
人工智能
The ShanghAI Lectures
上海授课

The Shanghai Lectures 2022

Natural and Artificial Intelligence in Embodied Physical Agents

November 17th, 2022

From Zagreb, Croatia

Today's program (CET)

08:30 sites begin connecting
08:55 all sites are ready
09:00 (Fabio) Welcome
09:05 Emerging Intelligence: Embodiment, Cognition from Interaction, Development and Evolution
09:50 Break
10:00 Guest Lecture by Martin Stoelen, Western Norway University of Applied Sciences, Bergen, Norway:
Soft robots for the hard problem of picking soft berries
10:45 Koan Announcement
11:00 Wrap-up

Today's Guest Lecture

10:00 CET Martin Stoelen, Western Norway University of Applied Sciences, Bergen, Norway

«Soft robots for the hard problem of picking soft berries»

Stay tuned!

Lecture 3

Emerging Intelligence: Embodiment, Cognition from Interaction, Development and Evolution

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 952275

www.heronrobots.com

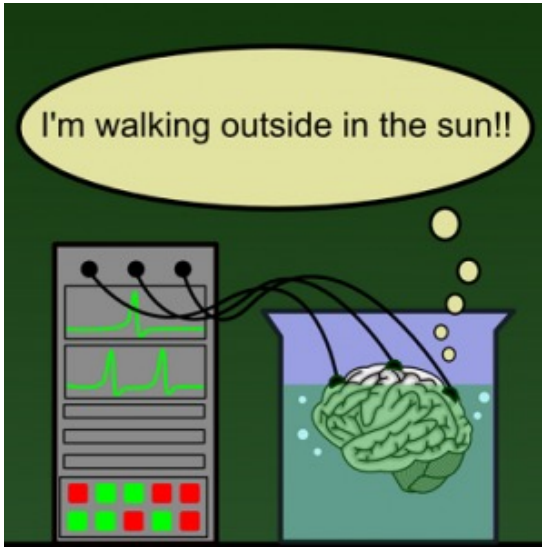
Today's topics

- In short
- Brain-in-a-vat
- self-organization at many levels
- self-organization and emergence in groups of agents
- modular robotics and self-assembly
- design principles for collective intelligence

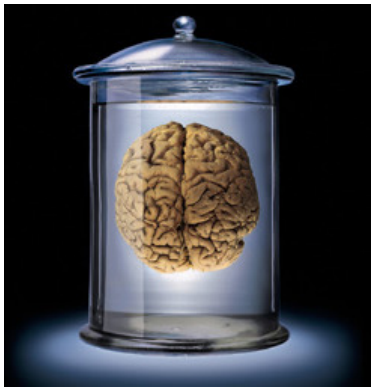
In short

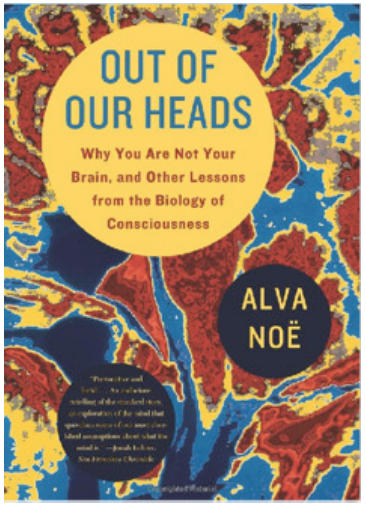
- given robot → evolve control (neural network)
- embodied approach → co-evolution of morphology and control

“Brain-in-a-vat”

