CoCoRo:
The Self-Aware Underwater Swarm

CogSys 2012,
Vienna, Austria

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CoCoRo - Collective Cognitive Robots GA No. 270382
http://cocoro.uni-graz.at/

Goal & Motivation

- How may a future system for ocean exploration look like?
- The ocean is big, dynamic, complex and harsh.
- Human operators should be able to interfere with the system.








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The ocean is big, dynamic, complex and harsh, thus …

- Sophisticated sensors
- Reliable & strong actuation
- High computational power

Big, heavy & expensive

- Keep it simple!
- Keep it cheap!
- Have many of those units!

Small, light, cheap & many

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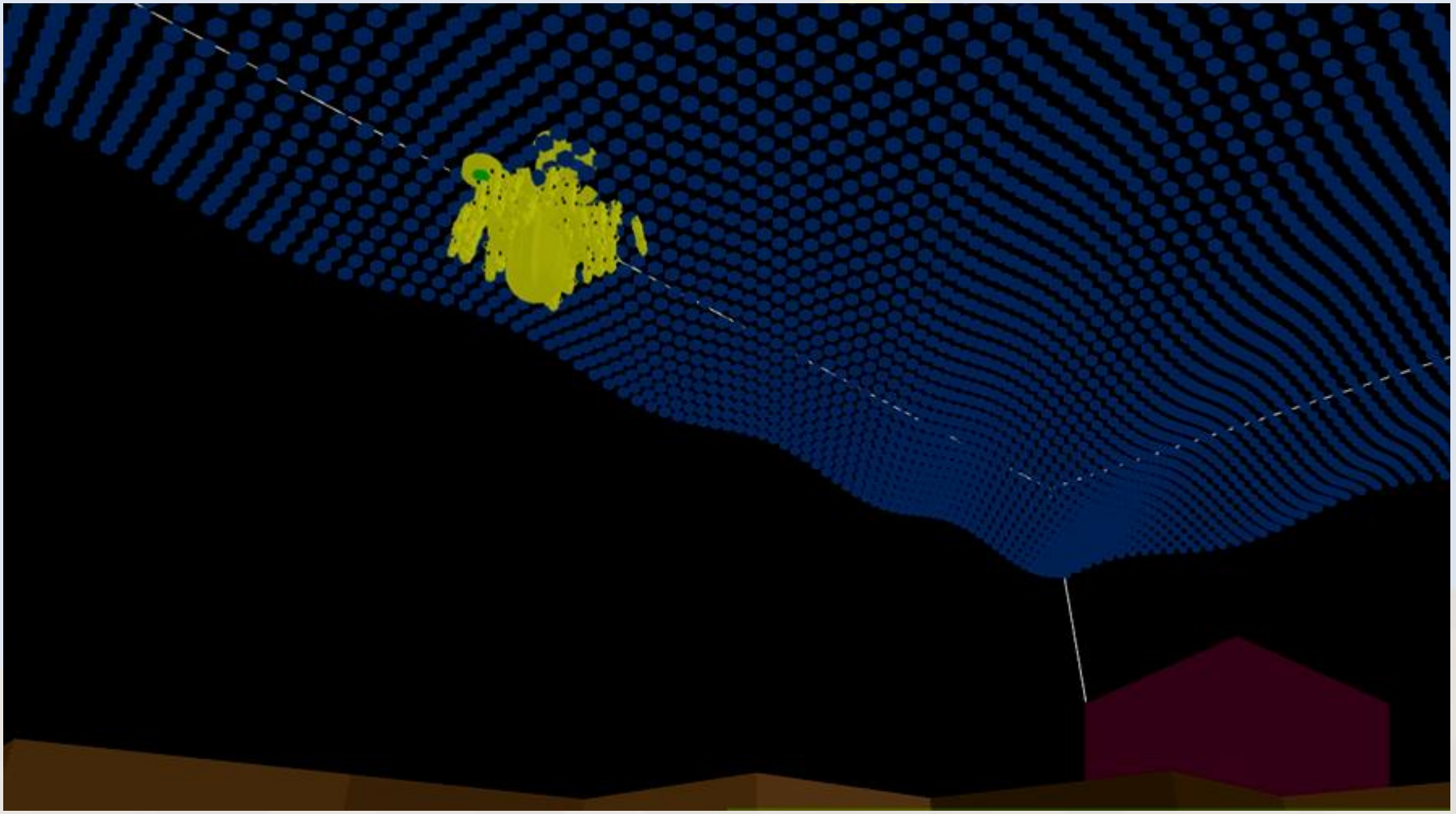
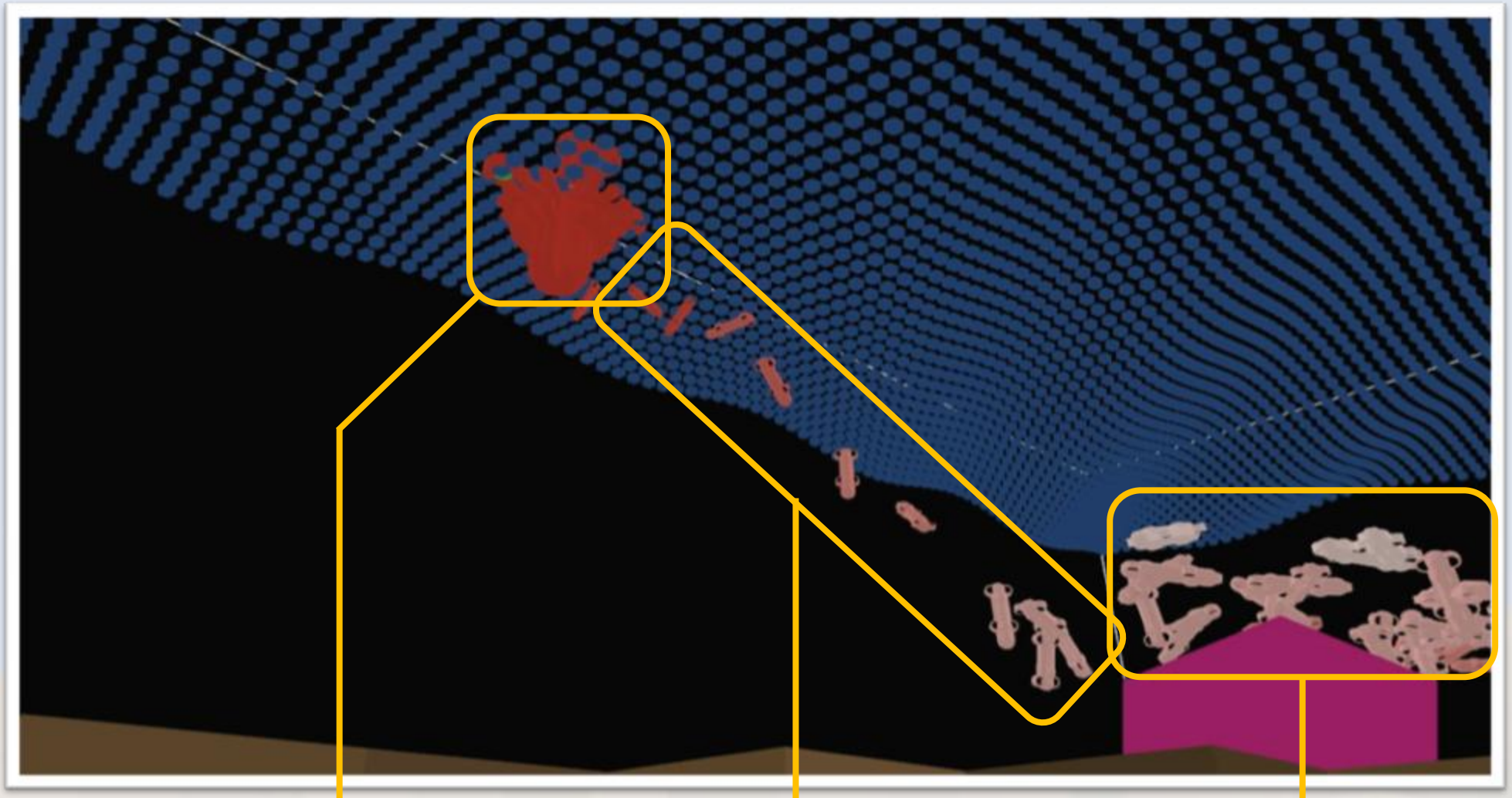
Big vision

