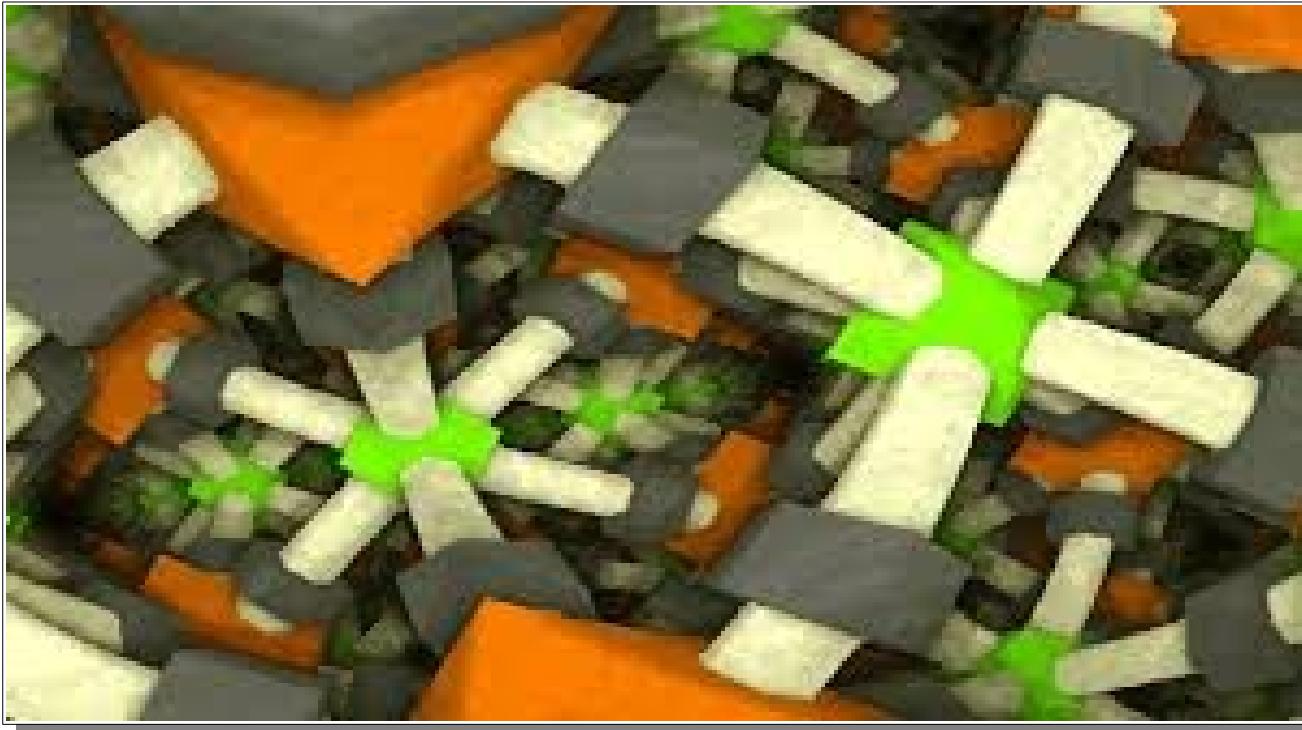


This page is intentionally left blank.

