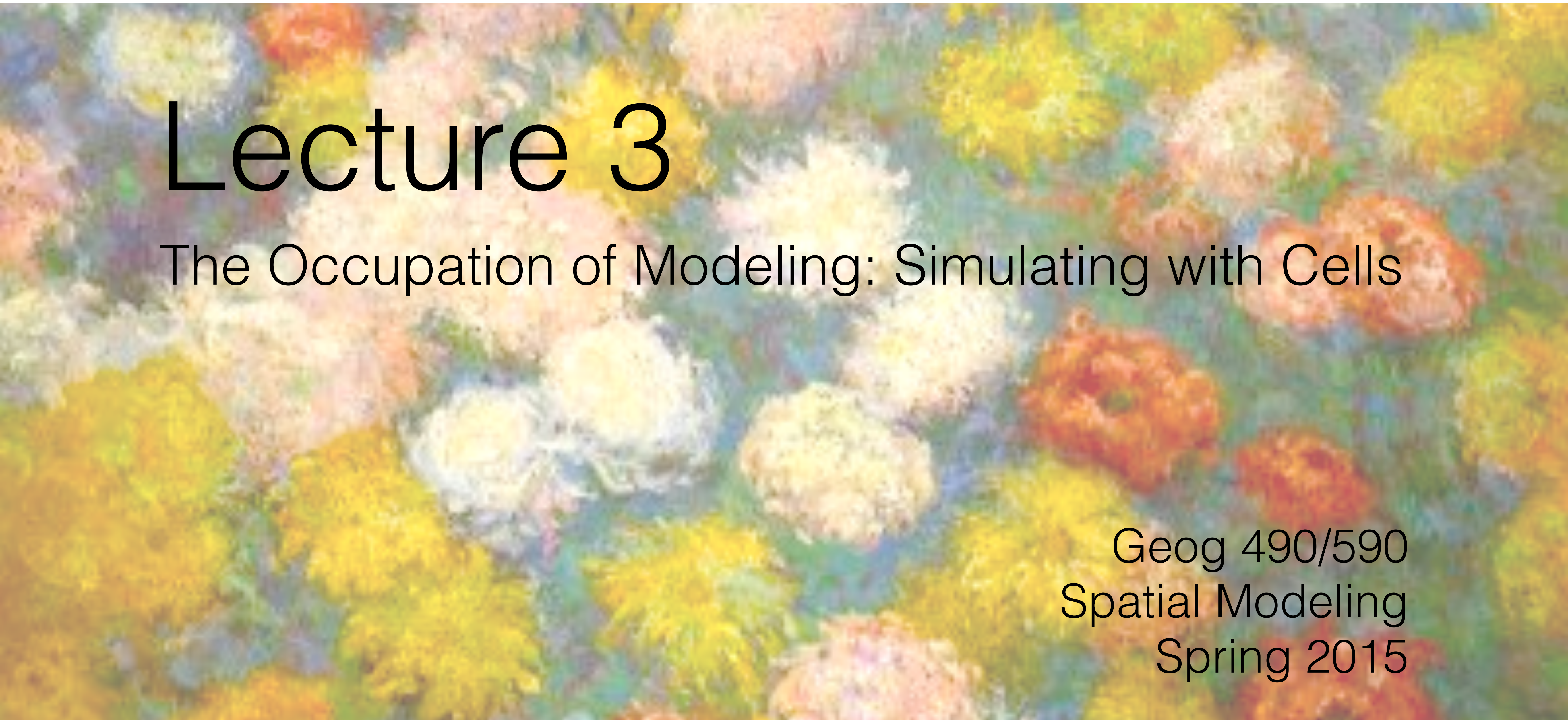


Lecture 3

The Occupation of Modeling: Simulating with Cells

Geog 490/590
Spatial Modeling
Spring 2015

what are models?

who are modelers?

