

Computer Simulation as a Social Science Laboratory

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Ukrainian National University of L'viv
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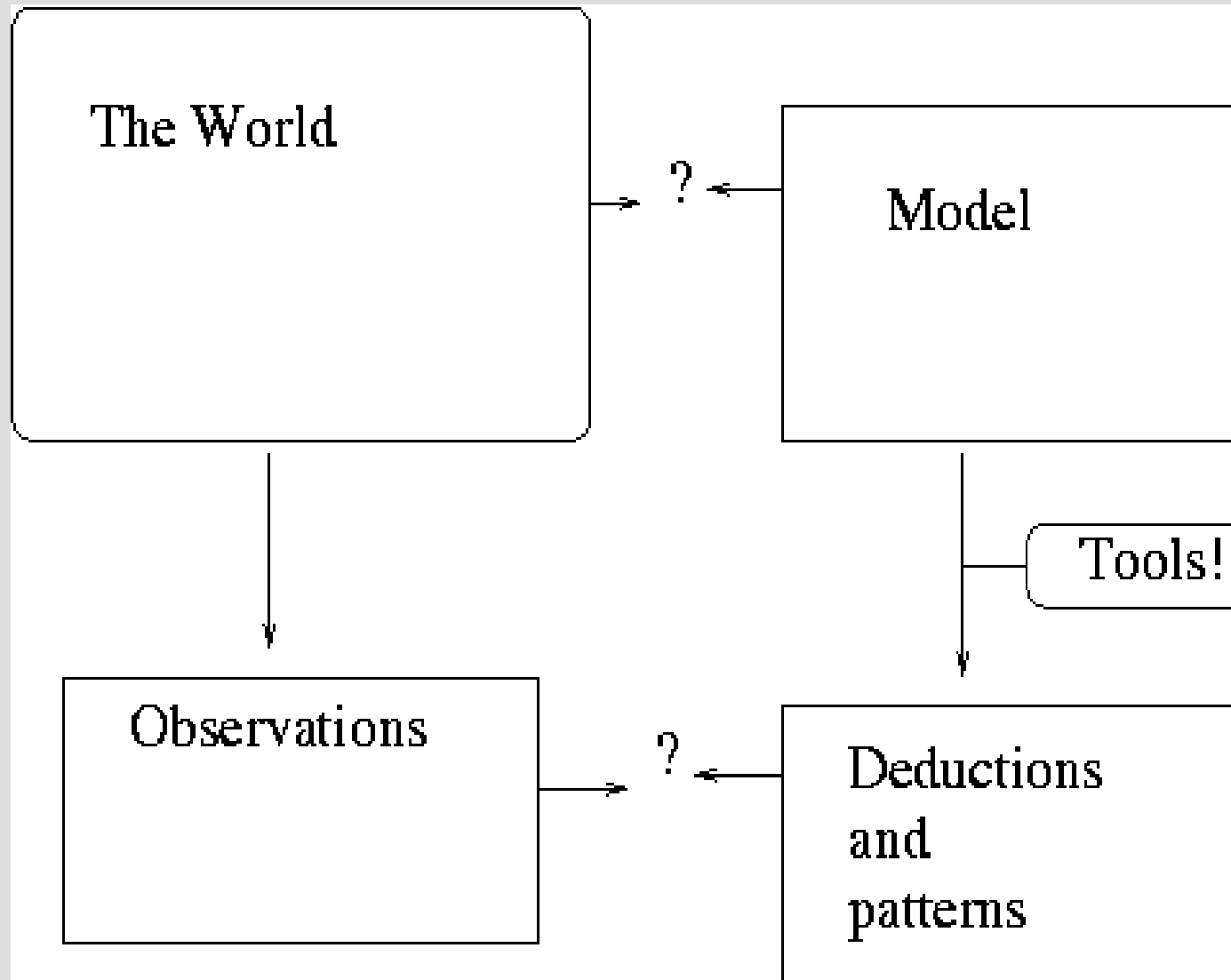
I am a Methodological Individualist!

- Sociological & Political theories *should* take individual behavior into account.
- Challenge: How to combine our knowledge of people to understand politics and crowds?
- Famous Book: Thomas Schelling, *Macromotives & Microbehavior* (WWW. Norton, 1978)

I am a Modeller!

- Scientists want “general mechanisms” to understand “specific cases”
- Model=Abstract “workable representation”

Knowledge & Models



Survey Research

- Most Famous book:
Campbell, Converse, Stokes, & Miller *The American Voter* (1959)
- Use statistical models to predict answers to questions (votes, opinions, etc)
- Predictors
 - Party Identification
 - Education
 - Income

What Bob Huckfeldt Taught Me

- Surveys show patterns of political disagreement and persuasion

But limitations exist:

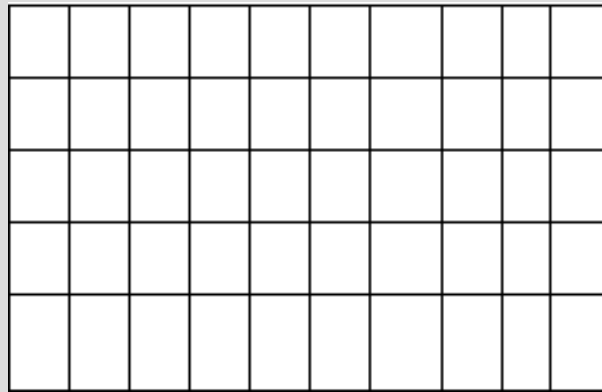
- Surveys are limited in ability to “project” effects over time
- Too many “endogenous” variables
 - Endogenous: depends on other variables you are considering

What is a Computer Model?

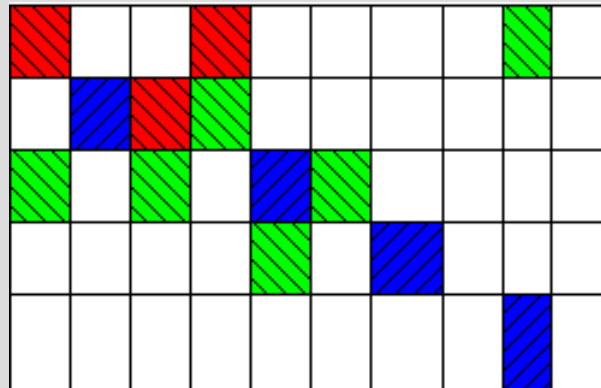
- Artificial Adaptive Agents
- Object: “self-contained” information & ability
- Agents interact with
 - Each other
 - Environment
- Computer software allows us to
 - Measure state of agents & society
 - Interact with computer agents

Cellular Automata (CA)

- World is a grid of cells

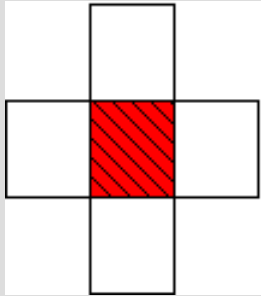


- Colors represent condition (state)

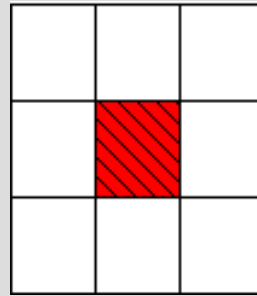


Rules for Updating Cells

- Rules specify state transition
- Usually depend on neighborhood



VonNeumann (4)

