Collective perception in a robot swarm

Biologically inspired strategies for swarm robotics

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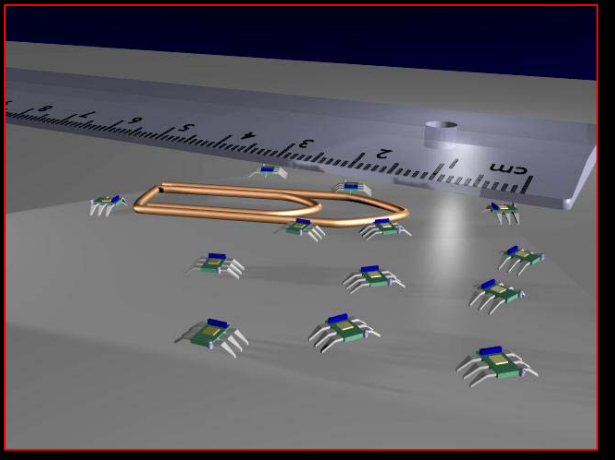
SAB, Rome, Italy, 2006

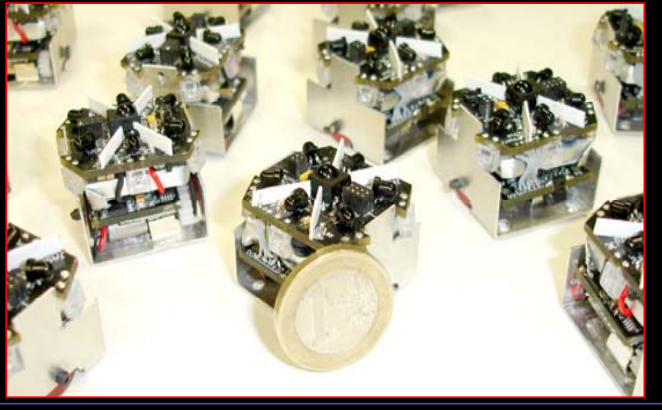

I-SWARM project
507006

Hardware

- I-SWARM Robots



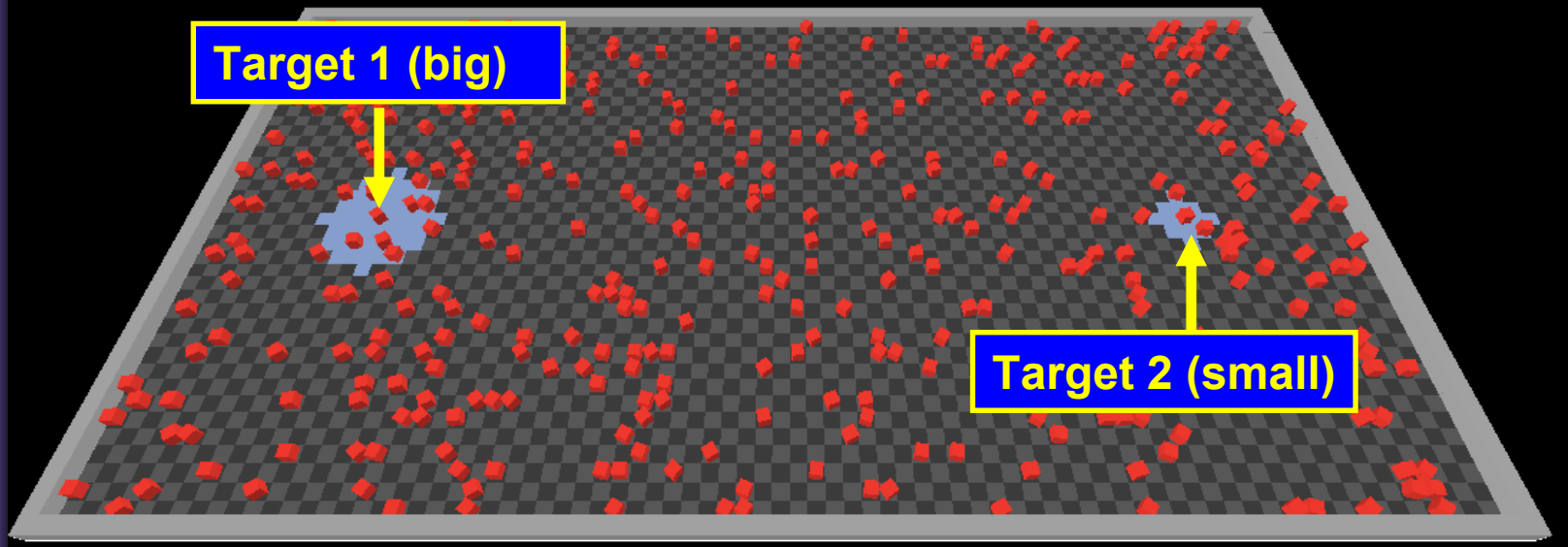
- JASMINE
  (www.swarmrobot.org)



The goal

- Robots should aggregate at a target area.
- When there are more targets, the swarm should split.
- If target sizes are of different size, the robot swarm should split proportionally to the target sizes.

Task:



The constraints

- Robots can communicate with **horrizontal** LED lights and phototransistors
  - Communication-radius = ~ 12-15cm
- Robots can detect targets **only** beneath their base plate
  - target-detection-radius = ~1.5cm
- We applied random error (10% / 15°) to communication and navigation.

