How to combine tiny bits of Python, physics, and art to create (hopefully) pretty pictures

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What is this all for anyway?

https://xkcd.com/1822/

Some **reasons** to write a computer program:

- Business interests
- Answer a science question
- Something else

In what follows, very much **something else** is going on!

Bridget Riley

Something else, in this case, was inspired by art!

Bridget Louise Riley CH CBE (born 24 April 1931) is an English painter known for her op art paintings.[1] She lives and works in London, Cornwall and the Vaucluse in France.[2]

Early life and education [edit]

Riley was born on 24 April 1931[3] in Norwood, London.[1] Her father, John Fisher Riley, originally from Yorkshire, had been an Army officer. He was a printer by trade and owned his own business. In 1938, he relocated the printing business, together with his family, to Lincolnshire.[4]

At the beginning of World War II, her father, a member of the Territorial Army, was

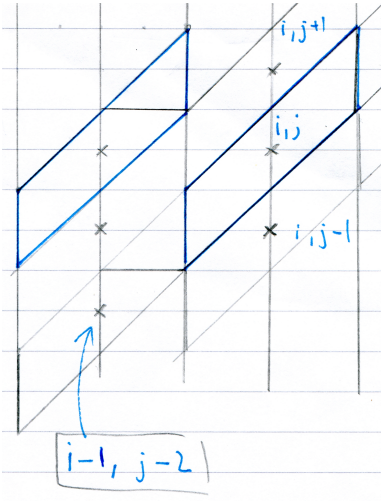
Bridget Riley
CH CBE

Born	Bridget Louise Riley 24 April 1931 (age 93) Norwood, London, England
Education	Cheltenham Ladies' College (1946–1948) Goldsmiths' College (1949–52) Royal College of Art (1952–55)
Known for	Painting · drawing · printmaking
Movement	Op art
Awards	Praemium Imperiale (2003)

Shadow Play, 1990, oil on canvas

https://en.wikipedia.org/wiki/Bridget_Riley

From analog beginnings...



- Create a 2-D lattice of space-filling tiles.
- Use integer tuple (i, j) to address each tile.
- *Neighboring* tiles interact.
- For tile (i, j):
  - upper neighbor is (i, j+1),
  - lower neighbor is (i, j-1),
  - left neighbor is (i-1, j-2),
  - right neighbor is (i+1, j+2).
- What do we mean by interaction? Physics!

...and applying some physics along the way...

Let us use a "simple" physics model coming from the study of **magnetism**!

- Lattice of *spins* s_i to represent our tiles.
- Each spin takes one of the q possible discrete values $(0, 1, 2, \ldots, q-1)$.
- Spins interact with their immediate neighbors up, down, left, and right on the lattice.

Potts model Hamiltonian (potential energy):

$$H = -J_{ij} \sum_{(i,j)} \delta(s_i, s_j)$$

where the sum runs over all pairs of neighboring spins, $\delta(n, m)$ equals one if $n = m$ and zero otherwise, and J_{ij} is the coupling constant between spins i and j and has a dimension of energy.

...to digital outcomes

We use a **computer simulation** to study the **thermodynamics** of the spin lattice at different **temperatures**.

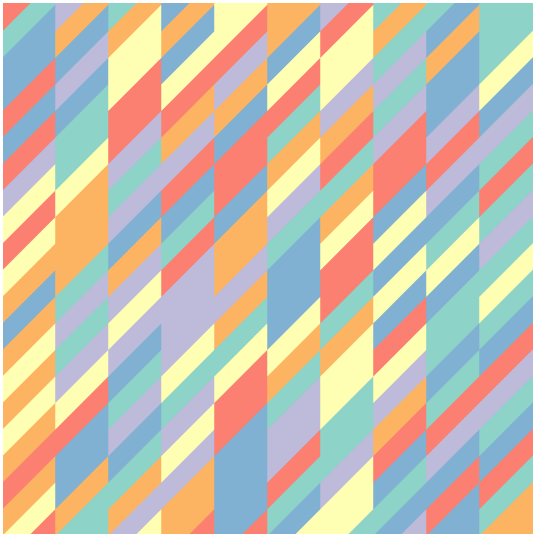
Algorithm: Metropolis Monte Carlo.

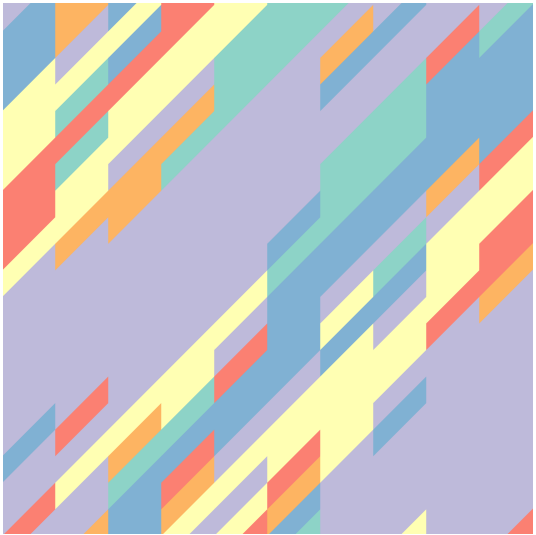
```
delta_e = e_new - e_old

if delta_e < 0:
    accept = True
else:
    if np.random.random() < np.exp(-beta * delta_e):
        accept = True

if accept:
    s[i, j] = s_new
```

Finally, the outcome is **visualized** with **Matplotlib**. Each spin on the lattice corresponds with a colored tile.

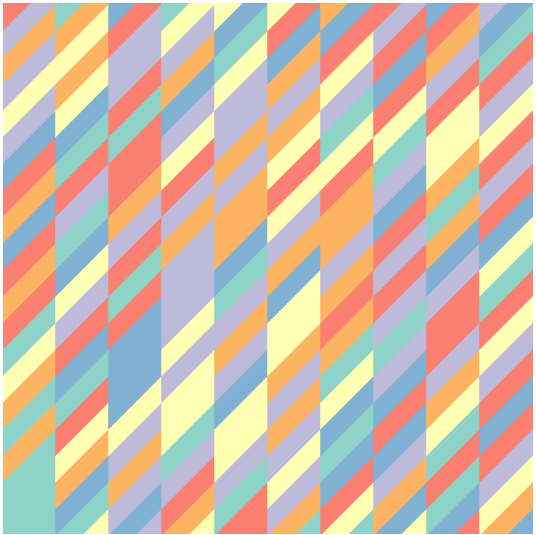
```
def mc_step(s, q, beta, inverse, m_grid, n_grid, traditional=False):
    """Main function: perform a single Monte Carlo move (in-place).

    Parameters
    ----------
    s : numpy.array[int, int]
        The spin lattice. This is modified in-place after a successful move.
    q : int
        Number of spin directions.
    inverse : bool
        If set to True, the interaction term is inverted, i.e. like spins are
        energetically worse than unlike ones.
    beta : float
        Thermodynamic beta = 1 / kT.
    m_grid, n_grid: int
        Grid dimensions in x and y direction.
    traditional : bool (default False)
        If set to True, use a regular Potts model with four neighbors, one on
        each side. If False, use modified model with "tilted" interaction, i.e.
        corresponding to where the tiles touch. The interaction is also stronger
        by an asymmetry factor along this second direction.

    Returns
    -------
    accept : bool
        True if trial move was accepted, False otherwise.
    """
```

Finally, some pictures: random initial lattice and after a simulation





So again, what is this all for?



Github:
`https://github.com/leitold/junegloom`

Some more text:
`http://christian.leitold.info/index.php?page=june-gloom`