How to Evolve Life in a Computer using Python

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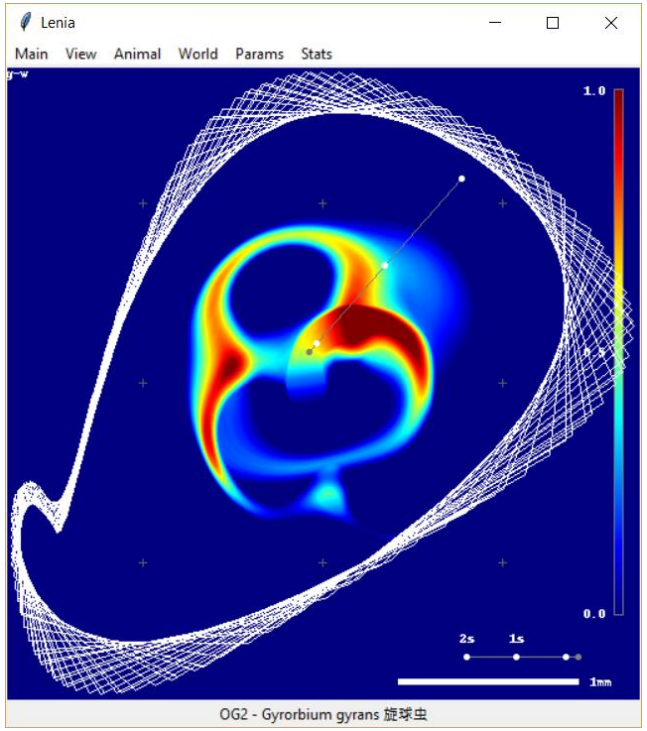
PyCon HK / Code Conf 2018



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Programming in the 1990's

- PC: **80286** (8MHz, 8MB RAM)
- OS: MS-DOS (Win3.1 too slow!)
- **Pascal**
  - Simulate life
  - Simulate gravity, fractals
  - Hack & decode games
- **Assembly**
  - Main loop – very fast!
  - Direct write to video cache

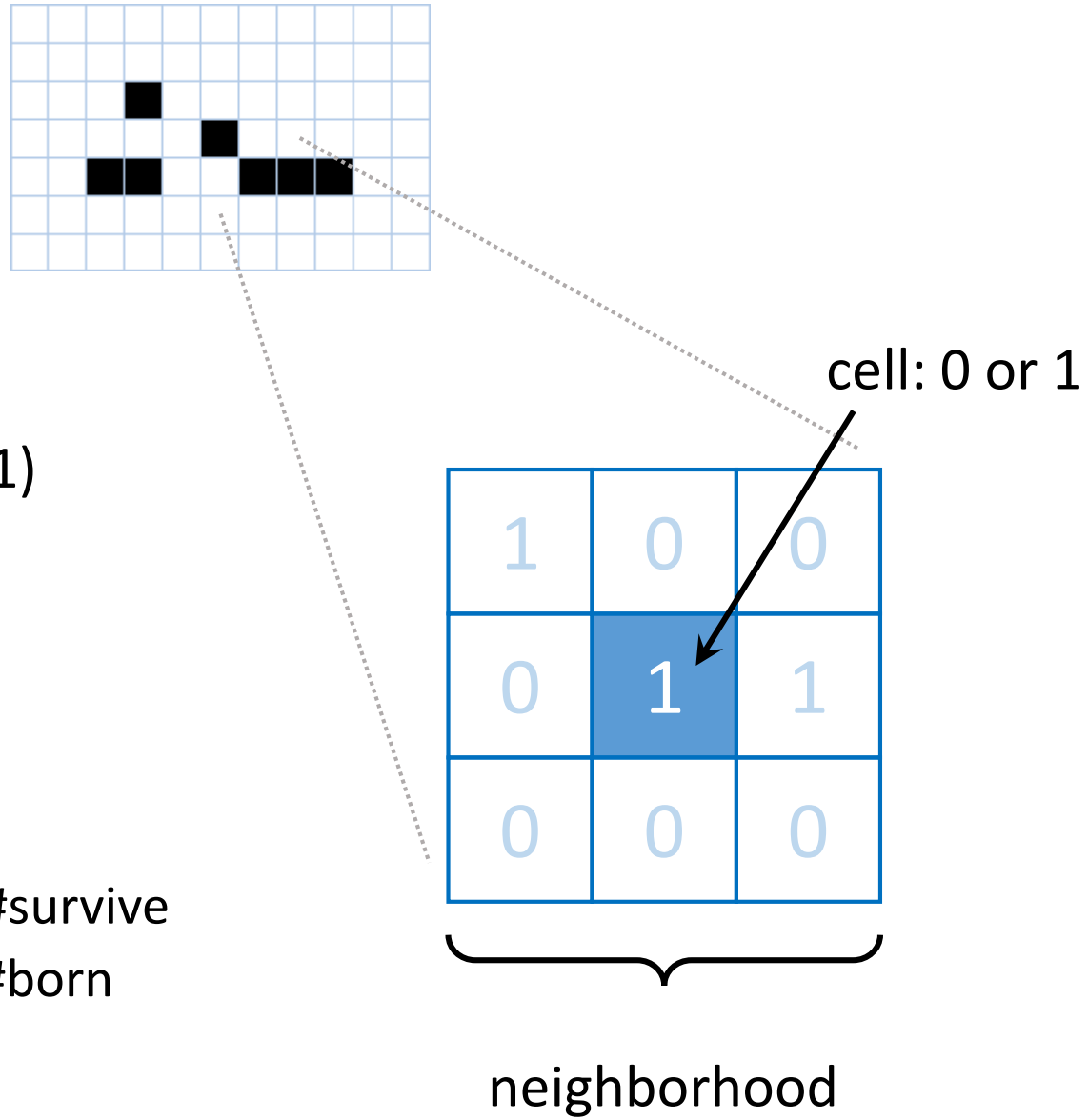
If you did coding and hacked stuffs in the 90's, you're a…