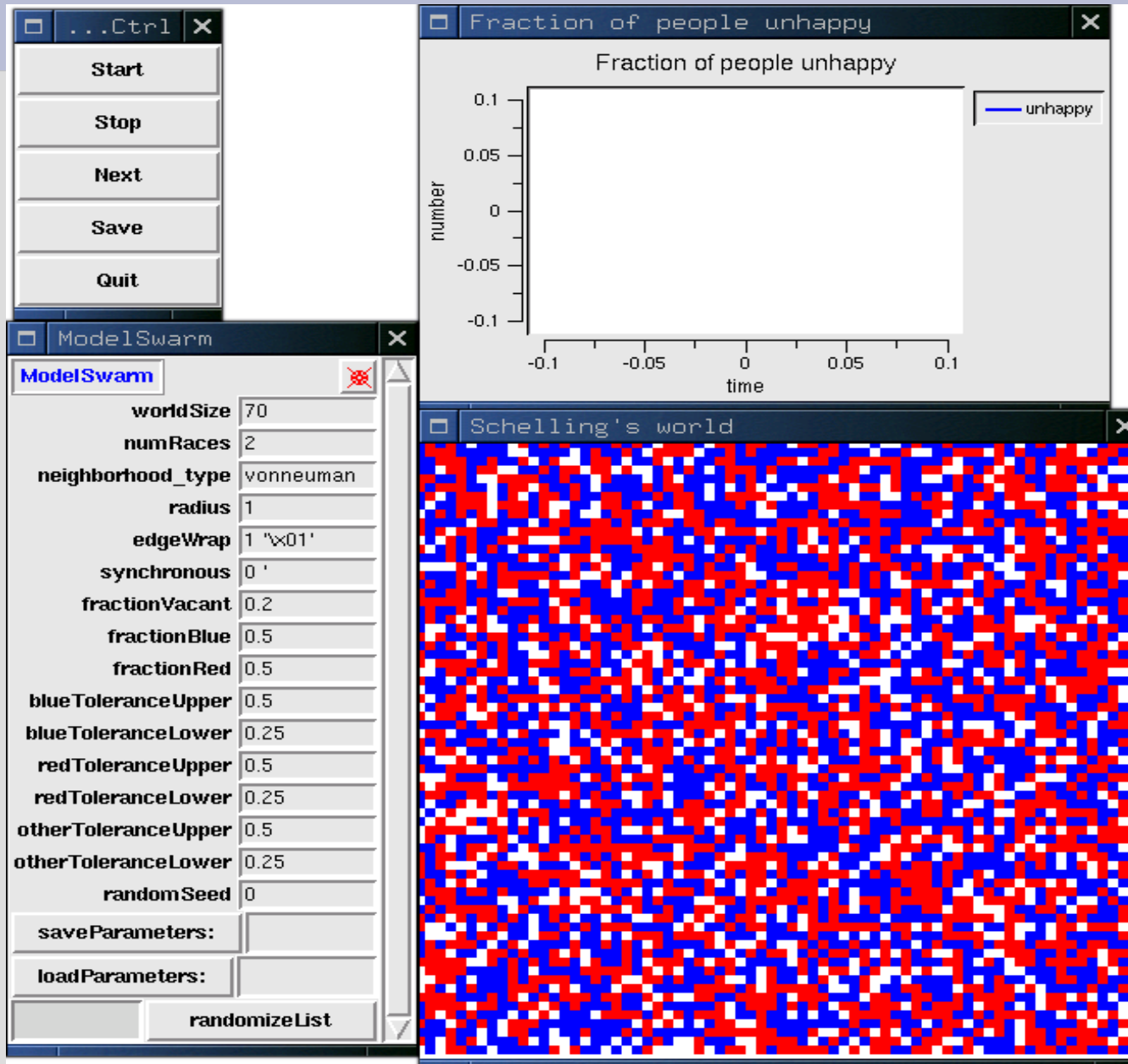


Moore (8)

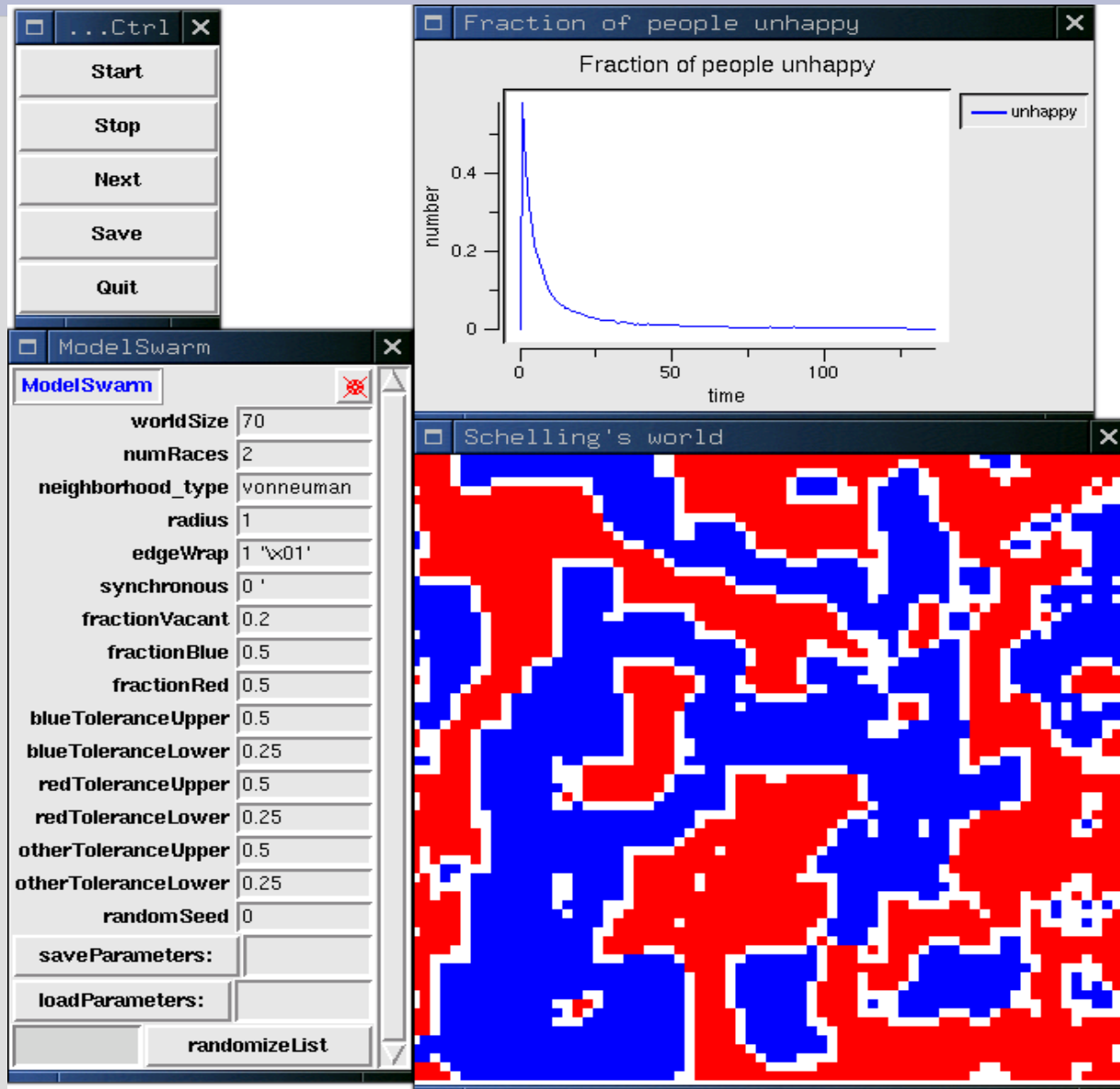
Schelling Segregation Model

- Thomas Schelling, “Dynamic Models of Segregation”, *Journal of Mathematical Sociology*, 1971
- Cells are “houses”
- White cells are empty
- Agents are “colored” and move about
- Can tolerate some diversity
- Prefer not to be grossly “outnumbered”