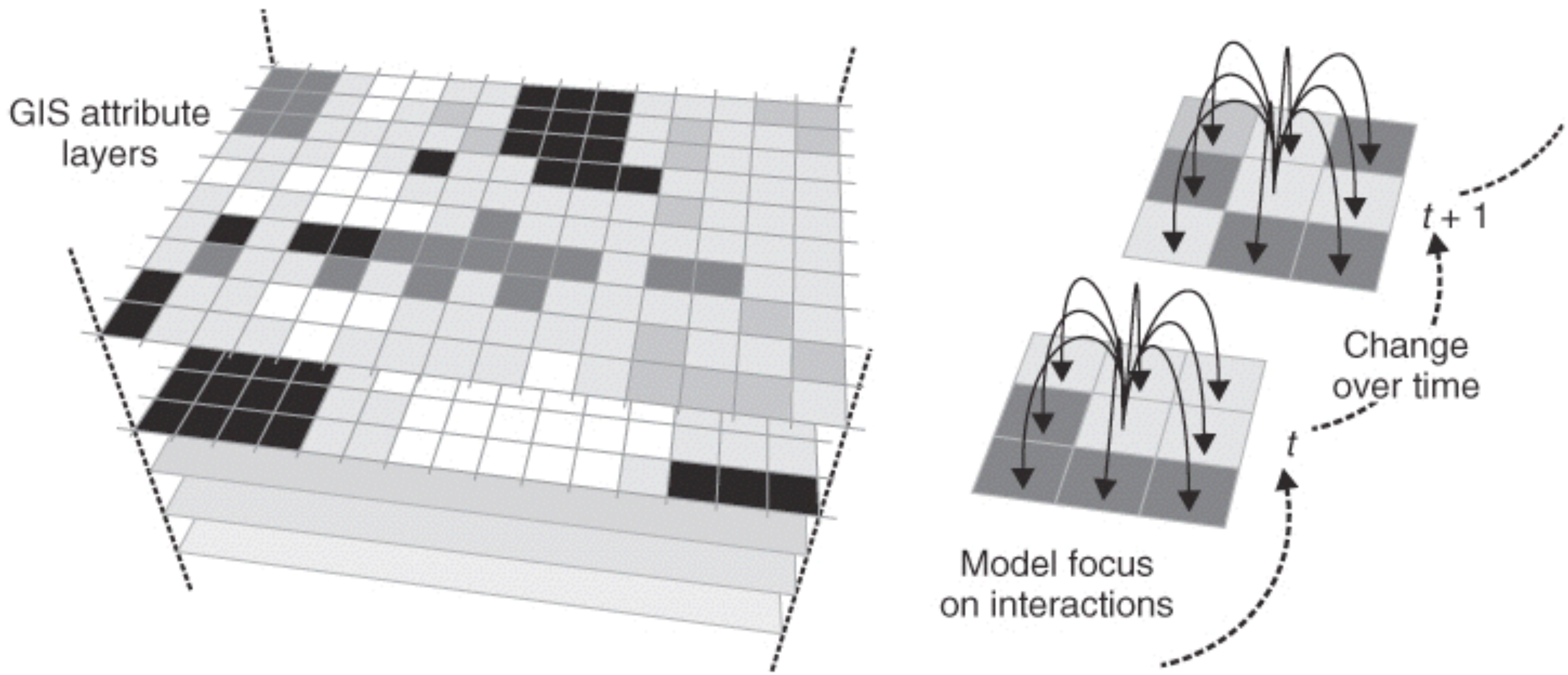
simulation models are used to emulate how a particular process takes place over <u>time</u>

spatial simulation models are used to emulate how a particular process takes place over <u>space</u> and <u>time</u>

