13. Cellular automata

Generative Music AI

THE SOUND OF AI

upf. Universitat Pompeu Fabra Barcelona

MTG Music Technology Group

Overview

1. Intuition
2. Formalisation
3. Music generation with CA
4. Strengths and limitations

What’s a cellular automaton (CA)?

Cellular automata are models used to simulate complex systems using rules on a grid of cells

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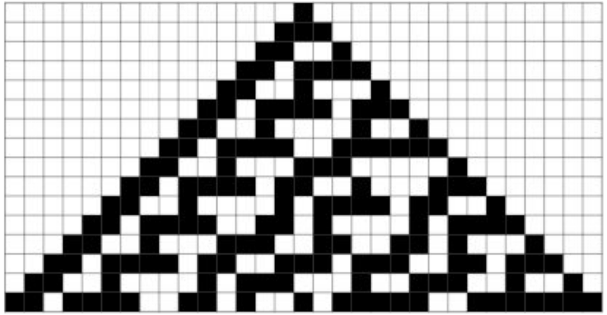

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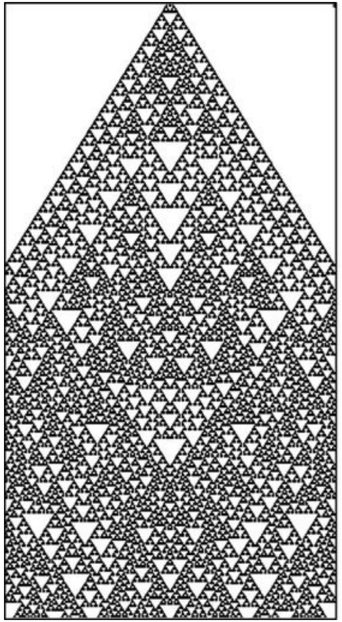

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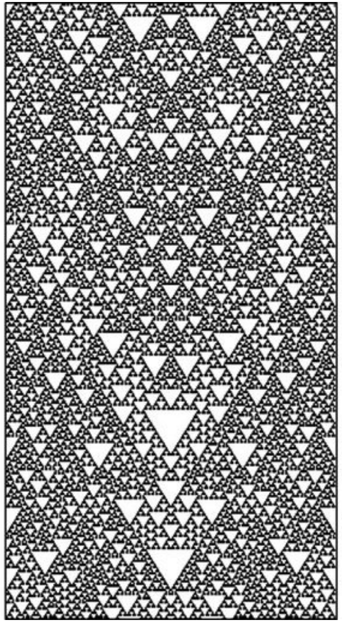
step 2



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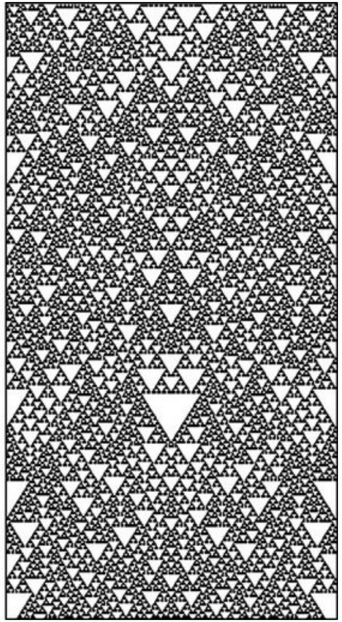
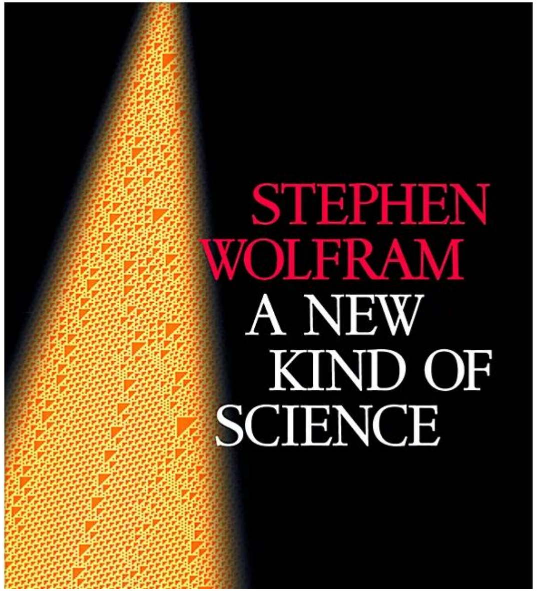
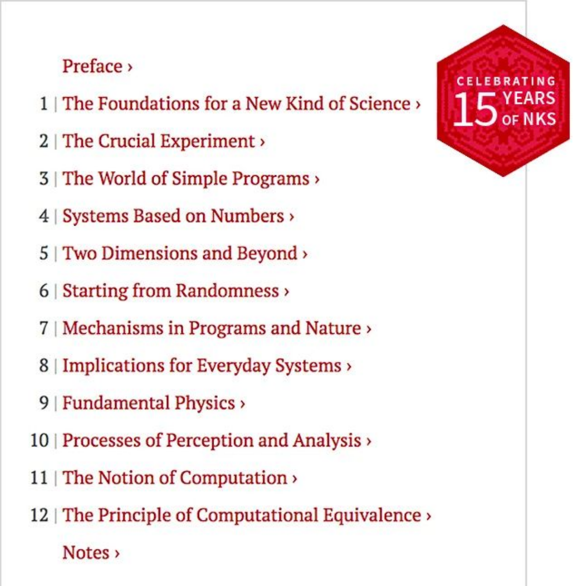
step 3