→A CoCoro system is deployed on the surface



Big vision

→How the components act together



surface station gets informed

relay chain bridged the info to surface

ground swarm stopped after finding an object

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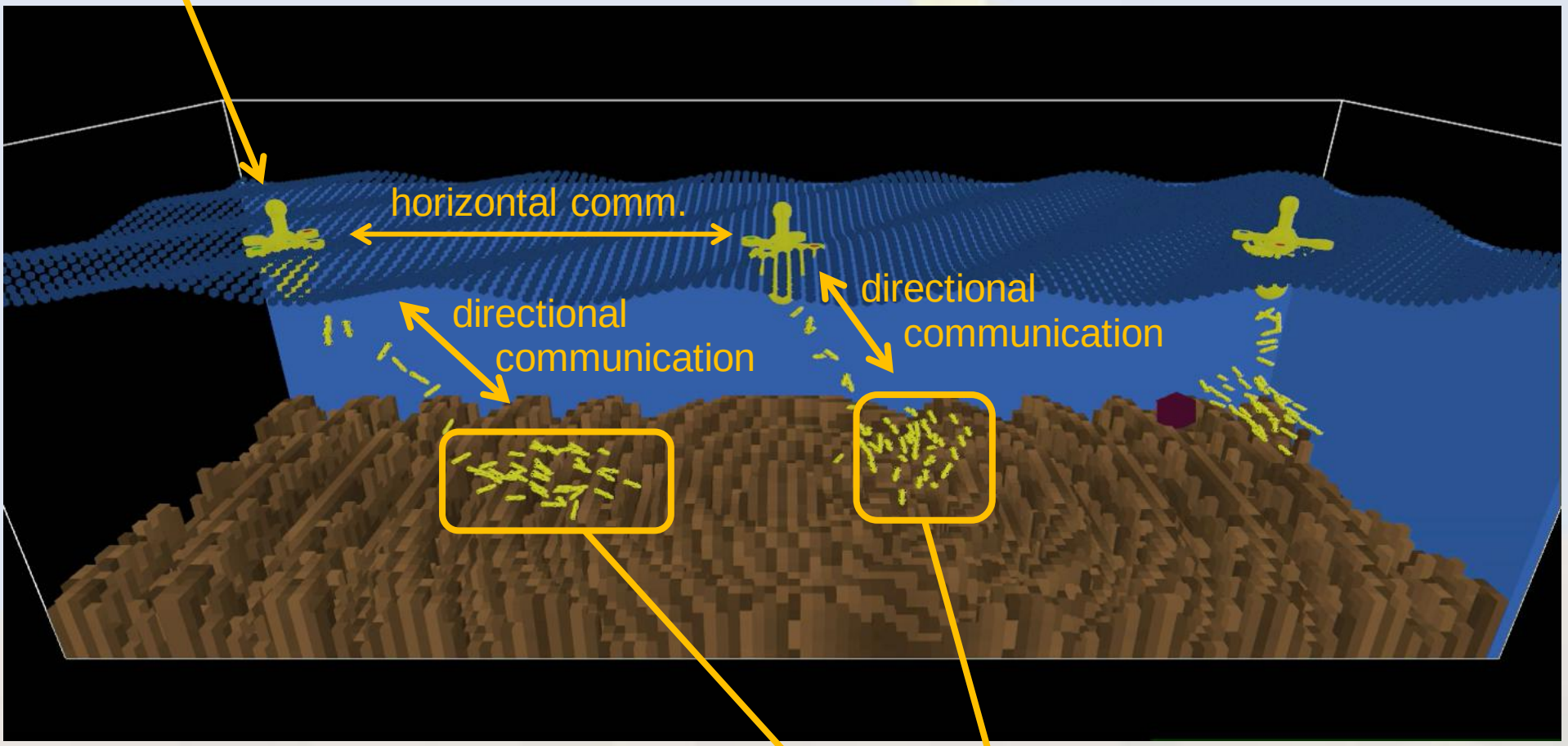
Big vision

→There might be several CoCoRo systems.



