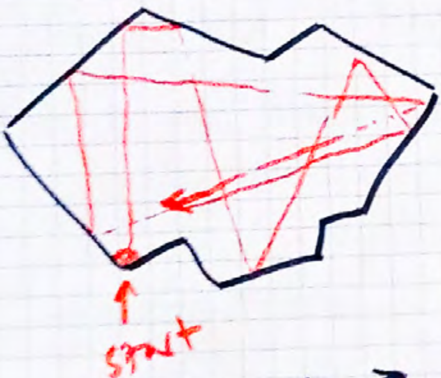
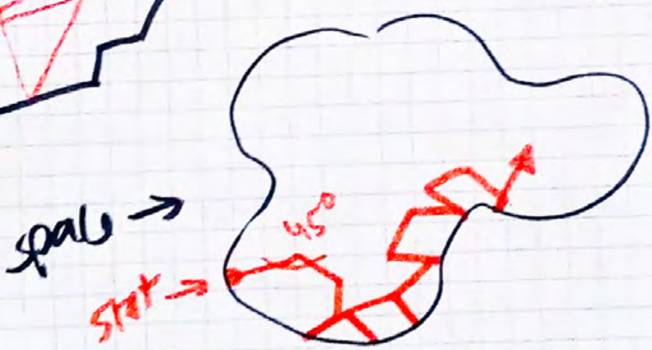
COGS 300 Emergence 01 Mar 3/26

Warm up: Draw a space. Make a "rule" for drawing. Follow it as far as you can. Repeat.

"Automatic drawing"



rule: bounce "light"



rule: straight + 45°
wall → reverse

Automata

↳ self-moving

is the body
a machine?

↓

is the brain a
computer?

Santa Fe
Institute

↳ is life "just" self-replication?

What are the core defendable
definitions of "life"?

→ novelty

→ experience

→ creativity

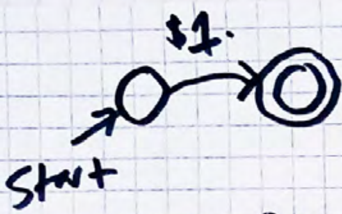
→ life implies death.

→ purpose

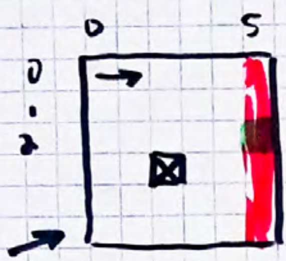
→ moves (state change)

→ cells (excluding viruses)

→ genetic material



transition rules.
↓



~~(x, y) → (x', y')~~

(x, y) → (x+1, y)

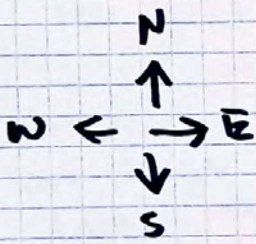
(5, y) → (5, y)

start = (rand(x), random(y))

↑ accepting

(5, 2) → (5, 2)

bad ↗



1 square

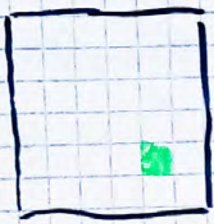
↓

taxicab / manhattan

topology

1 step

2 steps?



random start

goal

random(N, E, S, W)

(x, y) → (if N → x, y+1
if E → x+1, y
⋮
)

1. Design an automaton that will find the goal

2. characterize it on larger + larger environments.

→ what do you need to specially consider?

Chaos vs. randomness

☆ what emergent effects can w
characterize?

chaotic → run sim to find out

↓

vs stable initial conditions?

deterministic but can't "predict"

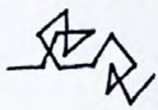
random → non-deterministic

Emergence 01

Warm up: Draw a pattern with an automatic rule.

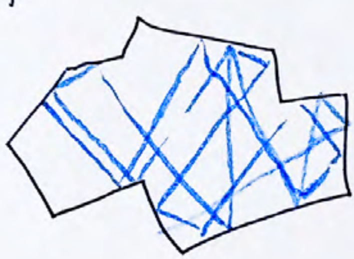
R 90° – straight(rand)

R(rand) – straight(1 cm)



Which rules are chaotic?

straight until wall:



Emergence in COGS is the study of how simple rules, processes, systems make more complex phenom. systems.

one simple example are automata.

