# Artificial life and society:

# Evolutionary models and simulations



## Basic approach

- Survival of the fittest is a general force
- Natural selection works also in economic and societal processes (big fish, small fish)
- Evolutionary simulations can be given:
  - Societal
  - Ecological (life-like)

  interpretations



## Sugarscape illustration

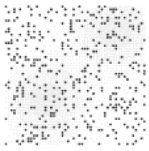
Sugarscape
- 2D grid world
- 1,2,… commodities (sugar, gold, …)
- Inhabitants are autonomous, for instance
  - Move (aided by vision capabilities)
  - Eat sugar (and burn it by their metabolism)
  - Collect gold
  - Trade, communicate, cooperate,…
  - Learn (adapt their behavior individually)
  - Evolve (mate and produce offspring)
- Some demos on The Brookings Institution Sugarscape page:
  - agents harvesting sugar
  - cultural agents, tribe formation
  - bilateral exchange in a spatially-distributed population



## Agents harvesting sugar

Agents (in red) harvest sugar (yellow) from a landscape of renewable resources. Each period each agent searches its neighborhood for the site richest is sugar, moves there and harvests the sugar. Sugar grows back at unit rate. Agents die if they are unable to find enough food to satisfy their metabolic demands.

Animation II-2

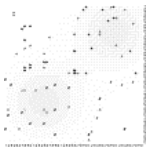




## Cultural agents, tribe formation

Agents, identified by their culture, are initially scattered around the sugarscape. Over time, purposive behavior (sugar harvesting) leads individual agents to the areas richest in sugar. There, they engage in sexual reproduction and cultural exchange, producing large, culturally-distinct, spatially-isolated populations ("tribes"). Eventually, population pressures mount, the tribes are forced onto less fertile land, and they begin to interact

Animation III-15



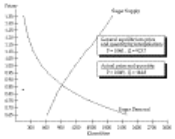


## Bilateral exchange in a spatially-distributed population

Bilateral exchange in a spatially-distributed population of agents may fail to produce a Pareto optimal allocation when agents also engage in production and consumption. This is demonstrated by this movie, in which aggregate supply and demand schedules are plotted together with actual average trade price and total trade quantity for exchange between Sugarscape agents,

animated over time.

Animation IV-2



## Tax and evolution

Publication downloadable from my home page

SugarScape model simple:
- one commodity (sugar)
- agents look around for the spot with the most sugar, go there and collect it
- TAX system: after each cycle agents' surplus taxed
- WELFARE system: after each cycle collected sugar redistributed evenly
- agents can starve (not enough sugar)



## Tax and evolution

Experiment setup
- initial population size: 400
- simulation time: 1000 cycles
- With and without evolution (mutation or crossover)
- With and without tax
- 50 independent runs for each setup

Measures monitored
- population size
- wealth (sugar assets): average and standard deviation
- tax paid: average and standard deviation
- "physical" features: vision (max reach), metabolism (burning rate)
- no spatial aspects considered



## Tax and evolution

Outcomes

| | **No taxation** | **Taxation** |
|---|---|---|
| **No evolution** | Small pop<br>Hi wealth<br>Hi st. dev | Large pop<br>Lo wealth<br>Lo st. dev |
| **Evolution** | Larger pop<br>Lo metab<br>Hi vision | Very large pop<br>Hi wealth<br>Hi st. dev |



## Tax and evolution

Conclusions:
- Effects of taxation
  - more agents alive at the end
  - agents get poorer
  - wealth differences become smaller
- Effects of evolution
  - agents can look farther and are more efficient
  - more agents alive at the end

Caveat: what does this say about the real world?



## Further research ideas

- Self-adaptive tax rates: agents carry an extra feature, their own ***tr*** →emergence of altruism of selfishness
- Agents can send/receive signals → emergence of communication
- Agents can (must) liaise to achive goals → emergence of cooperation
- Etc…..

Master thesis projects available from december 2002



## Artificial life

- Established field
- Includes work within e.g., organic chemistry, robotics, artificial immune systems, swarms, etc…
- One branch is concerned with evolution
- See demonstration movies
  - Ray's Tierra
  - Sims' evolved creatures