
| g#1:44:+02 | f-2:53:+05 | h-2:59:+02 | c-3:60:=00 | d-3:62:-02 |
| g-1:43:-01 | f-2:53:=00 | g-2:55:-04 | h-2:59:-01 | d-3:62:=00 |
| g-1:43:=00 | e-2:52:-01 | g-2:55:=00 | c-3:60:+01 | e-3:64:+02 |
| g-1:43:=00 | d-2:50:-02 | g-2:55:=00 | c-3:60:=00 | f-3:65:+01 |
| g-1:43:=00 | d-2:50:=00 | g-2:55:=00 | h-2:59:-01 | f-3:65:=00 |
| g-1:43:=00 | d#2:51:+01 | a-2:57:+02 | c-3:60:+01 | f#3:66:+01 |
| g-1:43:=00 | e-2:52:+01 | g-2:55:-02 | c-3:60:=00 | g-3:67:+01 |
| g-1:43:=00 | d-2:50:-02 | g-2:55:=00 | c-3:60:=00 | f-3:65:-02 |
| g-1:43:=00 | d-2:50:=00 | g-2:55:=00 | h-2:59:-01 | f-3:65:=00 |
| c-1:36:-07 | c-2:48:-02 | g-2:55:=00 | a#2:58:-01 | e-3:64:-01 |

```
c-1:36:=00 c-2:48:=00 f-2:53:-02 a-2:57:-01 c-3:60:-04 f-3:65:+29 c-3:60:+12 a-2:57:+04
c-3:60:+03 a-2:57:-03 f-2:53:+12 a-2:57:-03 f-2:53:-04 d-2:50:-10 f-2:53:-04 d-2:50:-03
c-1:36:-21 h-1:47:-06 g-3:67:+17 h-3:71:+18 d-4:74:+24 f-4:77:+41 d-4:74:+27 h-3:71:+04
d-4:74:+03 h-3:71:-03 g-3:67:-10 h-3:71:-03 d-3:62:-09 f-3:65:-09 e-3:64:-07 d-3:62:-05
```

```
c-1:36:+35 c-2:48:-14 e-3:64:-01 g-3:67:+03 c-4:72:+10
```