The constraints

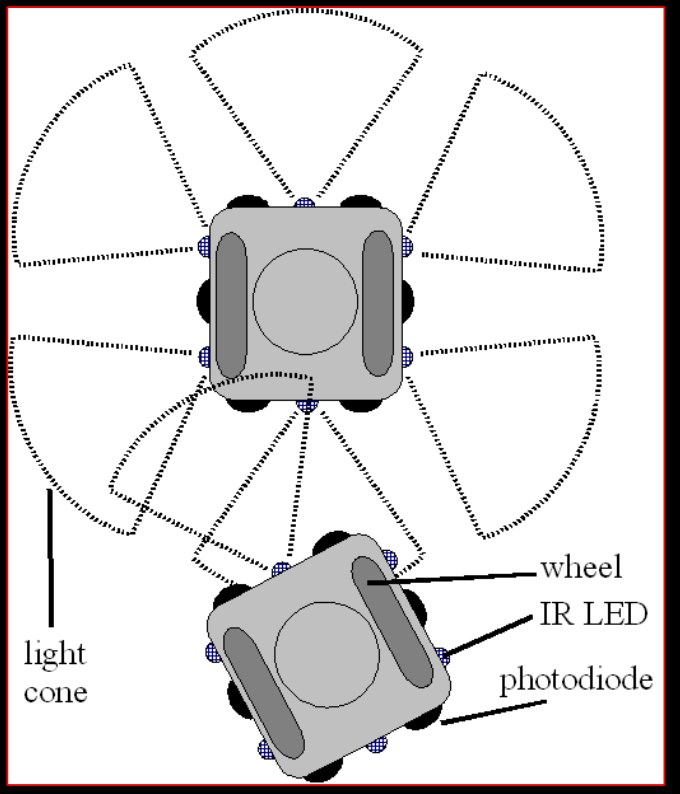
- **No global information!**
- **Purely autonomous robots!**

→ Robots should collectively generate a *map of the arena* and share this map.

= COLLECTIVE PERCEPTION

Technics

- Communication with horizontal LED light-cones and photodiodes
- Also obstacle avoidance is made this way
- Motion: two wheels → difference to I-SWARM