Standard Schelling Start



Standard Schelling End



Many Options can be considered

- Number of races
- Tolerance of individuals
- Set Neighborhood type- Moore or VonNeumann
- Radius of neighborhood
- Edge effects & Wrap Around
- Randomized ordering of agent actions at each step

Explore: flight1.setup

The screenshot displays the NetLogo interface for the 'flight1.setup' model. It consists of several windows:

- Control Panel (top left):** A vertical stack of buttons labeled 'Start', 'Stop', 'Next', 'Save', and 'Quit'.
- ModelSwarm (middle left):** A parameter list for the 'ModelSwarm' model. The parameters and their values are:

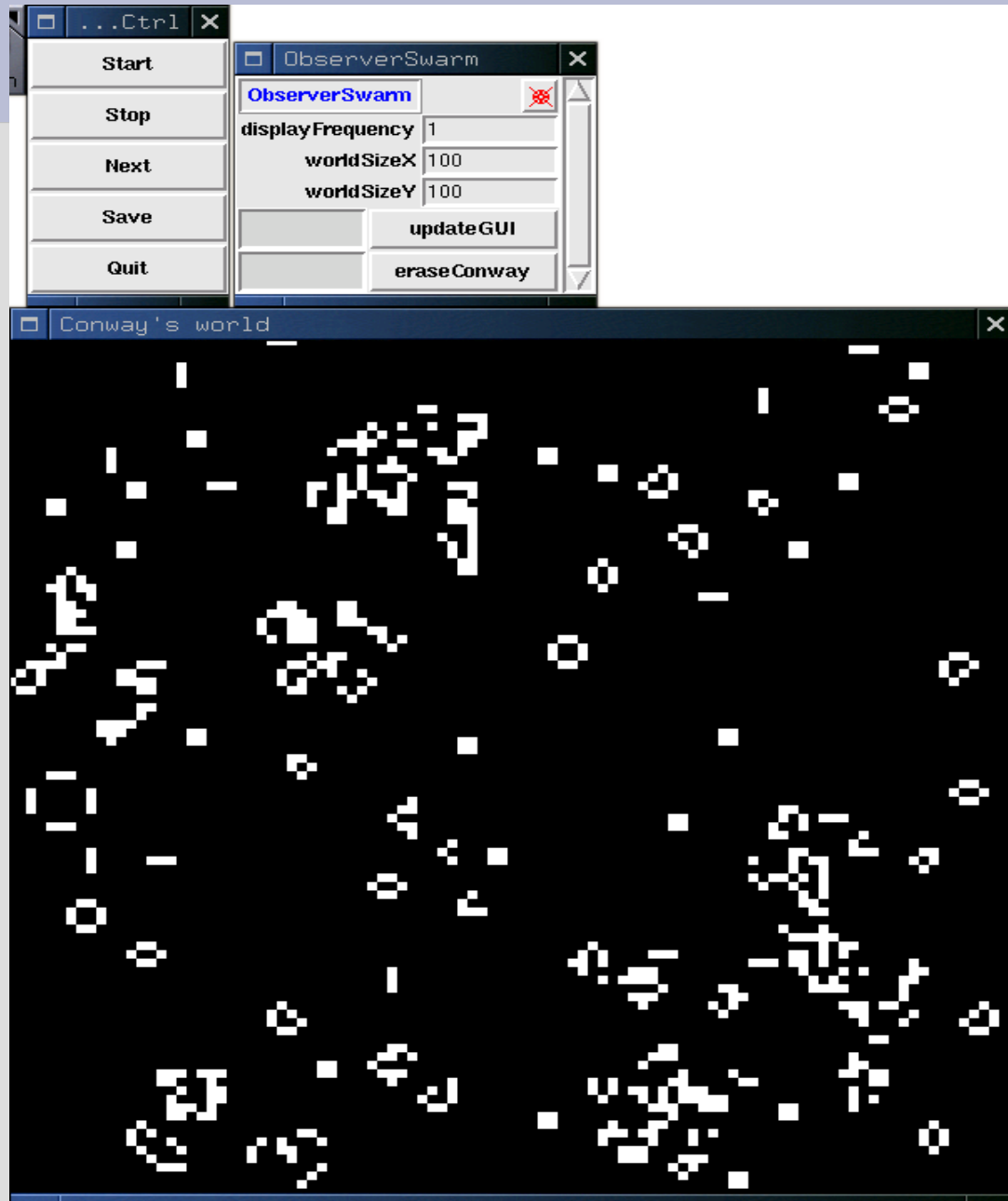
worldSize	100
numRaces	6
neighborhood_type	m
radius	4
edgeWrap	1 'x01'
synchronous	0
fractionVacant	0.2
fractionBlue	0.5
fractionRed	0.3
blueToleranceUpper	0.3
blueToleranceLower	0.2
redToleranceUpper	0.75
redToleranceLower	0.5
otherToleranceUpper	0.75
otherToleranceLower	0.5
randomSeed	0

Buttons for 'saveParameters:', 'loadParameters: flight1.setup', and 'randomizeList' are also present.
- Fraction of people unhappy (top right):** A line graph showing the 'number' of unhappy people over 'time'. The y-axis ranges from 0 to 0.8, and the x-axis ranges from 0 to 1000. The blue line starts at approximately 0.85, drops sharply to about 0.4 by time 100, and then fluctuates around 0.4 until time 1200, where it drops to 0.
- Schelling's world (bottom right):** A spatial map showing the distribution of six different 'races' (represented by colors: blue, red, cyan, yellow, purple, and green) on a grid. The map shows a complex, fragmented pattern of these colors, indicating a state of segregation or mixed distribution.

Conway's Game of Life

- Martin Gardner, “The Fantastic Combinations of John Conway's new solitar game “life”” *Scientific American*, 223, (1970)
- 2 States: on / off (alive / dead)
- Cells die if they are lonely (< 2 neighbors)
- Cells die if too crowded (> 3 neighbors)
- Cells turn on if neighbors = 3