Think Diff: raw-diff-5 data overview

```

c-3:60:/00 e-3:64:/00 g-3:67:/00 c-4:72:/00 e-4:76:/00
c-3:60:=00 d-3:62:-02 a-3:69:+02 d-4:74:+02 f-4:77:+01
h-2:59:-01 d-3:62:=00 g-3:67:-02 d-4:74:+00 f-4:77:+00
c-3:60:+01 e-3:64:+02 g-3:67:=00 c-4:72:-02 e-4:76:-01
c-3:60:=00 e-3:64:=00 a-3:69:+02 e-4:76:+04 a-4:81:+05
c-3:60:=00 d-3:62:-02 f#3:66:-03 a-3:69:-07 d-4:74:+07
h-2:59:-01 d-3:62:=00 g-3:67:+01 d-4:74:+05 g-4:79:+05
h-2:59:=00 c-3:60:-02 e-3:64:-03 g-3:67:-07 c-4:72:-07
a-2:57:-02 c-3:60:=00 e-3:64:=00 g-3:67:+00 c-4:72:+00
d-2:50:-07 a-2:57:-03 d-3:62:-02 f#3:66:-01 c-4:72:+00
g-2:55:+05 h-2:59:+02 d-3:62:=00 g-3:67:+01 h-3:71:-01
g-2:55:=00 a#2:58:-01 e-3:64:+02 g-3:67:+00 c#4:73:+02
f-2:53:-02 a-2:57:-01 d-3:62:-02 a-3:69:+02 d-4:74:+01
f-2:53:=00 g#2:56:-01 d-3:62:=00 f-3:65:-04 h-3:71:-03
e-2:52:-01 g-2:55:-01 c-3:60:-02 g-3:67:+02 c-4:72:+01
e-2:52:=00 f-2:53:-02 a-2:57:-03 c-3:60:-07 f-3:65:-07
d-2:50:-02 f-2:53:=00 a-2:57:+00 c-3:60:=00 f-3:65:=00
g-1:43:-07 d-2:50:-03 g-2:55:-02 h-2:59:-01 f-3:65:=00
c-2:48:+05 e-2:52:+02 g-2:55:+00 c-3:60:+01 e-3:64:-01
c-2:48:=00 g-2:55:+03 a#2:58:+03 c-3:60:=00 e-3:64:=00
f-1:41:-07 f-2:53:-02 a-2:57:-01 c-3:60:=00 e-3:64:=00
f#1:42:+01 c-2:48:-05 a-2:57:+00 c-3:60:=00 e-3:64:=00
g#1:44:+02 f-2:53:+03 h-2:59:+02 c-3:60:=00 d-3:62:-02
g-1:43:-01 f-2:53:=00 g-2:55:-04 h-2:59:-01 d-3:62:=00
g-1:43:=00 e-2:52:-01 g-2:55:+00 c-3:60:+01 e-3:64:+02
g-1:43:=00 d-2:52:-01 g-2:55:+00 c-3:60:+01 f-3:65:+01
g-1:43:=00 d-2:50:-02 g-2:55:+00 c-3:60:=00 f-3:65:+01
g-1:43:=00 d-2:50:-01 g-2:55:+00 h-2:59:-01 f-3:65:=00
g-1:43:=00 d#2:51:+01 a-2:57:+02 c-3:60:+01 f#3:66:+01
g-1:43:=00 e-2:52:+01 g-2:55:-02 c-3:60:=00 g-3:67:+01
g-1:43:=00 d-2:50:-02 g-2:55:+00 c-3:60:=00 f-3:65:-02
g-1:43:=00 d-2:50:=00 g-2:55:+00 h-2:59:-01 f-3:65:=00
c-1:36:-07 c-2:48:-02 g-2:55:+00 a#2:58:-01 e-3:64:-01

```

| | | | | | | | |
|------------|------------|------------|------------|------------|------------|------------|------------|
| c-1:36:=00 | c-2:48:=00 | f-2:53:-02 | a-2:57:-01 | c-3:60:-04 | f-3:65:+29 | c-3:60:+12 | a-2:57:+04 |
| c-3:60:+03 | a-2:57:-03 | f-2:53:-12 | a-2:57:-03 | f-2:53:-04 | d-2:50:-10 | f-2:53:-04 | d-2:50:-03 |
| c-1:36:-21 | h-1:47:-06 | g-3:67:+17 | h-3:71:+18 | d-4:74:+24 | f-4:77:+41 | d-4:74:+27 | h-3:71:+04 |
| d-4:74:+03 | h-3:71:-03 | g-3:67:-10 | h-3:71:-03 | d-3:62:-09 | f-3:65:-09 | e-3:64:-07 | d-3:62:-05 |

c-1:36:-35 c-2:48:-14 e-3:64:-01 g-3:67:+03 c-4:72:+10

Histogram of raw-diff-5 (27 values, 197 notes)

```
; -35 1 1 #
; -21 1 2 #
; -14 1 3 #
; -12 1 4 #
; -10 2 6 ##
; -09 2 8 ##
; -07 11 19 #####
; -06 1 20 #
; -05 2 22 ##
; -04 5 27 #####
; -03 11 38 #####
; -02 21 59 #####
; -01 22 81 #####
; =00 65 146 #####
; +01 15 161 #####
; +02 14 175 #####
; +03 5 180 #####
; +04 3 183 ###
; +05 6 189 #####
; +10 1 190 #
; +12 1 191 #
; +17 1 192 #
; +18 1 193 #
; +24 1 194 #
; +27 1 195 #
; +29 1 196 #
; +41 1 197 #
```