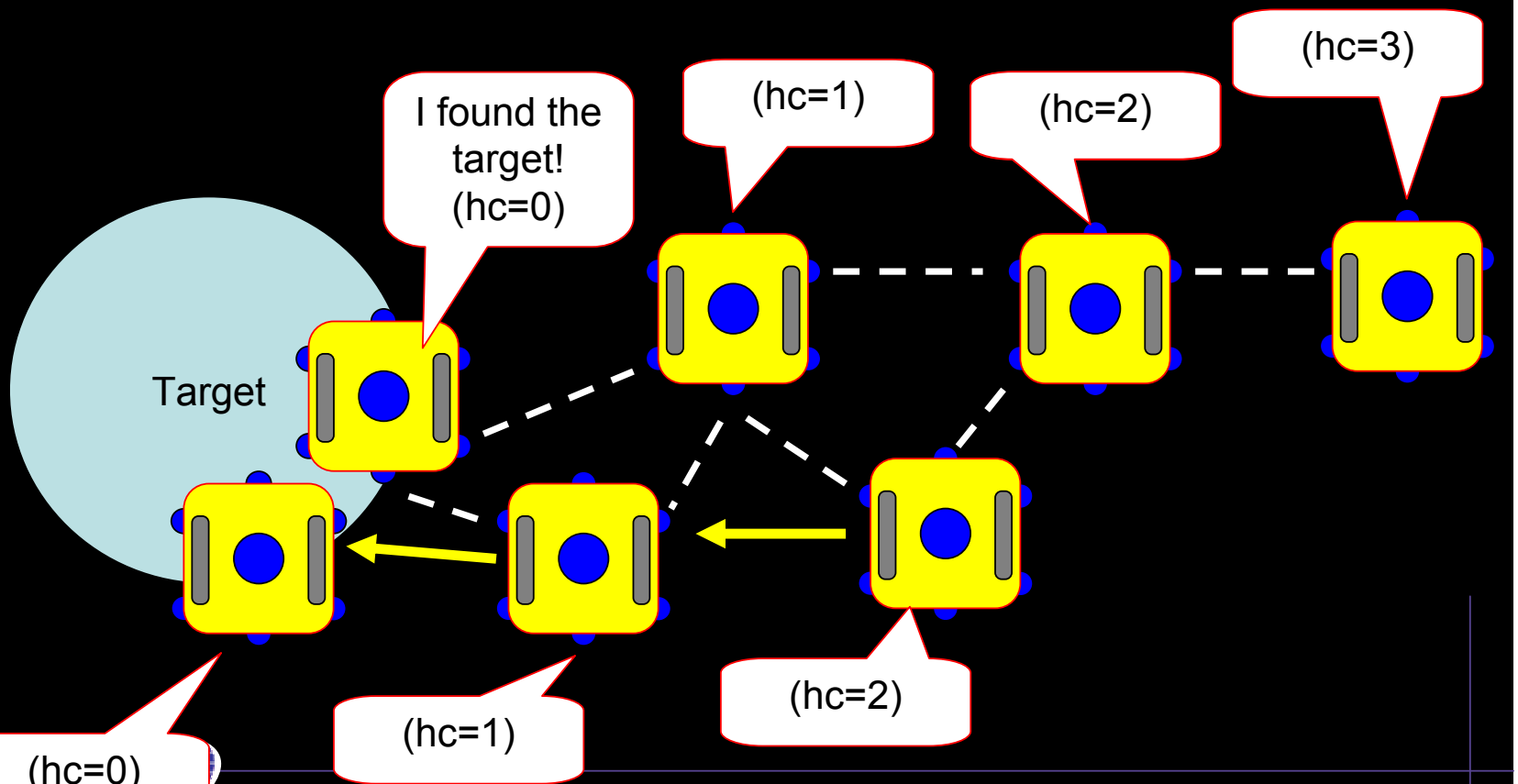


We developed

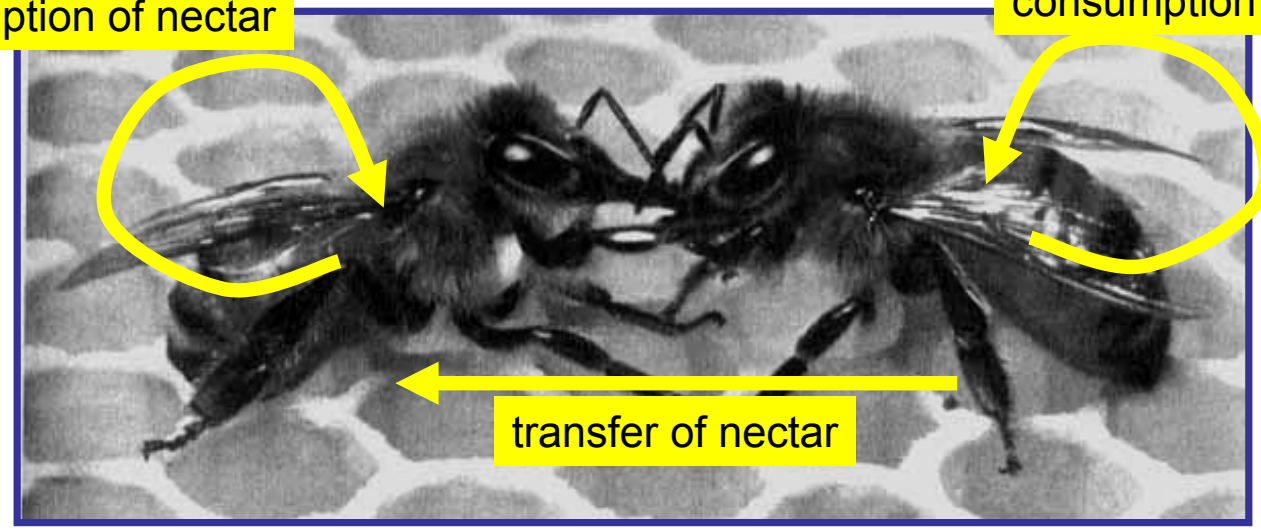
- Two control strategies:
  1. Hop Count – based (simple & straight-forward)
  2. Trophallaxis-derived strategy (more complex & bio-inspired)

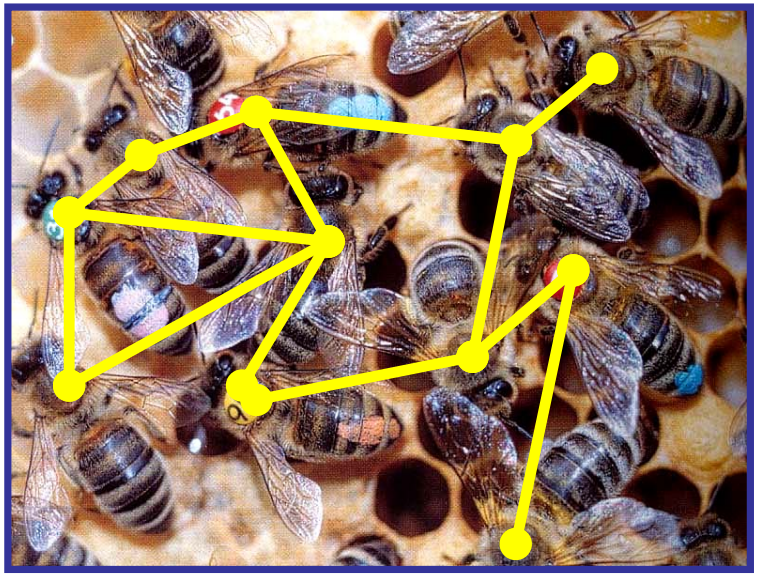
[1] trophallaxis = mouth-to-mouth feedings performed by honeybees