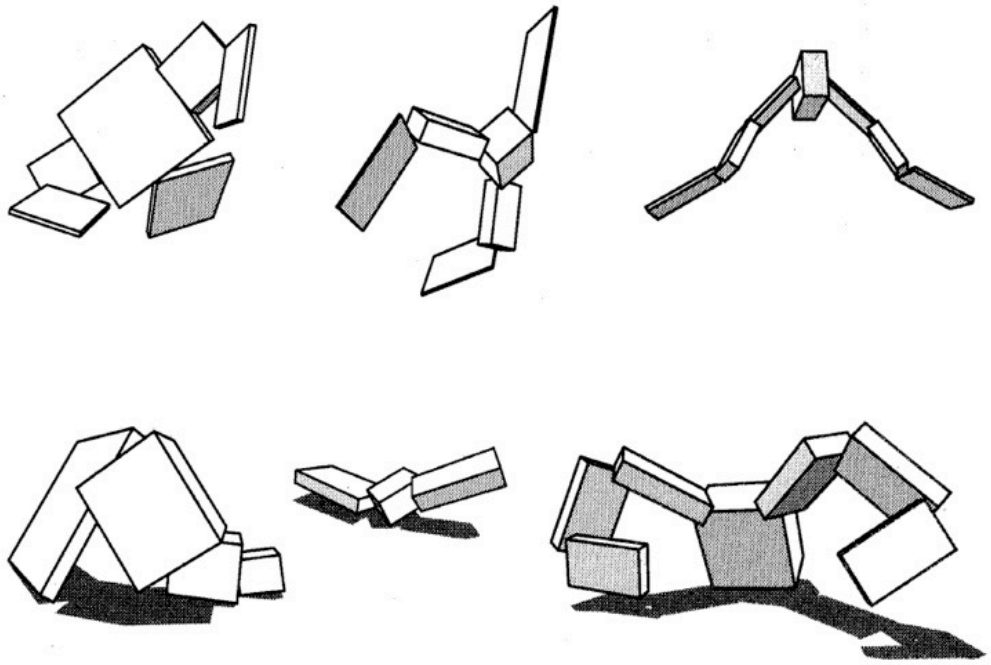


Alva Noë, “Out of our heads - why you are not your brain”, New York, Hill and Wang, 2009





Evolving morphology and control: Karl Sims's creatures

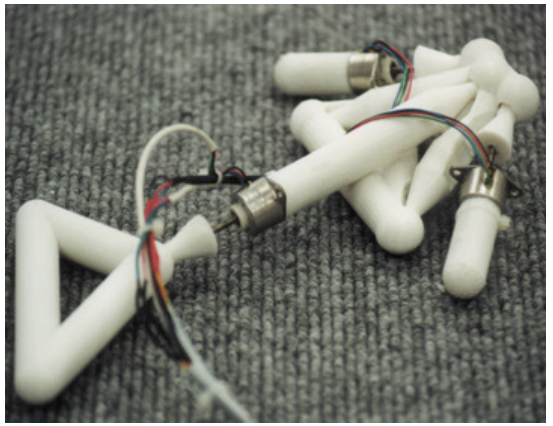


New version: Golem (Lipson and Pollack)

representation of morphology in genome

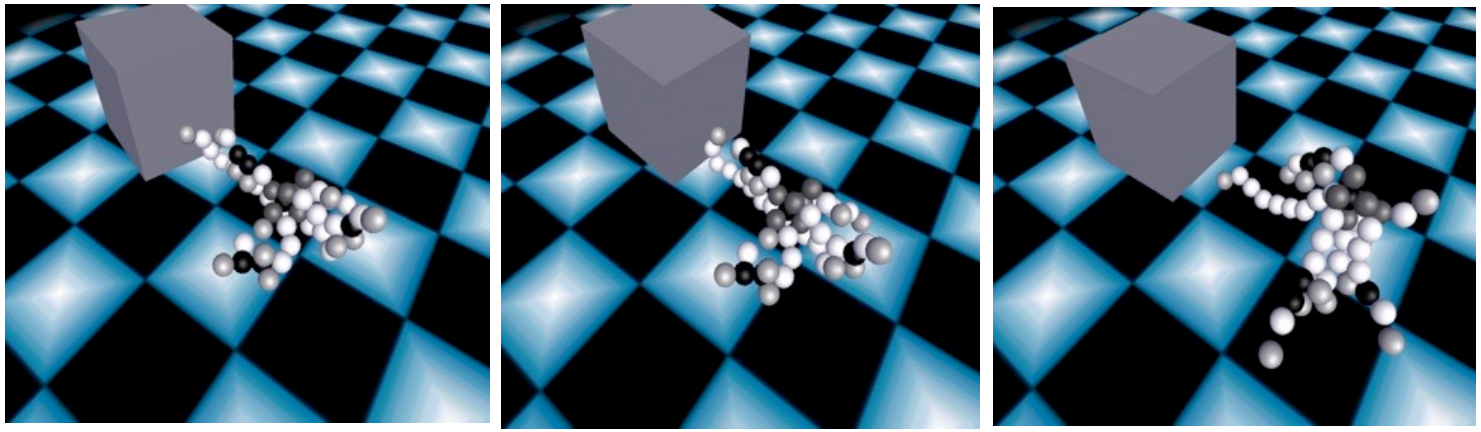
- **robot: bars, actuators, neurons**
- **bars: length, diameter, stiffness, joint type**
- **actuators: type, range**
- **neurons: thresholds, synaptic strengths**

(recursive encoding)