Histogram of raw-diff-5 (27 values, 197 notes)

```
; 1. =00 65 65 #####
; 2. -01 22 87 #####
; 3. -02 21 108 #####
; 4. +01 15 123 #####
; 5. +02 14 137 #####
; 6. -07 11 148 #####
; 7. -03 11 159 #####
; 8. +05 6 165 #####
; 9. -04 5 170 #####
; 10. +03 5 175 #####
; 11. +04 3 178 ##
; 12. -10 2 180 ##
; 13. -09 2 182 ##
; 14. -05 2 184 ##
; 15. -35 1 185 #
; 16. -21 1 186 #
; 17. -14 1 187 #
; 18. -12 1 188 #
; 19. -06 1 189 #
; 20. +41 1 190 #
; 21. +29 1 191 #
; 22. +27 1 192 #
; 23. +24 1 193 #
; 24. +18 1 194 #
; 25. +17 1 195 #
; 26. +12 1 196 #
; 27. +10 1 197 #
```

Histogram of raw-diff-5 (27 values, 197 notes)

```

; 1. =00 65 65 #####
; 2. -01 22 87 #####
; 3. -02 21 108 #####
; 4. +01 15 123 #####
; 5. +02 14 137 #####
; 6. -07 11 148 #####
; 7. -03 11 159 #####
; 8. +05 6 165 #####
; 9. -04 5 170 #####
; 10. +03 5 175 #####
; 11. +04 3 178 ##
; 12. -10 2 180 ##
; 13. -09 2 182 ##
; 14. -05 2 184 ##
; 15. -35 1 185 #
; 16. -21 1 186 #
; 17. -14 1 187 #
; 18. -12 1 188 #
; 19. -06 1 189 #
; 20. +41 1 190 #
; 21. +29 1 191 #
; 22. +27 1 192 #
; 23. +24 1 193 #
; 24. +18 1 194 #
; 25. +17 1 195 #
; 26. +12 1 196 #
; 27. +10 1 197 #

```

Top-heavy:
33% weight for
top value (0.4%)

Histogram of raw-diff-5 (27 values, 197 notes)

```

; 1. =00 65 65 #####
; 2. -01 22 87 #####
; 3. -02 21 108 #####
; 4. +01 15 123 #####
; 5. +02 14 137 #####
; 6. -07 11 148 #####
; 7. -03 11 159 #####
; 8. +05 6 165 #####
; 9. -04 5 170 #####
; 10. +03 5 175 #####


---


; 11. +04 3 178 #####
; 12. -10 2 180 #####
; 13. -09 2 182 #####
; 14. -05 2 184 #####
; 15. -35 1 185 #
; 16. -21 1 186 #
; 17. -14 1 187 #
; 18. -12 1 188 #
; 19. -06 1 189 #
; 20. +41 1 190 #
; 21. +29 1 191 #
; 22. +27 1 192 #
; 23. +24 1 193 #
; 24. +18 1 194 #
; 25. +17 1 195 #
; 26. +12 1 196 #
; 27. +10 1 197 #

```

Long tail:
11% weight for
63% of values

Compression

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- **Store most frequent values in short-words**

```
ccc  ccc  ccc  ccc  ccc  ccc  ccc  ccc  ccc
```

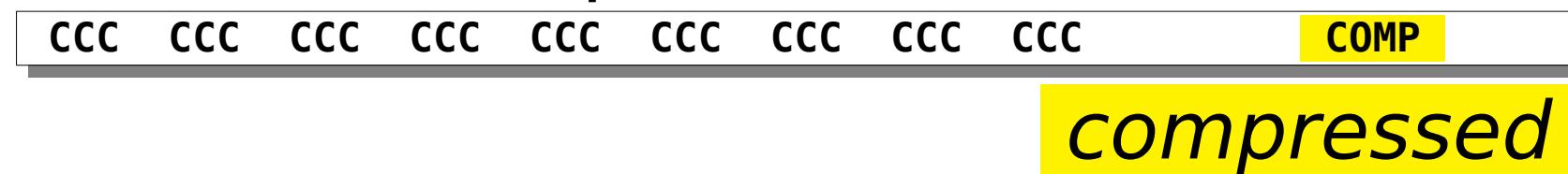
Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words

ccc ccc ccc ccc ccc ccc ccc ccc ccc COMP

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words



Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words

ccc ccc ccc ccc ccc ccc ccc ccc ccc COMP

A horizontal sequence of ten identical short words, each consisting of three lowercase letters 'ccc'. To the right of this sequence is a single long word 'COMP' enclosed in a yellow rectangular box.