space

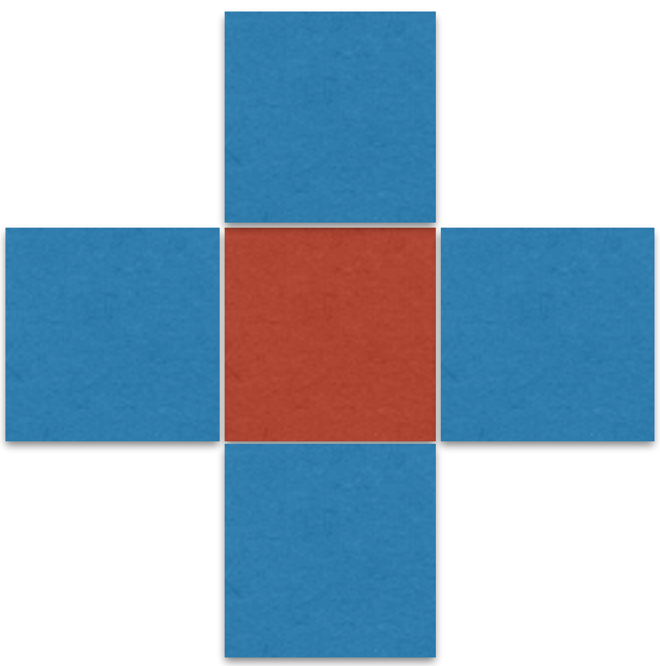
Discrete Space

raster grid or lattice
of cells or pixels

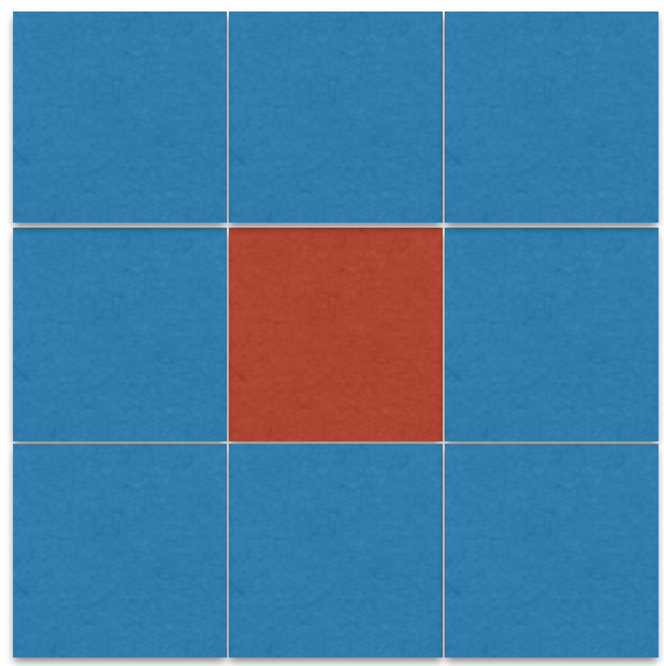


neighborhoods

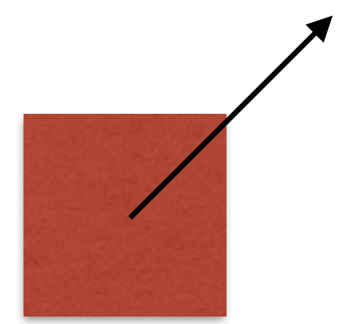
von Neumann



Moore



Euclidean



neighborhoods

von Neumann

$$N_V(c_{x,y}) = \begin{Bmatrix} & c_{x,y+1} & \\ c_{x-1,y} & & c_{x+1,y} \\ & c_{x,y-1} & \end{Bmatrix}$$

$$N_V(c_{x,y}) = \{c_{i,j} : |i-x| + |j-y| \le 1\}$$

neighborhoods

Moore

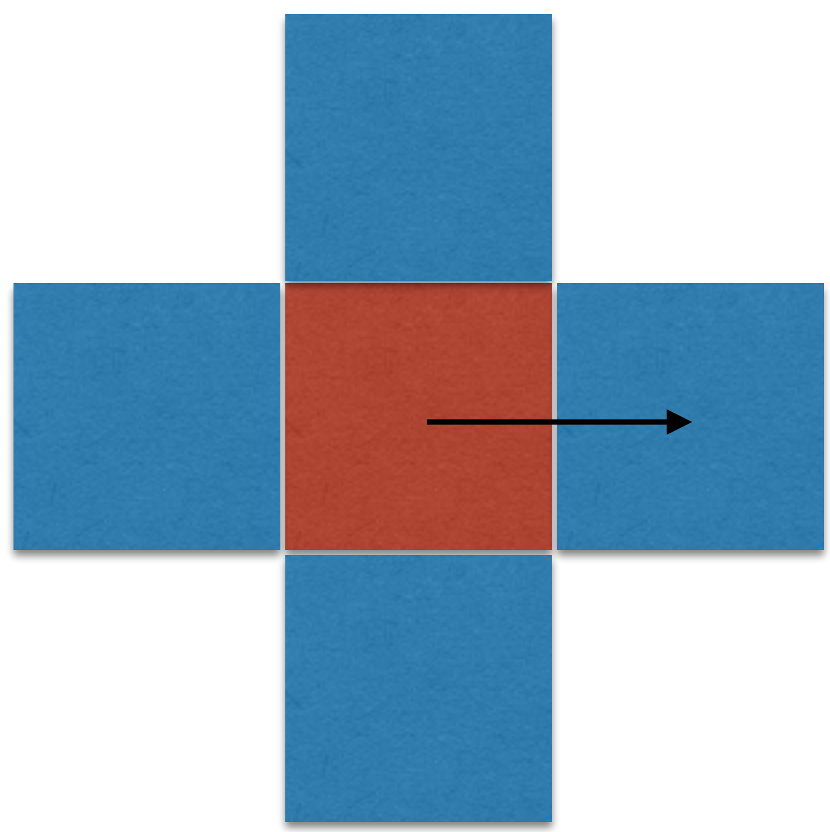
$$N_M(c_{x,y}) = \begin{Bmatrix} c_{x-1,y+1} & c_{x,y+1} & c_{x+1,y+1} \\ c_{x-1,y} & & c_{x+1,y} \\ c_{x-1,y-1} & c_{x,y-1} & c_{x+1,y-1} \end{Bmatrix}$$