STEPHEN
WOLFRAM
A NEW
KIND OF
SCIENCE


CELEBRATING
15 YEARS
OF NKS

CA and nature

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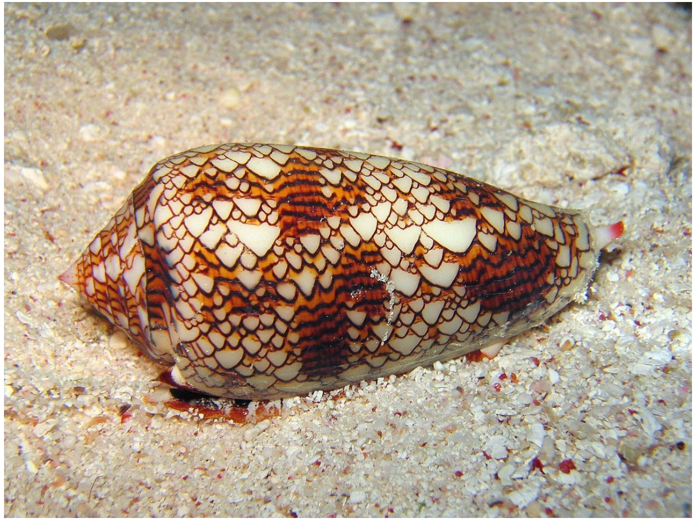
- Patterns on seashells



CA and nature

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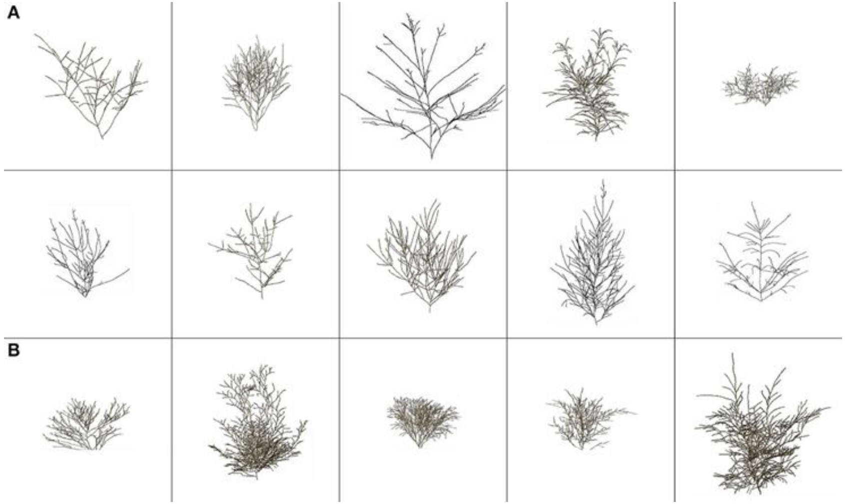