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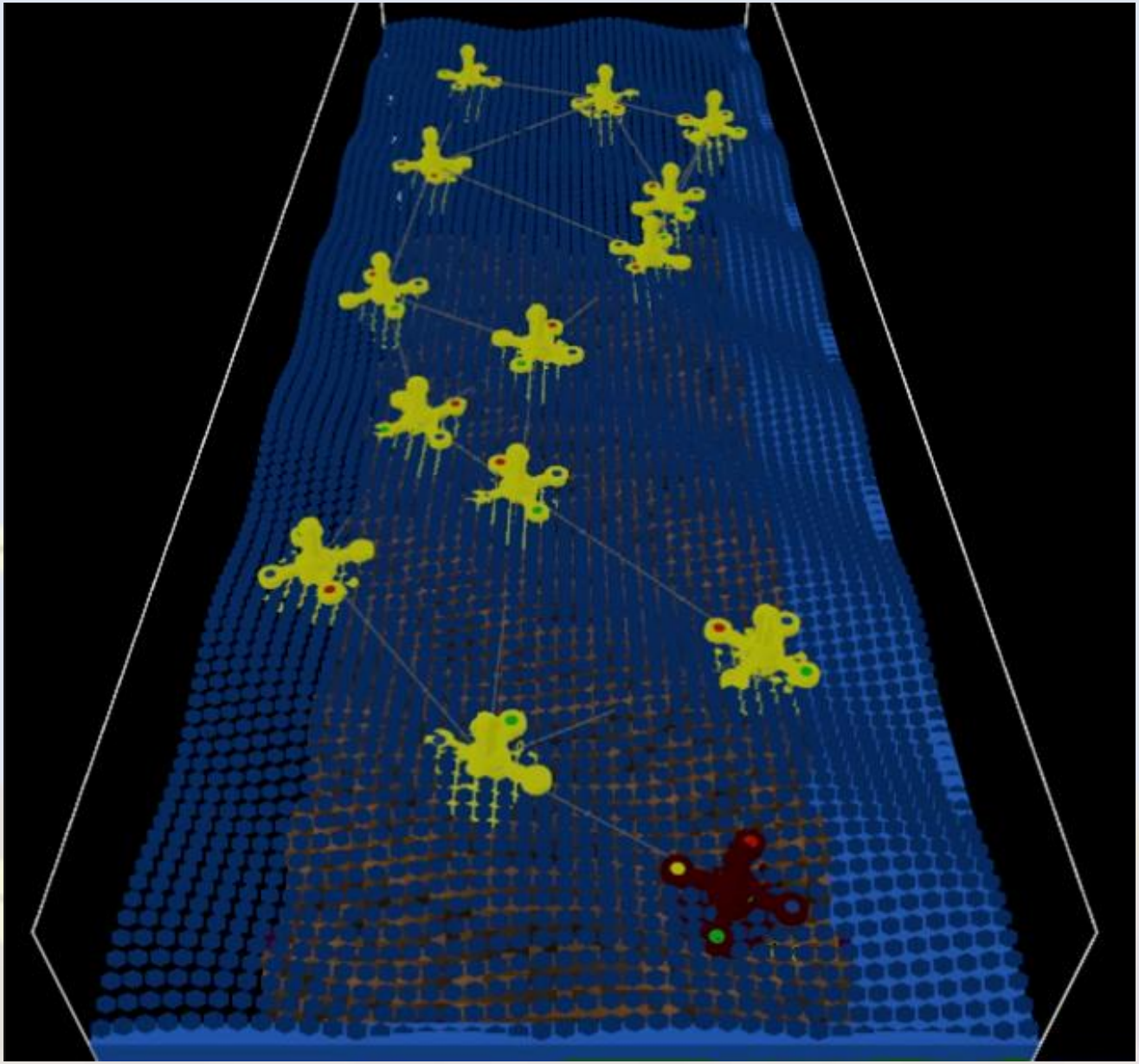
Big vision

- → Surface stations allow human intervention.
- → Surface stations allow horizontal communication.
- → Surface stations feed global information (GPS) into the system.