Simulate Life

- **Conway's Game of Life**
  - John Conway 1970
  - Cellular Automata – array of **cells** (0 or 1)
  - **Neighborhood** (8 cells, sum)

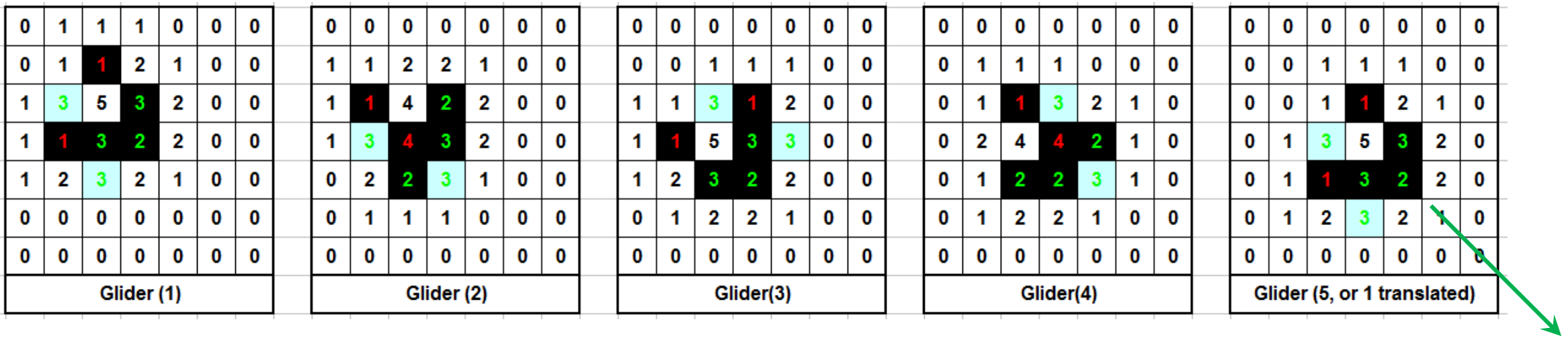
- Simple **if-then-else** rule

```
for cell in cells:
    if cell==1 and sum in [2, 3]: cell = 1    #survive
    elif cell==0 and sum in [3]:  cell = 1    #born
    else: cell = 0    #die
```



