Intelligence of the crowds in nature and culture

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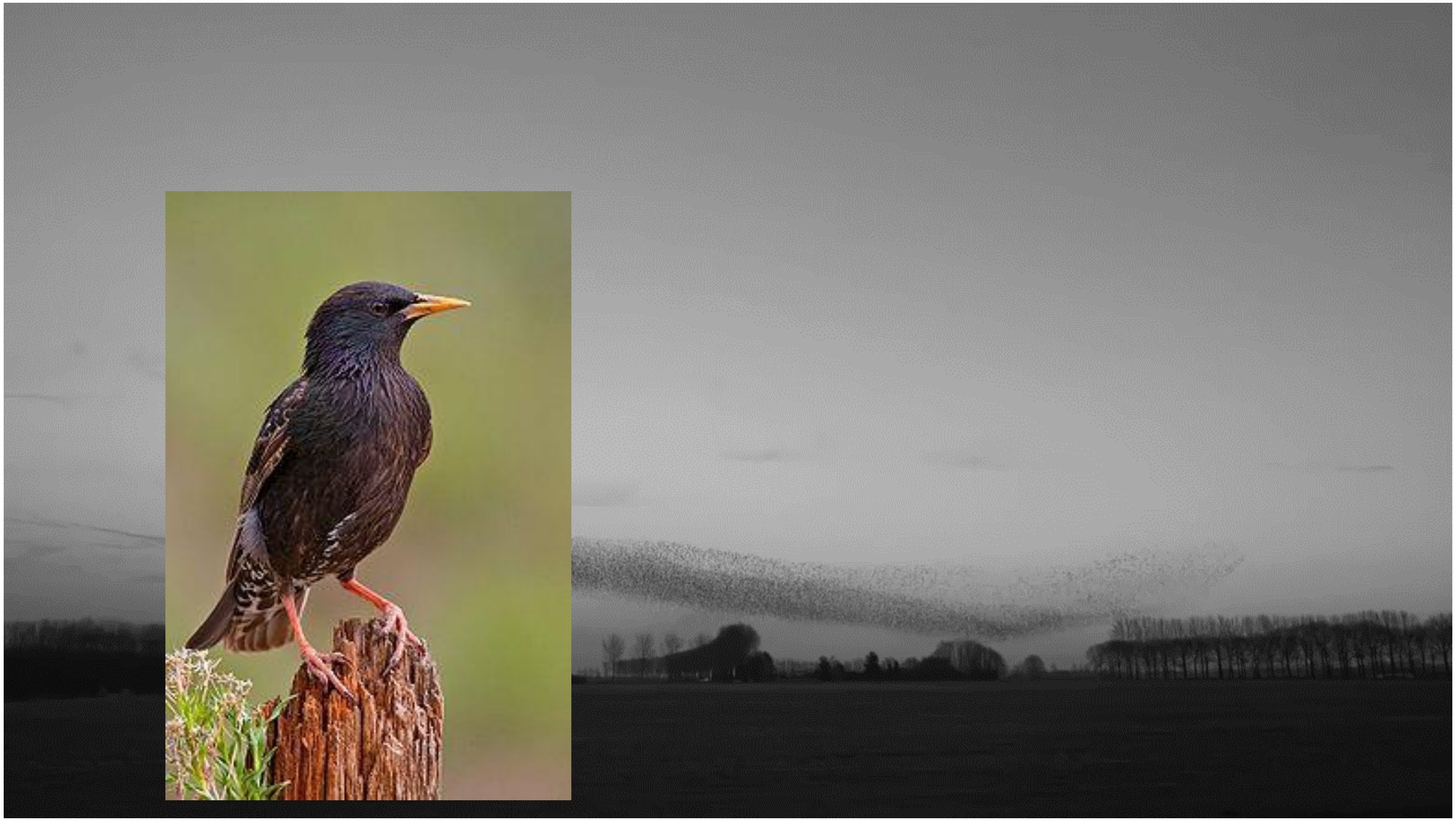
02.04.2018
Tartu, Semiosalong

Video, van Ijken (2015)

A starling murmuration



Common starling / Kuldnokk

Video, van Ijken (2015)

The mapping problem in complex systems

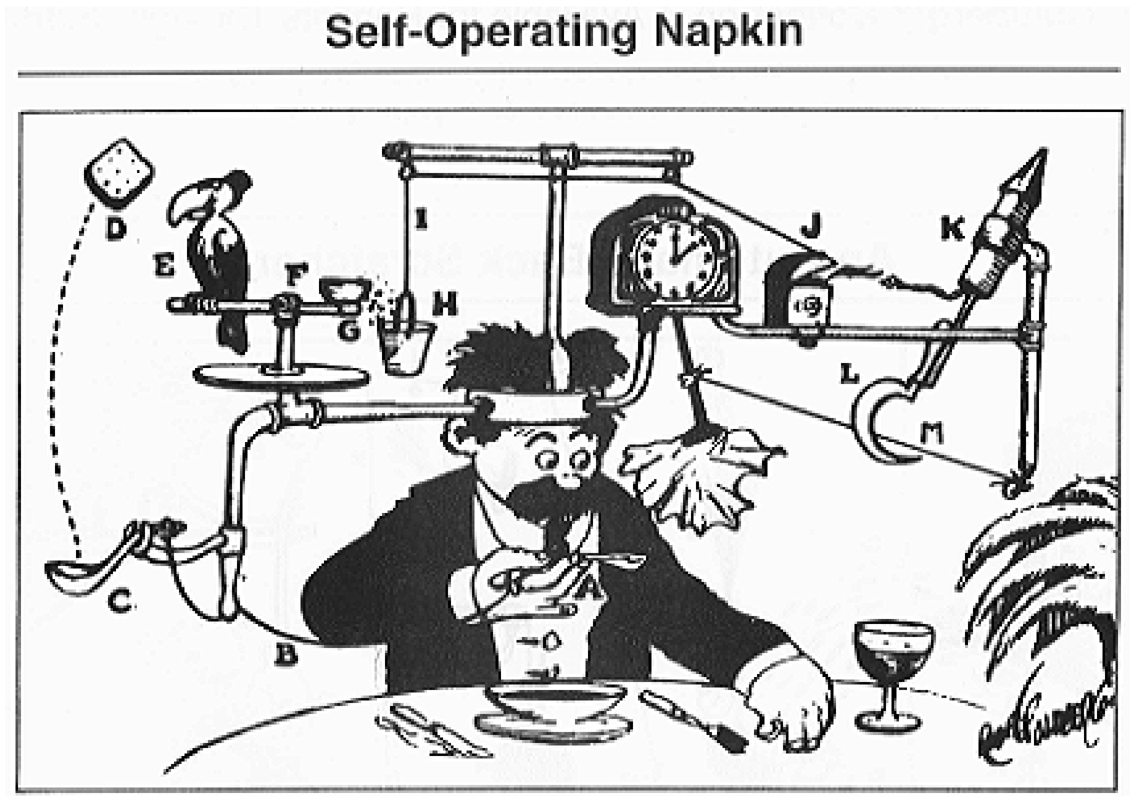
- Element <-> System
  - Individuals <-> Population

