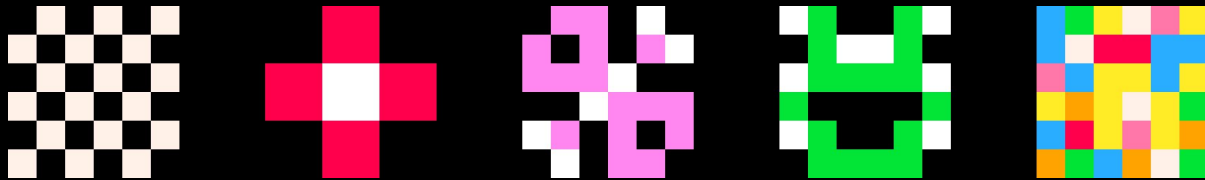


Why Oatmeal is Cheap

Kolmogorov Complexity & Procedural Generation





Younès Rabii

Indie gamedev
PhD Student at QMUL
IGGI programme



Michael Cook

Senior Lecturer
at King's College London



Orteil

@Orteil42

Follow



thanks to procedural generation, I can
produce twice the content in double the time

1:10 PM - 25 Nov 2016

a theorem about generators

A. 3 math properties

→ 3 intuitive concepts used by designers

B. how the theorem links them together



Orteil

@Orteil42

Follow



thanks to procedural generation, I can
produce twice the content in double the time

1:10 PM - 25 Nov 2016

a theorem about generators

A. **3 math properties**

→ **3 intuitive concepts used by designers**

B. how the theorem links them together

What we're studying: Ideal Generators

a generator G is **ideal** if it satisfies the following properties:

- ★ **Fixed Input Size**: It accepts input of a specific length
- ★ **Terminability** : It always outputs something
- ★ **Injectivity** : Different inputs give different outputs

We can take a non-ideal generator and turn into one that is ideal.

1. Length

```
--set palette
pal({1,8,3,9,14,4})
cls()
function _update()
  local x = rnd(128)
  local y = rnd(128)
  local e = t()
  for c=-2,1 do for r=-1,1 do
    local a=64+c*54+r%2*27
    local b=64+r*48
    line()
    -- draw hexagons
    for i=0,1,1/6 do
      line(a+sin(i)*30,b+cos(i)*30,7)
    end
    -- draw planets, bit by bit
    if(sqrt((x-a)^2+(y-b)^2) < 15+sin(c/7)*4+sin(r/2)*4)
      pset(x,y,2+c+r*2+sin(x/81+e)*2+cos(y/(14*c)))
    end
  end
end
```

(206 bytes)

|G| is the length of G's source code



```
pal({1,8,3,9,14,4})cls()s=sin::_::
x=rnd(128)y=rnd(128)e=t() for c=-2,1
do for r=-1,1do a=64+c*54+r%2*27b=64
+r*48line()for i=0,1,1/6do line(a+s(i)
*30,b+cos(i)*30,7)end if sqrt((x-a)^2+
(y-b)^2)<15+s(c/7)*4+s(r/2)*4) pset(x,y
,2+c+r*2+s(x/81+e)*2+cos(y/(14*c)))end
end goto _--
```

(140 bytes)

in its most compressed form

→ Encoded Knowledge

Knowledge...

- Learn how to compose artefacts
- Specify a precise procedure to make them

... you have to Encode

- Implement the procedure
- Test it
- Debug it
- Document it
- Optimise it



It ain't cheap.

2. Size of Possibility Space

	0	1	2	3	4	5	6	7	8	9
0										
1										
2										
3										
4										
5										
6										
7										
8										
9										

$p(G)$ is the number of unique artefacts in G 's possibility space.

$$p(G) = 100$$

$P(G)$ is the \log_2 of that number.

$$P(G) = \log_2(100) \approx 6.64$$

→ Scale



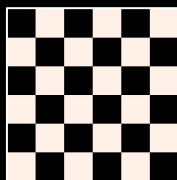
Borderlands 3



Animal Crossing:
New Horizons

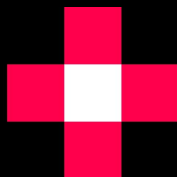
Picrew by @ASTROLAVAS

3. Kolmogorov Complexity (simplified)



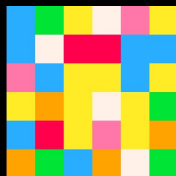
“alternate **black** and **white**”

4 words



“a 9x9 **red cross** overlaid with a 3x3 **white square** in the center”

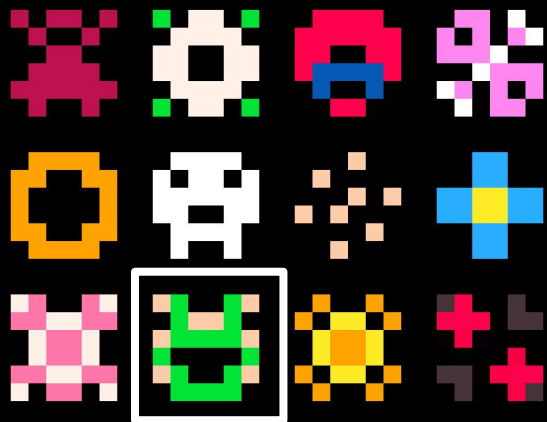
13 words



“**blue** then **green** then **yellow** then **white**
then **pink** then **yellow** then **blue** then
white then **two red** then **two blue** then...”

72 words

3. Kolmogorov Complexity (simplified)

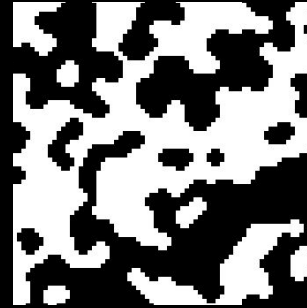
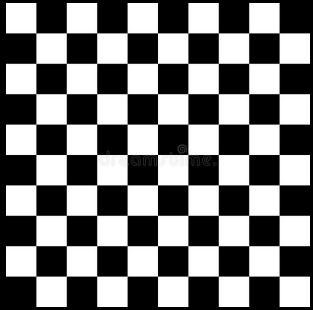


Most complex
artefact

$K(A)$ is the complexity of an artefact A .

$K^*(G)$ is complexity of the most complex artefact of G .

→ Pattern Density



Low K-Complexity

- Repetitive
- Patterns are easy to spot

High K-Complexity

- Noisy
- No spottable patterns



Orteil

@Orteil42

Follow



thanks to procedural generation, I can
produce twice the content in double the time

1:10 PM - 25 Nov 2016

a theorem about generators

A. 3 math properties

→ 3 intuitive concepts used by designers

B. how the theorem links them together

Theorem Statement

For an ideal generator G ,

$$|G| + P(G) \geq K^*(G) \geq P(G)$$

Scale

Pattern Density

Encoded Knowledge + Scale → is always in the shape of a pyramid

[Interactive demo time!]

Thank you!



Paper + Demo

pyrofoux.github.io/why-oatmeal-is-cheap/



@pyrofoux



yrabii.eggs@gmail.com

Exercise for the reader:

1. Using only $K^*(G)$ and $P(G)$, can you find a 4th stage to this pyramid?
2. Can you relate it to a concept designers use?

$$??? \geq |G| + P(G) \geq K^*(G) \geq P(G)$$

Scale

Pattern Density

Encoded Knowledge + Scale

[?]

Thank you!

Younès Rabil
aka **pyrofoux**



@pyrofoux



yrabil.eggs@gmail.com



pyrofoux.itch.io/super-is-hot