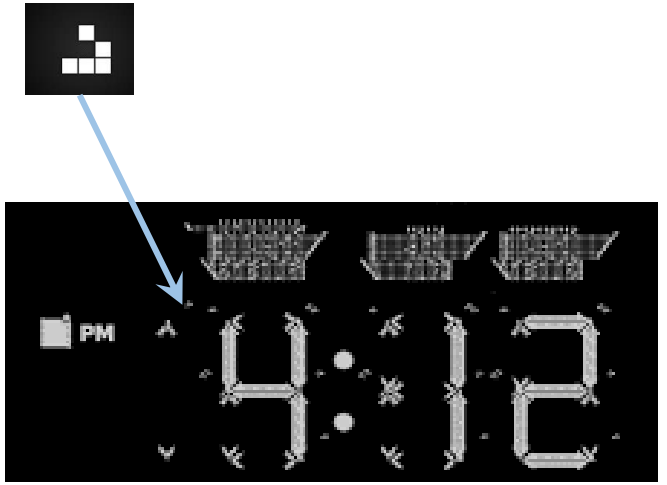
Conway's Game of Life

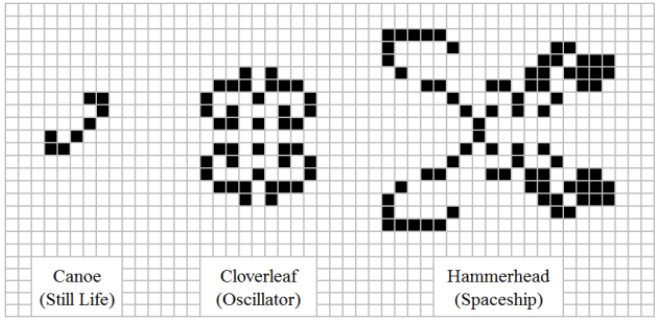
- The moving **glider**
- Green cells survive, blue cells are born, red cells die

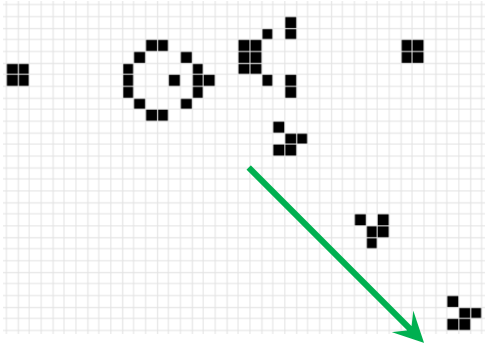


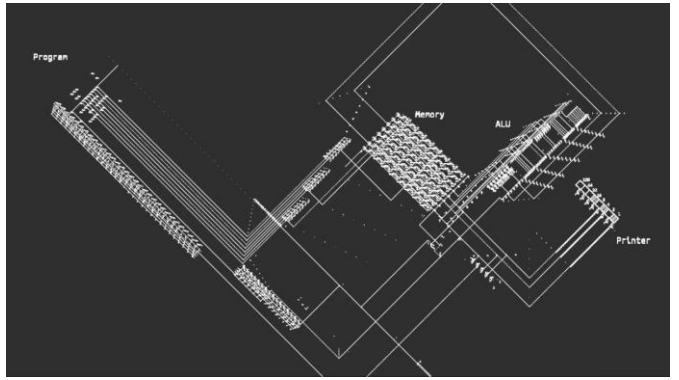
Conway's Game of Life

- Spaceships, glider gun…
- Logic gate, clock, computer…
- Hackers love it!
- Good way to learn programming!