- Individual <-> collective link can be very complex.

- Often not easy to know. Worth study in its own.

- Tools: theory, models, simulations etc.

Complex ≠ complicated



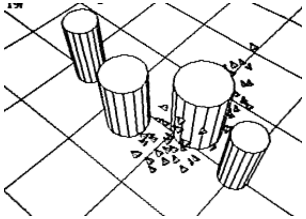
Goldberg 1931. Professor Butts and the Self-Operating Napkin

Image via Nicolas Perony| TEDxZurich 2013

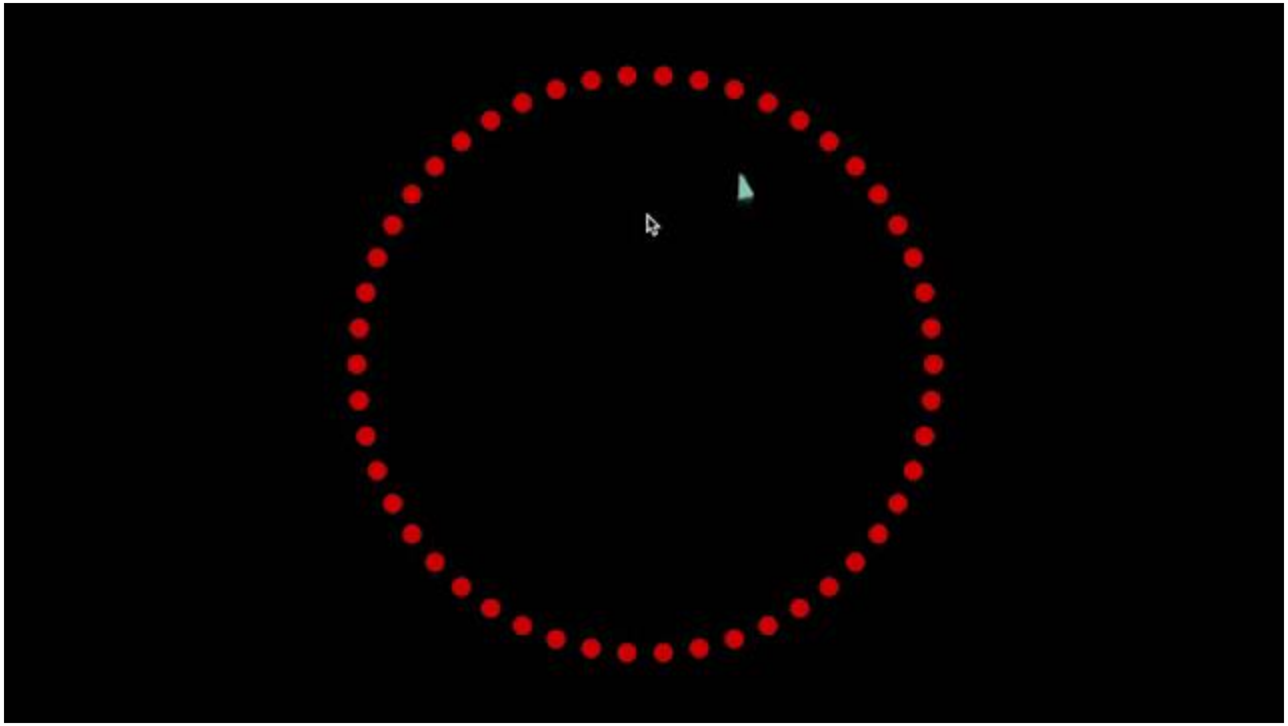
Swarms

- Swarming is a collective behaviour of entitites of similar size, aggregating together.
- Swarm (insects), flock/murmuration (birds), school/shoal (fish), bloom (algae), swarm (robots)
- Migration, aggregation, sorting, predator avoidance, decision-making, etc.
- How exactly?

How swarms can work

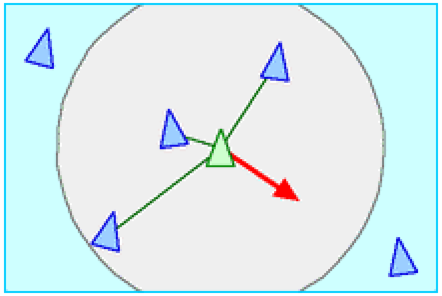


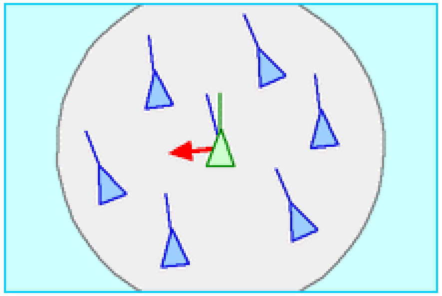
- Boids (1986), with newer graphics

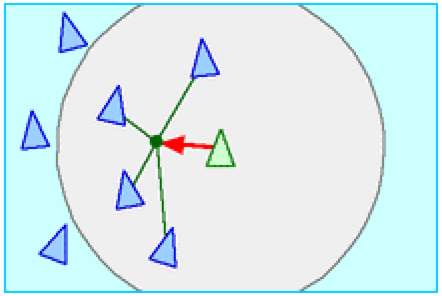


Reynolds 1987. Flocks, Herds, and Schools: A Distributed Behavioral Model
Mouse 2015. How do Boids Work? A Flocking Simulation