256-byte demoscene: extremly strong competition

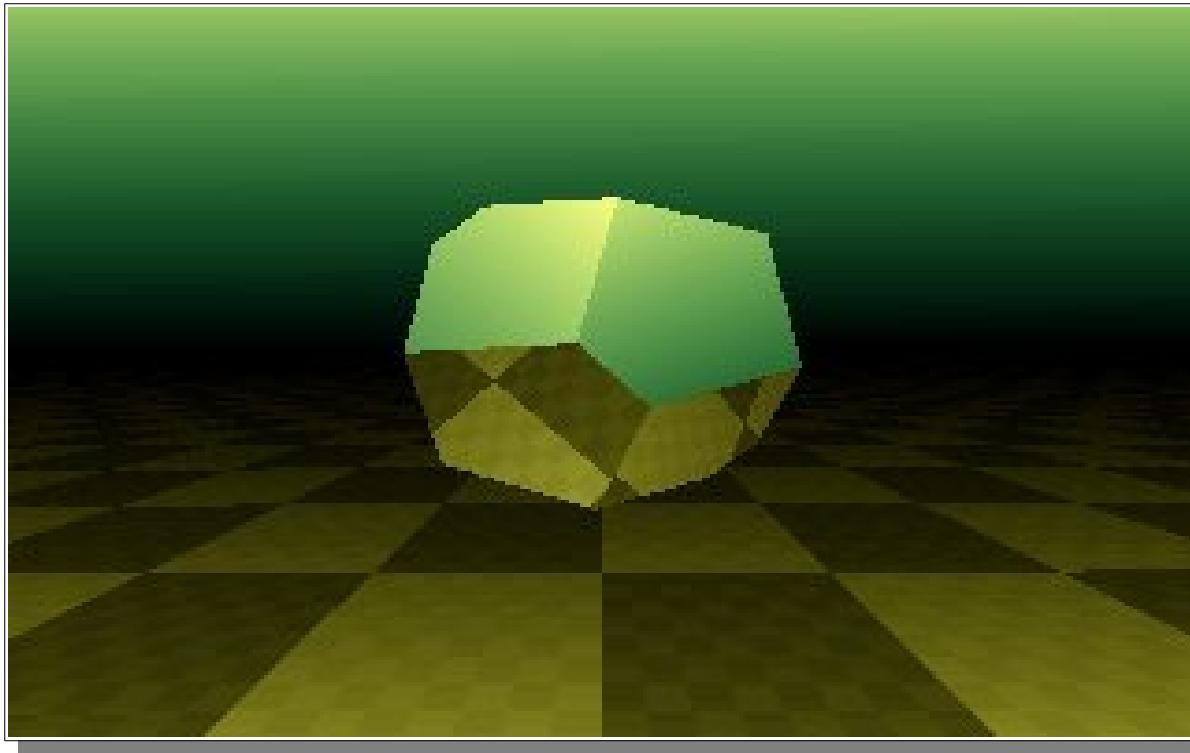


256-byte demoscene: extremly strong competition



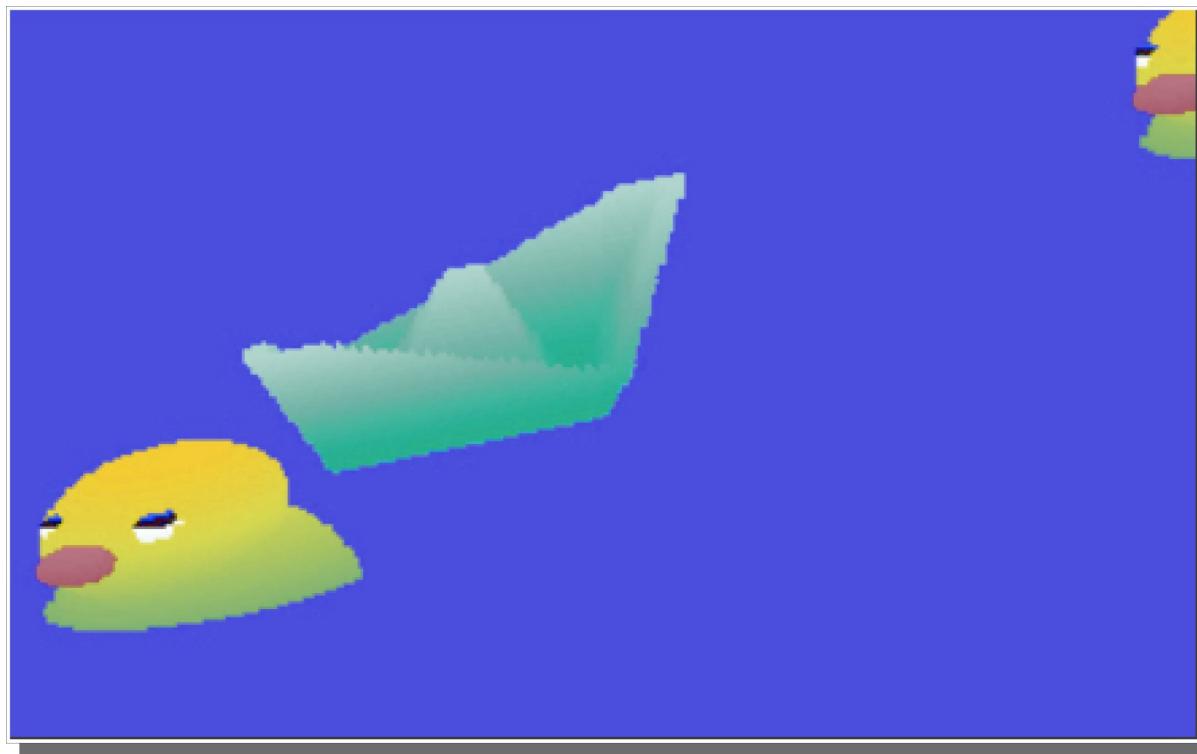
Řrřola: *Puls*

256-byte demoscene: extremly strong competition



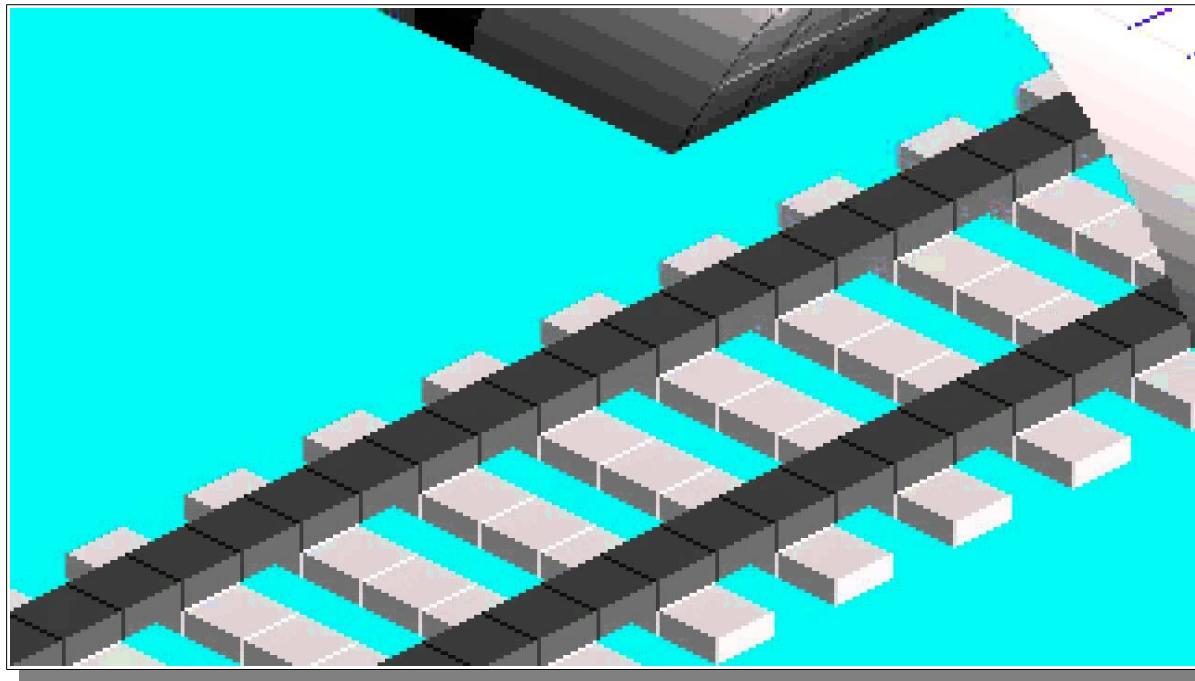
Řrřola: Pyrit