CA and nature

- Patterns on seashells
- Branching patterns in plants
- Crystal growth

CA formalisation

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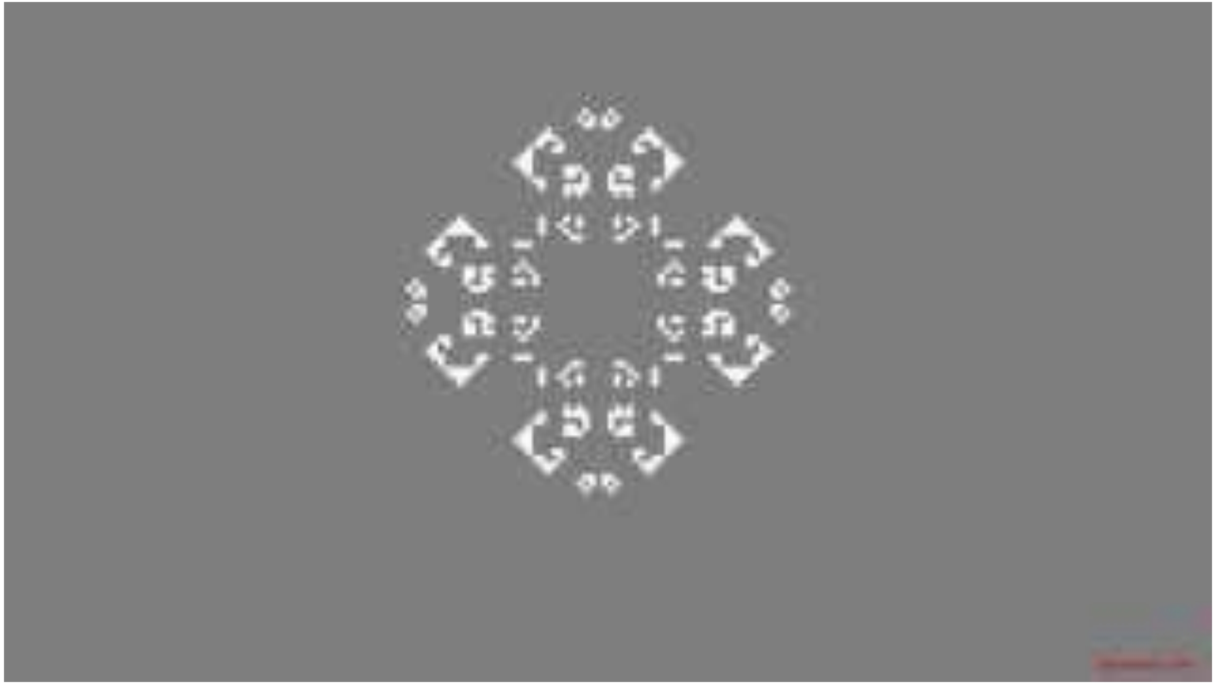
- *Initial conditions*: initial states of the grid (e.g., random, uniform, criteria)

Conway’s Game of Life



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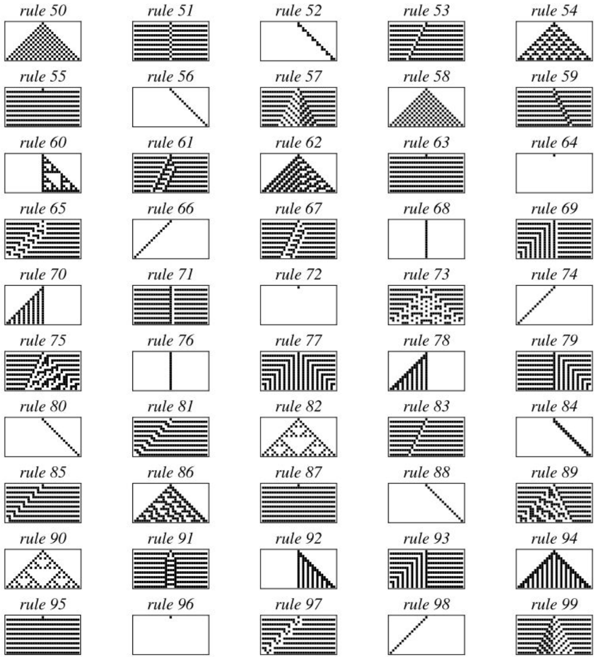
- *Initial conditions*: random or by design