How swarms can work



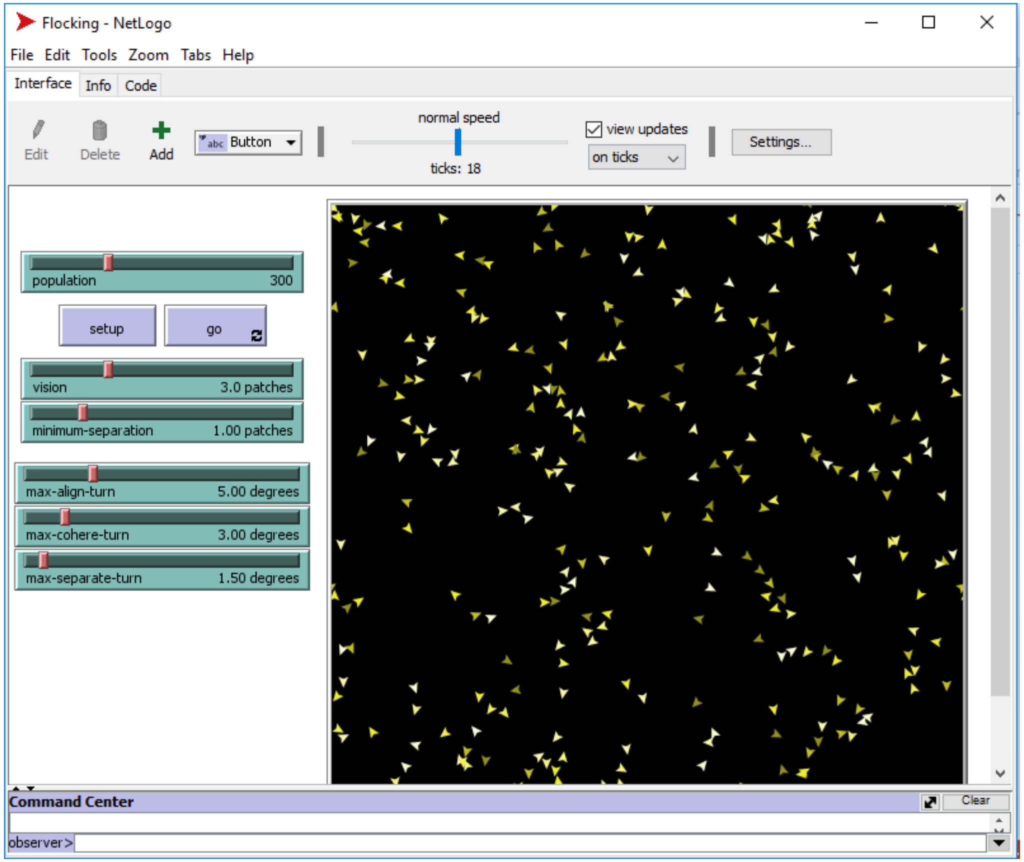




- **Separation:** steer to avoid crowding local flockmates
- **Alignment:** steer towards the average heading of local flockmates
- **Cohesion:** steer to move toward the average position of local flockmates

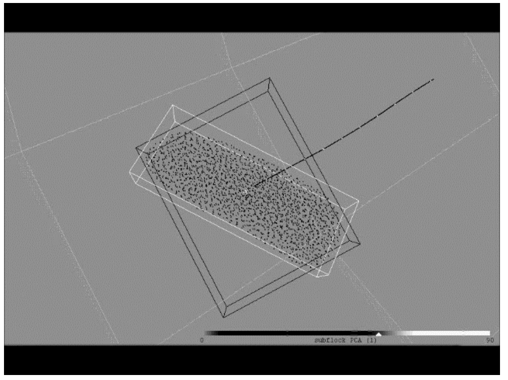
Reynolds 1987. Flocks, Herds, and Schools: A Distributed Behavioral Model

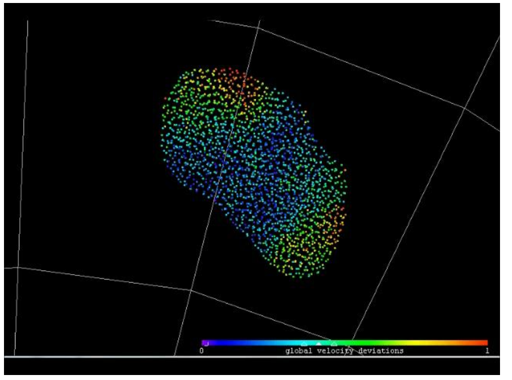
Simulated flocks

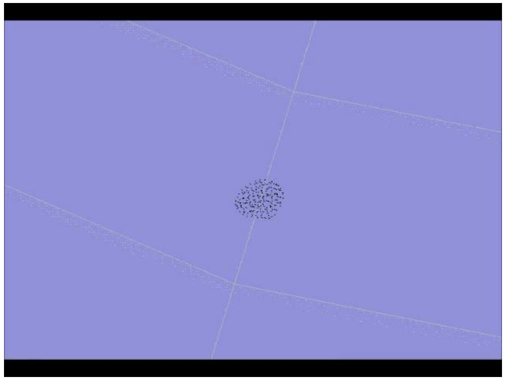


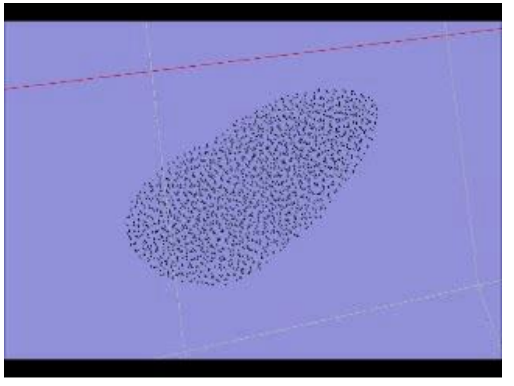
More advanced swarms

- Smaller sphere of interactions <-> more varied in volume and aspect ratios
- Lower variability in speed <-> more variation in shapes
- Higher variability of speed <-> Slowing down in inner corners while turning