256-byte demoscene: extremly strong competition



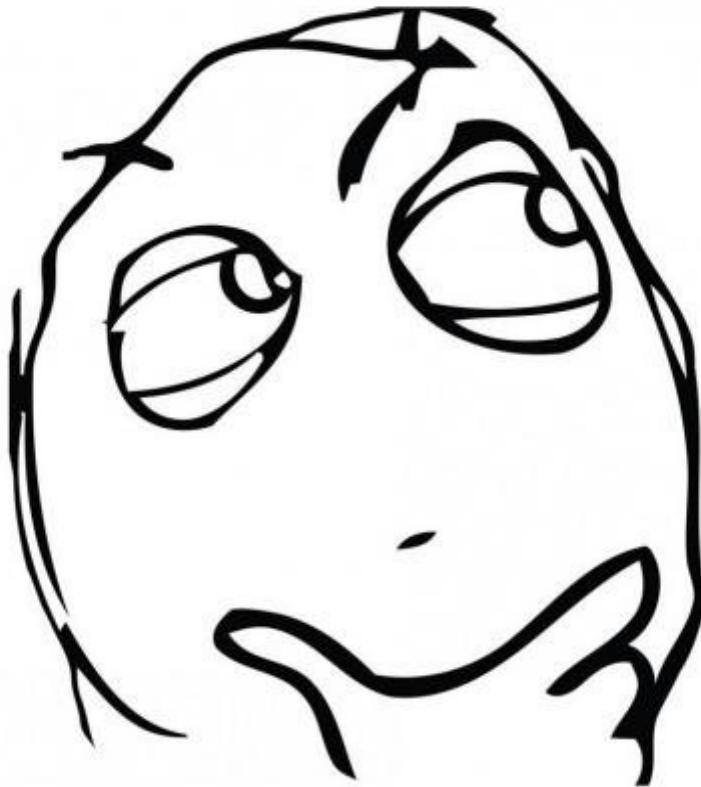
Digimind: Pool Patrol

256-byte demoscene: extremly strong competition



Digimind: Immediate Railways

256-byte demoscene: extremly strong competition

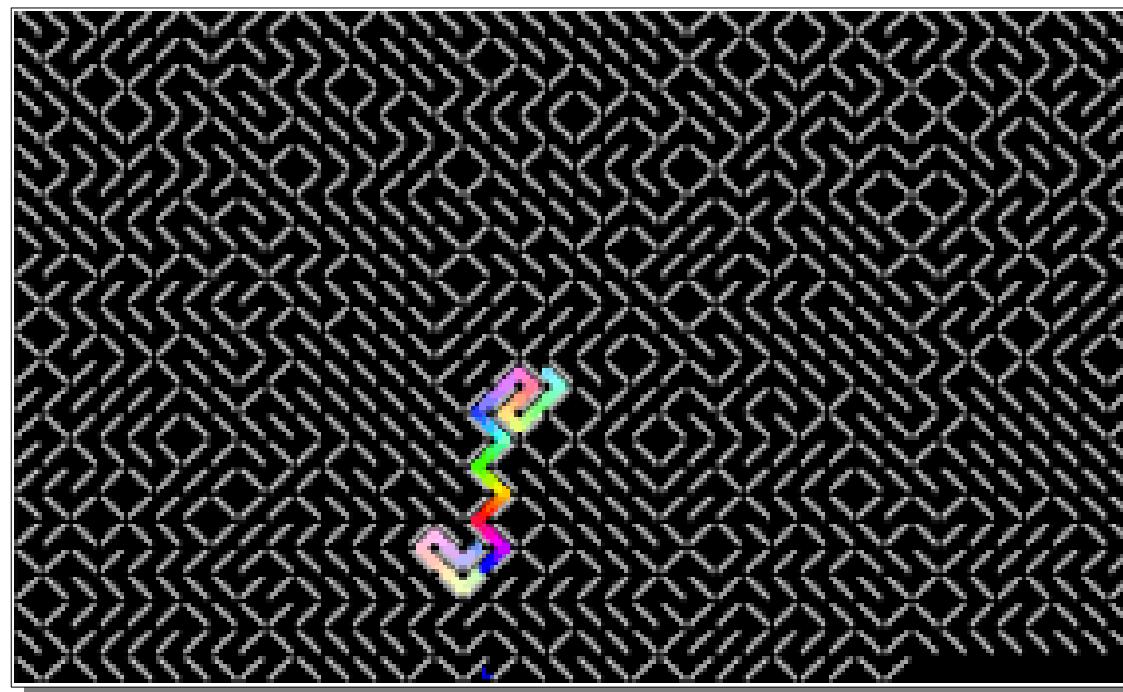


How to shine out of crowd?