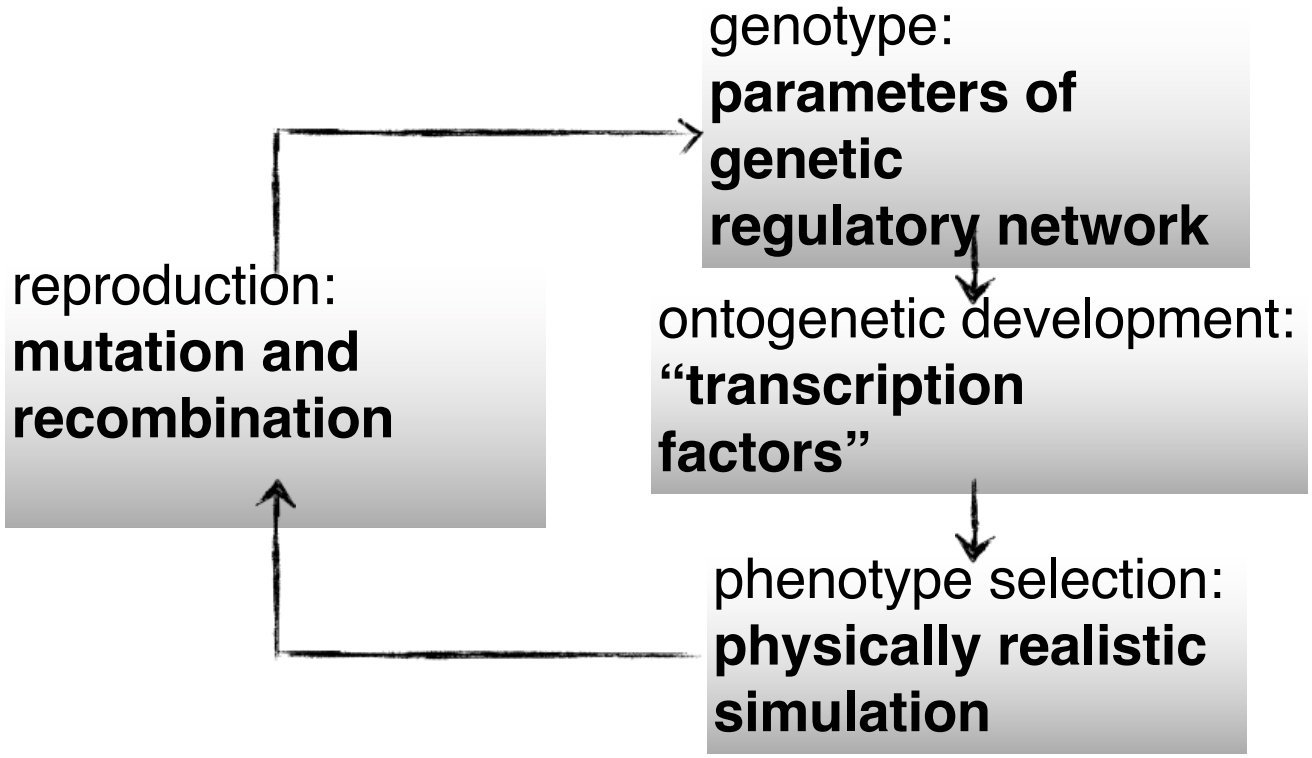


Genetic Regulatory Networks (GRNs): Bongard's "block pushers"

- development (morphogenesis) embedded into evolutionary process, based on GRNs
- testing of phenotypes in physically realistic simulation