- Store special marker short-word followed by a long-word for less frequent values

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words

ccc ccc ccc ccc ccc ccc ccc ccc COMP

- Store special marker short-word followed by a long-word for less frequent values

sss+uuuuu sss+uuuuu sss+uuuuu ccc ccc sss+uuuu

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words

ccc ccc ccc ccc ccc ccc ccc ccc COMP

- Store special marker short-word followed by a long-word for less frequent values

sss+uuuuu sss+uuuuu sss+uuuuu ccc ccc sss+uuuu ucomp

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words

ccc ccc ccc ccc ccc ccc ccc ccc COMP

- Store special marker short-word followed by a long-word for less frequent values

SSS+UUUUU SSS+UUUUU SSS+UUUUU CCC CCC SSS+UUUU UCOMP

uncompressed

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words



- Store special marker short-word followed by a long-word for less frequent values



- Needs index tables

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words



- Store special marker short-word followed by a long-word for less frequent values



- Needs index tables
- First notes must be stored (have no diff)

Compression

- Split data to top frequent and less frequent set of values around 80%..20% weight
- Store most frequent values in short-words



- Store special marker short-word followed by a long-word for less frequent values



- Needs index tables
- First notes must be stored (have no diff)

Compression: raw-diff-5 @ 2

```

; 1. =00 65 65 ##########
; 2. -01 22 87 #####
; 3. -02 21 108 #####
; 4. +01 15 123 #####
; 5. +02 14 137 #####
; 6. -07 11 148 #####
; 7. -03 11 159 #####
; 8. +05 6 165 #####
; 9. -04 5 170 #####
; 10. +03 5 175 #####
; 11. +04 3 178 #####
; 12. -10 2 180 ##
; 13. -09 2 182 ##
; 14. -05 2 184 ##
; 15. -35 1 185 #
; 16. -21 1 186 #
; 17. -14 1 187 #
; 18. -12 1 188 #
; 19. -06 1 189 #
; 20. +41 1 190 #
; 21. +29 1 191 #
; 22. +27 1 192 #
; 23. +24 1 193 #
; 24. +18 1 194 #
; 25. +17 1 195 #
; 26. +12 1 196 #
; 27. +10 1 197 #

```

55%: 2-bit

45%: 7-bit

Compression: raw-diff-5 @ 3

| | |
|--|--|
| <pre> ; 1. =00 65 65 ##### ; 2. -01 22 87 ##### ; 3. -02 21 108 ##### ; 4. +01 15 123 ##### ; 5. +02 14 137 ##### ; 6. -07 11 148 ##### ; 7. -03 11 159 ##### <hr/> ; 8. +05 6 165 ##### ; 9. -04 5 170 ##### ; 10. +03 5 175 ##### ; 11. +04 3 178 ##### ; 12. -10 2 180 ##### ; 13. -09 2 182 ##### ; 14. -05 2 184 ##### ; 15. -35 1 185 # ; 16. -21 1 186 # ; 17. -14 1 187 # ; 18. -12 1 188 # ; 19. -06 1 189 # ; 20. +41 1 190 # ; 21. +29 1 191 # ; 22. +27 1 192 # ; 23. +24 1 193 # ; 24. +18 1 194 # ; 25. +17 1 195 # ; 26. +12 1 196 # ; 27. +10 1 197 # </pre> | 81%: 3-bit <hr/> 19%: 7-bit |
|--|--|