Hop-Count strategy



The idea: Trophallaxis





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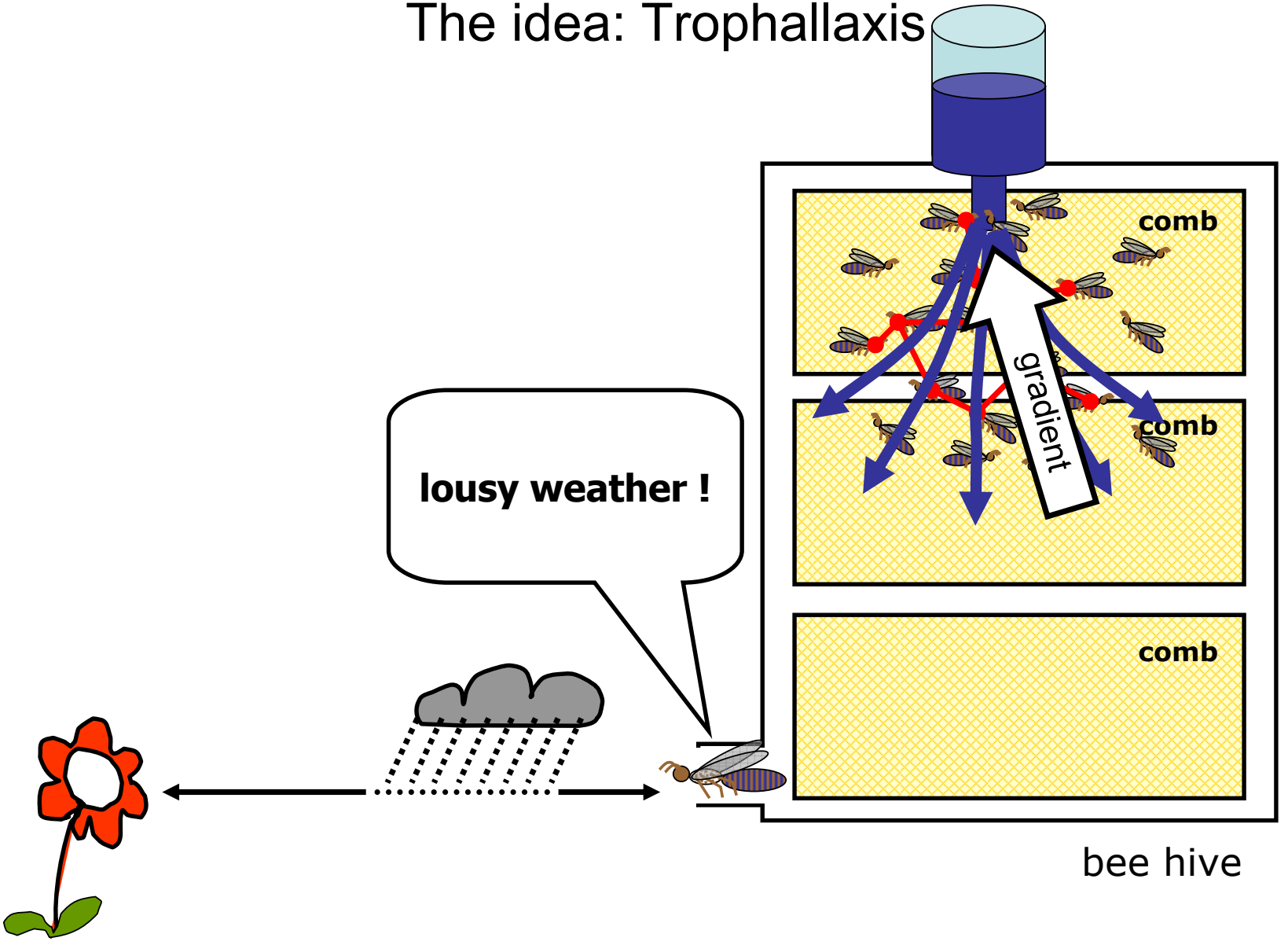
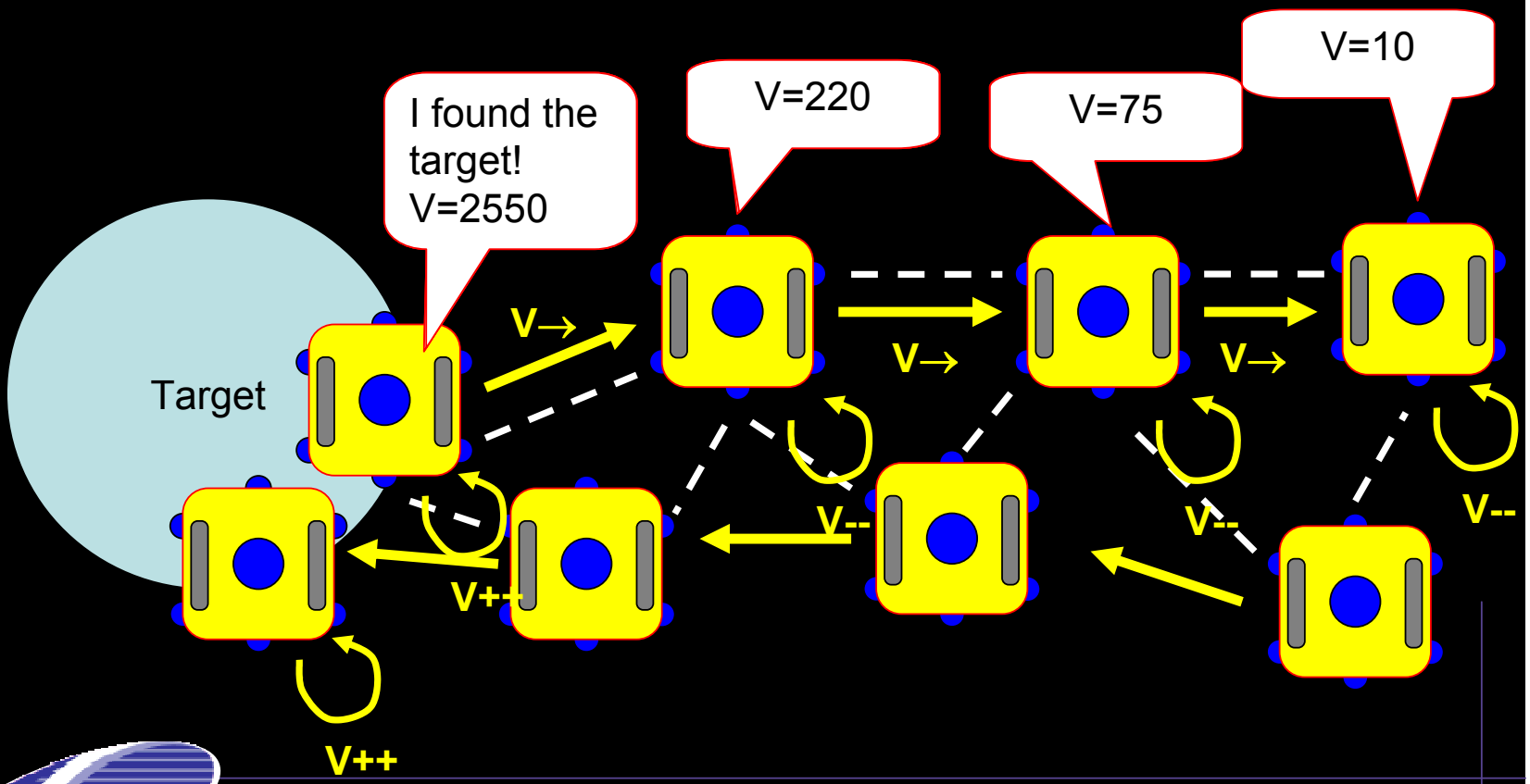
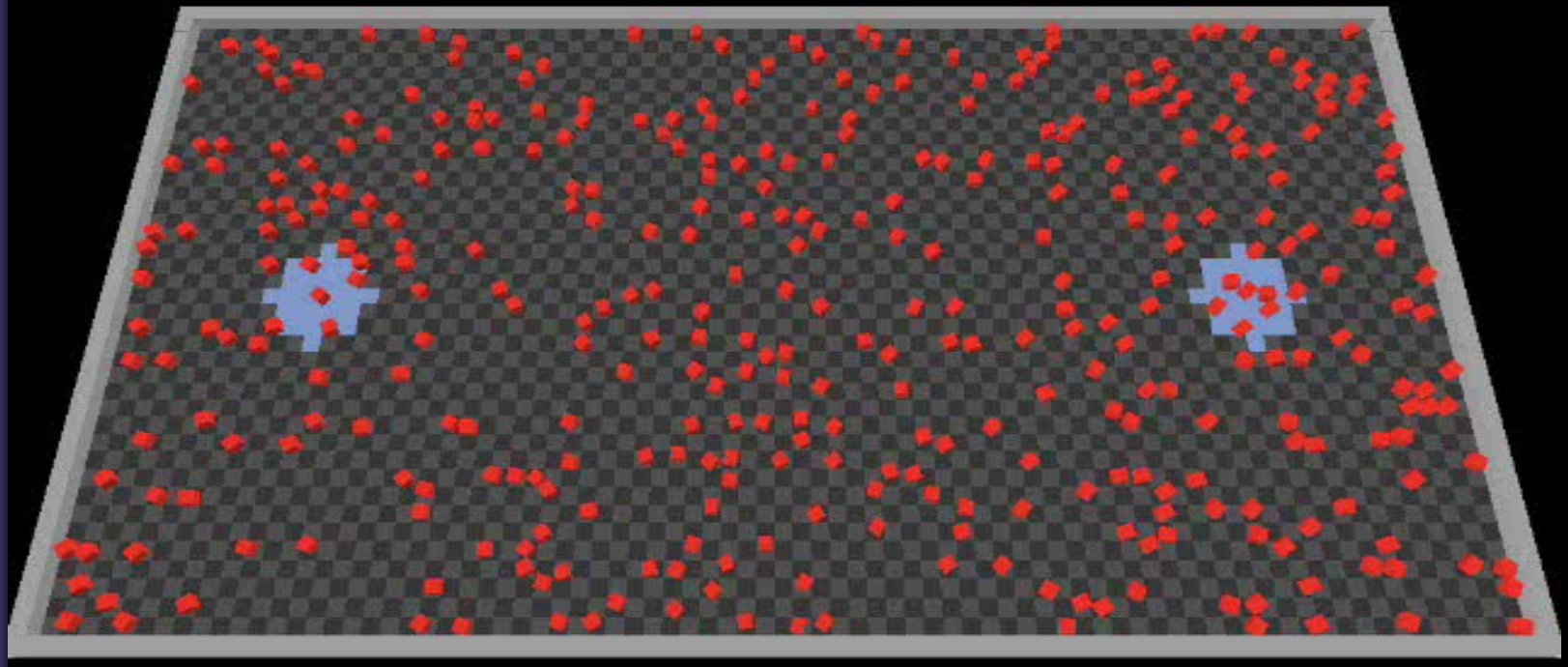