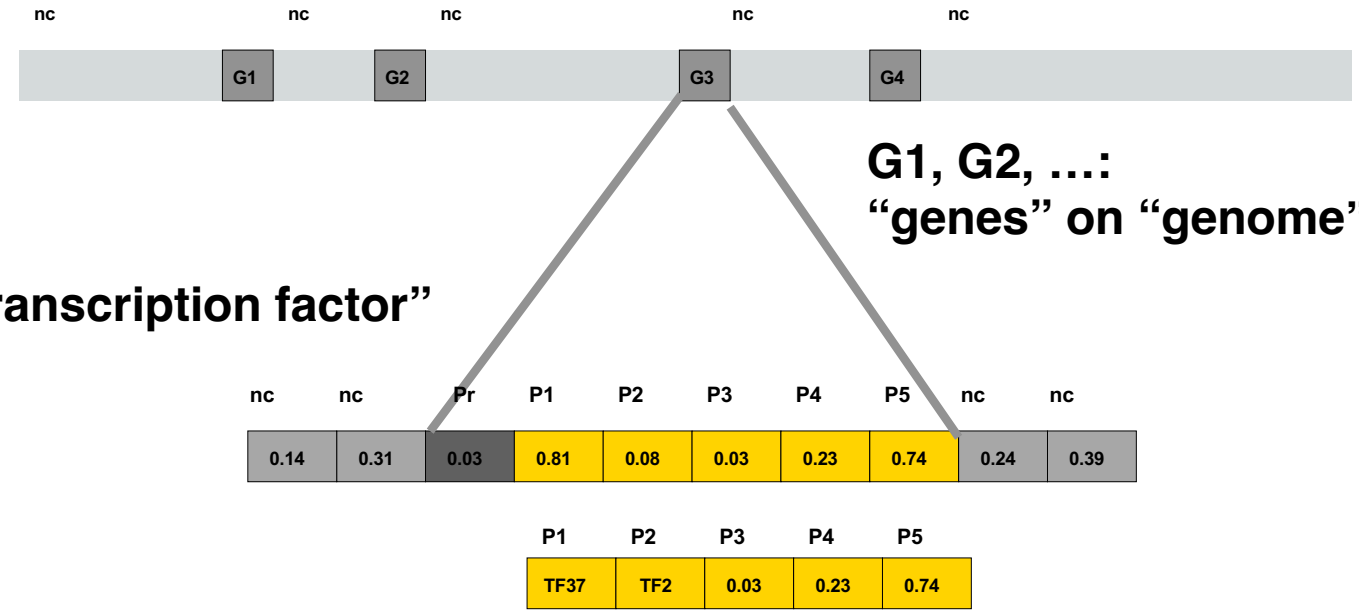


Bongard's evolutionary scheme



Representation of “gene”

nc: “non-coding region”



Xenobots


Say hello to...
XENOBOTS 3.0
The world's first
self-replicating
living robots.

Limitations of artificial evolution?

think about:

Where are the limits of artificial evolution?

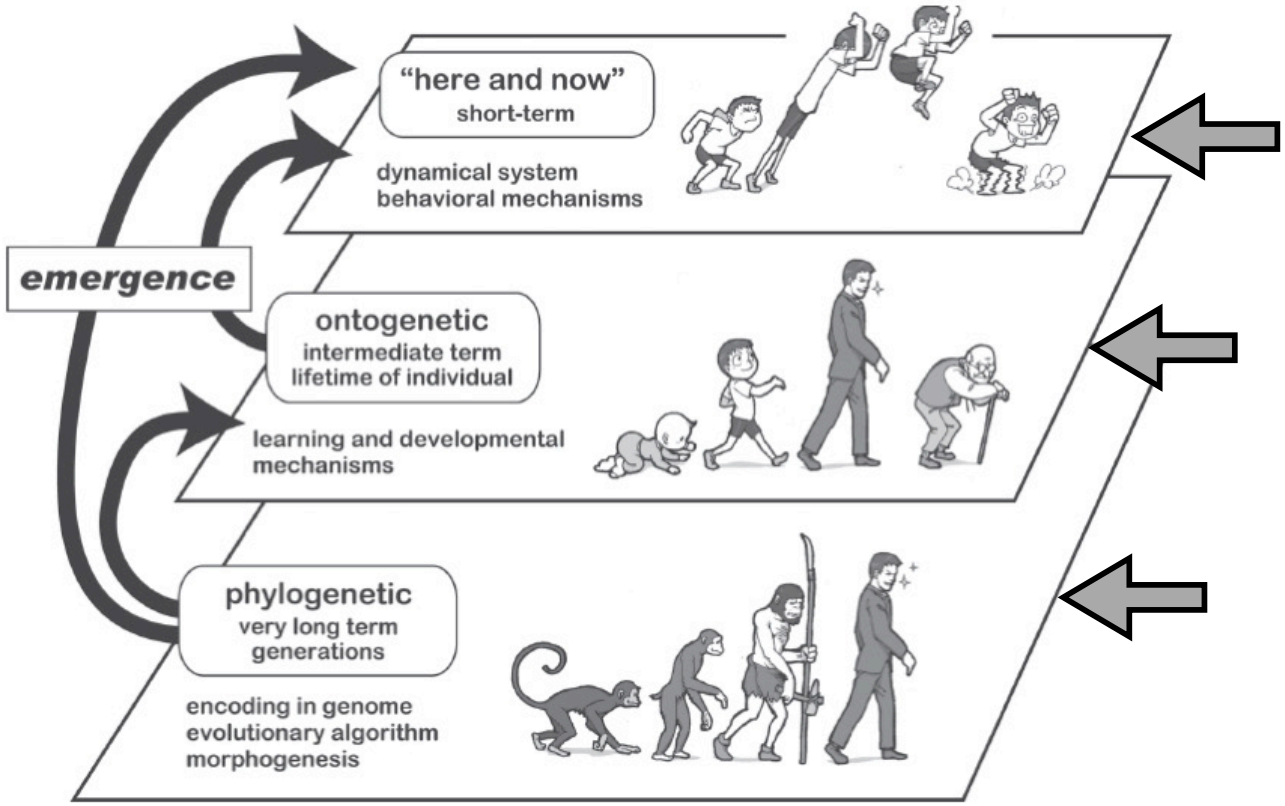
Or is the potential unlimited?