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?

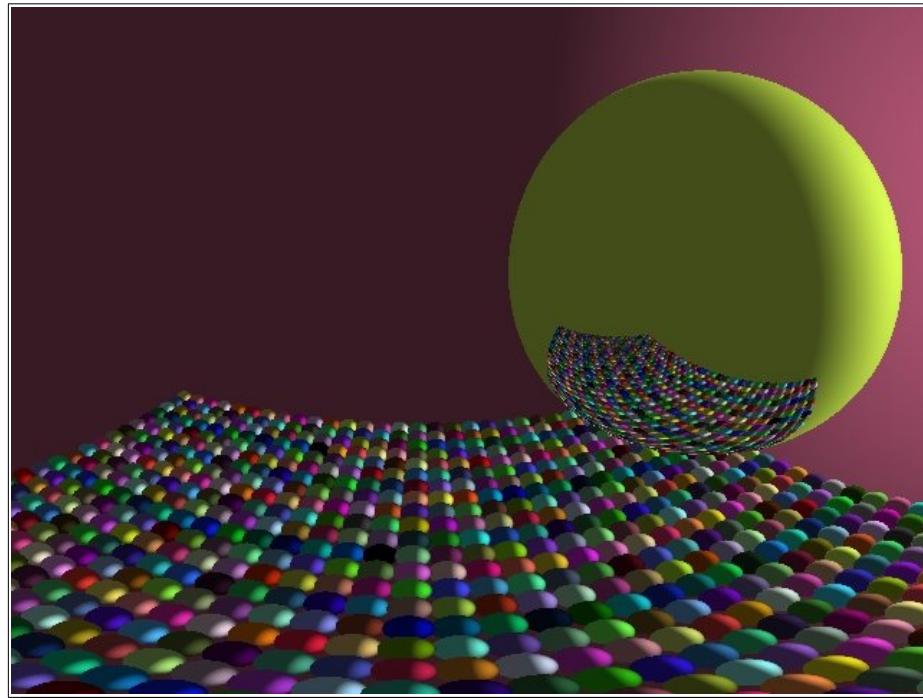
Image processing + fun



TomCat: Be Happy!

256-byte demoscene: how to beat competition?

Raytracing



TomCat: Colorful

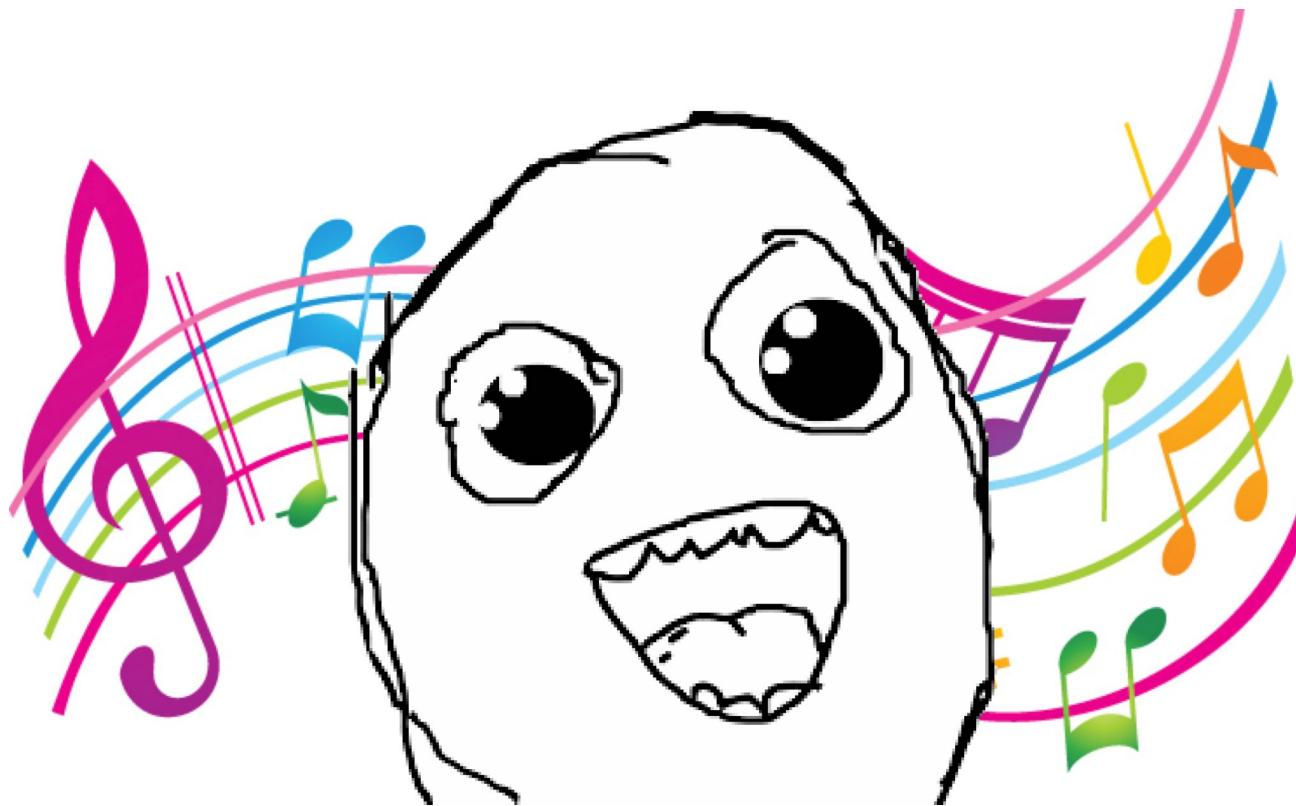
256-byte demoscene: how to beat competition?