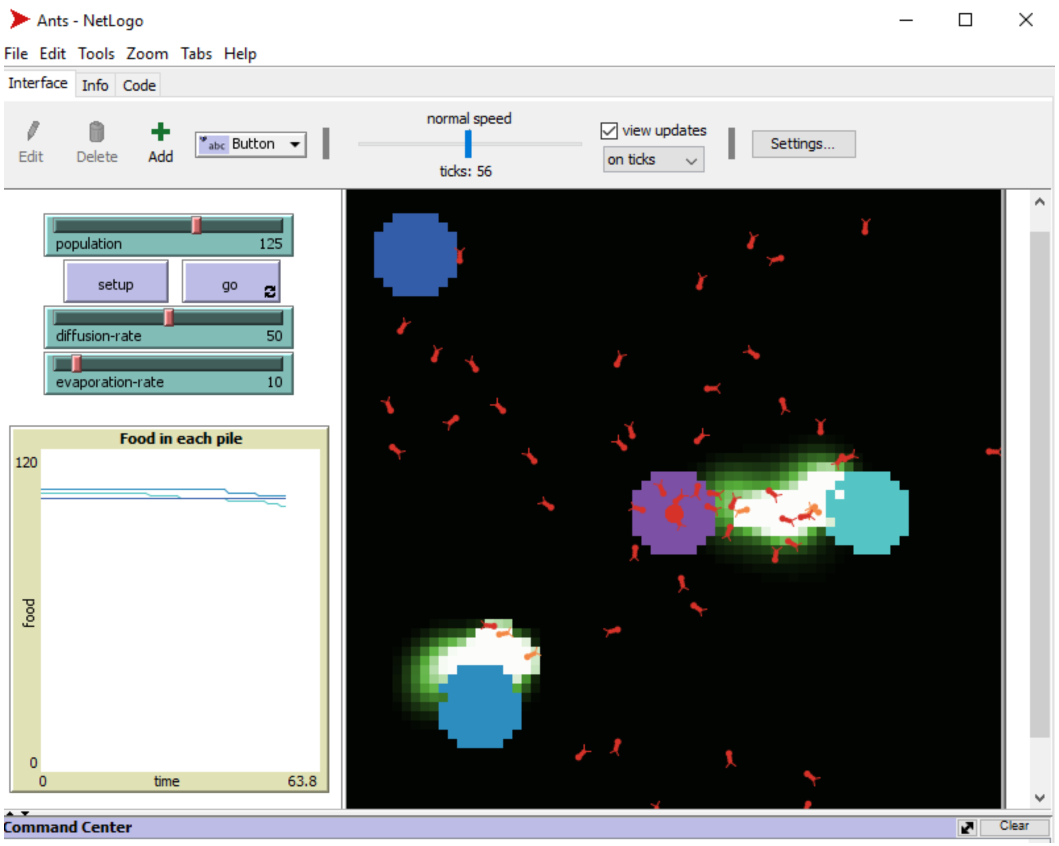




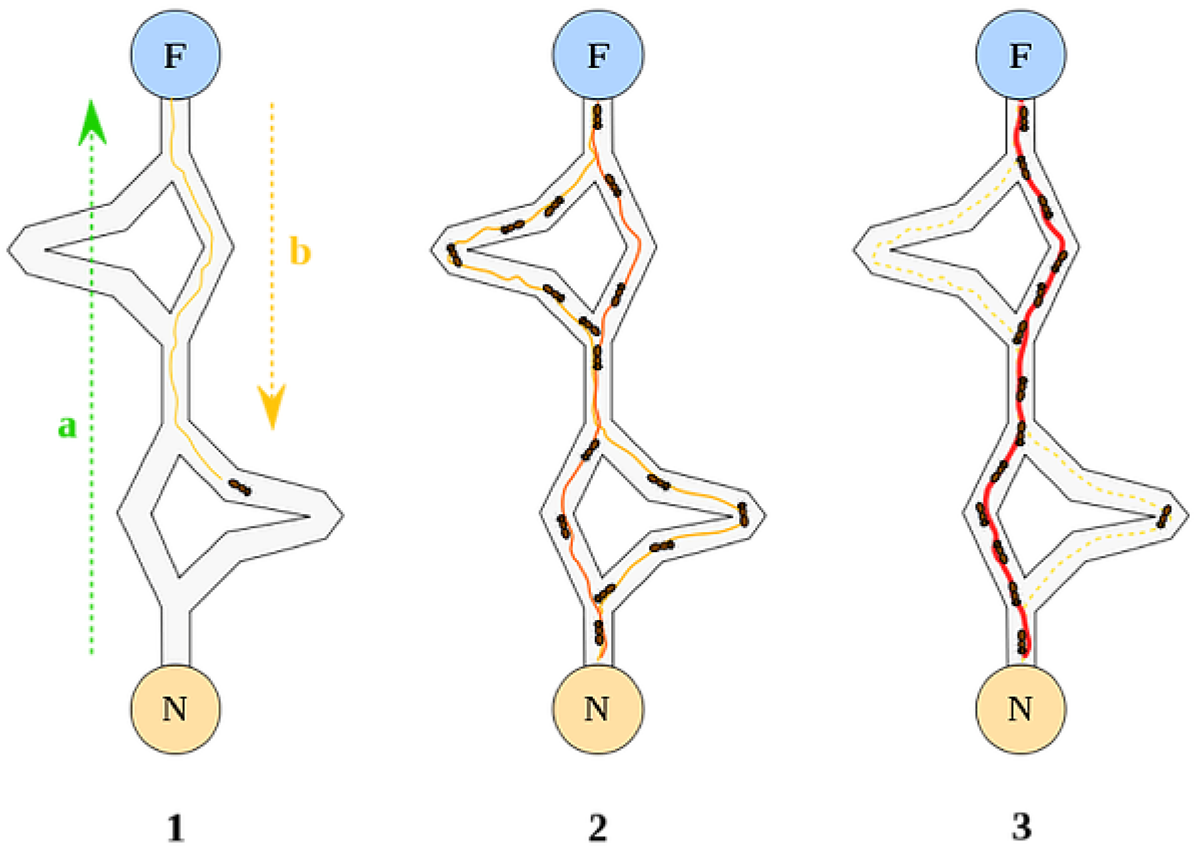
Hemelrijk & Hildenbrandt. 2011. Some Causes of the Variable Shape of Flocks of Birds