$$N_M(c_{x,y}) = \{c_{i,j} : \max(|i-x|, |j-y|) \le 1\}$$

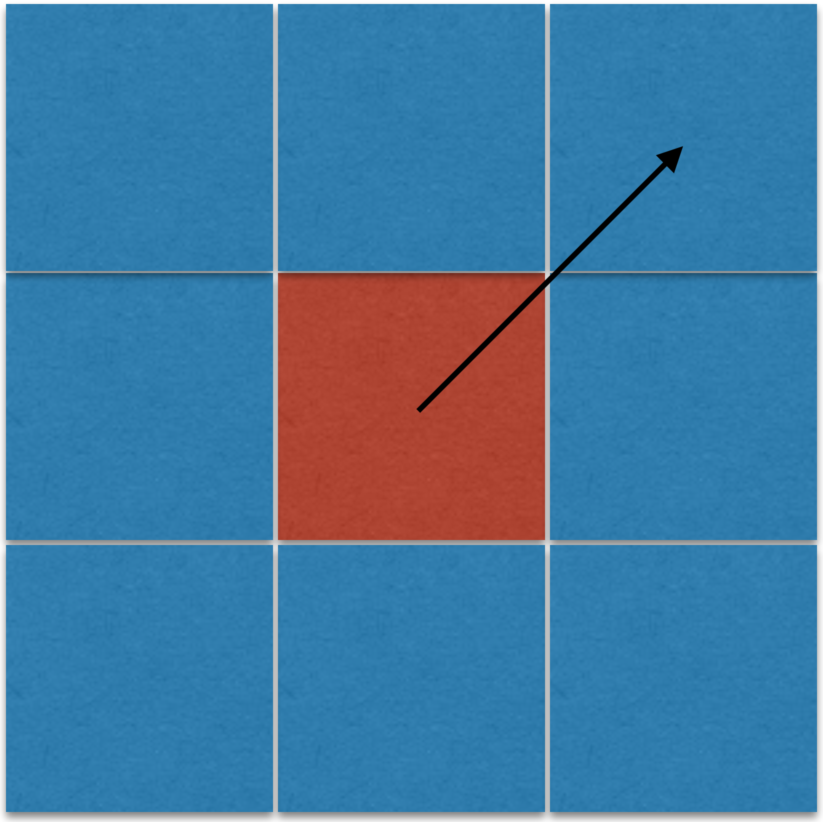
neighborhoods

Euclidean $$N_r(c_{x,y}) = \left\{ c_{i,j} : \sqrt{(i-x)^2 + (j-y)^2} \leq r \right\}$$