Conway



Social Impact Model

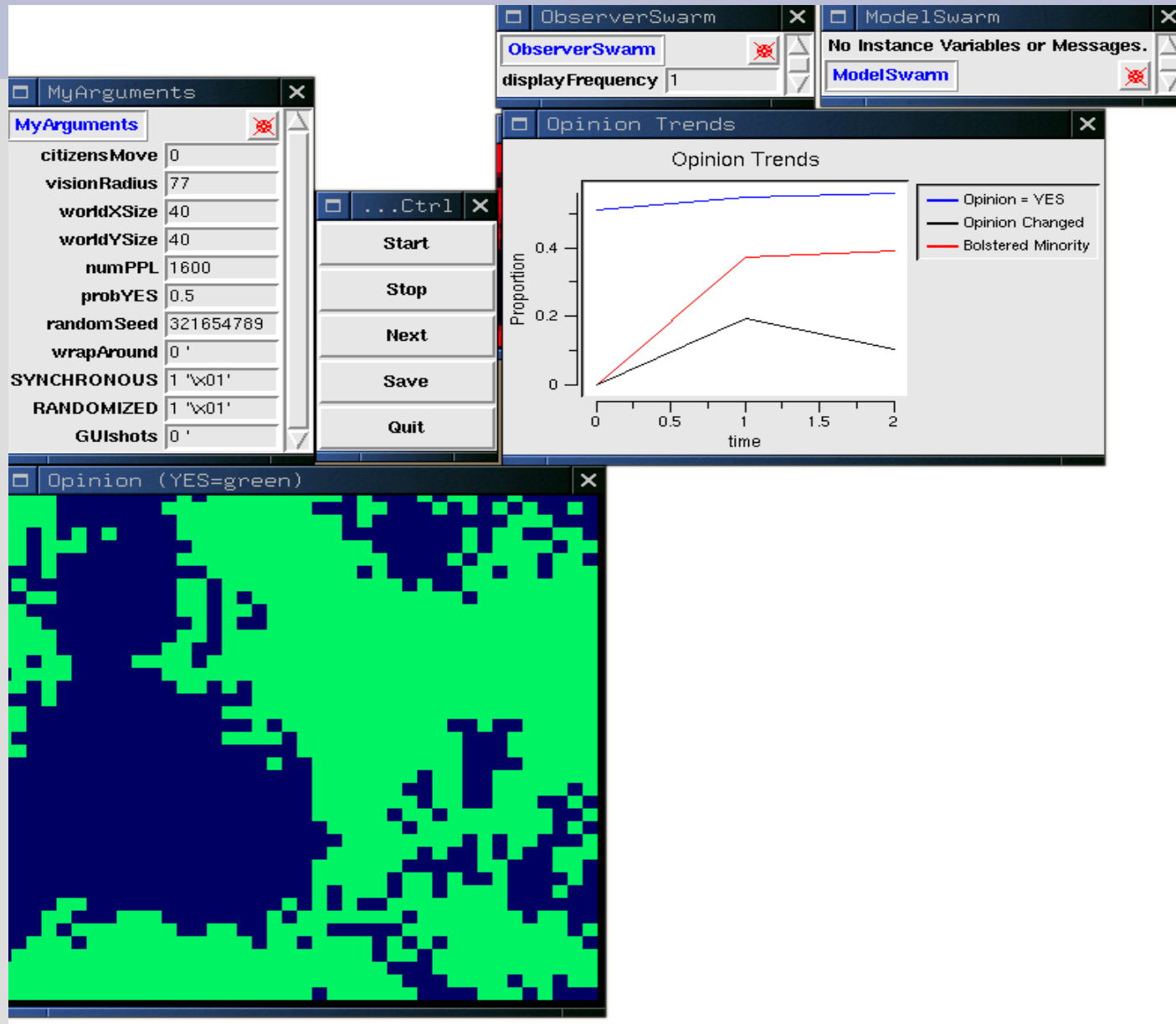
- Nowak & Latane: social psychologists

A. Nowak, J. Szamrej, B. Latane. "From private attitude to public opinion: A dynamic theory of social impact" *Psychological Review* 97 (1990)

Latane's theory

- Agents change opinion YES or NO depending on social pressure
- Agents gather “support” from like-minded others
- Agents subjected to pressure from other-minded agents
- Influence is distance weighted: closer agents have more influence

Social Impact Model



Sugarscape

- Famous Book:
- Joshua Epstein & Robert Axtell, Growing Artificial Societies (MIT Press, 1996)

Very influential “bottom up” theory

- Sugarscape is “abstract world”
- Agents live to find sugar
- Die if metabolism exhausts resources

ModelSwarm

Start

Stop

Next

Save

Quit

numAgents: 400

alpha: 1

replacement: 0

maxMetabolism: 4

maxVision: 6

minInitialSugar: 5

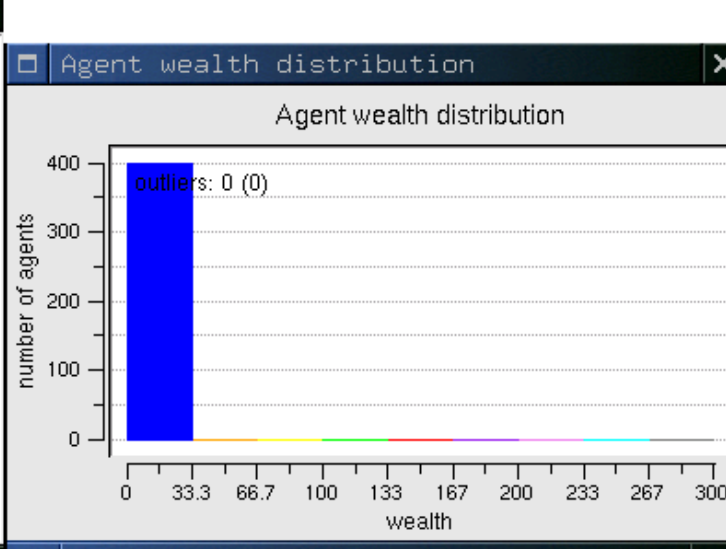
maxInitialSugar: 25

deathAgeMin: 99998

deathAgeMax: 100000

datafile: sugarspace.pgm

addNewRandomAgent



ObserverSwarm

ObserverSwarm

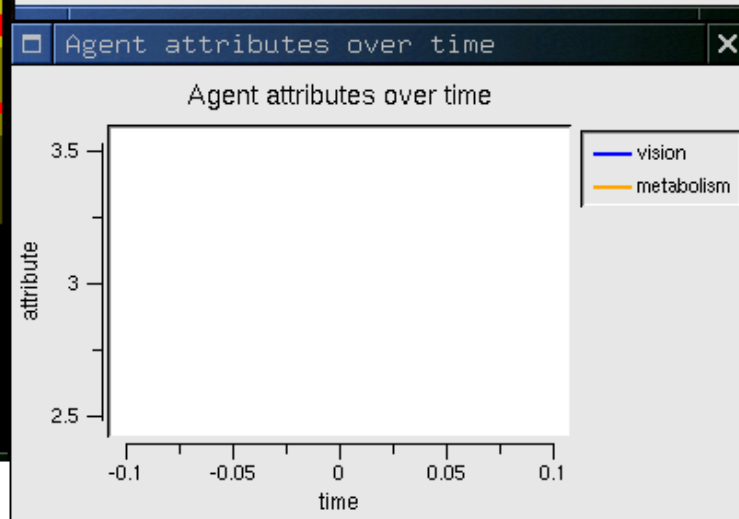
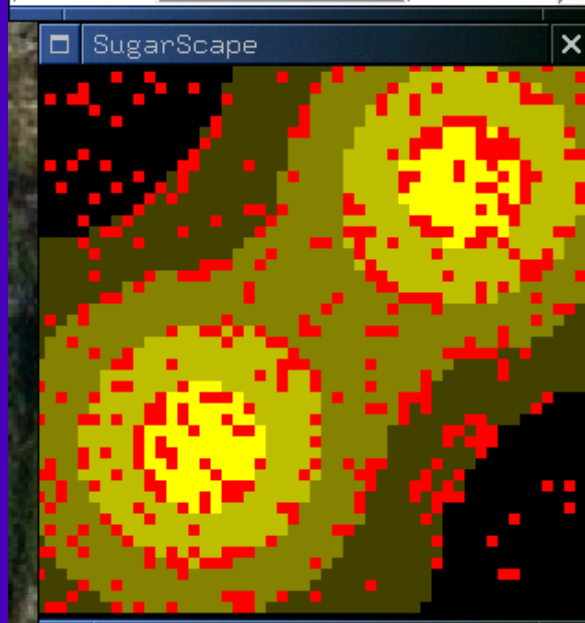
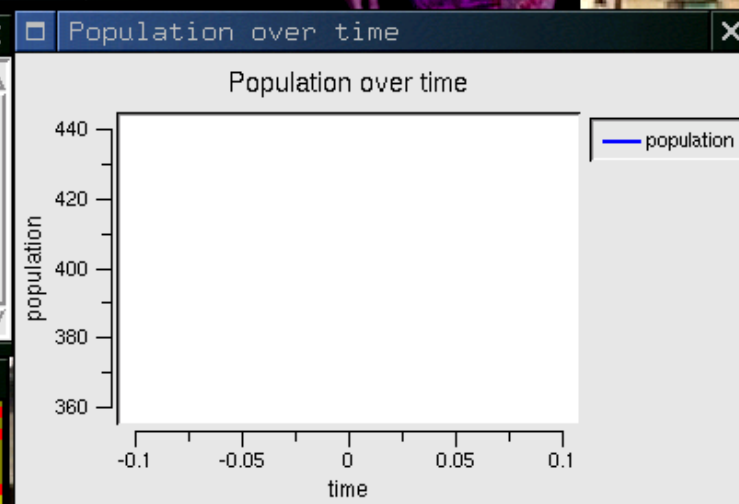
drawPopulationGraph: 1

drawWealthHistogram: 1

displayFrequency: 1

setParameterFile:

saveParameters:



ModelSwarm

Start

Stop

Next

Save

Quit

numAgents: 400

alpha: 1

replacement: 0

maxMetabolism: 4

maxVision: 6

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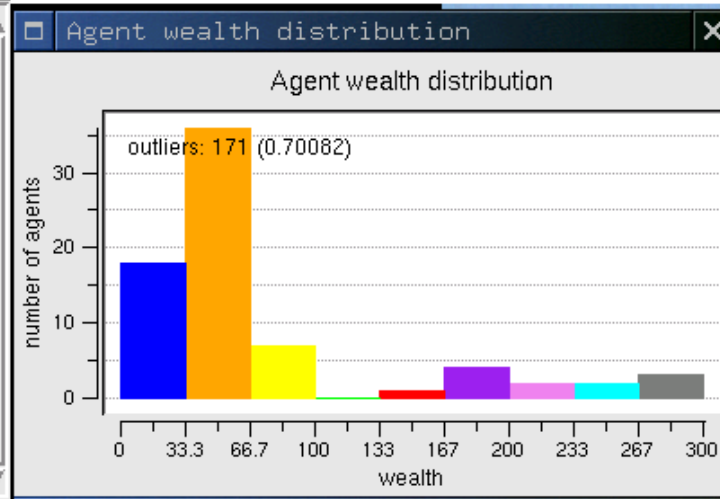
maxInitialSugar: 25

deathAgeMin: 99998

deathAgeMax: 100000

datafile: sugarspace.pgm

addNewRandomAgent



ObserverSwarm

ObserverSwarm

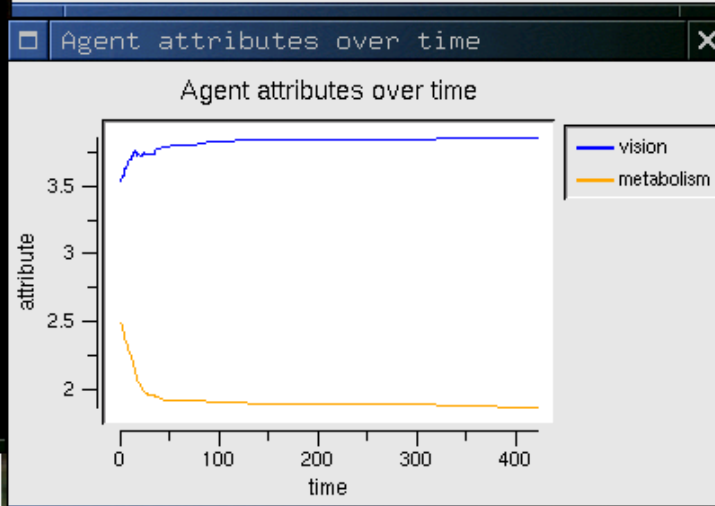
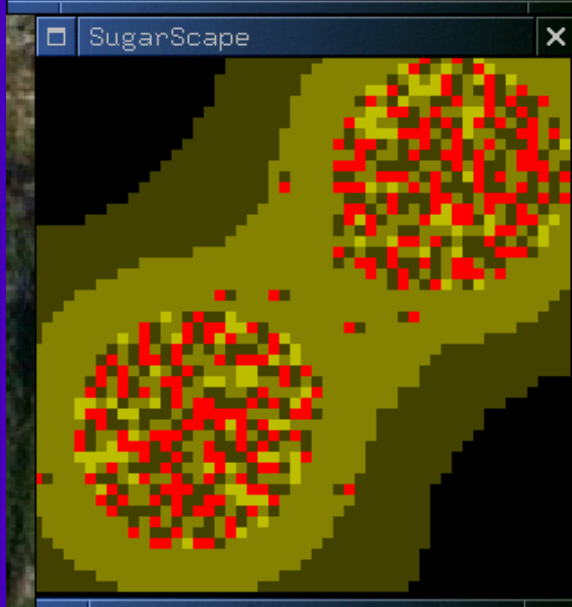
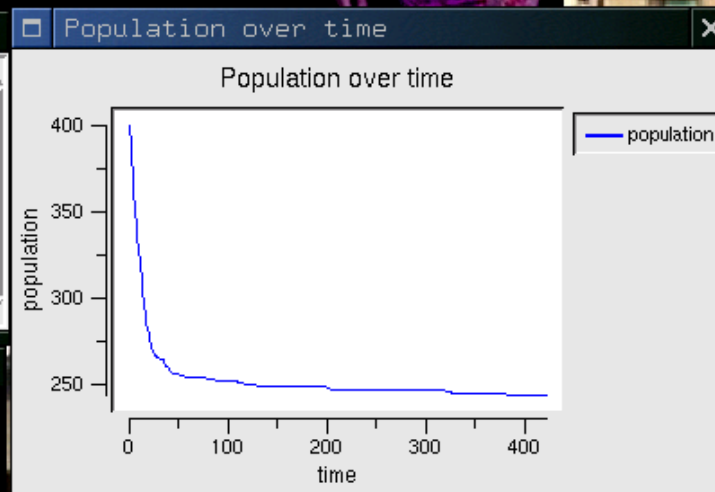
drawPopulationGraph: 1

drawWealthHistogram: 1

displayFrequency: 1

setParameterFile:

saveParameters:



Public Opinion

- Huckfeldt, Johnson, Sprague, *Political Disagreement: The Survival of Diverse Opinions within Communication Networks* (Cambridge, 2004)
- Surveys show: more diversity & disagreement than expected
- Axelrod Culture Model predicted elimination of diversity

