

# Emergence and self-organization in Framsticks

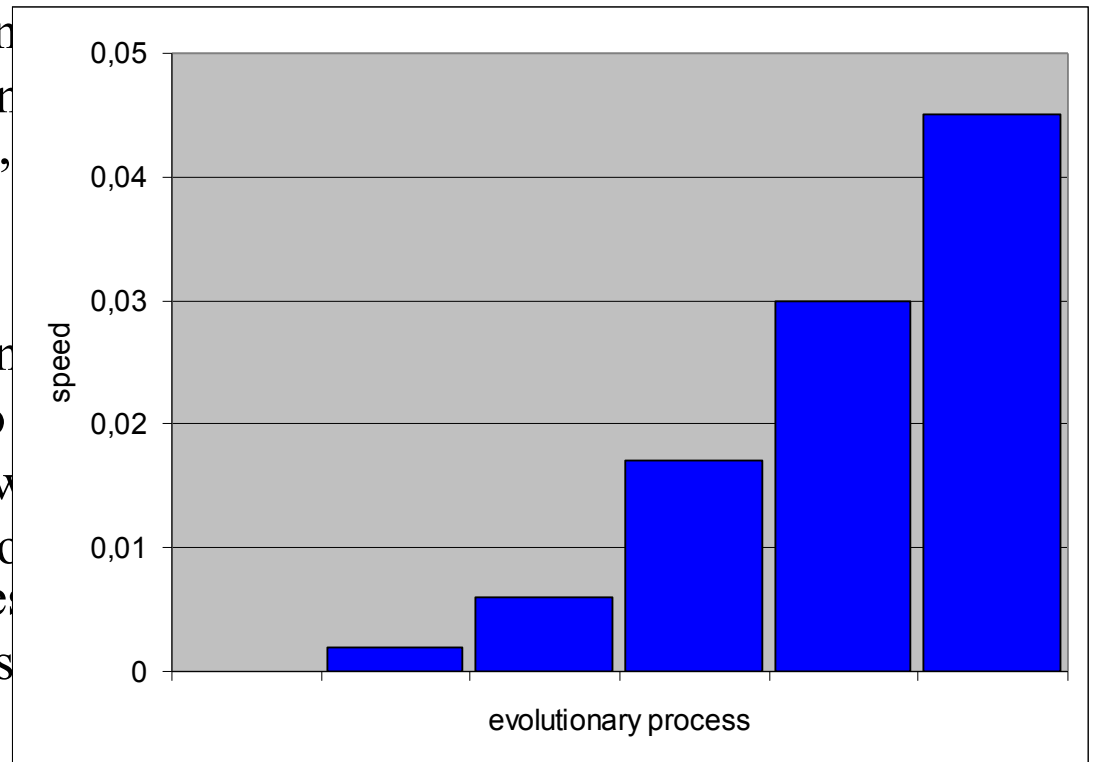
[www.framsticks.com](http://www.framsticks.com)

# Study #1

- Provided:
  - Basic building blocks (sticks, neurons, connections)
  - Fitness function (selection, reproduction)
  - Environment
  - Change
- Emergence of *locomotion*
- Self-organization of
  - Body design
  - Brain control
  - Body and brain coupling/cooperation

# Study #1, analysis

- See `sampleevol_hq.avi`, `evolutionary_stages.gen`
- We got:
  - Body design appropriate for walking
  - Brain, sensors, muscles evolved to obtain high speed
  - Neural control adjusted to control a walking body (coordination!)
  - Emergence of *walking* (fitness)
  - Another environment → another solution (rolling, swimming, flying, ...)
- Analysis reveals
  - Redundancy
  - Hidden interconnections and dependencies
  - Evolution does not have to be optimal
  - Evolution can discover new solutions
  - Evolution may be unable to find a solution in a monotonic, limited process
  - Solutions (agents) are not stable