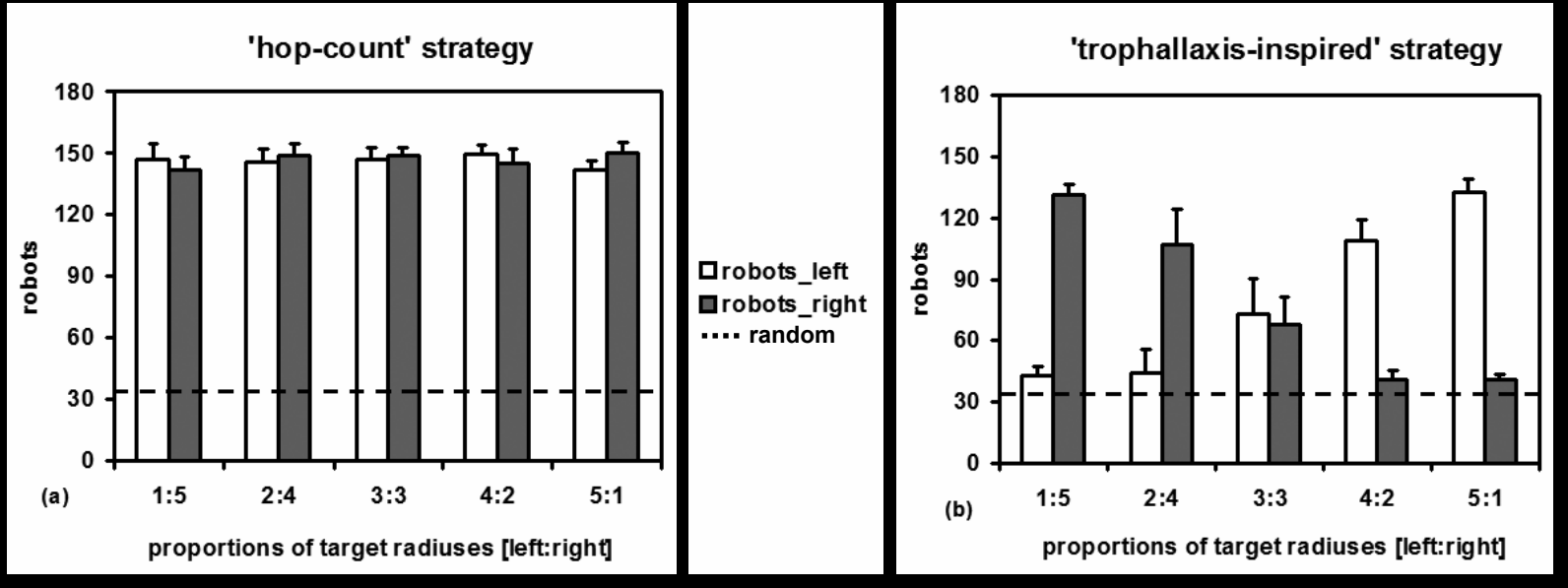
Trophallaxis strategy



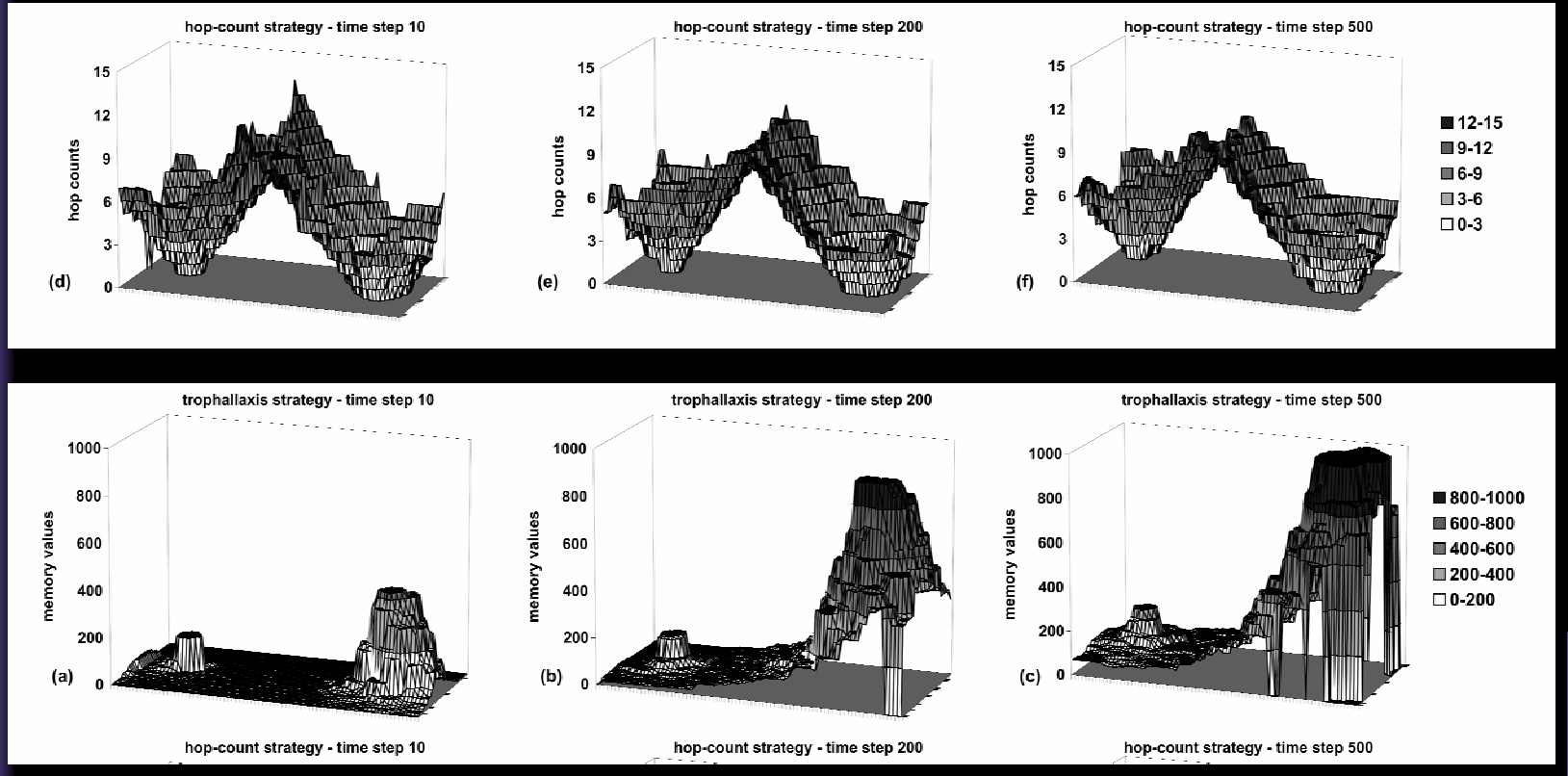
The trophallaxis-derived strategy at runtime