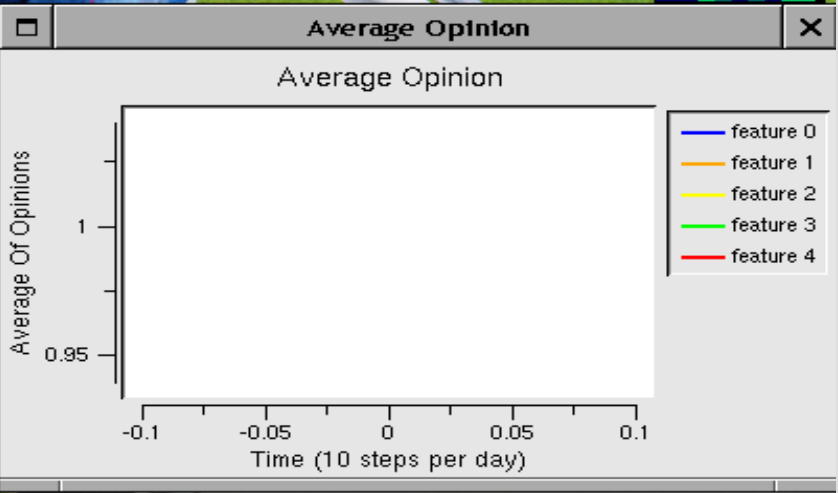
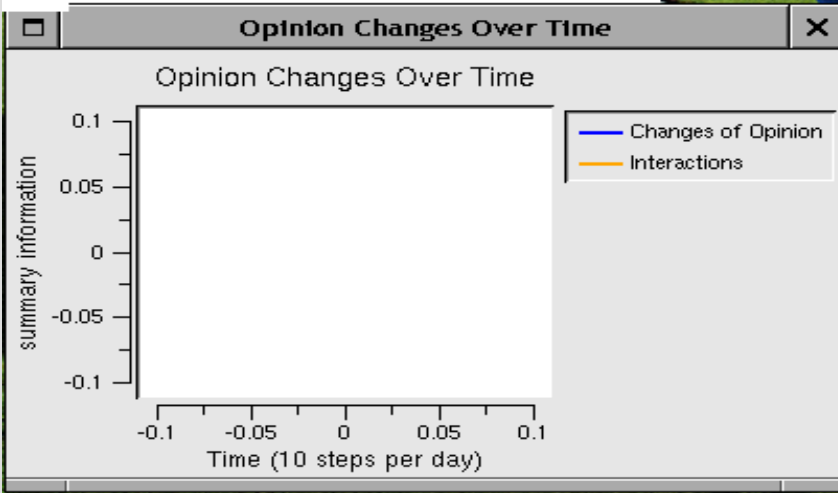
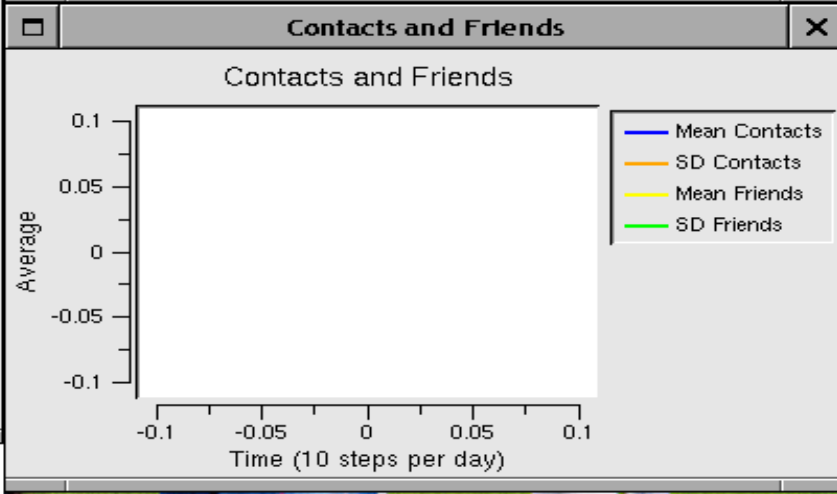
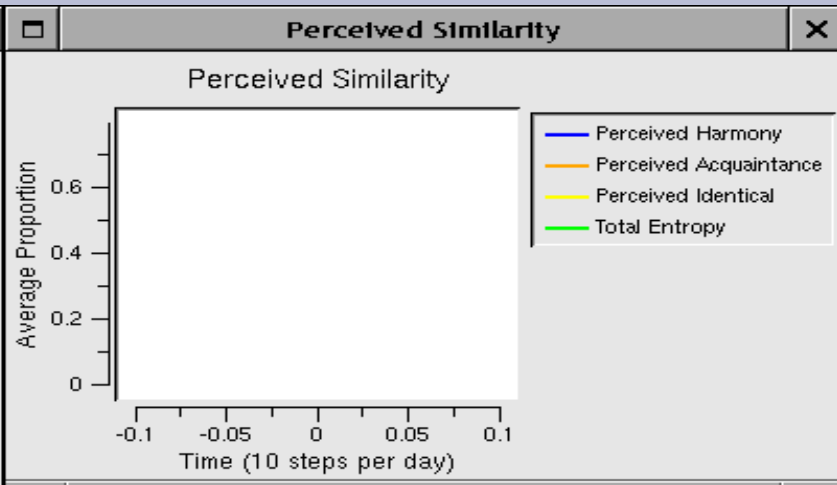
Axelrod Culture Model

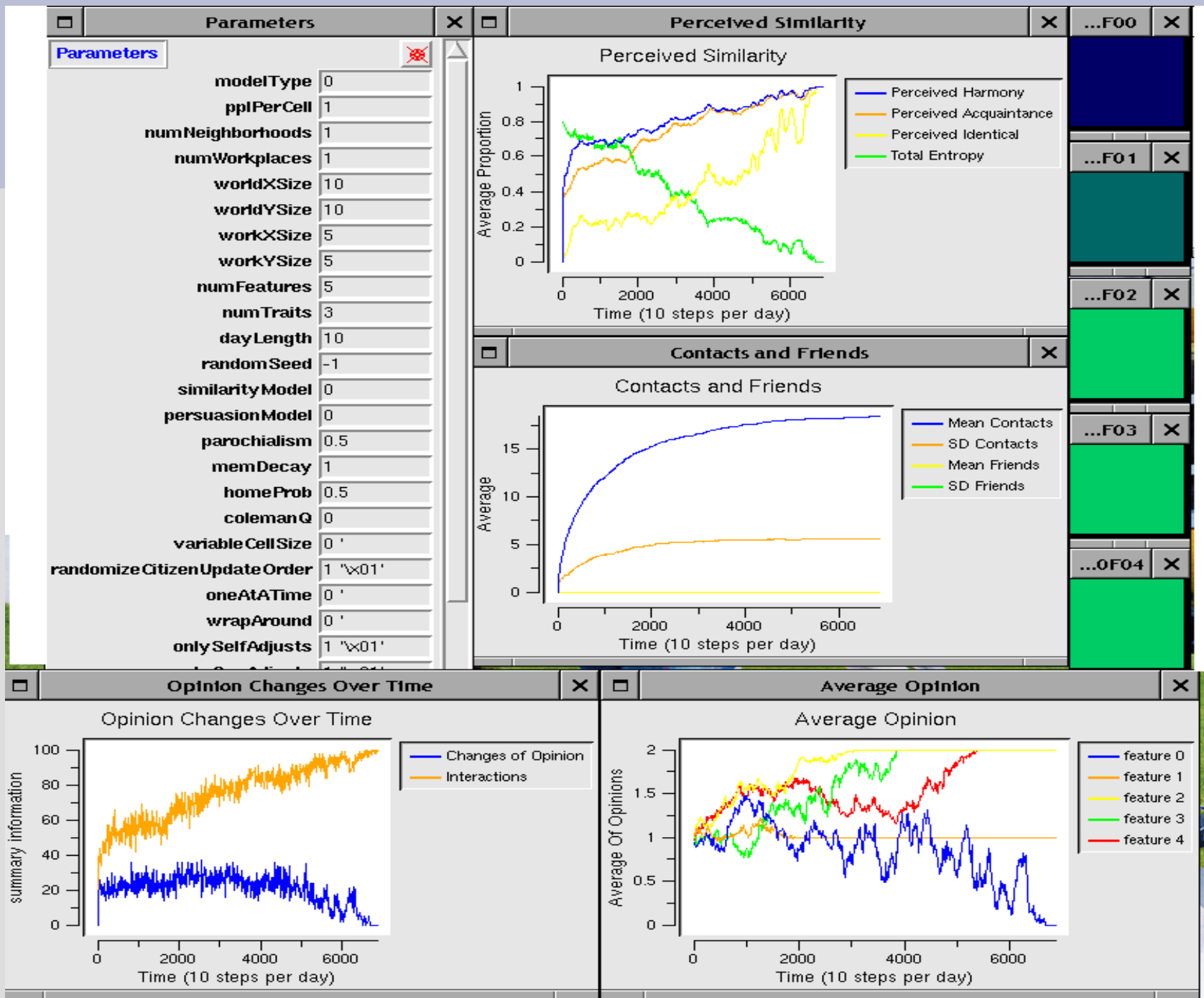
- Robert Axelrod, *“The Dissemination of Culture: A Model with Local Convergence and Global Polarization”* *Journal of Conflict Resolution* 41, 1997