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Heterogenous Hardware

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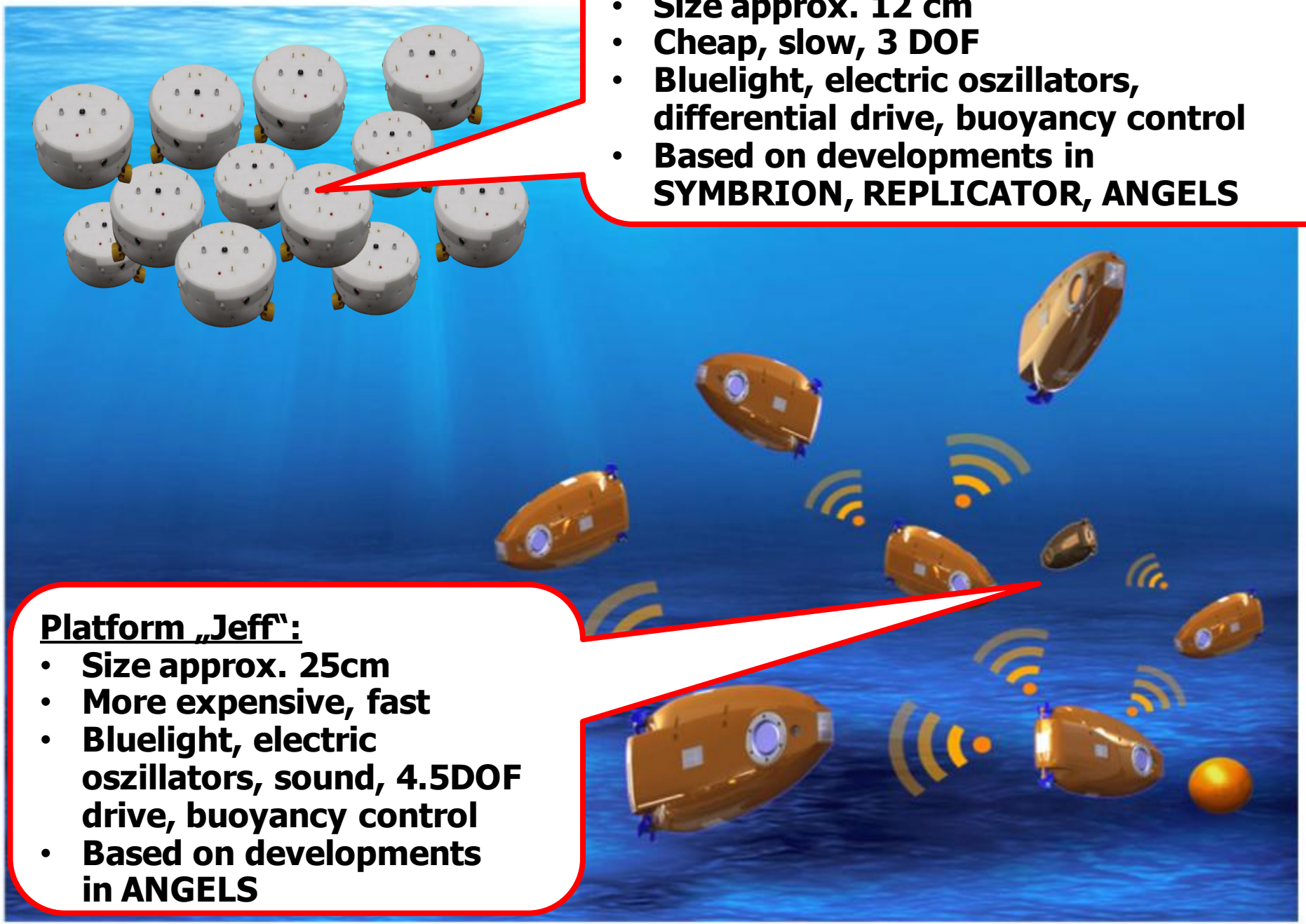
Heterogenous Hardware



Platform „Lilly“:

- Size approx. 12 cm
- Cheap, slow, 3 DOF
- Bluelight, electric oszillators, differential drive, buoyancy control
- Based on developments in SYMBRION, REPLICATOR, ANGELS

Platform „Jeff“:

- Size approx. 25cm
- More expensive, fast
- Bluelight, electric oszillators, sound, 4.5DOF drive, buoyancy control
- Based on developments in ANGELS