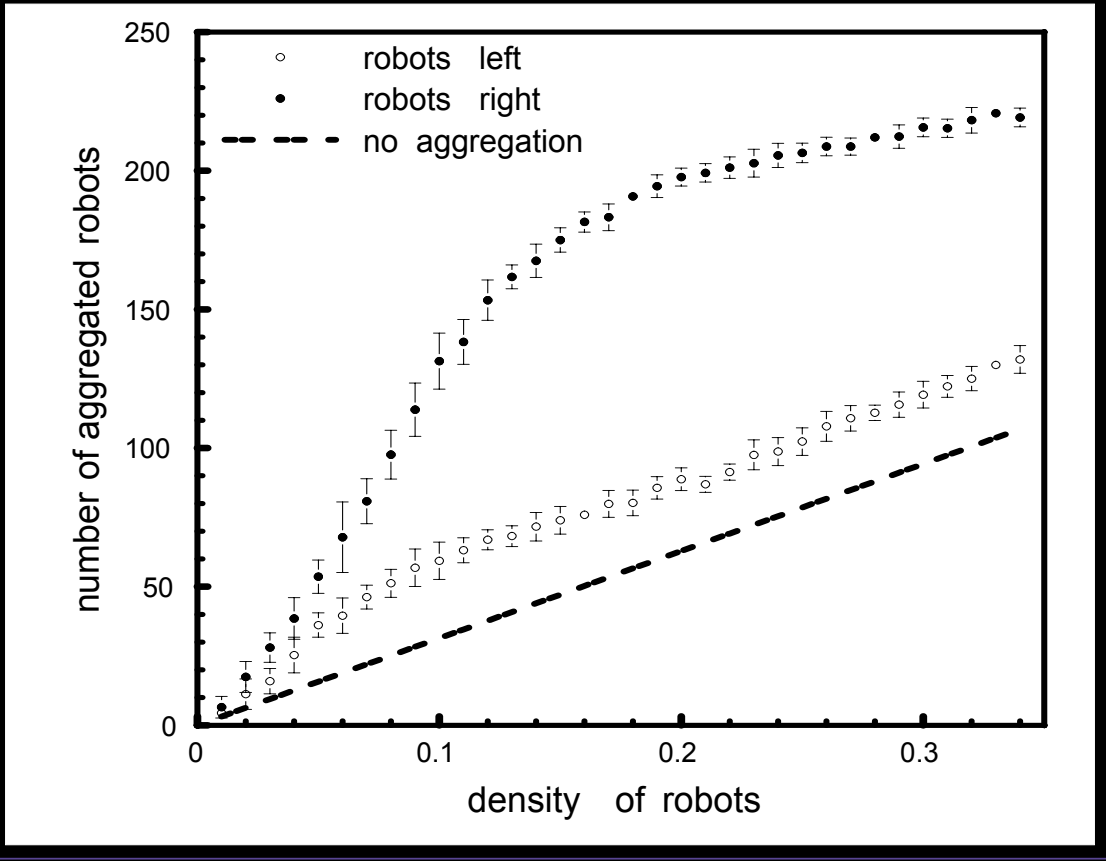
Recruiting proportionally to differently sized targets



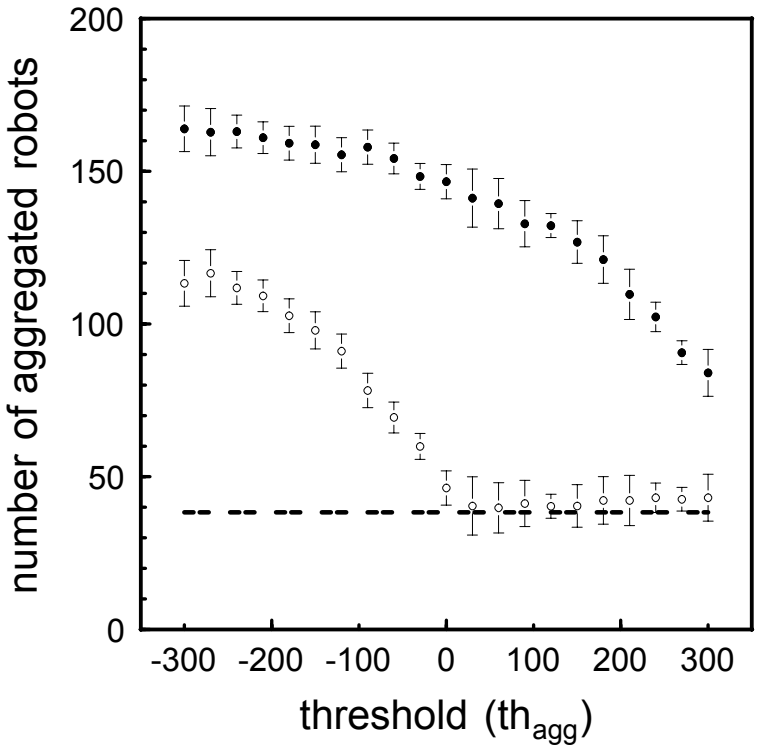
Why?


hop-count strategy - time step 10
hop-count strategy - time step 200
hop-count strategy - time step 500
hop counts
15
12
9
6
3
0
(d)
(e)
(f)
12-15
9-12
6-9
3-6
0-3
trophallaxis strategy - time step 10
trophallaxis strategy - time step 200
trophallaxis strategy - time step 500
memory values
1000
800
600
400
200
0
(a)
(b)
(c)
800-1000
600-800
400-600
200-400
0-200
hop-count strategy - time step 10
hop-count strategy - time step 200
hop-count strategy - time step 500

Density of robots



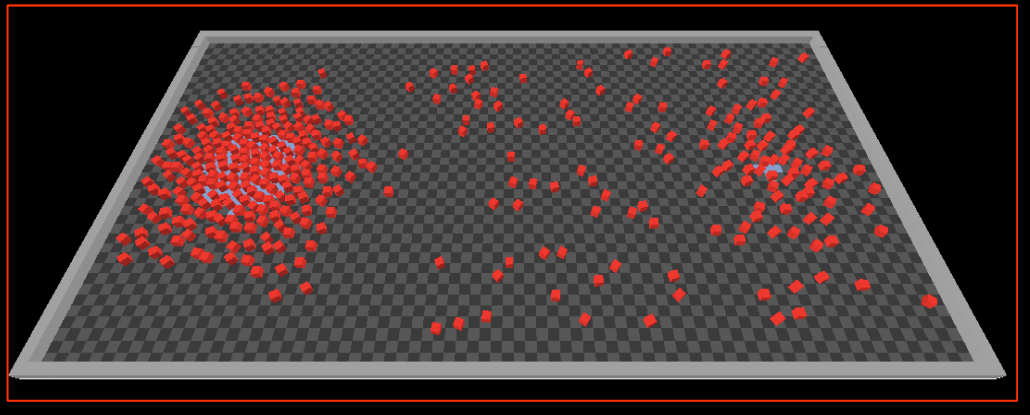
The proportionality can be adjusted by a threshold