Raytracing + fun



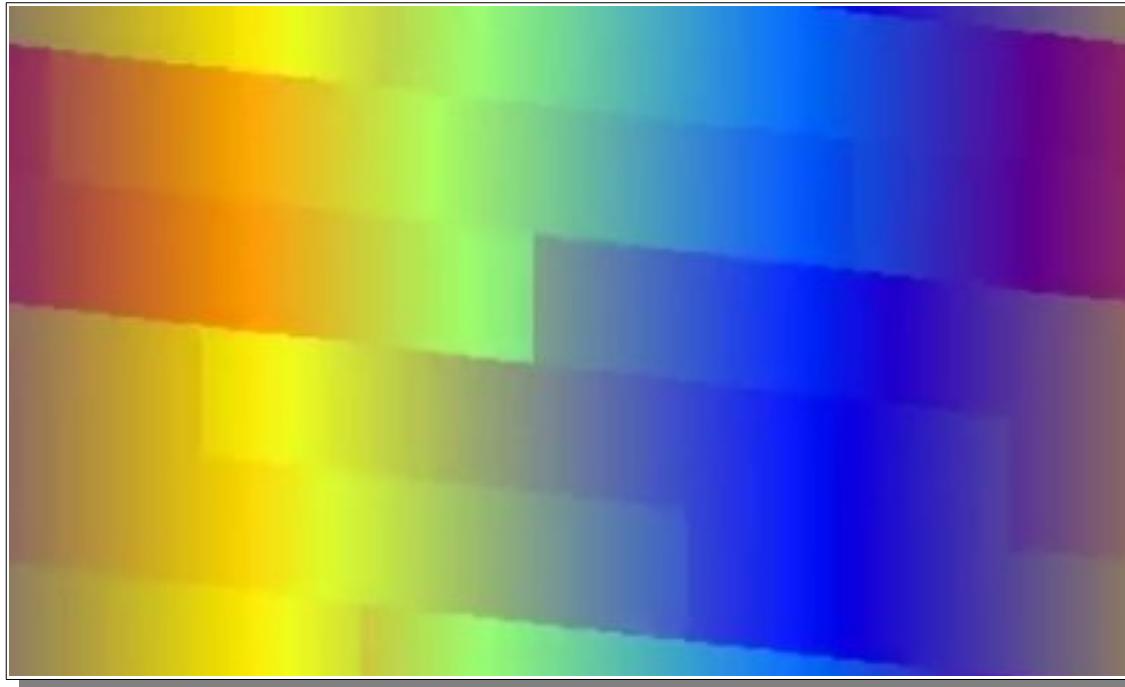
TomCat: Pokeball

256-byte demoscene: how to beat competition?



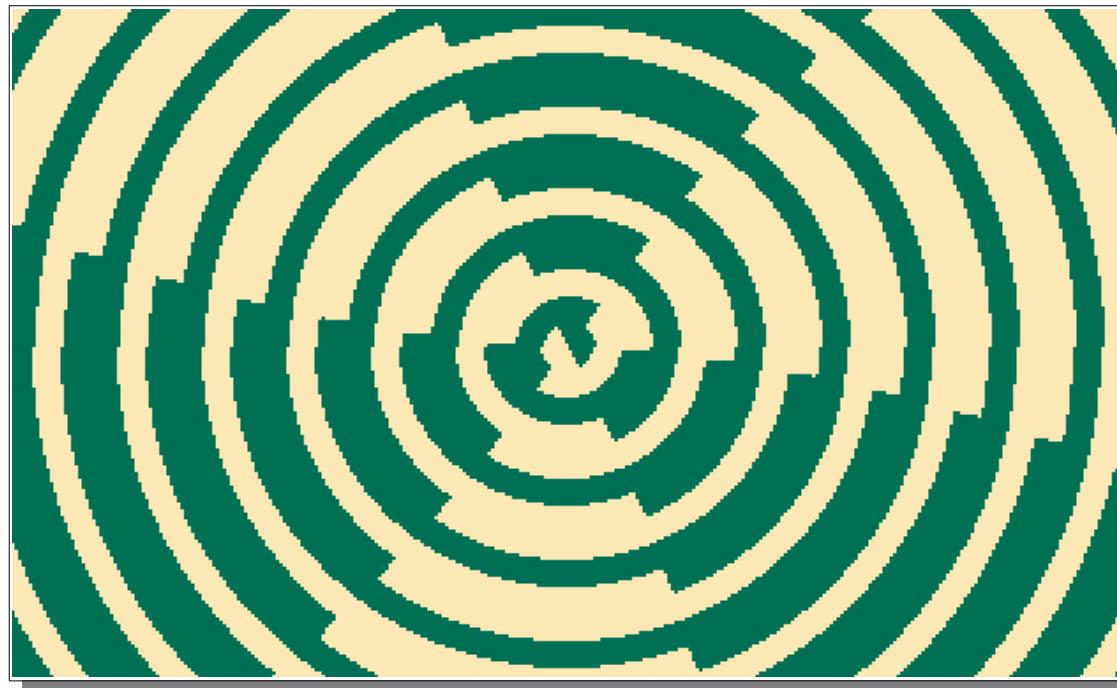
Music! Add music in 256-byte intros!