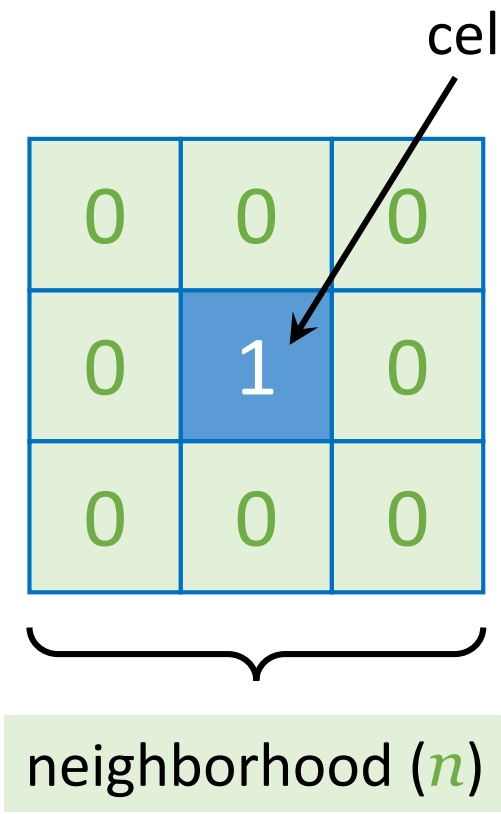






Play with the rules

- What if we…

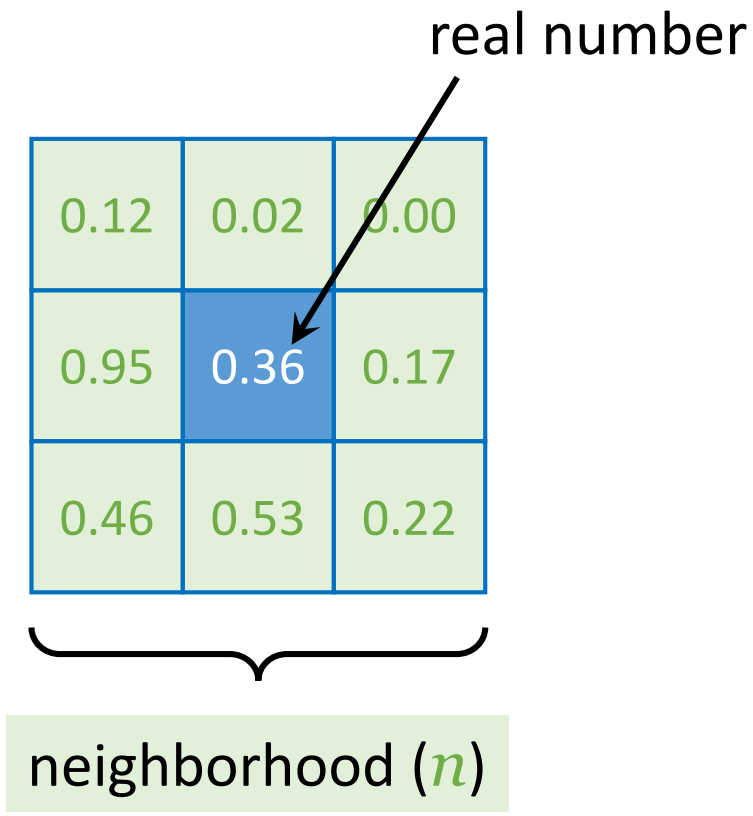


sum = $\sum n$

cell = (if sum … then … else …)

Play with the rules

- What if we…
  - Use floating point?