Ants

Agents + Environment



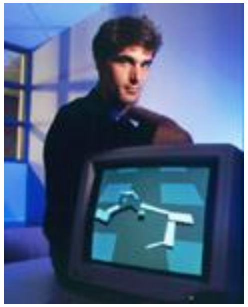
Collective problem solving



Evolution

(Interpretation of evolution from Keith Jensen, 2017)

Evolution can be creative



Sims 1994. Evolved Virtual Creatures, Evolution Simulation.
See also: Lehmann et al. 2018. The Surprising Creativity of Digital Evolution

Evolution can be creative

40% Of Worker Ants Just Hang Around, Doing Nothing All Day

September 18, 2017

Photo credit: Daniel Charbonneau

Temnothorax rugatulus

Charbonneau & Dornhaus 2015. Workers ‘specialized’ on inactivity

Charbonneau et al. 2017. Who needs ‘lazy’ workers? Inactive workers act as a ‘reserve’ ...

What can these systems do?

Complexity from simple behavior

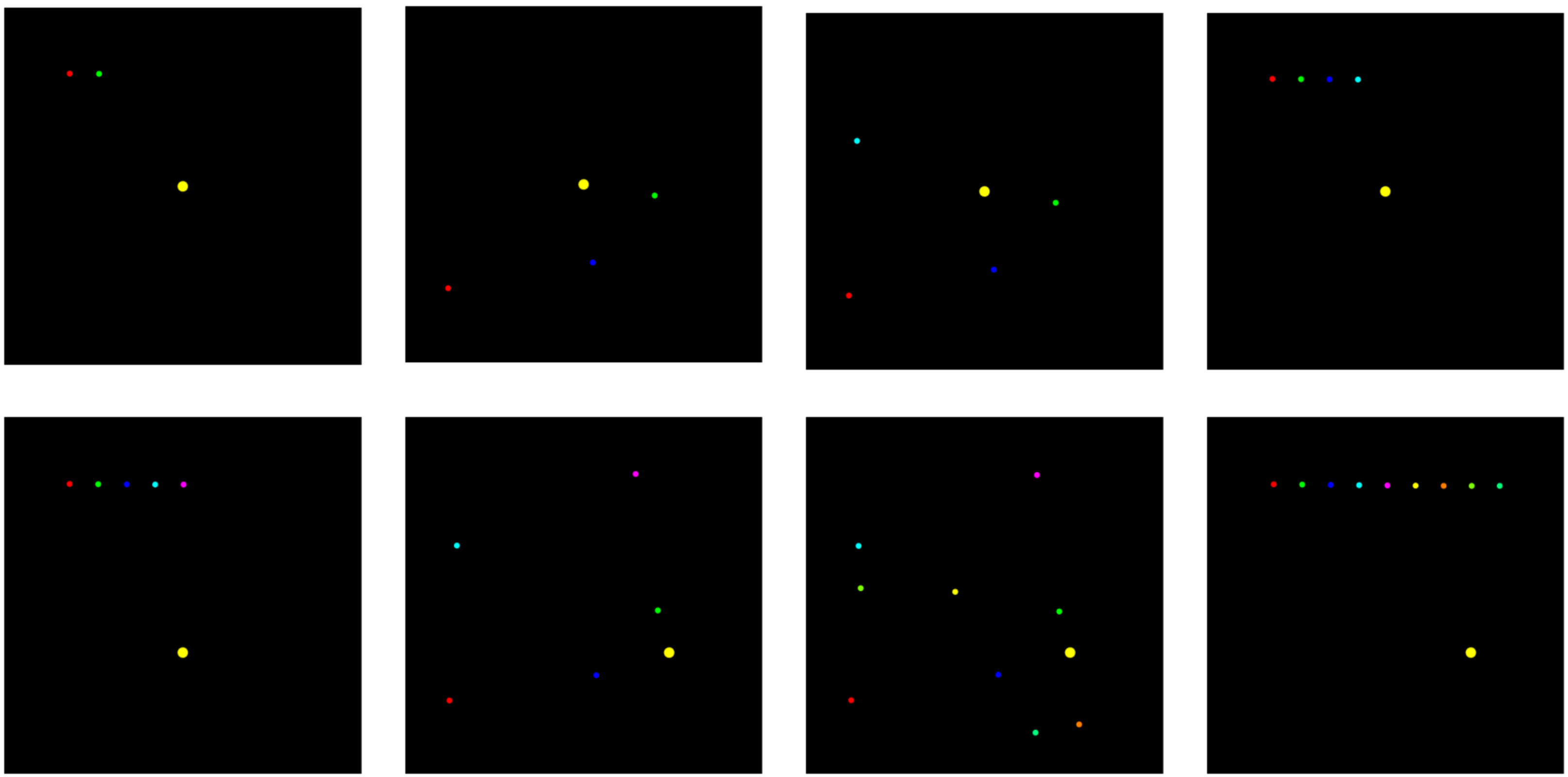
- Wolf pack hunting

Typical wolf-pack hunting behaviors. A bison in Yellowstone National Park is chased by a pack of nine wolves. (A) Approach, track and pursuit. (B–D) Pursuit, harass and encircling maneuver. (E) Wolves lying down at the end of the hunt in the final stationary configuration approximating a regular polygon.