256 byte intro with music



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

256 byte intro with music



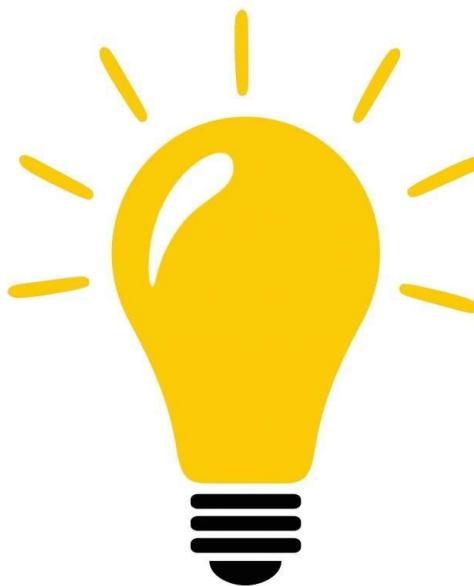
TomCat: No Sleep!
(buzzer music by ern0)

256 byte intro with music

Everyone loves it!



Create universal bytebeat tool



Create universal bytebeat tool

- Bytebeat player & editor

TomCat



Create universal bytebeat tool

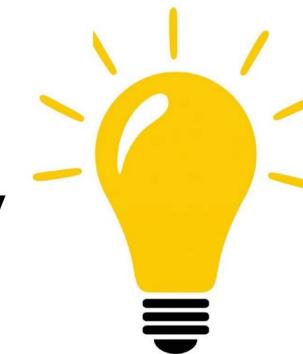
- Bytebeat player & editor

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



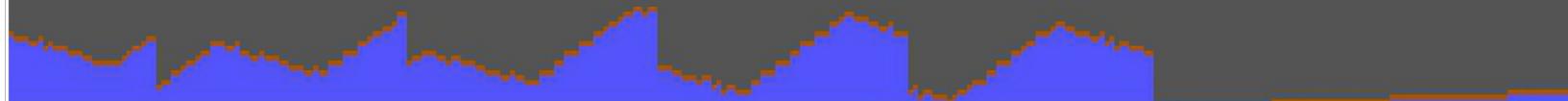
- Formula compiler for assembly

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-based configuration section with various parameters for instruments and effects. Below this is a waveform visualization consisting of five blue triangles on a grey background. At the bottom, there is a hex dump of the bytebeat data.

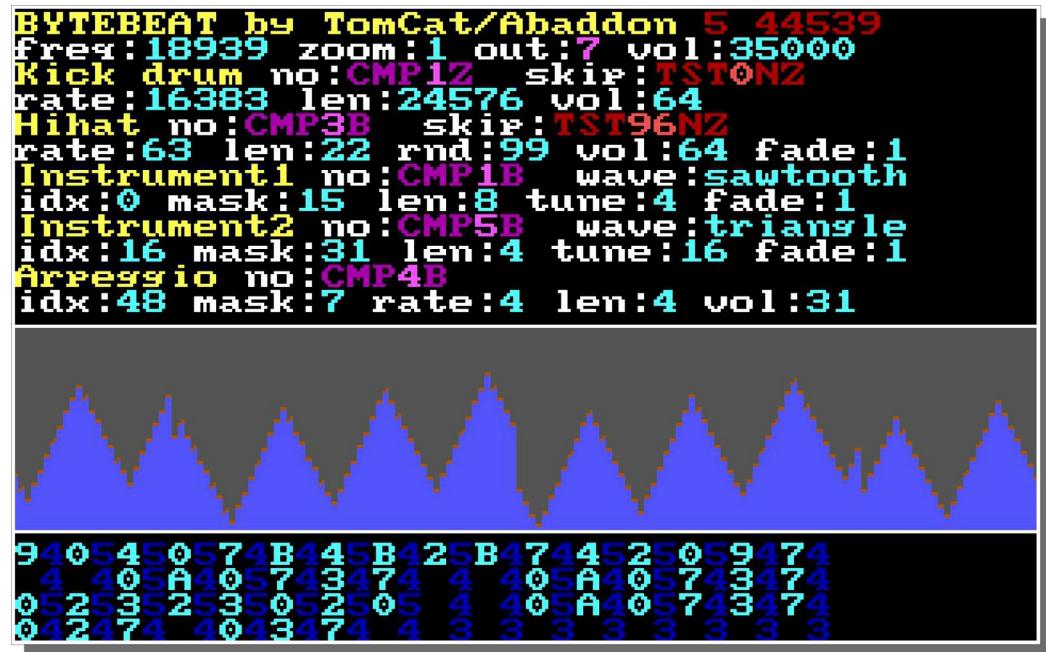
```
BYTEBEAT by TomCat/Abaddon 2 12981
freq:18939 zoom:1 out:7 vol:35000
Kick drum no:CMP1Z skip:TSTONZ
rate:16383 len:24576 vol:64
Hihat no:CMP3B skip:TST96NZ
rate:63 len:22 rnd:99 vol:64 fade:1
Instrument1 no:CMP1B wave:sawtooth
idx:0 mask:15 len:8 tune:4 fade:1
Instrument2 no:CMP5B wave:triangle
idx:16 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 a window titled "BYTEBEAT by TomCat/Abaddon 2 12981". Inside, there's a text-based configuration section and a graphical representation of a sound wave.

Configuration (Text):