Euclidean neighborhood

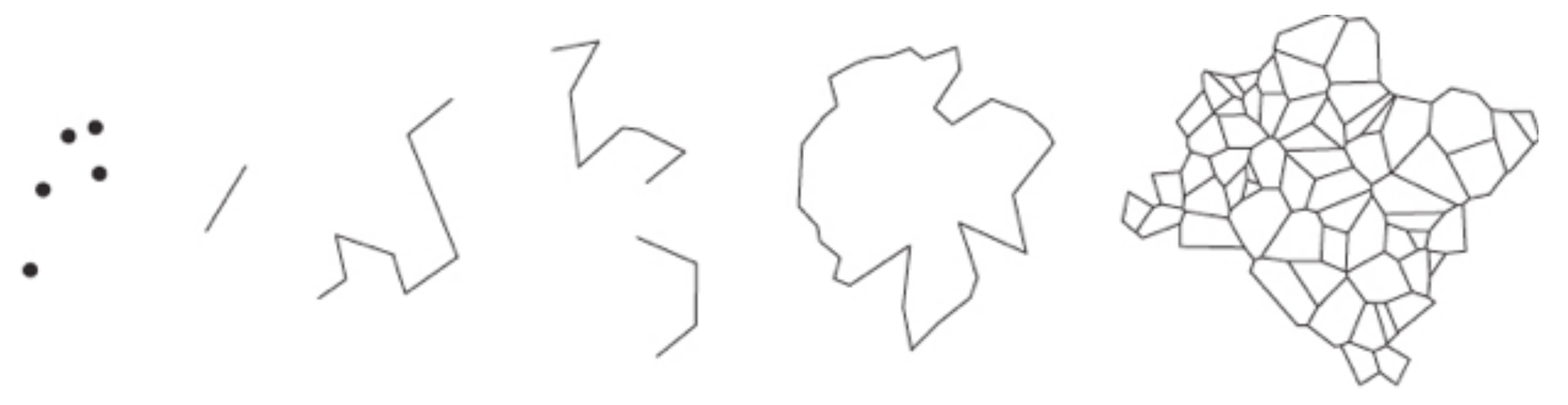


Euclidean neighborhood

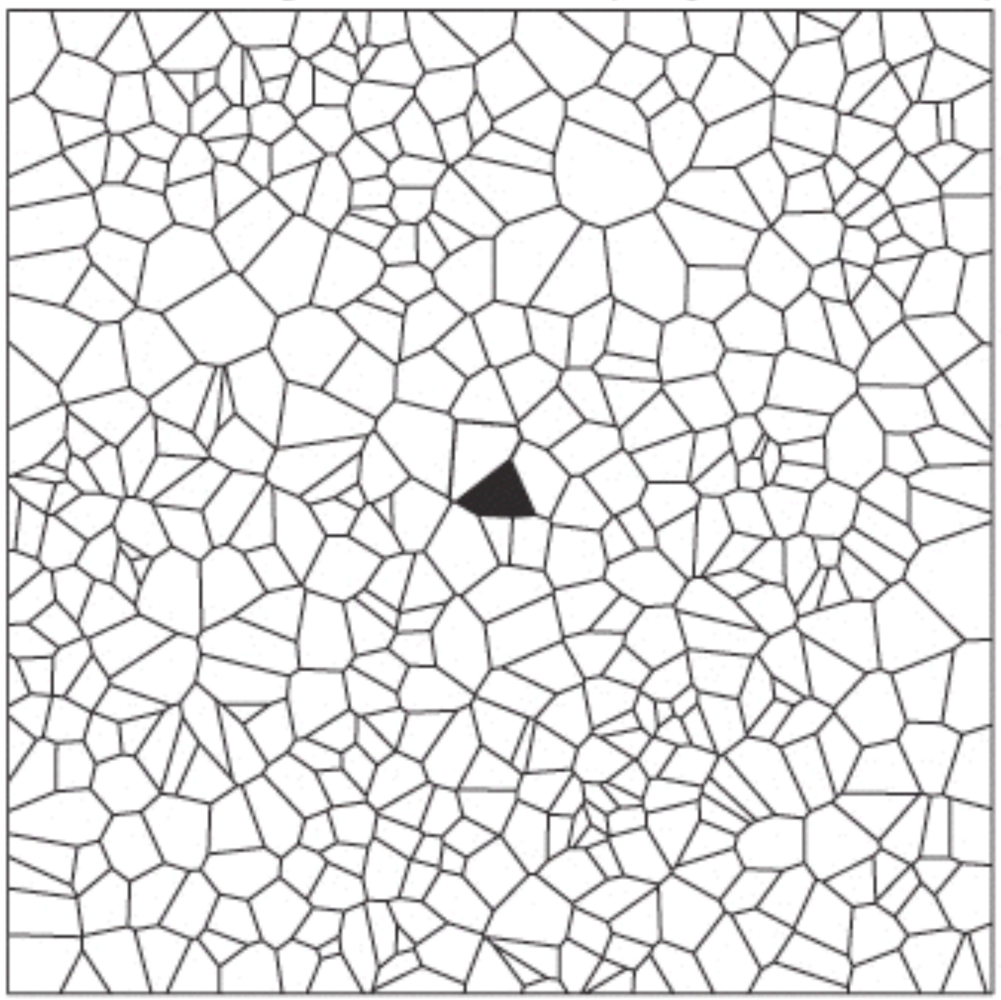


Continuous Space

points, lines and polygons



models 6.5



spatial extent of study site

1. Finite
2. Infinitely extensible