Collective intelligence

Self-organization and emergence at many levels

- molecules
- cells
- organs
- individuals
- groups of individuals

Time perspectives



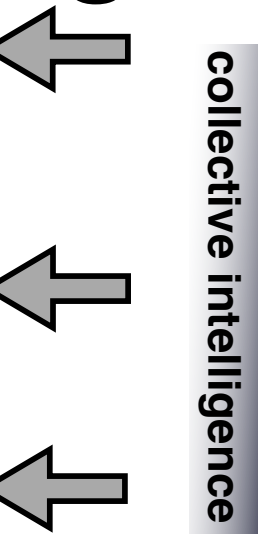
collective intelligence

Time perspectives in understanding and design

state-oriented **"hand design"** — **"here and now" perspective**

learning and development
initial conditions, learning and developmental processes — **"ontogenetic" perspective**

evolutionary
evolutionary algorithms, morphogenesis — **"phylogenetic" perspective**



Understanding: **all three perspectives required**
Design: **level of designer commitments, relation to autonomy**
Collective intelligence: **emergence from interaction**

Examples of collective behavior — self-organization

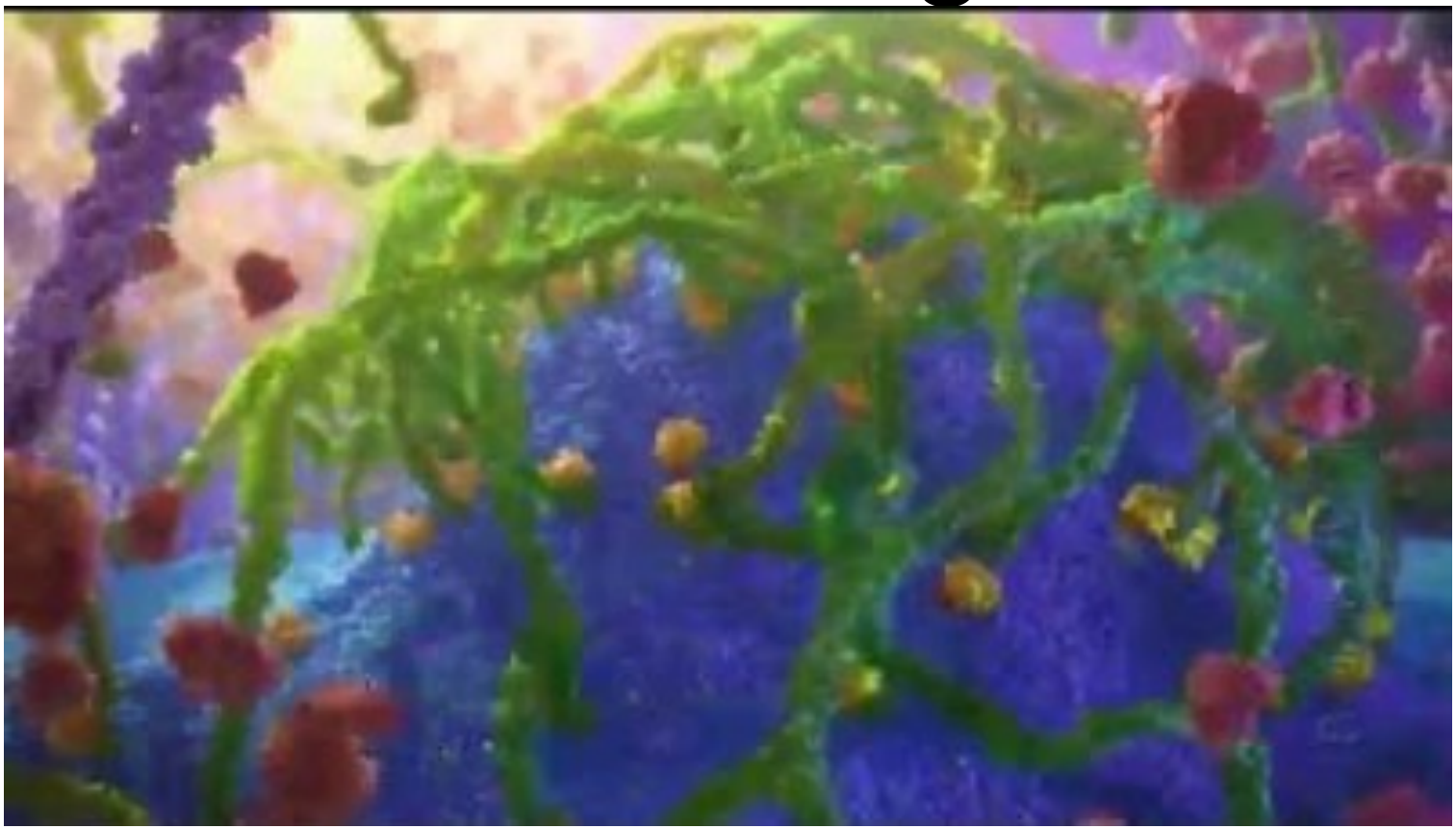
bee
hive

termite mound

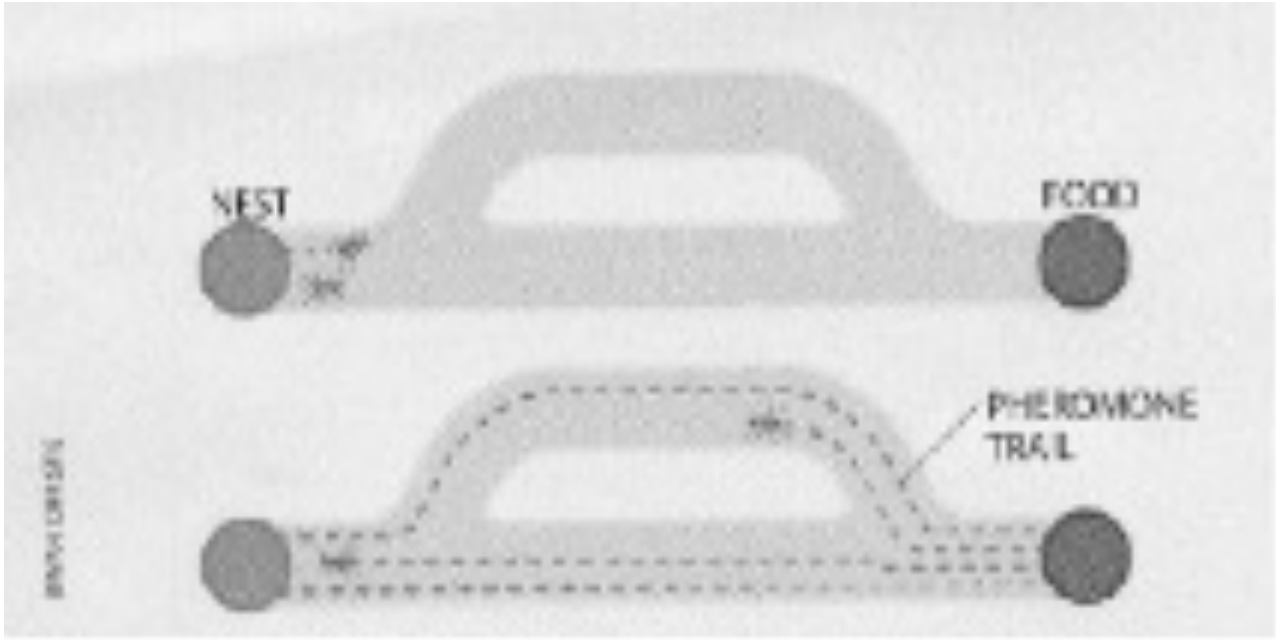
“wave”in stadium

open source development community

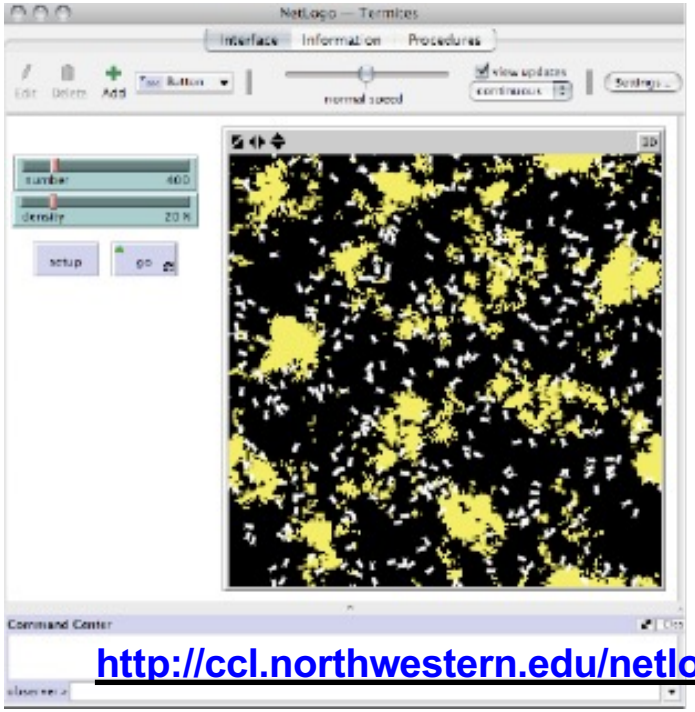
Examples of collective behavior — self-organization