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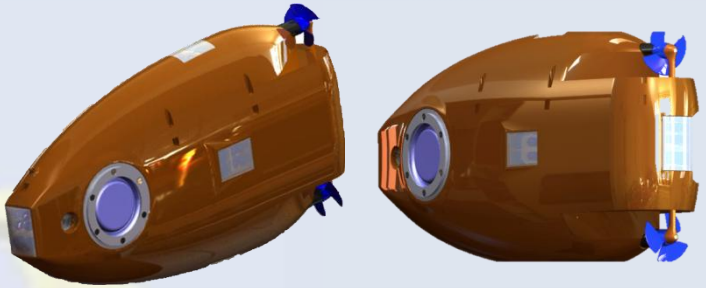
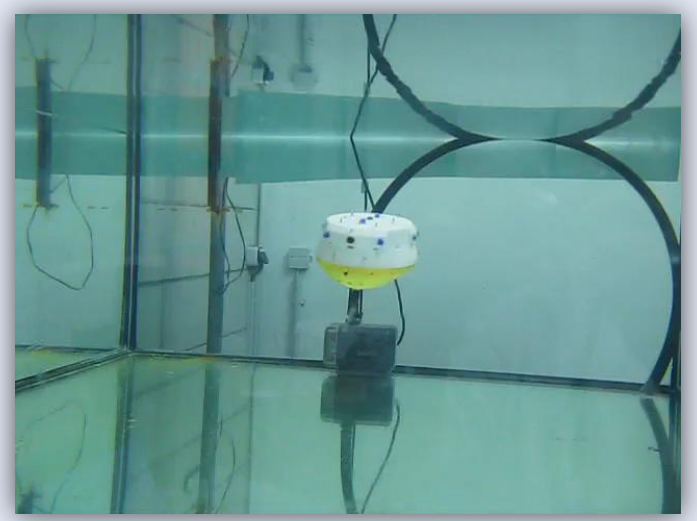
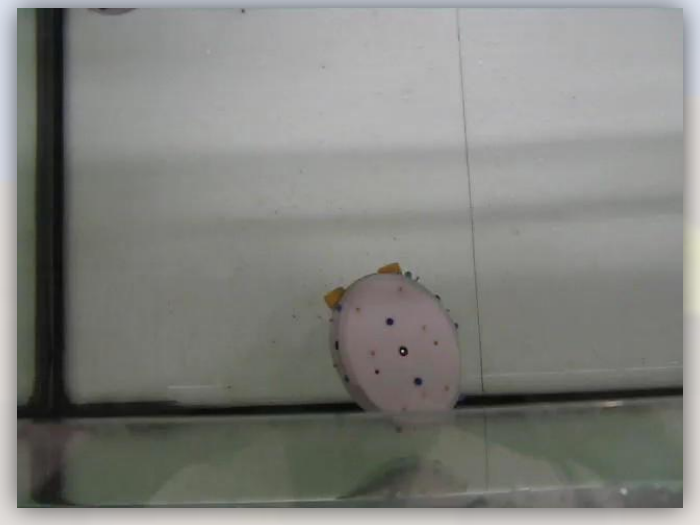
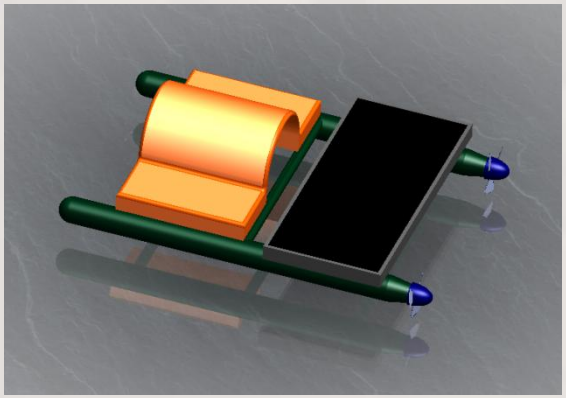
Current hardware development