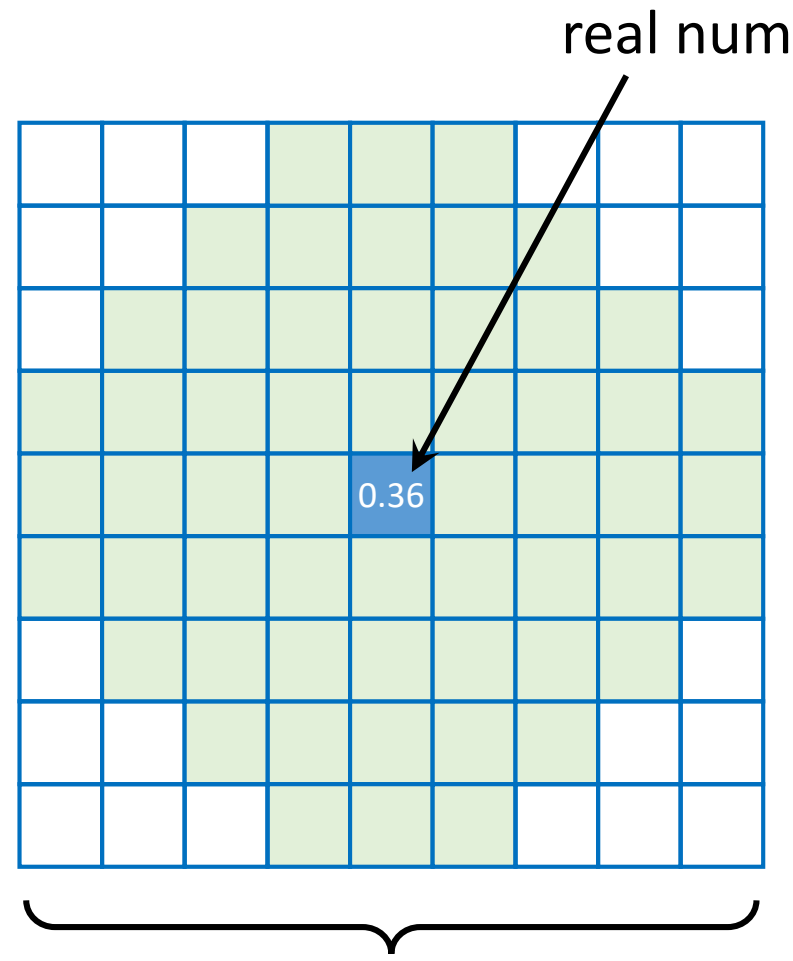


sum = $\sum n$

cell = (if sum … then … else …)

Play with the rules

- What if we…
  - Use floating point?
  - Bigger neighborhood? Circular?

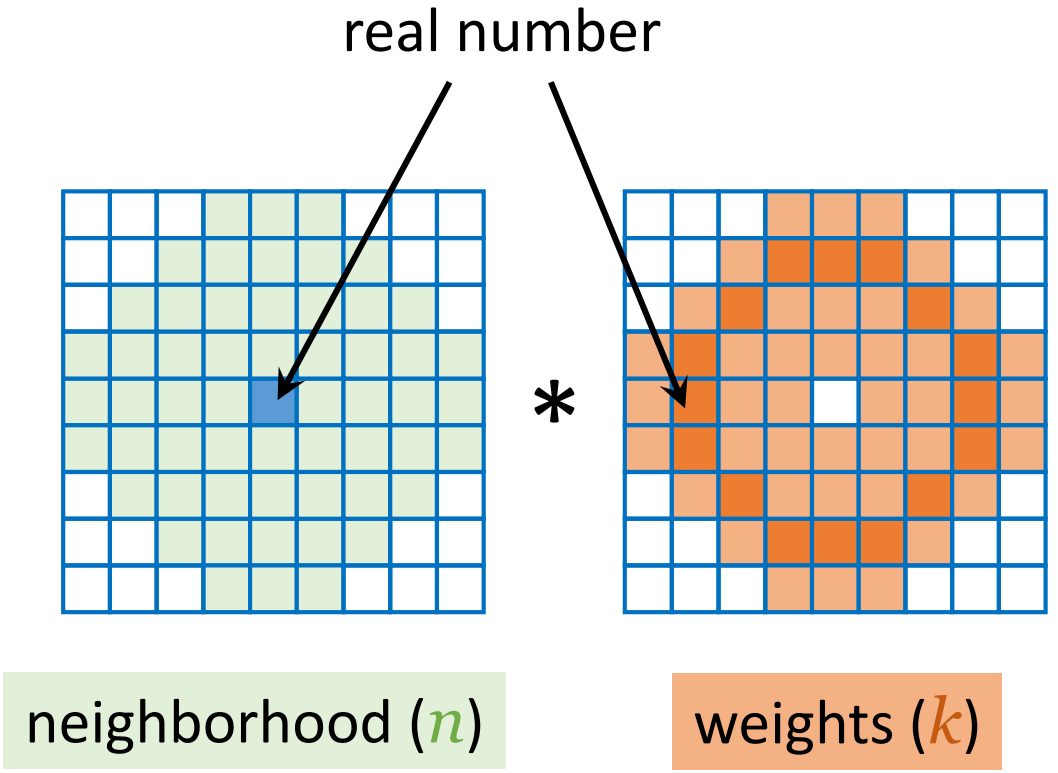


sum = $\sum n$

cell = (if sum … then … else …)

Play with the rules

- What if we…
  - Use floating point?
  - Bigger neighborhood? Circular?
  - Weighted sum?