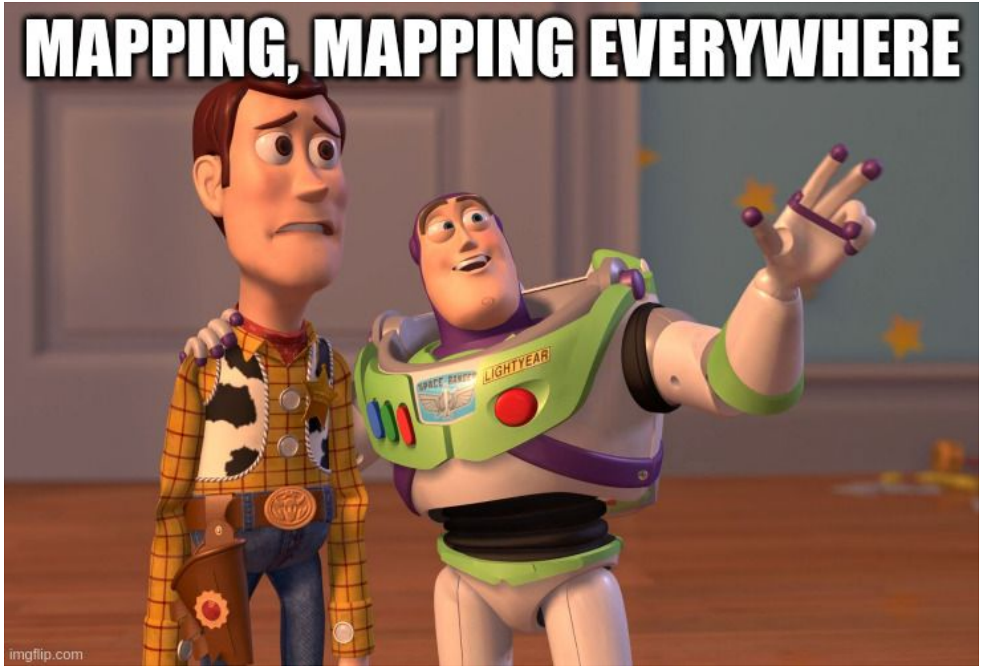
Want more CA?



Elementary cellular automaton

- 256 rules (Wolfram)

CA for music generation



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1. Map axes to different musical params
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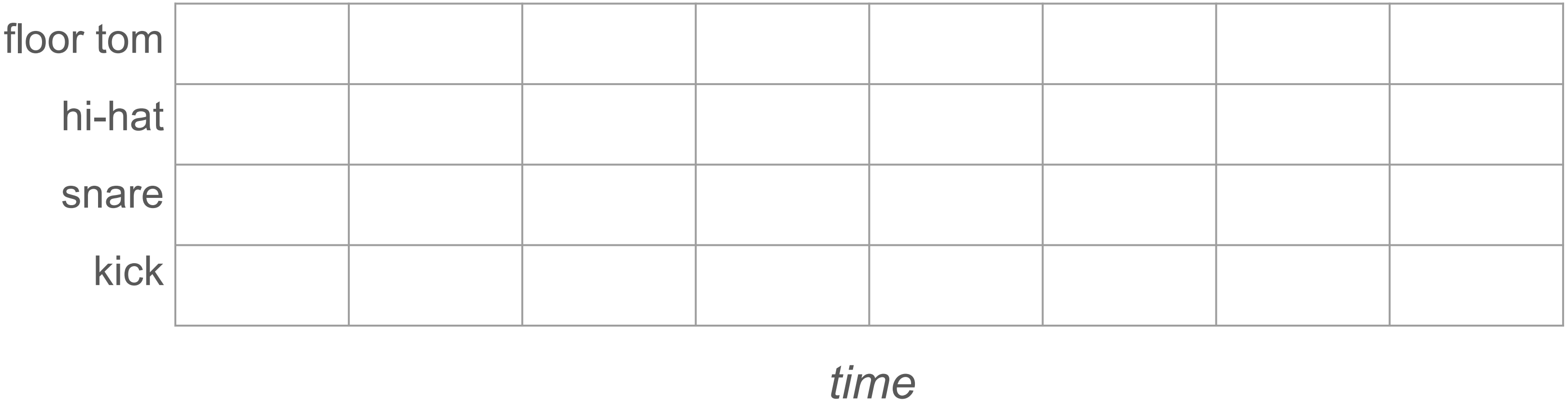
4. Map time (e.g., 1 beat = 1 step)