Muro et al. 2011. Wolf-pack (Canis lupus) hunting strategies emerge from simple rules in computational simulations

Complexity from simple behavior

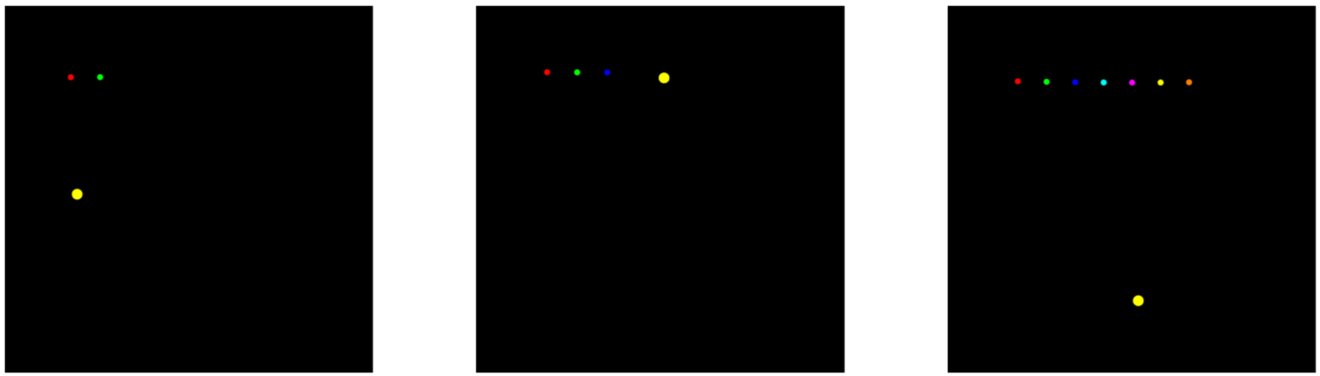
- Wolf pack simulation (N = 2…8)



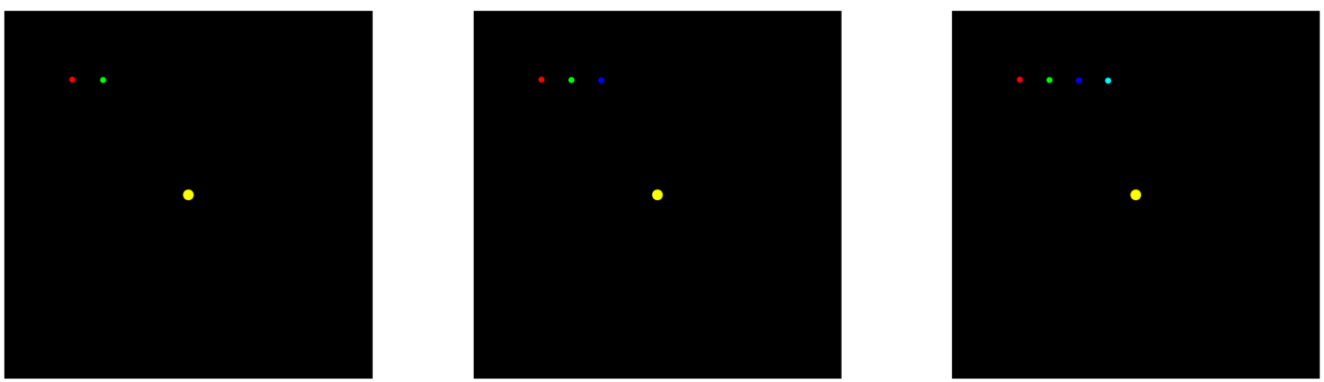
Muro et al. 2011. Wolf-pack (Canis lupus) hunting strategies emerge from simple rules in computational simulations

Complexity from simple behavior

- Moving prey (n= 2, 3, 7)



- Escaping prey (n= 2,3,4)



Muro et al. 2011. Wolf-pack (Canis lupus) hunting strategies emerge from simple rules in computational simulations

Complexity from simple behavior

- Rules are
- (1) move towards the prey until a minimum safe distance to the prey is reached
- (2) when close enough to the prey, move away from the other wolves that are close to the safe distance to the prey
- => wolf-pack hunting here an emergent collective behavior
  - which does not necessarily rely on the presence of effective communication
  - and that no hierarchy is needed in the group to achieve the task properly.

Muro et al. 2011. Wolf-pack (Canis lupus) hunting strategies emerge from simple rules in computational simulations

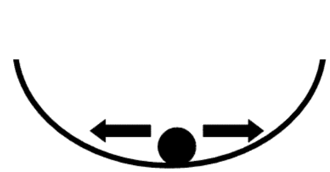
Complexity from simple behavior

Video from Nicolas Perony| TEDxZurich 2013

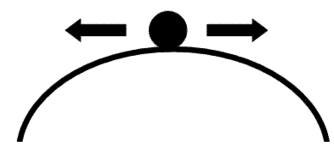
Simplicity from complex maintenance

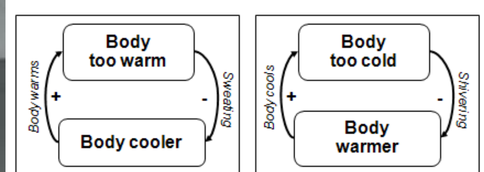
- Some systems are robust against change.
- Others will unravel with a small disturbance.

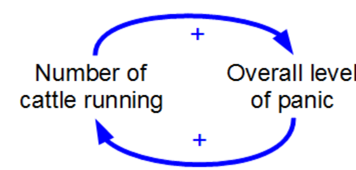
Negative feedback loops create a stable equilibrium