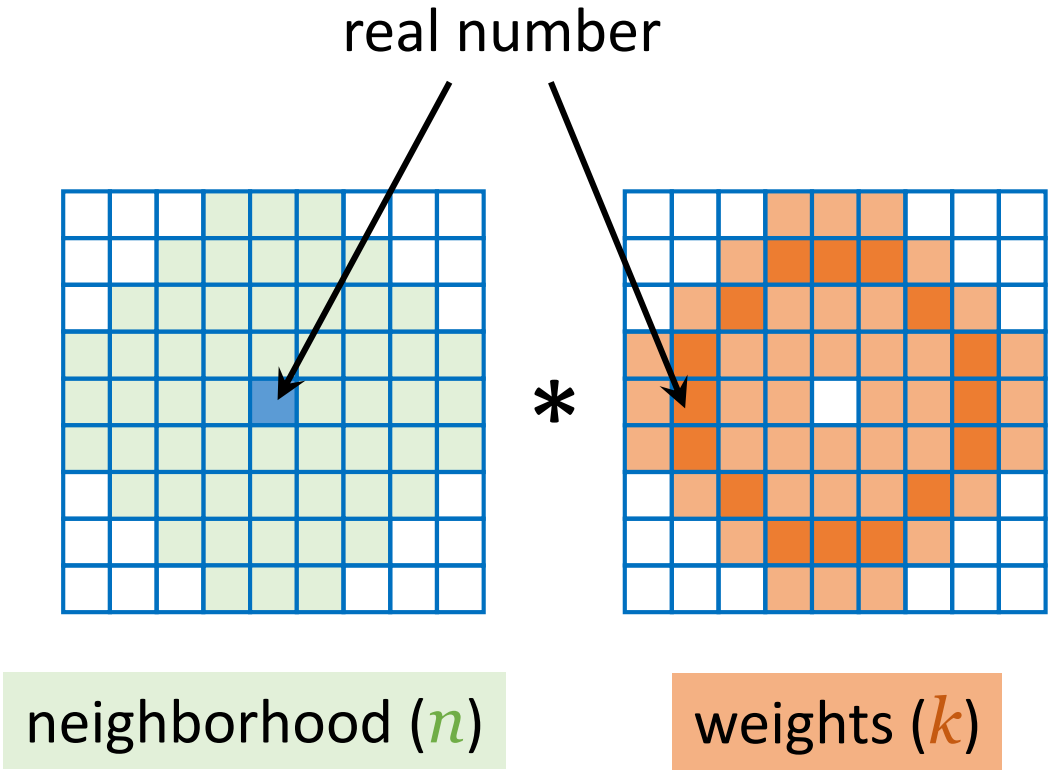


$$\text{sum} = \sum nk$$

cell = (if sum … then … else …)

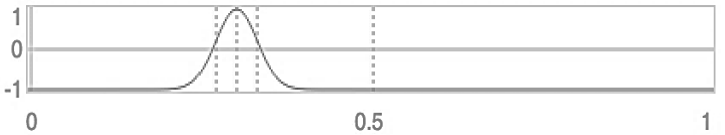
Play with the rules

- What if we…
  - Use floating point?
  - Bigger neighborhood? Circular?
  - Weighted sum?
  - Smooth update?



$$\text{sum} = \sum nk$$

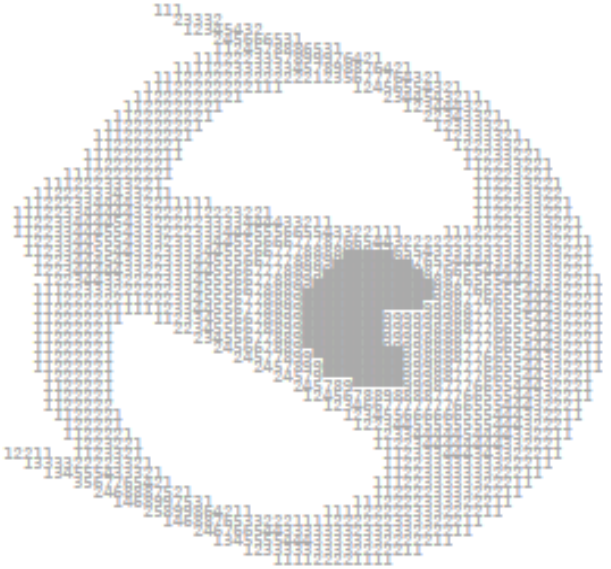
cell = cell + 0.1 * f(sum)