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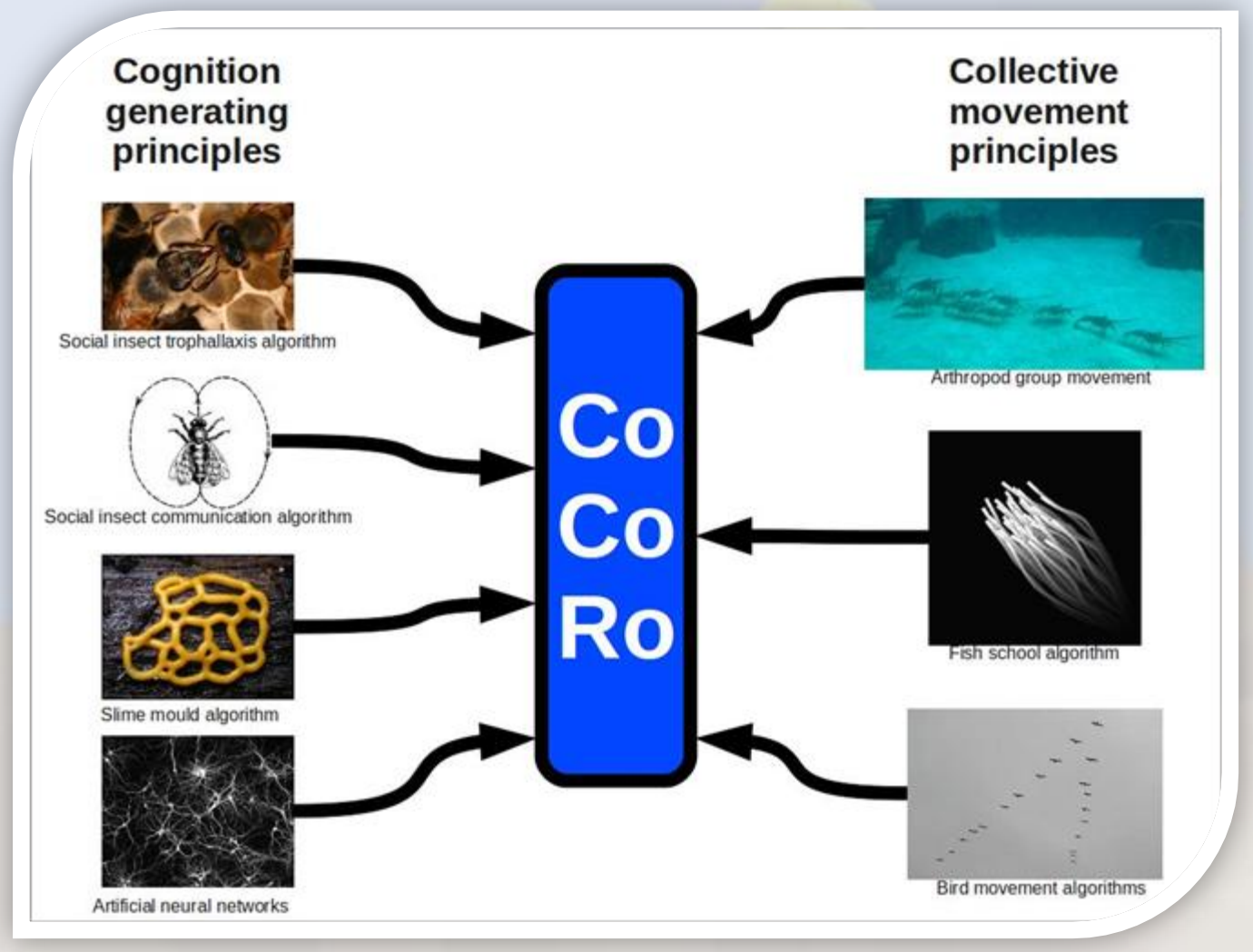
Cognition-generating algorithms

Bio-inspired cognition-generating algorithms are mixed with bio-inspired motion-generating algorithms.



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Test for collective decision making

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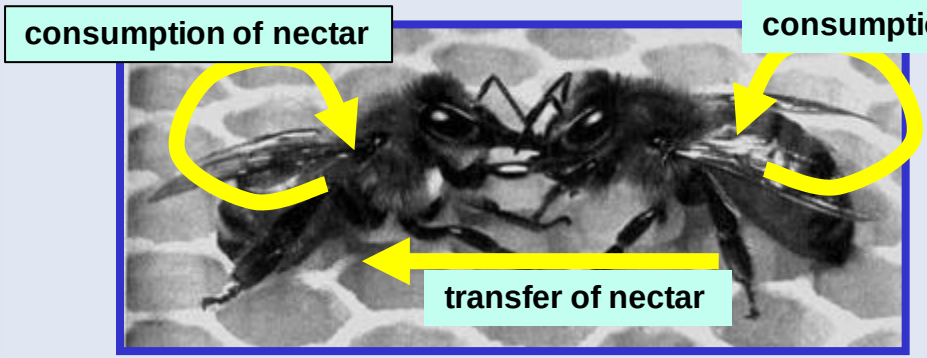
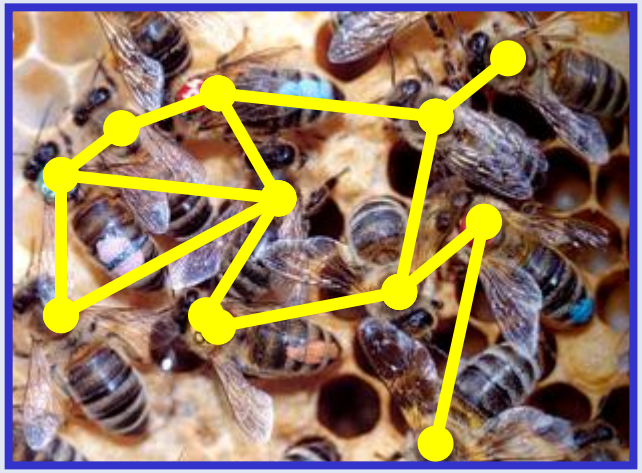
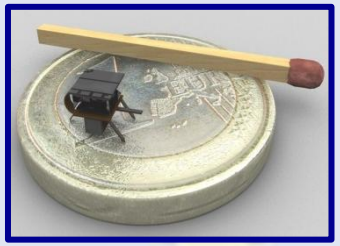
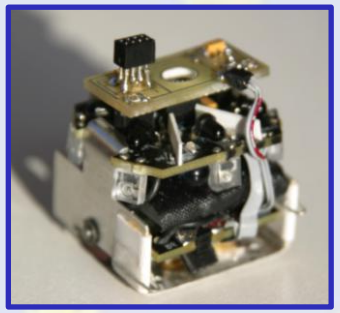
Self-organizing gradients