Finding the shortest path to a food source



Simulation



Mitchell Resnick, MIT: “Turtles, Termites and Traffic Jams”
MIT Press, 1997.

http://ccl.northwestern.edu/netlogo/models/run.cgi?Ants.790.569

Recall: Emergence

- collective behavior: global patterns from local interactions (e.g. “ bird flocks, fish schools, clapping)
- behavior of individual: emergent from interaction with environment
- from time scales

Swarm behavior

birds

humans

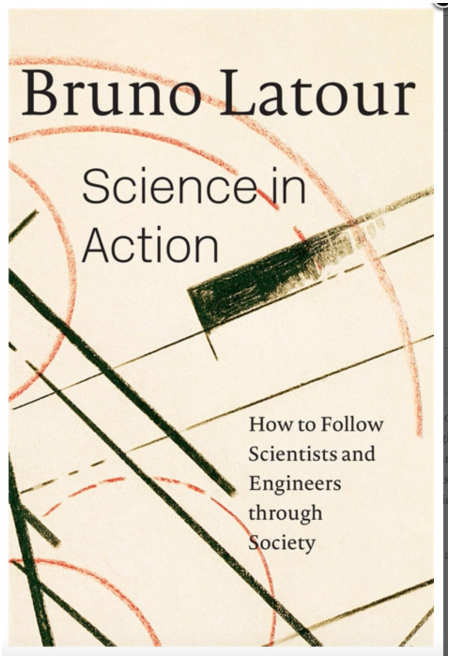
sheep

insects

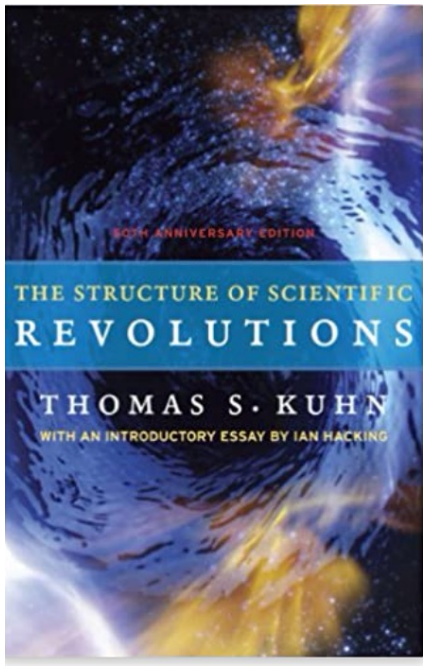
fish

Swarm behavior

Collective science and technology work

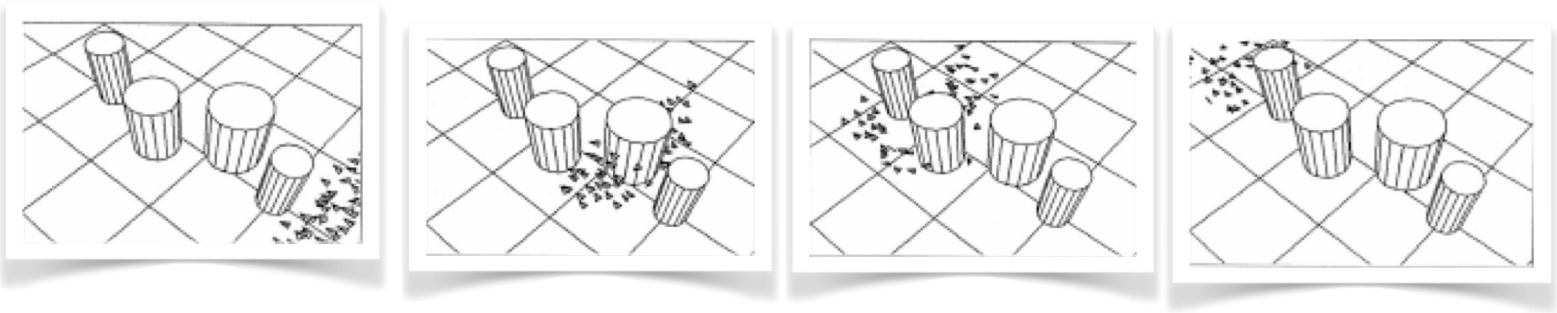


Science in action: how to follow scientists and engineers through society,
Bruno Latour, Harvard Univ. Press, (reprint from 1987), 2015



The Structure of Scientific Revolutions: 50th Anniversary Edition,
Thomas Kuhn, University of Chicago Press, (fourth edition from 1962), 2012