Play with the rules

- What if we…
  - Use floating point?
  - Bigger neighborhood? Circular?
  - Weighted sum?
  - Smooth update?

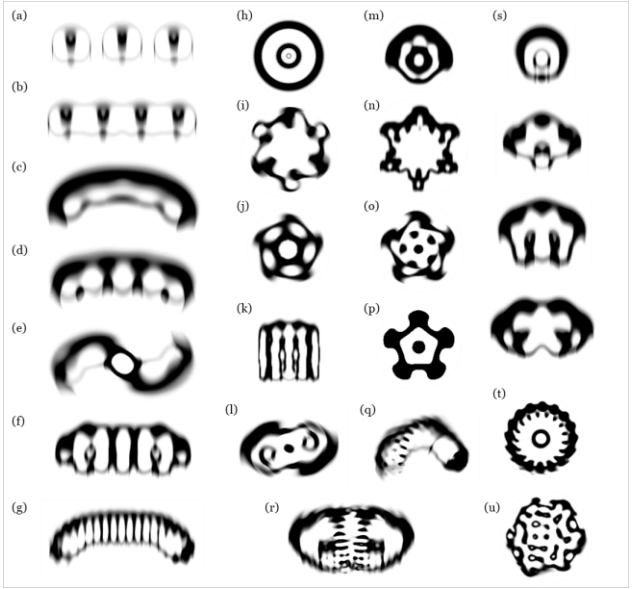
- Spooky things happened…



OMG WHAT IS THIS??

Lenia

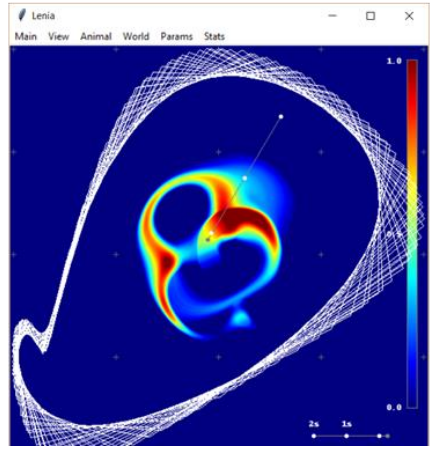
- New kind of **Artificial Life**
  - Microorganism-like creatures
  - Discovered 400+ species
  - Study their anatomy, behavior, physiology…



- Good programming exercise
  - JavaScript, C#, MATLAB, Python

(a)

(b)



Video

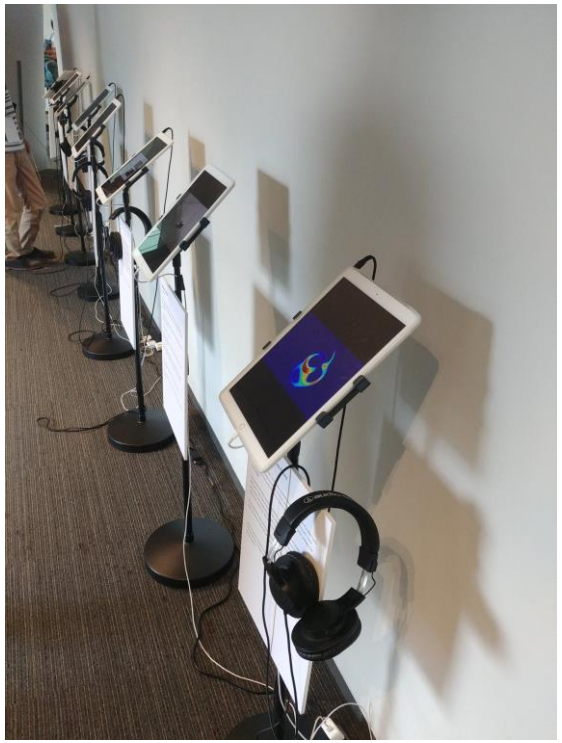
- Python → showcase video
- https://vimeo.com/277328815