```
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
```

Graphical Sound Wave:

A dark gray rectangular area containing a series of blue triangular peaks of varying heights, representing the amplitude of the sound over time.

Hex Dump (Text):

```
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 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
4405A4057434744405A405743474
05253525350525054405A405743474
042474404347443333333333333333

Bytebeat Editor (TomCat)

Features:

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



Issues:

- more than 70 hotkeys

```
BYTEBEAT 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
4405A4057434744405A405743474
05253525350525054405A405743474
042474404347443333333333333333
```

Bytebeat Editor (TomCat)

Features:

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

Issues:

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

4	4	0	5	0	4	0	5	7	4	3	4	7	4	4
0	5	2	5	3	5	2	5	3	5	0	5	2	5	0
0	4	2	4	7	4	4	0	4	3	4	7	4	4	3
0	4	2	4	7	4	4	0	4	3	4	7	4	4	3

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

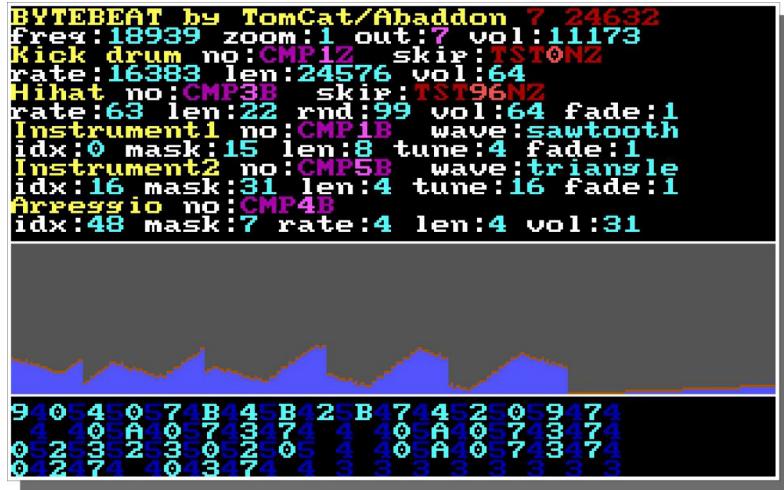
Bytebeat Editor (TomCat)



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)



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
0629352935062905400574
042174401347443333333333

Verdict:

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



Assemblylyzator (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 5c3 501 5c3 501
main mov mov mov mov
eax,0x175e0e4
ret

~~Vc, optimized!
such compiler!~~



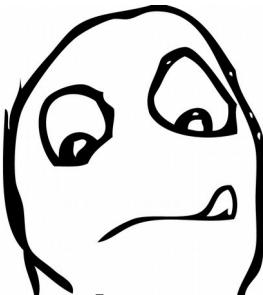
No modern compiler exists for **16-bit** target.

Assemblyzator (ern0)

Let's write a compiler thing!

Assemblylyzator (ern0)

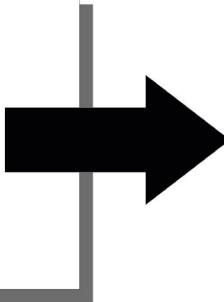
Let's write a compiler thing!



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
- handle num arrays
- handle string arrays
- remove duplications

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

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.
 $A = (B \text{ op } C ? D : E)$
improperly designed Abstract Syntax Tree