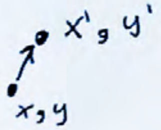
your robot is an automaton.

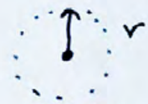
An automaton has a state:

(x, y)

transition rules: (x, y) → (x', y')

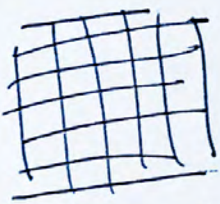
Eg. Any $(x, y$ [redacted]$) \to (x', y'$ [redacted]$)$
if dist($(x,y$ [redacted]$)$, $(x', y'$ [redacted]$)$)
$x, y \in \{0 .. N-1\}$ < max_dist = r
N x N





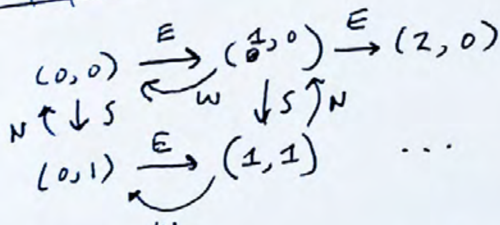
possible states.

Let's just do "taxicab" movement to start.

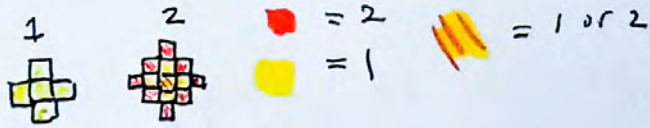


grid
movement ∈ {N, S, E, W}

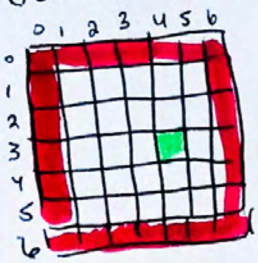
PFA



If max dist = 1, what's the shape?
" = 2 "



Goals. choose a state.



goal = (4, 3) $\xrightarrow{*}$ (4, 3)
(accepting)

Boundaries:

(x, 0) $\xrightarrow{S}$ (x, 1)
(x, 6) $\xrightarrow{N}$ (x, 5)
(0, y) $\xrightarrow{E}$ (1, y)
(6, y) $\xrightarrow{W}$ (5, y)

start/init = (rand (0,6), rand(0,6))

otherwise:

(x, y) $\xrightarrow{N}$ (x, y−1)
(x, y) $\xrightarrow{S}$ (x, y+1)
(x, y) $\xrightarrow{E}$ (x+1, y)
(x, y) $\xrightarrow{W}$ (x−1, y)

all other movement impossible, ie.
(x, y) $\xrightarrow{*}$ (x, y)

Alg:
1. Rand({N E S W}) = move
2. Transition (move)

fully defined automaton.
→ possible states
→ special states. (start, goal, etc...)
→ transition rules.
→ procedure / alg.

☆ Is this a good alg?

↳ big or small grid.

→ analytical vs. experimental

Design a better one with <u>no</u> sensing and <u>no</u> memory except last symbol (+ initial ~~condition~~ definitions)

Why? Get out of habit of "knowable"

Robots have orientation. New model:

$\Sigma = \{cw, ccw\}$ @ $90°$ ↻ ↺ $y \in \bar{y} = \{0..h\}$

$\phi \in \Phi = \{N, E, S, W\}$

state $= (x, y, \phi)$ $x \in \bar{x} = \{0..w\}$

goal $= (rand(\bar{x}), rand(\bar{y}), \phi)$

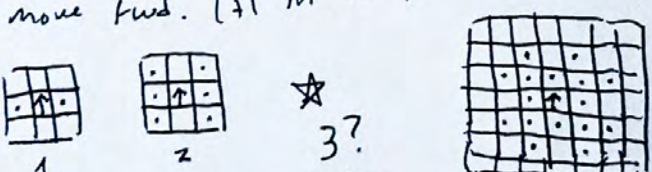
trans. $= (x, y, N) \xrightarrow{ccw} (x-1, y, W)$

etc.

turn then move +1 fwd

Σ except boundary (no move)

1. rand (Φ) = dir
2. move fwd. (+1 in dir)



1 mv.

2 mv.

☆ 3? mvs.

emergent pattern.

→ simulate.