Kyoto

- Won GECCO Virtual Creatures Contest, Kyoto
- Honorable Mention in ALIFE Art Award, Tokyo
- Meet my AI hero – @hardmaru
  - David Ha (Google Brain Tokyo)

GECCO

ALIFE 2018



Using Python

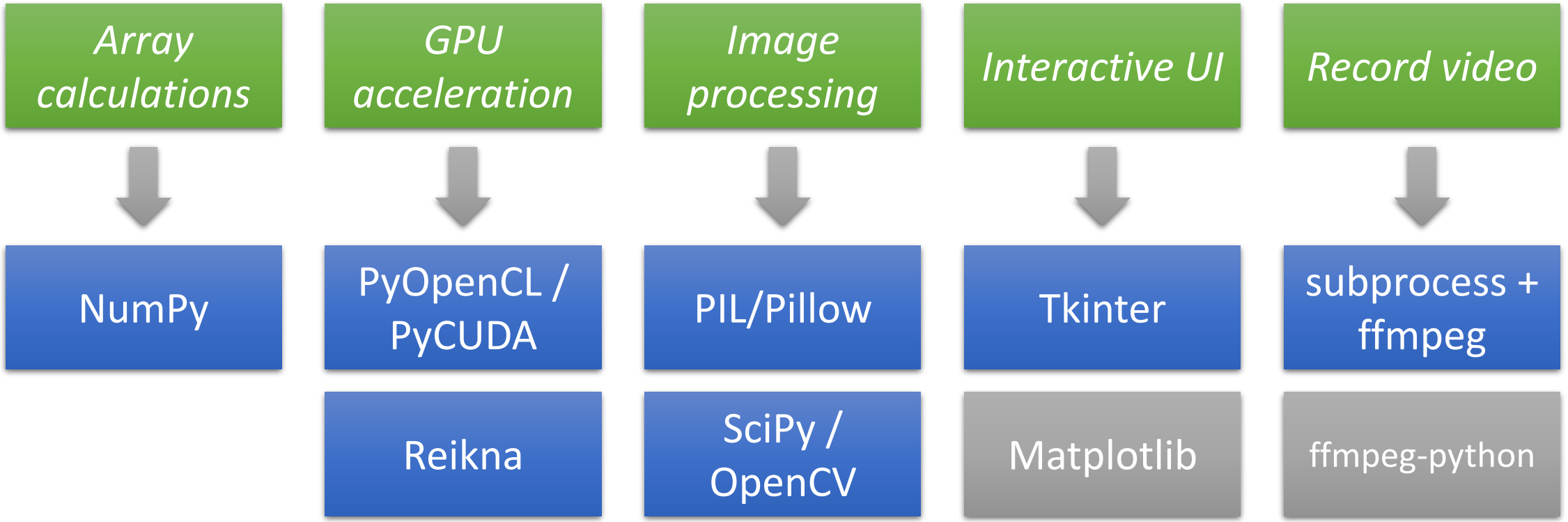
for PyCon HK

Why Python?

- Good performance
- Fast coding
- Nice syntax (indent, list comprehension, etc)
- Lots of useful libraries
- Vibrant community (PyCon, GitHub…)

Python Libraries

- “Rule 34” of Python
  - *“If there is a need, there is a Python library for it.”*



NumPy

- Fast array calculations
  - ✓Machine learning, deep learning
  - ✓Basis of image processing, time-series
  - ✓Cellular automata (weighted sum using FFT)

- Main loop of Lenia in 3 lines

```
potential_fft = np.fft.fft2(cells) * kernel_fft
potential = np.fft.fftshift(np.real(np.fft.ifft2(potential_fft))
cells_new = np.clip(cells + dt * g(potential, m, s), 0, 1)
```

PyOpenCL/PyCUDA + Reikna

- GPU acceleration
  - (NVIDIA) CUDA → PyCUDA
  - (Apple) OpenCL → PyOpenCL