Parameters

Parameters

- modelType: 0
- pplPerCell: 1
- numNeighborhoods: 1
- numWorkplaces: 1
- worldXSize: 10
- worldYSize: 10
- workXSize: 5
- workYSize: 5
- numFeatures: 5
- numTraits: 3
- dayLength: 10
- randomSeed: -1
- similarityModel: 0
- persuasionModel: 0
- parochialism: 0.5
- memDecay: 1
- homeProb: 0.5
- colemanQ: 0
- variableCellSize: 0'
- randomizeCitizenUpdateOrder: 1 '\x01'
- oneAtATime: 0'
- wrapAround: 0'

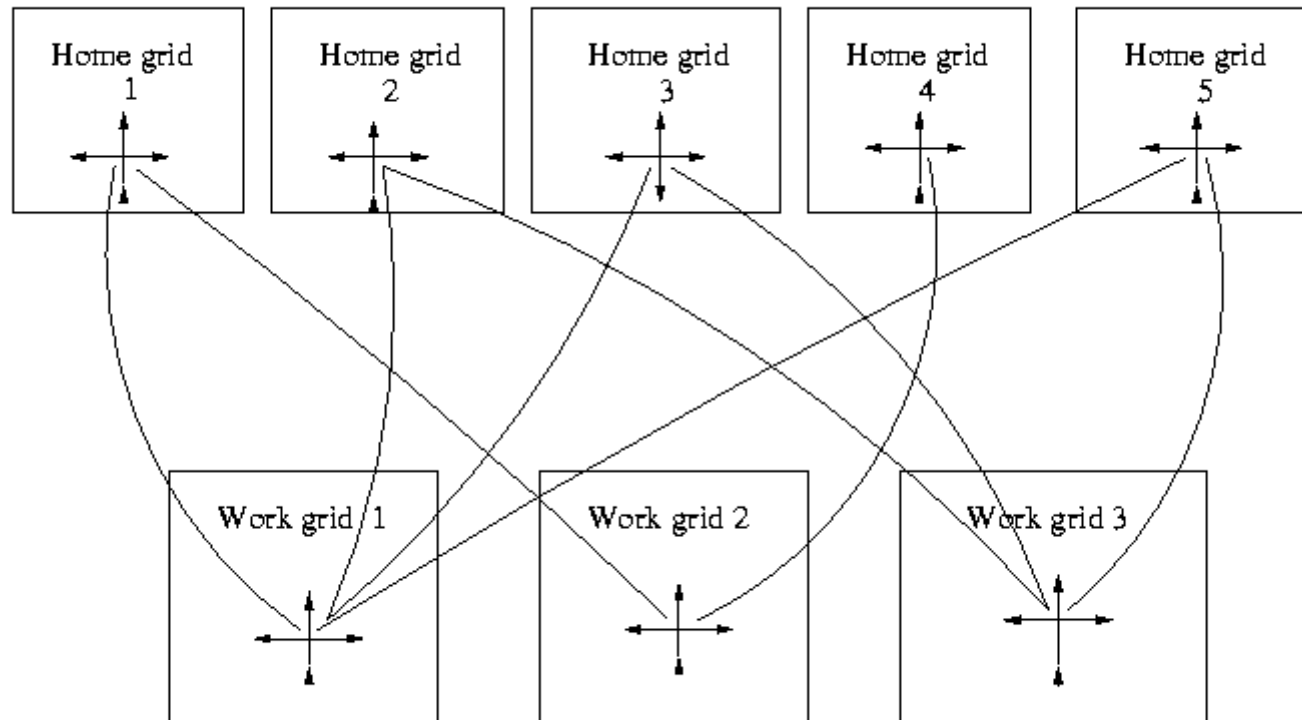




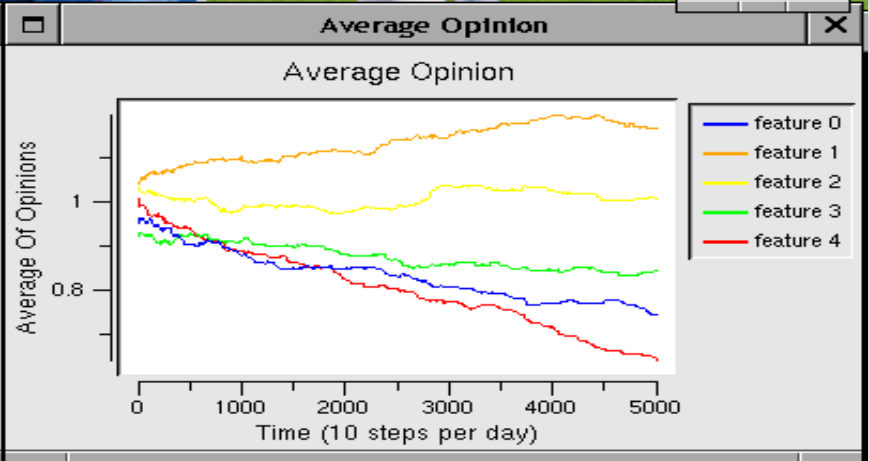
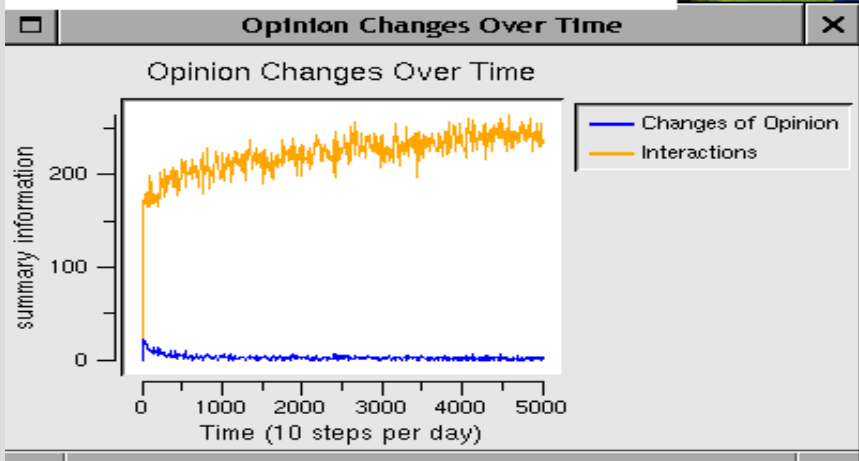
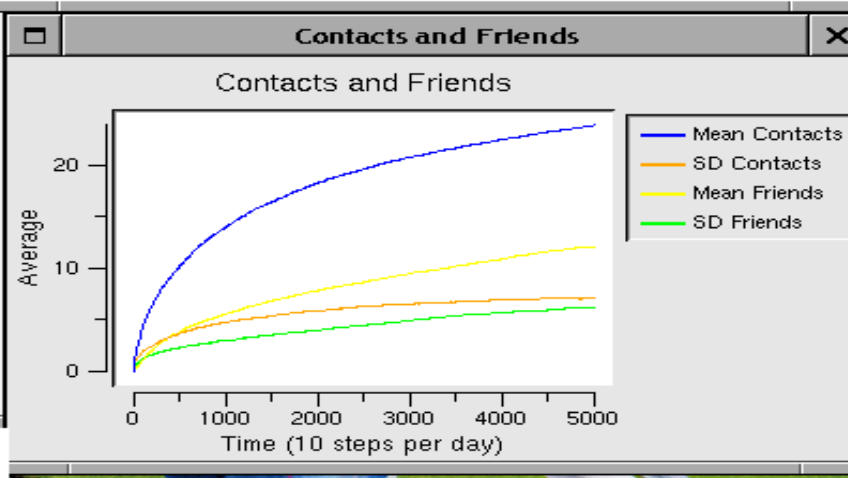
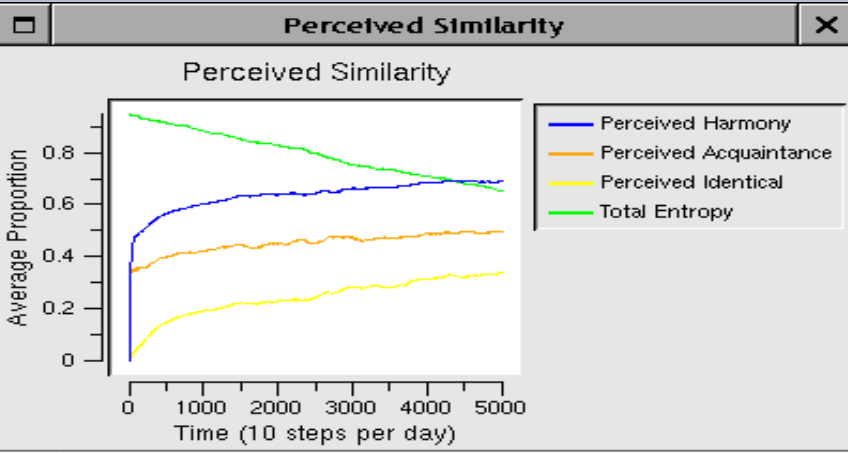
How can we preserve diversity?