Compression: raw-diff-5 @ 4

```

; 1. =00 65 65 ##########
; 2. -01 22 87 #####
; 3. -02 21 108 #####
; 4. +01 15 123 #####
; 5. +02 14 137 #####
; 6. -07 11 148 #####
; 7. -03 11 159 #####
; 8. +05 6 165 #####
; 9. -04 5 170 #####
; 10. +03 5 175 #####
; 11. +04 3 178 ###
; 12. -10 2 180 ##
; 13. -09 2 182 ##
; 14. -05 2 184 ##
; 15. -35 1 185 #


---


; 16. -21 1 186 #
; 17. -14 1 187 #
; 18. -12 1 188 #
; 19. -06 1 189 #
; 20. +41 1 190 #
; 21. +29 1 191 #
; 22. +27 1 192 #
; 23. +24 1 193 #
; 24. +18 1 194 #
; 25. +17 1 195 #
; 26. +12 1 196 #
; 27. +10 1 197 #

```

94%: 4-bit

6%: 8-bit

Compression: nutab

No Uncompressed Table

Compression: nutab

No Uncompressed Table:

- High number of values – large table

Compression: nutab

No Uncompressed Table:

- High number of values – large table
- Low utilization of the table (1..5 notes)

Compression: nutab

No Uncompressed Table:

- High number of values – large table
- Low utilization of the table (1..5 notes)
- Range of minimum and maximum value is not much bigger than table size

Compression: nutab

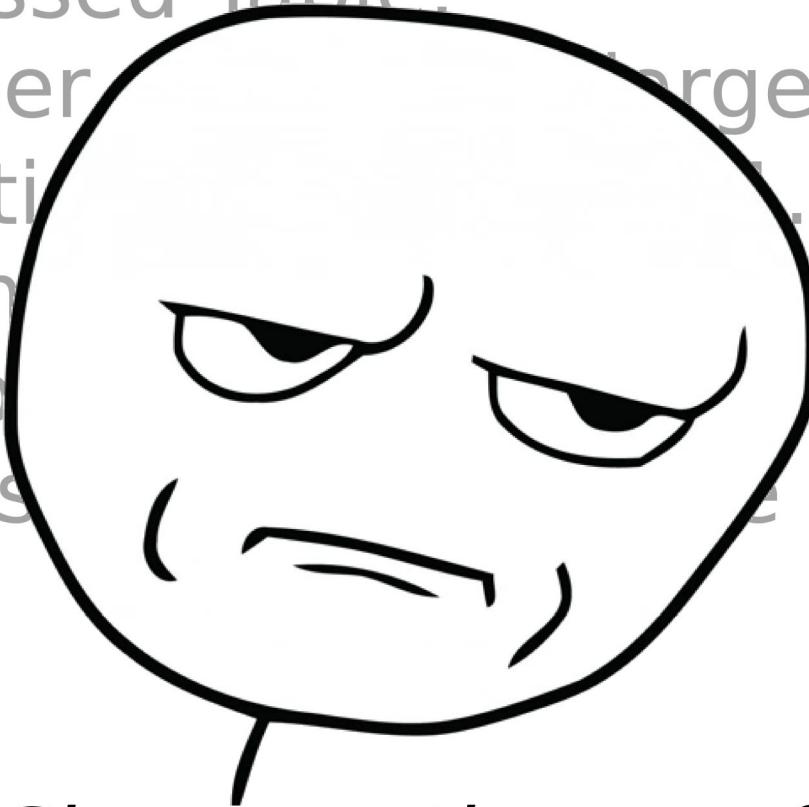
No Uncompressed Table:

- High number of values – large table
- Low utilization of the table (1..5 notes)
- Range of minimum and maximum value is not much bigger than table size
- **Table needs some extra code**

Compression: nutab

No Uncompressed Table:

- High number of entries (large table)
- Low utilization (1..5 notes)
- Range of many values (high num of entries)
- Table size is large
- Table needs to be compressed