Positive feedback loops create an unstable equilibrium

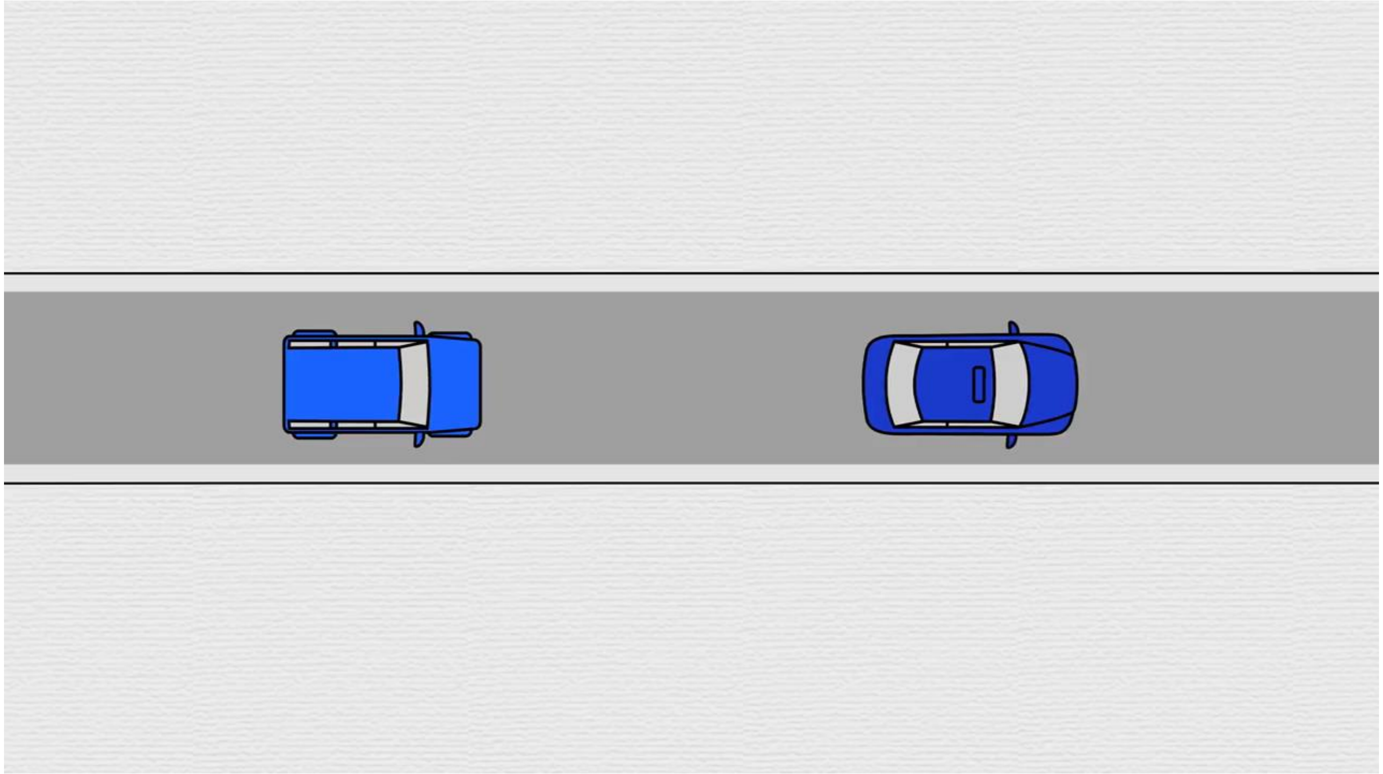






Systems may misbehave (despite what everyone wants)

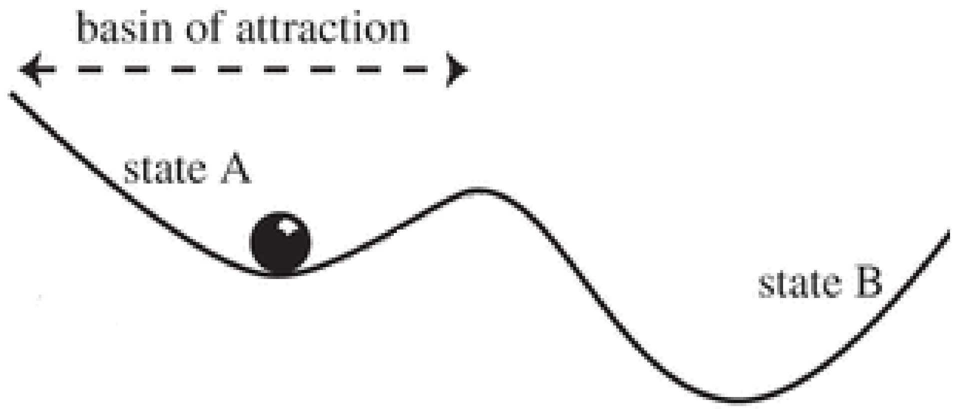
- Small bugs may make systems misbehave



Sugiyama 2008. Traffic jams without bottlenecks
Grey 2016. The simple solution to traffic.

When is slower faster

- 1. There is an instability (internal or external) in the system.
- 2. The instability is amplified, sometimes through cascading effects.
- 3. There is a transition from the unstable to a new stable state which leads to inefficiency.
- 4. Such a state can be characterized as “overloaded”.

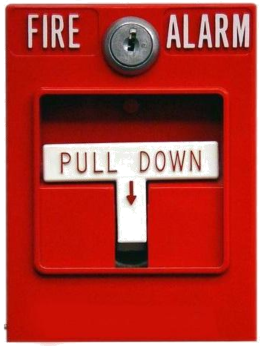


Gersehson & Helbing. 2015. When slower is faster.

Some real world relevance

Bumping heads

- Move quickly to the nearest exit – do not panic!