CA for drum generation



floor tom

hi-hat

snare

kick

time

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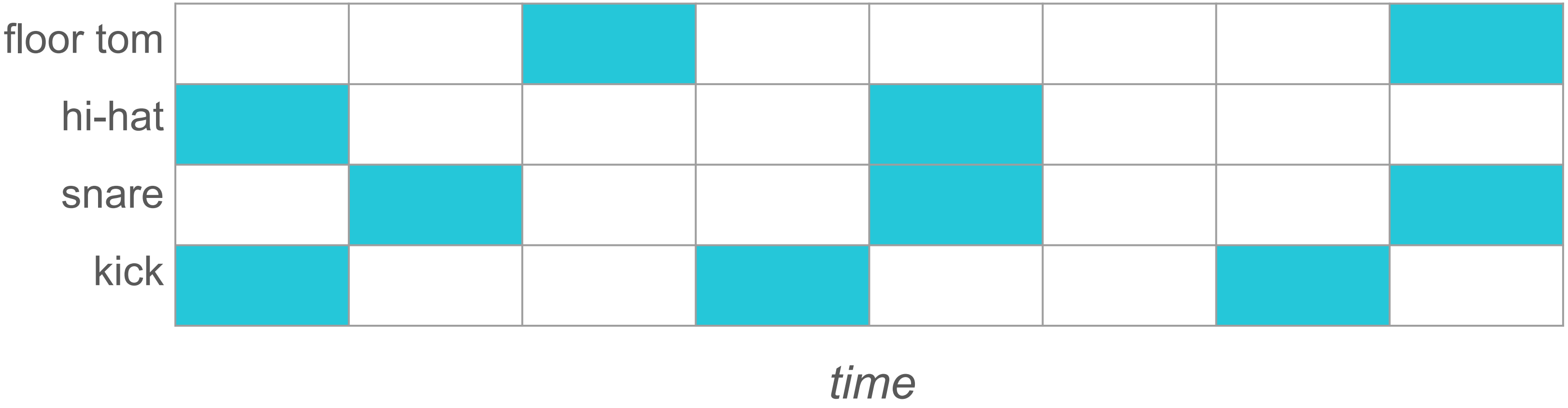
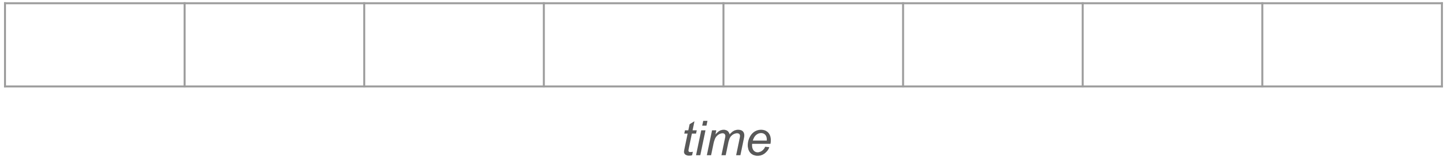


floor tom			■					■
hi-hat	■				■			
snare		■			■			■
kick	■			■			■	

CA for melody generation

$$States = \{C, D, E, F, G, A, None\}$$



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C		E		F	D	C	

time

CA for expressive chord generation

$$States = \{pp, p, mf, f, ff, None\}$$

synth					
piano					
organ					
	C	D	E	G	A

CA for expressive chord generation

$$States = \{pp, p, mf, f, ff, None\}$$

step 1 = beat 1

	C	D	E	G	A
synth	*pp*				*p*
piano		*f*		*p*	
organ			*ff*		*mf*

CA for expressive chord generation

$$States = \{pp, p, mf, f, ff, None\}$$

step 2 = beat 2

synth			*pp*		
piano		*mf*		*p*	*p*
organ	*ff*			*f*	
	C	D	E	G	A

Music strategies for CA

- Generate entire score

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- Guideline for improvisation

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- Generate entire score
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- Integrate CA-generated instrumentation into a composition

Pros and cons of CA

+

- Flexible
- Experimentation
- OK for raw material

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−

- Bad musical output
- No music knowledge

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- States and grid mapped to different musical params
- CA can be used for many generation tasks
- Music output is OK as raw material

What’s up next?

Drum generation with cellular automata