Emergence and self-organization in Framsticks

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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 was *speed*)
  - Another environment $\rightarrow$ another emergent phenomenon (rolling, swimming, flying, problem solving, ...)
- Analysis reveals
  - Redundancy
  - Hidden interconnections and relations
  - Evolution does not have to proceed towards complexity
  - Evolution can discover new ideas and drop them
  - Evolution may be unable to discover obvious ideas, it is a monotonic, limited process
  - Solutions (agents) are not strictly optimal

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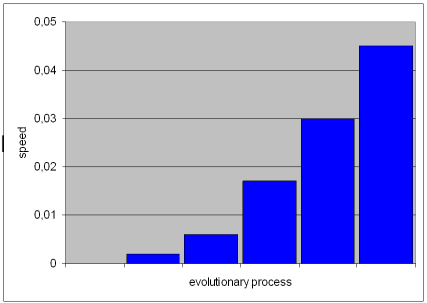


Study #2

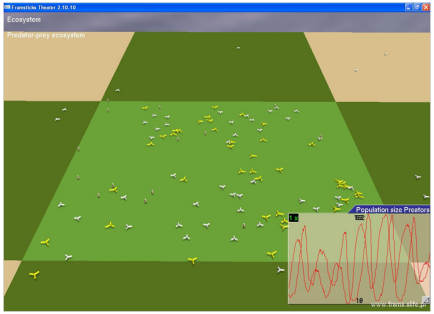
- Provided:
  - Agents: consumers and food
  - Environment
    - consumer reproduction based on energy (food) found
    - food added at a constant rate
  - Change
- Self-organization of ?
- Emergence of ?

Study #2

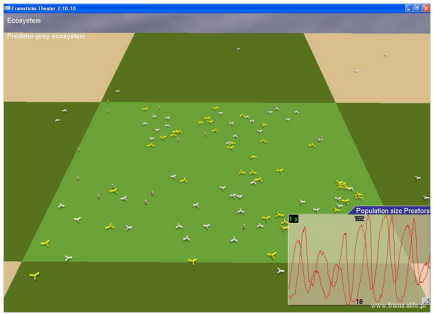
Three cases

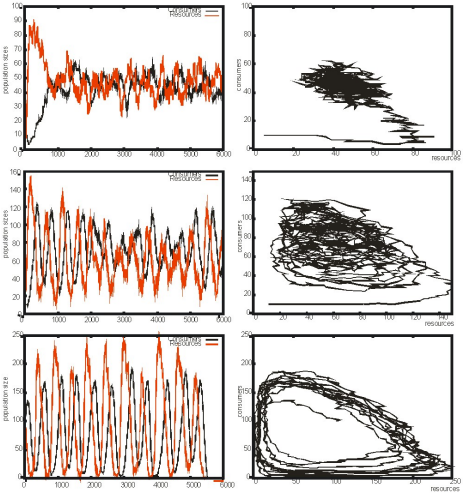
- **A**. Consumers' ability to ingest food constant
- Consumers' ability to ingest food evolved
  - **B**. Consumer reproduction: random location
  - **C**. Consumer reproduction: close to parent

Study #2. Case A



Study #2. Case A





For more details, see [Bac06].

Study #2. Cases B and C

- Case B. Eat more and reproduce! $\ddot{\smile} \rightarrow$ extinction

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- Case C. Selection on groups. Some groups do "B",
  but some... do not. $\rightarrow$ stability.
- A single change in rules causes the 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

References I

[Bac06] Walter de Back. "Eco-evolutionary experiments with situated agents". MA thesis. 2006. URL: http://www.framsticks.com/files/common/MSc_deBack_EcologyEvolution.pdf.