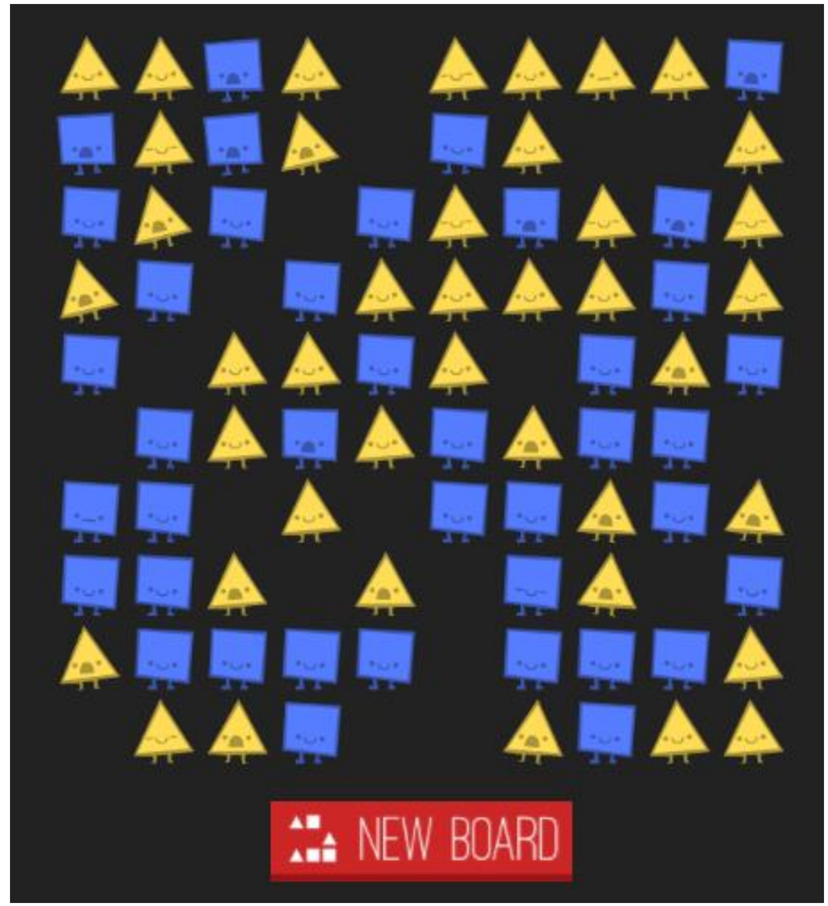


Helbing 2000. Simulating dynamical features of escape panic

Garcimartin et al. 2014. Experimental evidence of the “Faster Is Slower” effect

Garcimartin et al. 2015. Flow and clogging of a sheep herd passing through a bottleneck

Segregation and housing crises

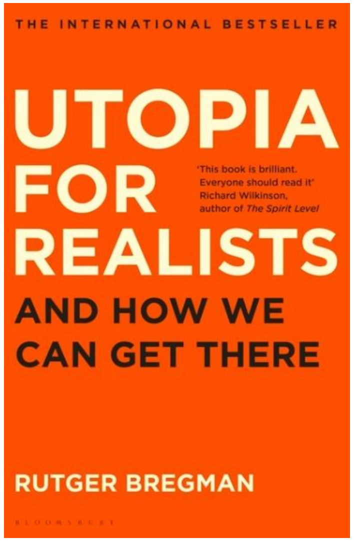


Schellig 1971. Dynamic model of segregation.
Case 2014. Parable of the Polygons. http://ncase.me/polygons/

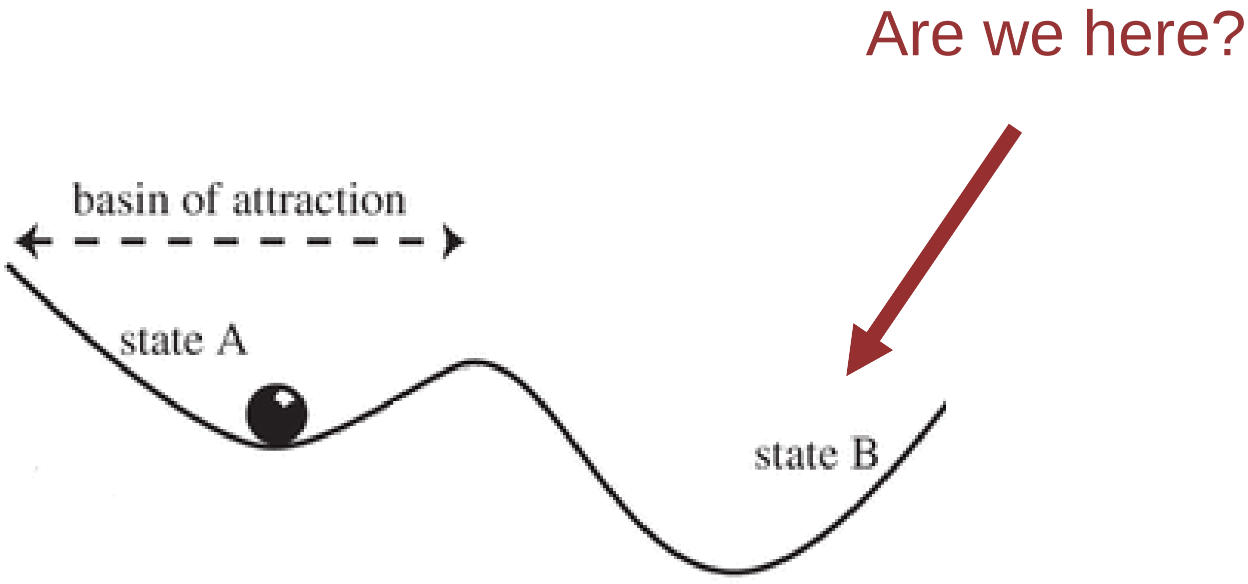
Traffic jam of working too hard?

- Work related problems
  - Stress
  - Accidents
  - Climate change
  - Unemployment
  - Emancipation of women
  - Aging population
  - Inequality

- „Is there anything working less does not solve?“
  - Rutger Bregman



Traffic jam of working too hard?



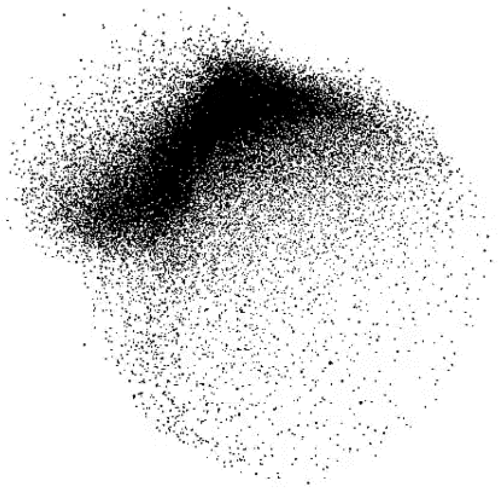
To conclude

- Complex systems can be found everywhere.
- How they work can be non-obvious.

- If the system behaves not as we want, perhaps the balances in the system can be changed.
- E.g. traffic jams, obstacles, working too hard?

Thanks

- Thanks for your attention



Wood 2015. Murmuration of Starlings – Simulation in C.