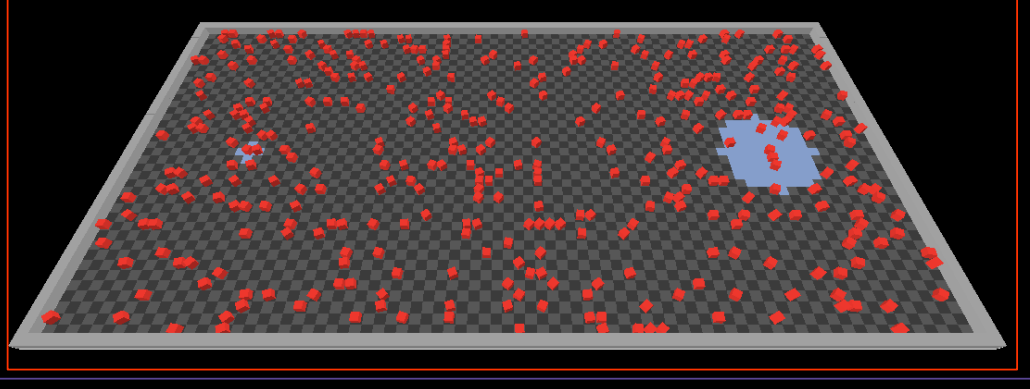
$$P_{(i,t)}^{uphill} = \min\left(\frac{m_{(i,t)} - th_{agg}}{1000};0.75\right)$$

Dynamic environments

Start:

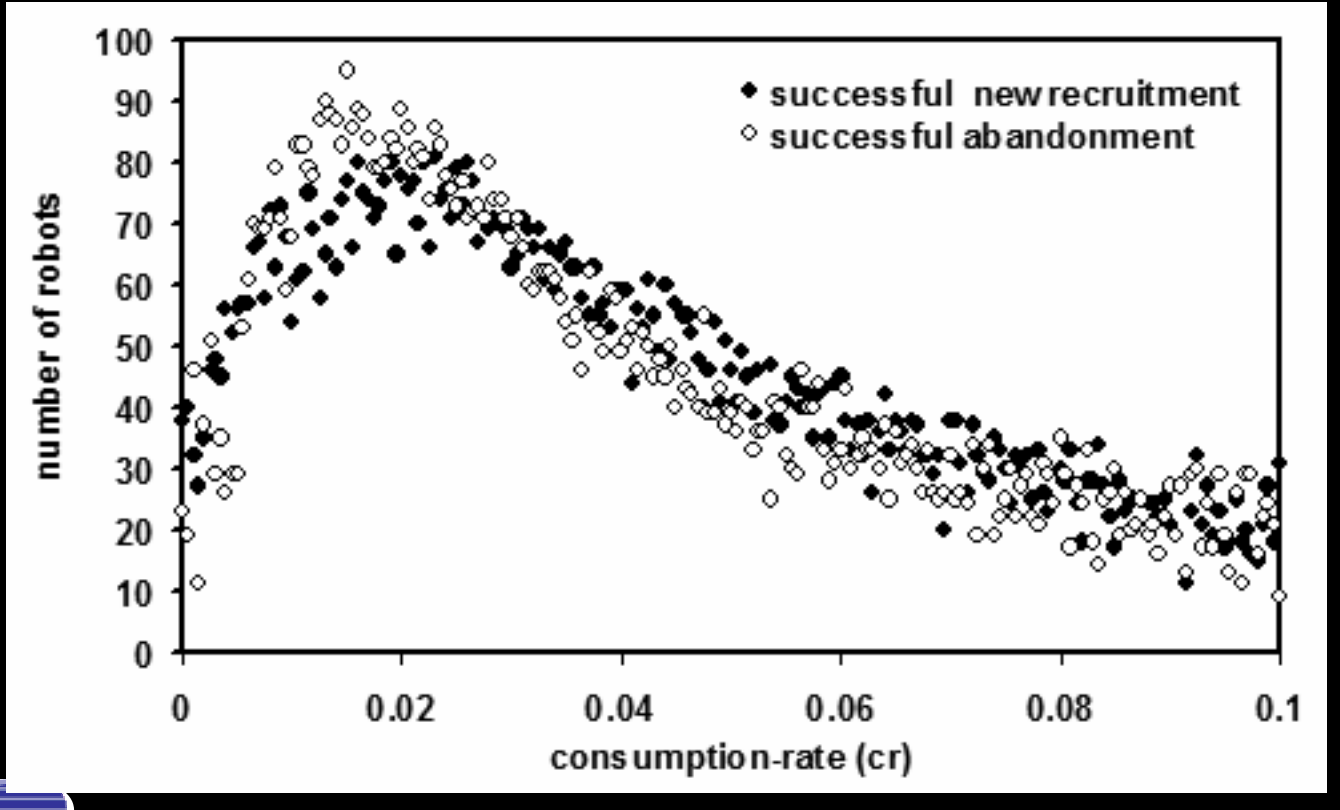


After 500 timesteps, we changed the environment to this:



final picture?
consumption-rate?

Dynamic environments



Conclusion

- The trophallaxis-derived strategy allows
  - Gradient navigation
  - Proportional recruitment
  - Works without any global information
- It is robust against random errors and perturbation.
- It is flexible, because out-dated information leaves the system over time.

Thank you!