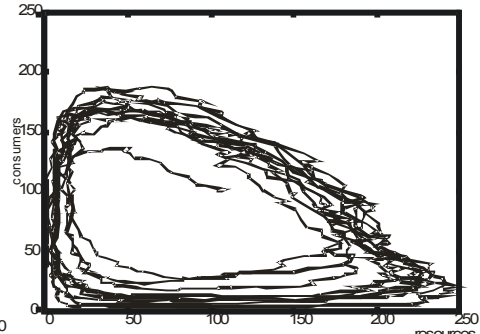
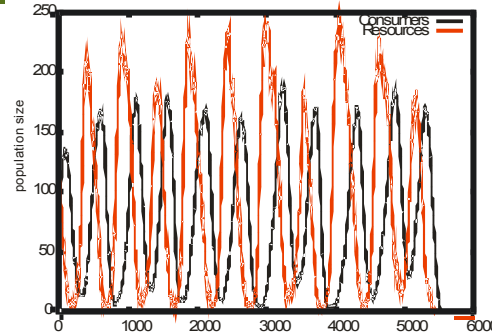
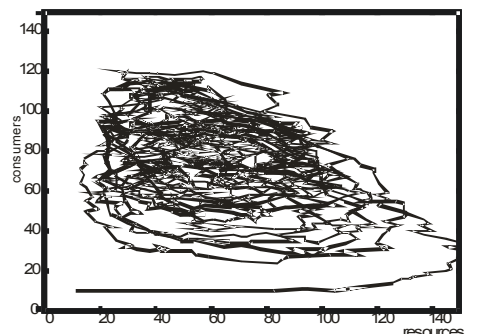
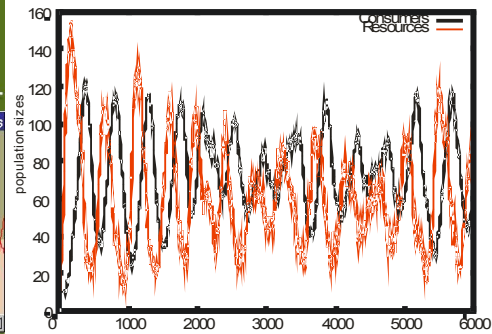
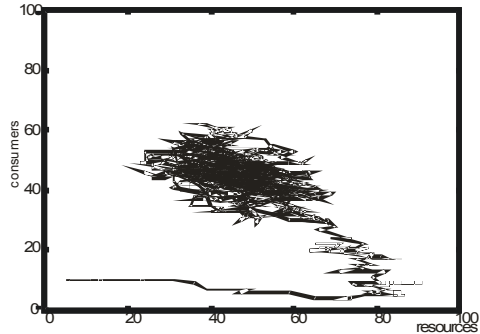
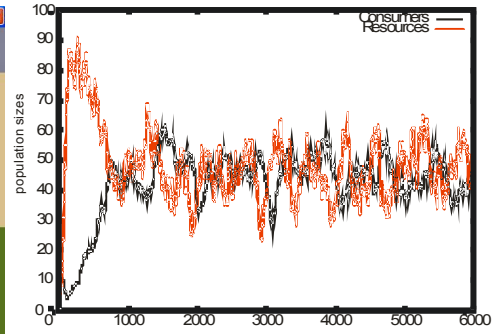
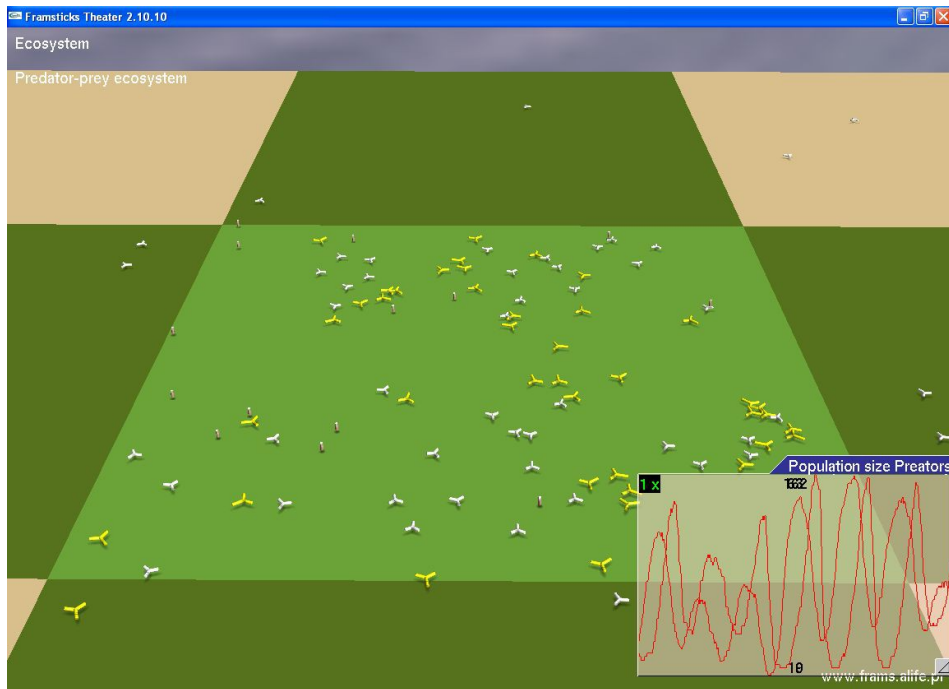
# Study #2

- Provided:
  - Agents: consumers and food
  - Environment
    - consumer reproduction based on energy (food) found
    - food added at a constant rate
  - Change
- Self-organization of ?
- Emergence of ?

# Study #2

- Three cases:
  - A. Consumers' ability to ingest food constant
  - Consumers' ability to ingest food evolved
    - B. Consumer reproduction: random location
    - C. Consumer reproduction: close to parent

# Study #2. Case A



# Study #2. Cases B and C

- Case B.  
Eat more and reproduce! → extinction 😊
- Case C.  
Selection on groups. Some groups do "B",  
but some... do not. → stability.
- A single change in rules causes emergence  
of a totally different system behavior!

# Study #2, analysis

- Emergent population dynamics: periodic changes. (Un)stability. Attractors. Chaos. Sensitivity analysis. Group behaviors. Swarming. Extinction. Group selection. Food chain. Geographical differentiation. Tragedy of the commons. Restraint. Altruism.
- microscale = individual, macroscale = population, mesoscale = groups