System Dynamics

or, “The World According to Will Wright”

2/18/16
Structure

- leaves
- trunk
- roots
- main stem
- limbs
- boughs
Dynamics
Humans build models
Calculus

\[ E = \sum_{i=1}^{n} (\hat{Y}_i - Y_i)^2 \]

Simulation

Linear Story

Parallel Gameplay
Monte Carlo Technique

Crops

\[ \frac{7}{15} \rightarrow 47\% \]
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Network Theory | Adaptive Systems | Chaos Theory | Cellular Automata | System Dynamics | Cybernetics | Paradigms |
Topologies
Growth
The tipping point
population – disease
World Population Growth Through History

Billions of people

2.5 million years

7000 B.C.

6000 B.C.

5000 B.C.

4000 B.C.

3000 B.C.

2000 B.C.

1000 B.C.

1 A.D.

1000 A.D.

2025 A.D.

Old Stone Age

New Stone Age Commences

New Stone Age

Bronze Age

Iron Age

Middle Ages

Modern Age

Black Death - the plague
Throw until hit
Propagation

Material
Information
Pattern
Material (people, cargo)
Pattern (compression traffic)
through networks
Time

now
Light Cone

Dynamics act via space+time
Vector Fields
through space or community
Horizontal propagation

Gossip
Cheats
New features

Casual
Hardcore
Casual

Wave amplitude, length
Vertical propagation
Global

Local

Information propagation
Pollination
Grouping

Economies of scale
Enabled by communication
Encourages specialization
Similar - Complementary
Attraction

Flocking – Schooling
Boundaries

conflict - arbitration
Specialization

Communication
Economies of scale
Grouping

Queen

Soldier

Worker

Drone
enabled by communication – competition as larger agent
Specialization breeds networks

auto industry
Allocation

**Conservative**
- Cash: 30%
- Bonds: 20%
- Stocks: 50%

**Moderate**
- Cash: 20%
- Bonds: 20%
- Stocks: 60%

**Aggressive**
- Bonds: 10%
- Cash: 10%
- Stocks: 80%

Time material

RTS Simcity
Mapping

temporary associations - functional reasons
State Machines

Environmental Situation

Fight
Flee
Eat
Forage
Nest

Behavioral Response
Grand Theft Pro Skater 1942
Nesting
Agents

[Diagram of interconnected agents]
Networks
Layers
Emergence

Ecology

Biology

Chemistry

Physics
“All science is either physics or stamp collecting.” – Ernest Rutherford
SimWar

- Production
- Offense
- Defense
Player Decisions

- Short vs. Long Term
- Risk vs. Reward
- Order (production, missions)
- Allocation (time, resources)
- Network Design
- Mapping
Short term

Long term
Risk - Reward

High

Low
Order
Allocation
Supply Networks
Competition → Nesting (level jump) → Growth → Grouping → Specialization → Control → Networks → Mapping → Allocation → Propagation → Specialization → Grouping → Growth → Competition
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- Chaos Theory
- Cellular Automata
- System Dynamics
- Cybernetics
Dupont's Wonderful World of Chemistry musical
An epic drama of adventure and exploration

Space Station One: your first step in an Odyssey that will take you to the moon, the planets and the distant stars.

2001: a space odyssey
Cybernetics

Feedback

IN → OUT

NEGATIVE

POSITIVE

control theory
Analog computation
System Dynamics

Stock

Flow

births

birth rate

Population

deaths

death rate

birth rate

population

deaths

decay

birth rate

magnetic-core memory
Industrial Ecosystem at Kalundborg, Denmark

- Plasterboard plant
- Oil refinery
- Electric power station
- Sulfuric acid producer
- Cement factory
- Fish culture
- Local farmers
- Pig farmers
- Bioplant
- Fermentation sludge
- Municipality of Kalundborg
- Road construction
- Yeast

Flow of materials:
- Gas
- Gypsum
- Sludge
- Sulfur
- Steam
- Waste heat (return)
- Volatile ashes
- Sludge
Cellular Automata

Glider Gun
Chaos Theory

Phase space
Disordered

Random

Fractals

Homeostatic

Limit Cycles

Frozen

Ordered

Complexity

Chaotic Systems
Complex Adaptive Systems
genetic algorithms – neural networks – etc.
Adaptive Landscape

gene combination fitness

gene 1

gene 2
Gameplay Landscape (Sims)
Network Theory
Power law distribution

100,000 Random Web Pages

- **x-axis**: number of inbound links
- **y-axis**: number of pages

The graph shows the distribution of pages based on the number of inbound links, with a heavy-tailed distribution characteristic of power laws.
TSO – Most Popular (number of friends)
Social Networks
Weak Links

Social web
4th grade class
Costa Rican families
Weak Links
PROTECTION
$1K to $10K per real time hour; Maximum of 3 hours; 1/2 down payment
Piss someone off? Afraid to be home alone? Maybe you just want to look cool and have a couple of bodyguards hanging around you? Whatever the reason you may need for protection, we’re the people you want protecting you. More secretive than the Secret Service, The Sim Mafia will make sure no Sim interrupts your game play under our watch.

HIT
$10K to $25K; 1/2 down payment
Want to take a Sim out of the picture? Maybe you want to make sure that Sim never messes with you again? Hit is a combination of all that we do in The Sim Mafia to make someone unhappy as possible and not only bring the Sim characters social, fun, energy, hygiene, and hunger down, but make the real life player want to log out for the time being until it blows over. This can be done anonymously so that the victim does not know you hired us to do the job.

RAID
$5K to $10K; 3/4 down payment
Want to hurt someone’s business? Want to send a message? A Raid consists of a crew or several crews coming onto a property and slapping around a few of the customers to let them know how you feel. Once we’re done with the customers we go after the intended target. Raid’s can get messy and are rarely done. For this reason, we require 3/4 down payment if we decide to take the job on.

ASSAULT
$1K to $5K; 1/4 down payment
Did another Sim beat you up? Steal from you? There are lots of reasons for wanting another Sim assaulted. Whatever your reason may be, we’re more than happy to handle the situation for you. We have several ‘melee’ options available to us and muscle with high body ratings. This can be done anonymously so that the victim does not know you hired us to do the job.

BRIBERY
1/4 of the bribery amount to get unbanned; No payment if not unbanned; No down payment
Did you make someone really mad and get banned? Are you an innocent person and have no clue why you