*Show me the proof!
I need evidence*

Compression: nutab

| <i>split</i> | <i>table</i> | <i>value range</i> | <i>bits per item</i> | <i>storage + table</i> | <i>ucomp total</i> |
|----------------|--------------|--------------------|----------------------|------------------------|--------------------|
| raw-diff-5 @ 2 | yes | 24 | 5 | 77 + 24 | 101 |
| | nutab | 76 | 7 | 100 | 100 |
| raw-diff-5 @ 3 | yes | 20 | 5 | 38 + 20 | 58 |
| | nutab | 76 | 7 | 47 | 47 |
| raw-diff-5 @ 4 | yes | 12 | 4 | 12 + 12 | 24 |
| | nutab | 62 | 6 | 15 | 15 |

Compression: nutab

| <i>split</i> | <i>table</i> | <i>value range</i> | <i>bits per item</i> | <i>storage + table</i> | <i>ucomp total</i> |
|----------------|--------------|--------------------|----------------------|------------------------|--------------------|
| raw-diff-5 @ 2 | yes | 24 | 5 | 77 + 24 | 101 |
| | nutab | 76 | 7 | 100 | 100 |
| raw-diff-5 @ 3 | yes | 20 | 5 | 38 + 20 | 58 |
| | nutab | 76 | 7 | 47 | 47 |
| raw-diff-5 @ 4 | yes | 12 | 4 | 12 + 12 | 24 |
| | nutab | 62 | 6 | 15 | |

Okay.



Compression: nctab

No Compressed Table

Compression: nctab

No Compressed Table:

- Top values are almost continuous

Compression: nctab

No Compressed Table:

- Top values are almost continuous
- Swap values for continuous range

Compression: nctab

No Compressed Table:

- Top values are almost continuous
- Swap values for continuous range
- Small compromise for eliminating
Compressed Table

Compression: nctab

```

; 1. =00 65 65 ##########
; 2. -01 22 87 #####
; 3. -02 21 108 #####
; 4. +01 15 123 #####
; 5. +02 14 137 #####
; 6. -07 11 148 #####
; 7. -03 11 159 #####


---


; 8. +05 6 165 #####
; 9. -04 5 170 #####
; 10. +03 5 175 #####
; 11. +04 3 178 ###
; 12. -10 2 180 ##
; 13. -09 2 182 ##
; 14. -05 2 184 ##
; 15. -35 1 185 #

```

Swap -07: 11 notes
With +03: 5 notes

Compression: nctab

```

; 1. =00 65 65 ##########
; 2. -01 22 87 #####
; 3. -02 21 108 #####
; 4. +01 15 123 #####
; 5. +02 14 137 #####
; 10. +03 5 175 #####
; 7. -03 11 159 #####
; 8. +05 6 165 #####
; 9. -04 5 170 #####
; 6. -07 11 148 #####
; 11. +04 3 178 ###
; 12. -10 2 180 ##
; 13. -09 2 182 ##
; 14. -05 2 184 ##
; 15. -35 1 185 #

```

Swap -07: 11 notes
With +03: 5 notes

Compression: select method

Compression: select method

| <i>note</i> | <i>diff</i> | <i>compressed word size</i> | <i>compressed table</i> | <i>uncompressed table</i> |
|-------------|--|-----------------------------|-------------------------|---------------------------|
| raw-indexed | diff-1 diff-2 diff-3 diff-4 diff-5 diff-6 diff-7 diff-8 diff-mixed/1/5 | @ 2 @ 3 @ 4 @ 6 | yes nctab | yes nutab |

$$1 * 9 * 4 * 2 * 2 = \mathbf{144} \text{ variations}$$

Compression: select method

Select compression method:

- Create estimation for all the 144 variations

Compression: select method

Select compression method:

- Create estimation for all the 144 variations
- Accurate estimation of data and table sizes

Compression: select method

Select compression method:

- Create estimation for all the 144 variations
- Accurate estimation of data and table sizes
- Can't calculate required code size

Compression: select method

Select compression method:

- Create estimation for all the 144 variations
- Accurate estimation of data and table sizes
- Can't calculate required code size



Challenge accepted.

Compression: select method