3. Toroidal

models 6.6 and 1.1

time

Updating Time

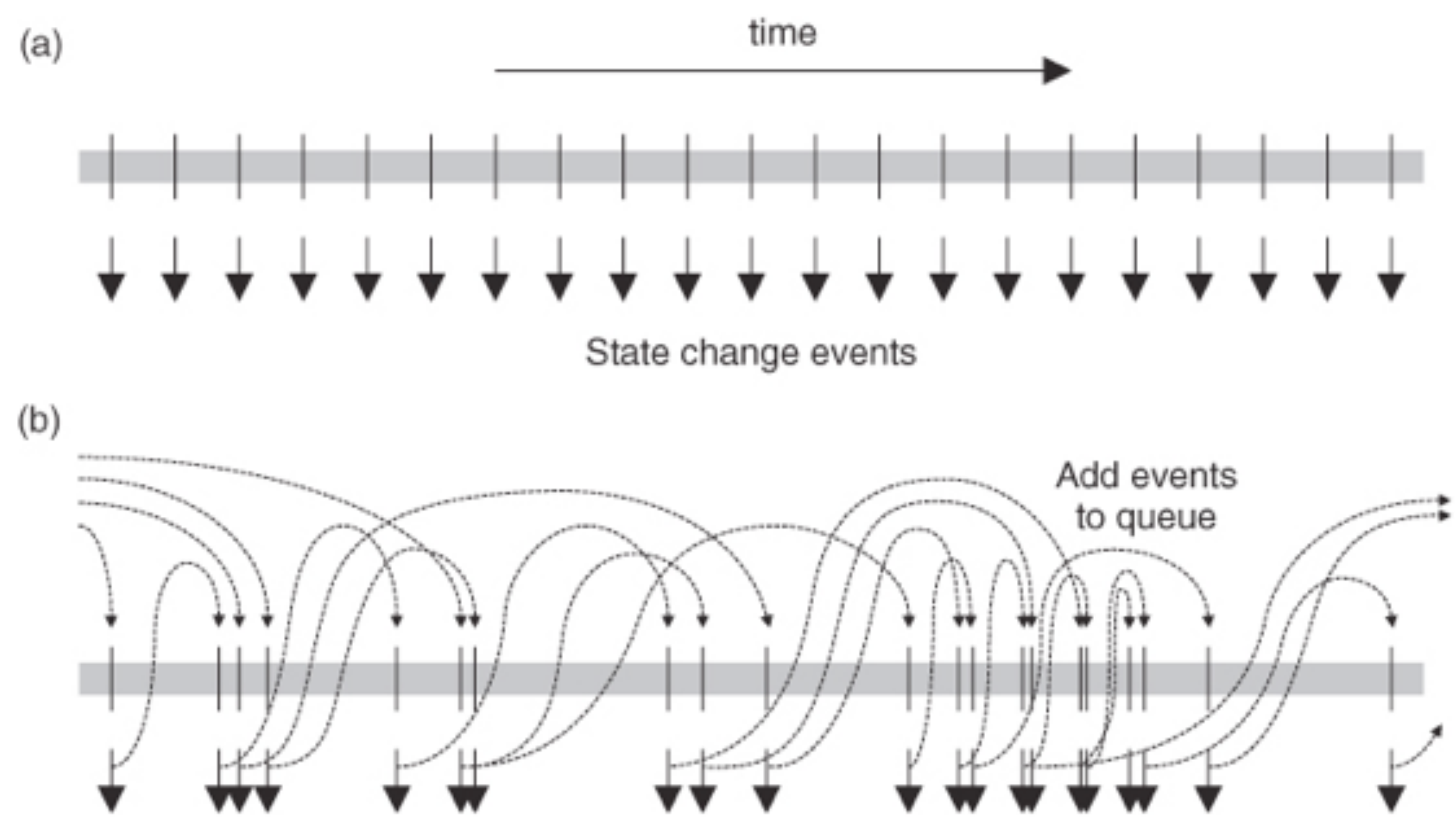
synchronous vs asynchronous

1. Synchronous update
2. Random asynchronous without replacement
3. Random asynchronous with replacement
4. Systematic Asynchronous