- Answer: “autoregressive influence”
- People have social networks
- Check with “friends” before adopting new opinions

Many agents per cell allowed



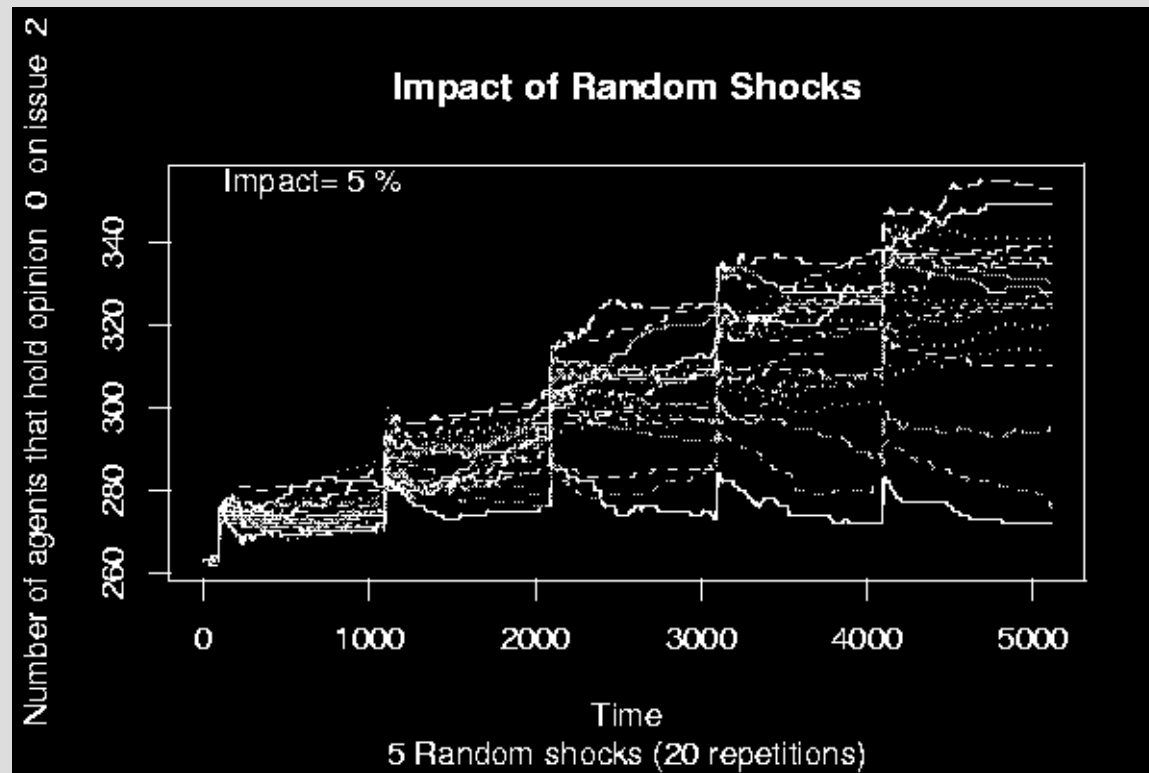
Parameters	
modelType	2
pplPerCell	1
numNeighborhoods	5
numWorkplaces	3
worldXSize	10
worldYSize	10
workXSize	5
workYSize	5
numFeatures	5
numTraits	3
dayLength	10
randomSeed	-1
similarityModel	0
persuasionModel	0
parochialism	0.5
memDecay	1
homeProb	0.5
colemanQ	0
variable CellSize	0'
randomize CitizenUpdate Order	1 '\x01'
oneAtATime	0'
wrapAround	0'



Opinion Model #2

- Serialization: Save model into a file
- Run model to equilibrium
- Restart repeatedly after small random shocks.

20 restarts



Artificial Stock Market

- Pioneering study.

R.G. Palmer, Brian Arthur, John Holland, Blake LeBaron, & Paul Taylor, “Artificial economic life: a simple model of a stockmarket”
Physica D 75: 264-274.

- Swarm project on Sourceforge

<http://ArtStkMkt.sf.net>

Code revisions discussed Johnson, “Agent-based Modeling...”, Soc. Sci. Computer Review, 2001.

What's in the ASM?

- Agents buy or sell a single stock
- Agents receive info on the world and on stock price patterns
- Each agent has an intricate “mental model” of the world (Genetic Algorithm)
- Agents invest in isolation: never meet
- Runs for hours in order for agents to “learn”

ASM In Action

Start

Stop

Next

Save

Quit

ASMObserverSwarm

displayFrequency 100

writeSimulationParams

toggleDataWrite

lispSaveSerial:

ASMModelParams

numBFagents 25

initholding 1

initialcash 20000

minholding -5

mincash -2000

intrate 0.1

baseline 10

mindividend 5e-05

maxdividend 100

amplitude 0.0673

period 19.5

maxprice 99999

minprice 0.001

taup 50

exponentialMAS 1

sptype 1

maxiterations 20

minexcess 0.01

BFPParams

numcasts 100

condwords 1

condbits 12

mincount 2

gafrequency 1000

firstgatime 100

longtime 4000

individual 1

tauv 75

lambda 0.5

maxbid 10

bitprob 0.1

subrange 1

a_min 0.7

a_max 1.2

b_min 0

b_max 0

c_min -10

Price v. time

Volume v. time

fraction of bits used (by type)

Relative Wealth of Agents

Agent Position

plinear 0.333

prandom 0.333

pmutation 0.03

plong 0.2

pshort 0.2

nhood 0.05

genfrac 0.25

gaprob 0.001

npool 20

nnew 20

nnulls 4

npoolmax 20