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

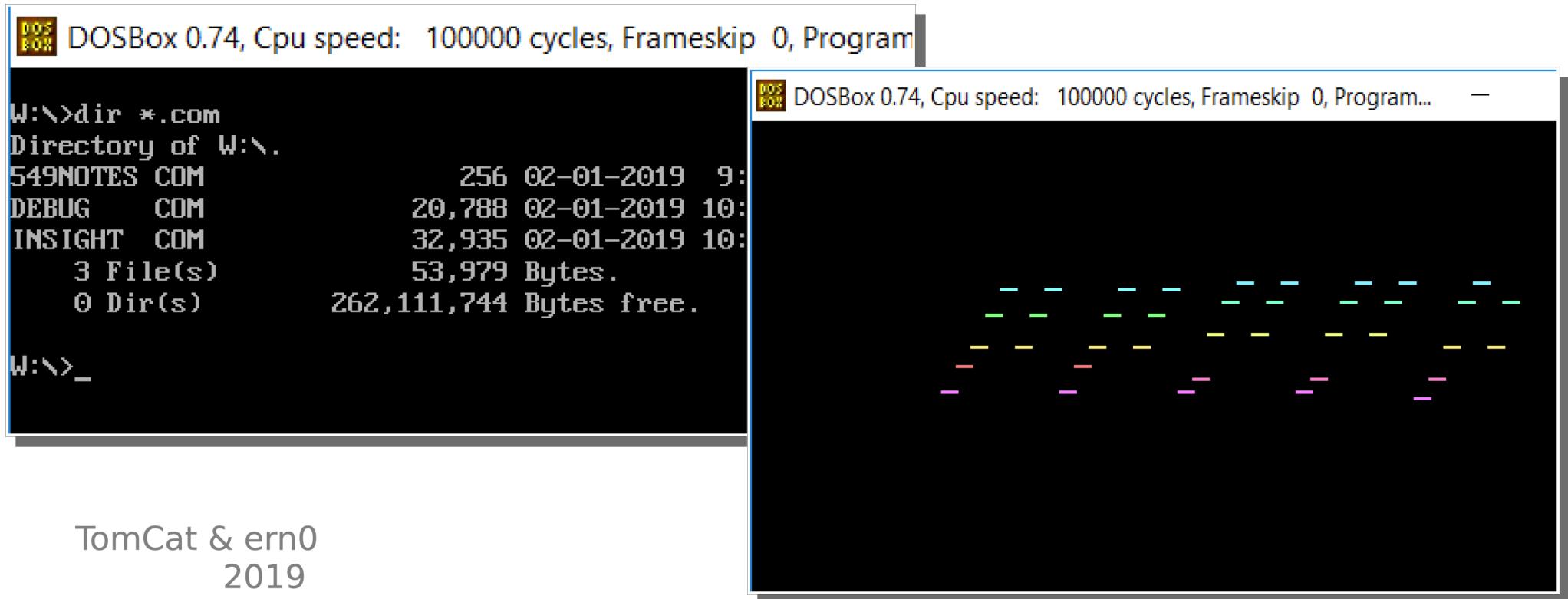


Table Of Contents

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
```



```
; key down, ch=1  
; pitch  
; velocity=127
```

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 displays two staves for a piano. The top staff uses a treble clef and a common time signature (indicated by a '4'). The bottom staff uses a bass clef and a common time signature. Both staves feature a key signature of one sharp (F#). The music consists of repeating eighth-note patterns. In each measure, there is a sixteenth note followed by a sixteenth note tied to another sixteenth note, with a short rest. This pattern repeats four times in the top staff and three times in the bottom staff.

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

Repeating patterns 1/2:

Piano

The image displays two staves of a piano score. The top staff is in common time (indicated by '4') and the bottom staff is in common time (indicated by '4'). The music consists of eighth-note patterns. The first staff features a repeating pattern of sixteenth-note pairs followed by eighth-note pairs. The second staff follows a similar pattern. Colored ovals highlight specific groups of notes: green ovals group the first two measures of each staff; blue ovals group the next two measures; and pink and purple ovals group the final two measures. The bass clef is used for both staves, and the treble clef is present on the top staff.

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

Repeating patterns 1/2:

Piano

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 six 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 fifth measure. The bass line remains consistent 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 (indicated by '4') and the bottom staff is in common time (indicated by '4'). The music consists of eighth-note patterns. 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 (indicated by '4') and the bottom staff is in common time (indicated by '4'). The music consists of eighth-note patterns. 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 analysis

"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 analysis

```
"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 analysis

```
"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 analysis

```
"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:

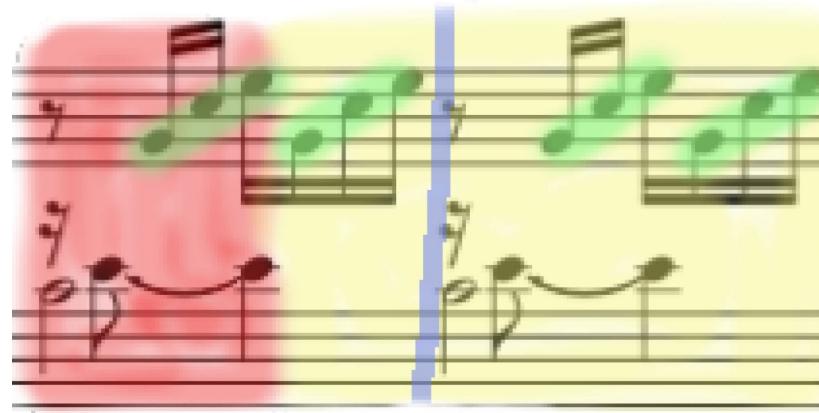
- 32 lines x 5 notes
- last 3 notes are repeated
- (8-note) lines are repeated

Data analysis

```
"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 analysis

```
"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 analysis

```
"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

```
"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-2:53	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-3:68	12	#####
; h-1:47	1	#		; 6. a-2:59	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	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	#

note range: 36 .. 81: 45 values

values: 6 bit x 197 = 148 byte

