

Rutgers 642:613 - Fall 2003

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Cellular Automata Simulations of Excitable Systems

<http://www.math.rutgers.edu/~sontag/613.html>

Interconnections Gives Rise to Interesting Behavior

until now studied small region (one channel of each type)

but excited channels excite neighboring ones

PDE (reaction-diffusion) is one way to model

simpler but not physiologically realistic: cellular automata

we'll see a simple such model before looking at PDE's

each small patch of neural tissue will be thought of

as a three-state "cell"

(not at all a cell, but this is usual terminology in C.A.!)

states: A , R , I (active, refractory, inactive) and we impose these rules, for synchronous updates at integer times:

- if cell in A , then turn to R
- if cell in R , then turn to I
- if cell in I , turn to A only if there is at least one A neighbor

(excited if \exists excited ngbd cell; stays in modes A or R for one time step; assume: boundary is always " I " type

first: one dimension

assume that start at state $IRAI$ then:

$IRAI \rightsquigarrow$

$IIRAI \rightsquigarrow$

$IIIRAI \rightsquigarrow$

$IIIIA$

i.e. a *travelling spike wave*

if instead two states, A and I (no refractory) then get activation wave:

$AAAI \rightsquigarrow$

$AAAAI \rightsquigarrow$

$AAAAAI \rightsquigarrow$

$AAAAAA$

(we'll study this also for PDE's, after "cable equation")

in two-dim case, one gets very interesting behavior,

including spiral waves, and current heart modeling

(for instance) studies such issues

let's assume that only 4 horiz/vert ngbd affected (not diags):

A R

A R

A R

A R

A R

A R

A

A R

A R

A R

A R A

A

A R

A R

A R *A*

A R *R A*

A R A

A

A R

A R

A

A R

A R A

A R

R A

A R

R A

A R A

A

scrolls can appear too
when starting far from boundary

A R

A R

A R

A

A R

A R

A R

A

A

A R A

A R

A R

A R

A R A

A

A R A

A R R A

A R A

A R

A R A

A R R A

A R A

A

A R R A

A R R A

A R A R A

A R A

A R A R A

A R R A

A R R A

A R A

<http://www.cnd.mcgill.ca/bios/bub/CAs.html>

cellular automaton simulation of excitable media and spiral waves

stop-run-start to restart

set delay in parameters (click for window) at 2000 for slow motion

start with neighborhood=1