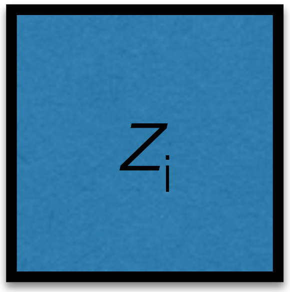
models 6.1 & 6.2

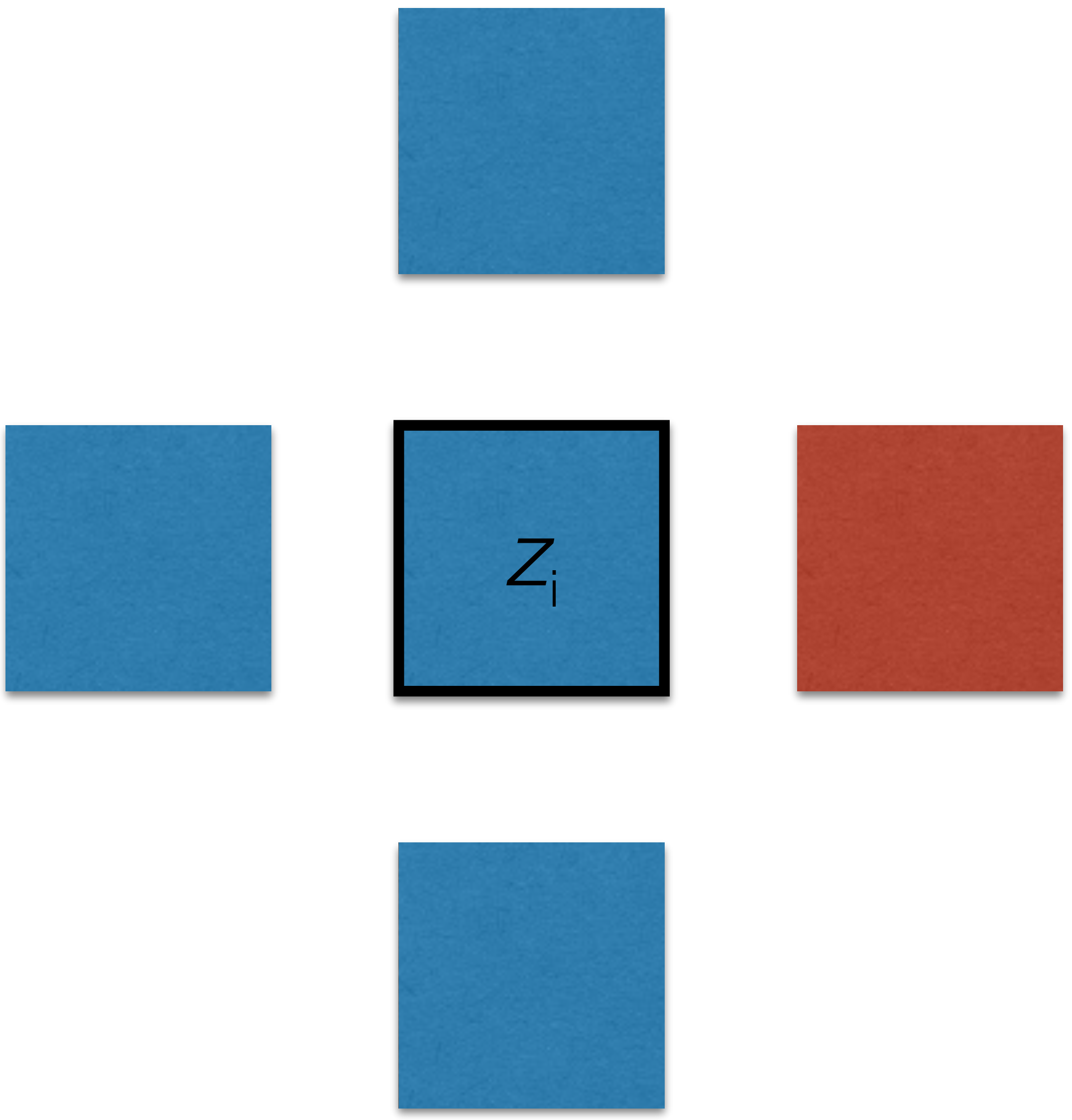
representing time

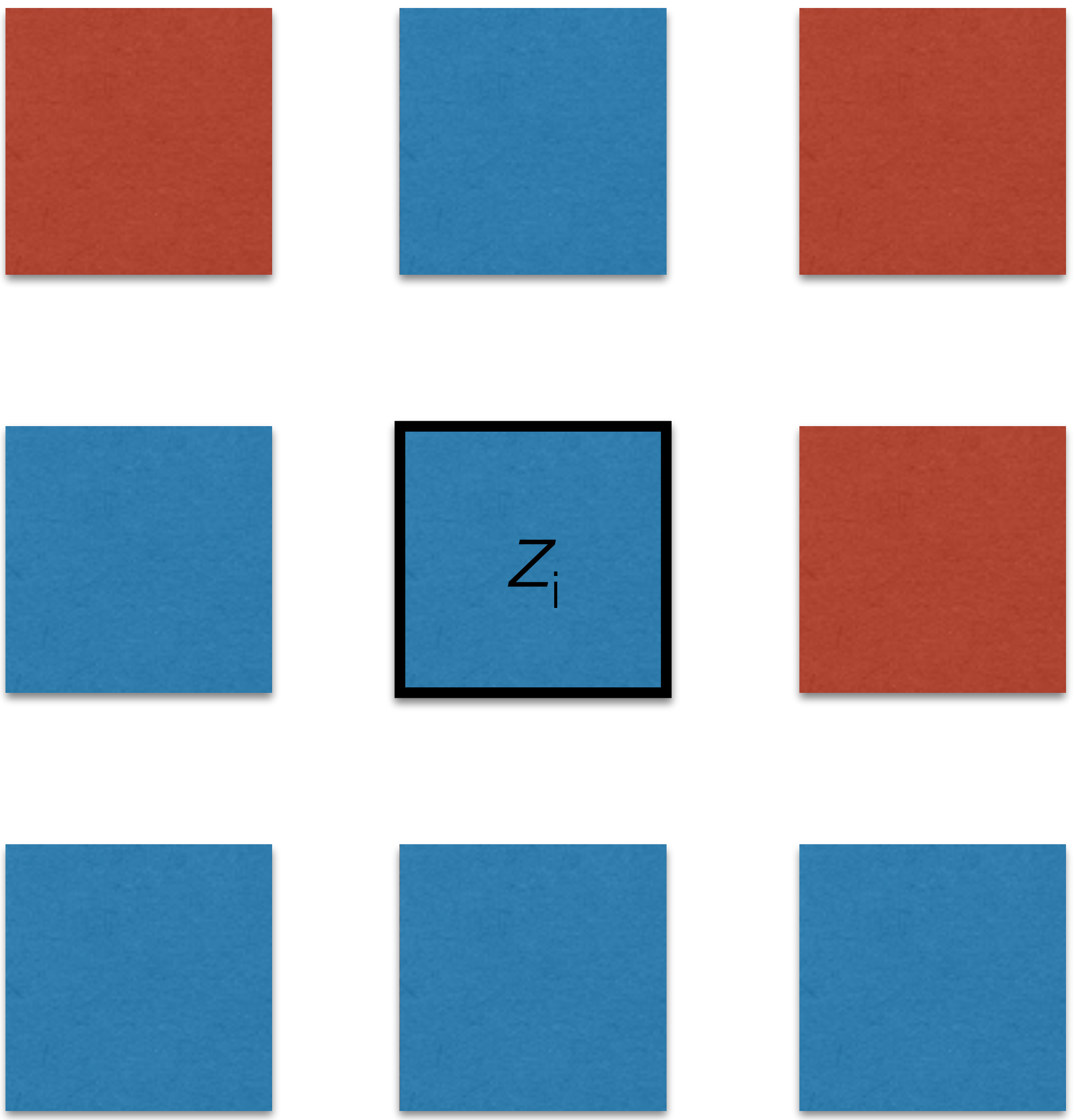
1. Discrete
2. Event-driven
3. Continuous



Cellular Automata


Z_i


z_i


z_i

majority rules

von Neumann

$$z_i(t+1) = \begin{cases} 1 \text{ if } (z_i(t) = 0 \text{ and } \sum z_j > 2) \text{ or } (z_i(t) = 1 \text{ and } \sum z_j \geq 2) \\ 0 \text{ otherwise} \end{cases}$$

Moore

$$z_i(t+1) = \begin{cases} 1 \text{ if } (z_i(t) = 0 \text{ and } \sum z_j > 4) \text{ or } (z_i(t) = 1 \text{ and } \sum z_j \geq 4) \\ 0 \text{ otherwise} \end{cases}$$

life-like rules

$\beta_1 \longleftarrow$ birth rate $\longrightarrow \beta_2$

$\delta_1 \longleftarrow$ death rate $\longrightarrow \delta_2$

interacting particle systems

If the site is occupied, then with some probability p the particle dies

If the site is vacant, then a new particle is born with a probability given by the proportion of neighboring sites that are currently occupied

cyclical relationships between states

If the states $z_i = z_j$, then nothing happens

If the neighboring site dominates the central site ($z_j > z_i$), then $z_i \longrightarrow z_j$

Otherwise, if $z_i > z_j$, then $z_j \longrightarrow z_i$

Shelling Models

Shelling Models

1. Two types of individuals are located in cells in a two-dimensional grid.

2. A proportion of cells, p_v, must remain vacant to allow individuals to reorganize themselves.

3. Individuals tolerate individuals of opposite type in their neighborhood, BUT desire to be in locations with some mimim proportion of neighboring individuals p_{like} of the same type as themselves.

4. Any individuals dissatisfied with their current location move to the nearest available locational which their requirements are satisfied.

individual preferences

=

micro-motives

aggregate outcome

=

emergent patterns