Craig Reynolds's flocking rules

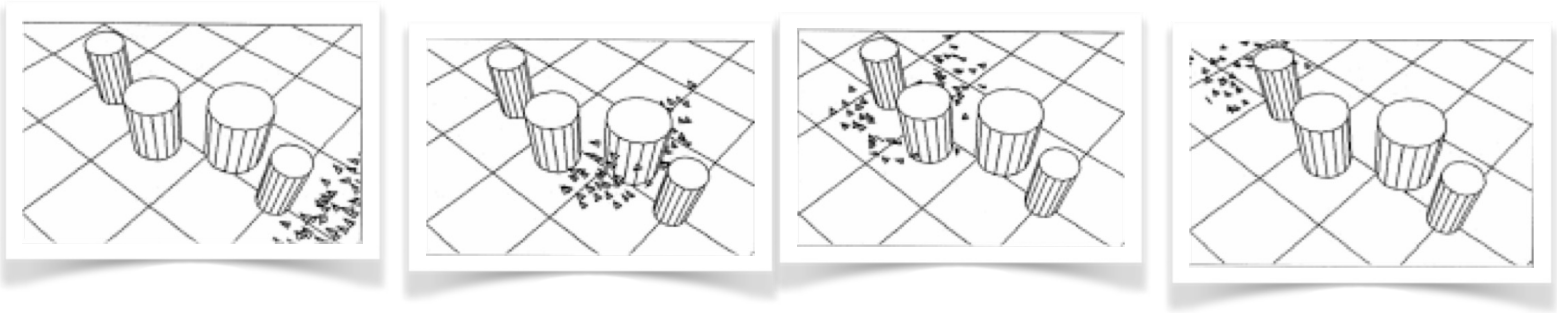


1.

2.

3.

Craig Reynolds's flocking rules



1. **Collision avoidance**: Avoid collisions with nearby flockmates (and other objects)
2. **Velocity matching**: attempt to match velocity of nearby flockmates
3. **Flock centering**: attempt to stay nearby flockmates

Problem to think about: Modeling swarm behavior

frame-of-reference?

situated vs. “god’s eye view”

“god’s eye view”: straightforward

situated view: biologically more plausible but more difficult to implement

Social simulations

- **Shelling's segregation model (1971)**
- **Epstein and Axtell's "Sugarscape model" (1996)**
- **Macroeconomics as complex dynamics emergent from multi agent systems (many)**

Design principles for collective systems

Principle 1: Level of abstraction

Principle 2: Design for emergence

Principle 3: From agent to group

Principle 4: Homogeneity/heterogeneity

Assignments for next week

- Check “How the body…” for self-study
- Think about how to design a simulation model for flocking from a situated perspective

Today's Guest Lecture

10:00 CET Martin Stoelen, Western Norway University of Applied Sciences, Bergen, Norway

«Soft robots for the hard problem of picking soft berries»

Stay tuned!

End of lecture 3

Thank you for your attention!

stay tuned for lecture 4

“Morphological Computation, Self-Organization of Behaviors and Adaptive Morphologies»

Short Bio

The ShanghAI Lectures 2013-

Prof. Fabio Bonsignorio is **ERA Chair in AI for Robotics** at FER, University of Zagreb, Croatia. He is **Founder and CEO of Heron Robots (advanced robotics solutions),** see **www.heronrobots.com**. He has been visiting professor at the **Biorobotic Institute of the Scuola Superiore Sant'Anna in Pisa from 2014 to 2019**. He has been a professor in the Department of System Enginering and Automation at the **University Carlos III of Madrid until 2014**. In 2009 he got the **Santander Chair of Excellence in Robotics** at the same university. He has been working for some 20 years in the high tech industry before joining the research community.

He is a **pioneer and has introduced the topic of Reproducibility of results in Robotics and AI**. He is a **pioneer in the application of the blockchain to robotics and AI (smart cities, smart land, smart logistics, circular economy). He coordinates the Topic Group of euRobotics about Experiment Replication, Benchmarking, Challenges and Competitions. He is co-chair of the IEEE Robotics & Automation Society (RAS) Technical Committee, TC-PEBRAS (PErformance and Benchmarking of Robotics and Autonomous Systems)**.

He is a **Distinguished Lecturer** for **IEEE Robotics and Automation Society.**' Senior Member of IEEE and member of the Order of the Engineers of Genoa, Italy.

He coordinates the task force robotics, in the G2net,an EU network studying the application of **Machine Learning and Deep Learning (Apprendimento Profondo) to Gravitational wave research, la Geophysics and Robotics**.

Has given invited seminars and talks in many places: MIT Media Lab, Max Planck Institute, Imperial College, Politecnico di Milano in Shenzhen, London, Madrid, Warsaw, San Petersburg, Seoul, Rio Grande do Sul.…

Thank you!

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement No. 952275

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