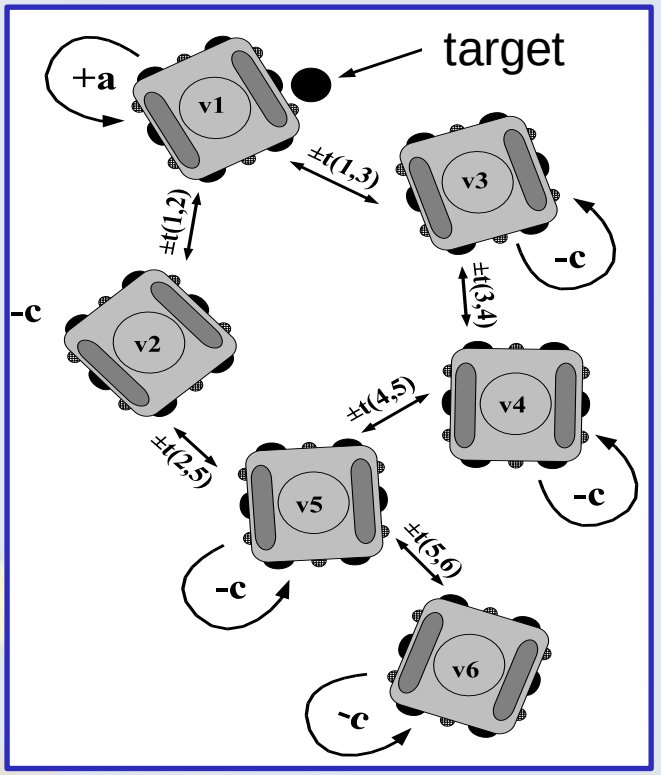


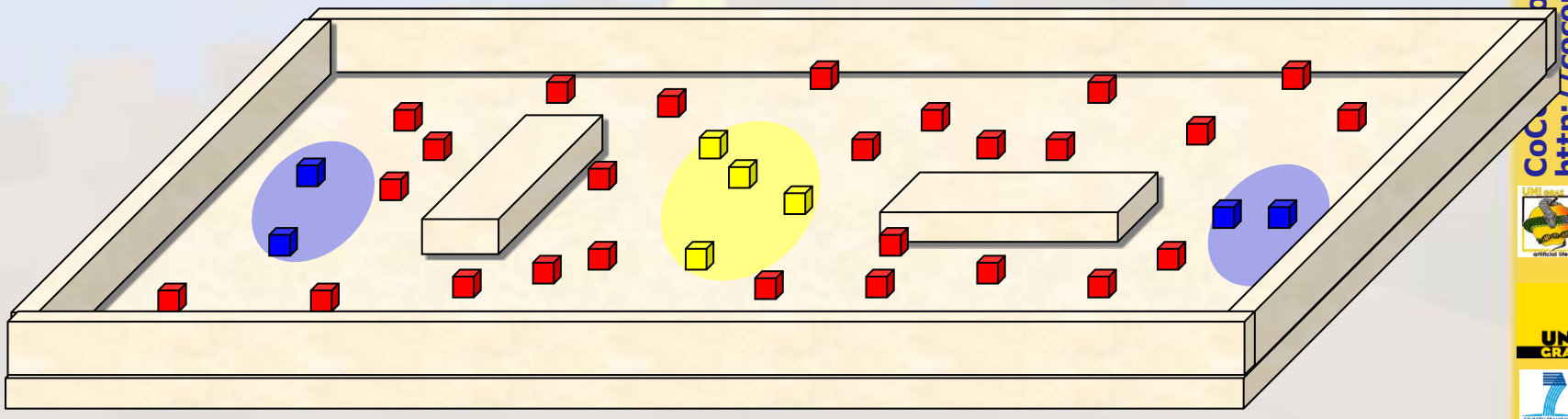


Trophallaxis algorithm









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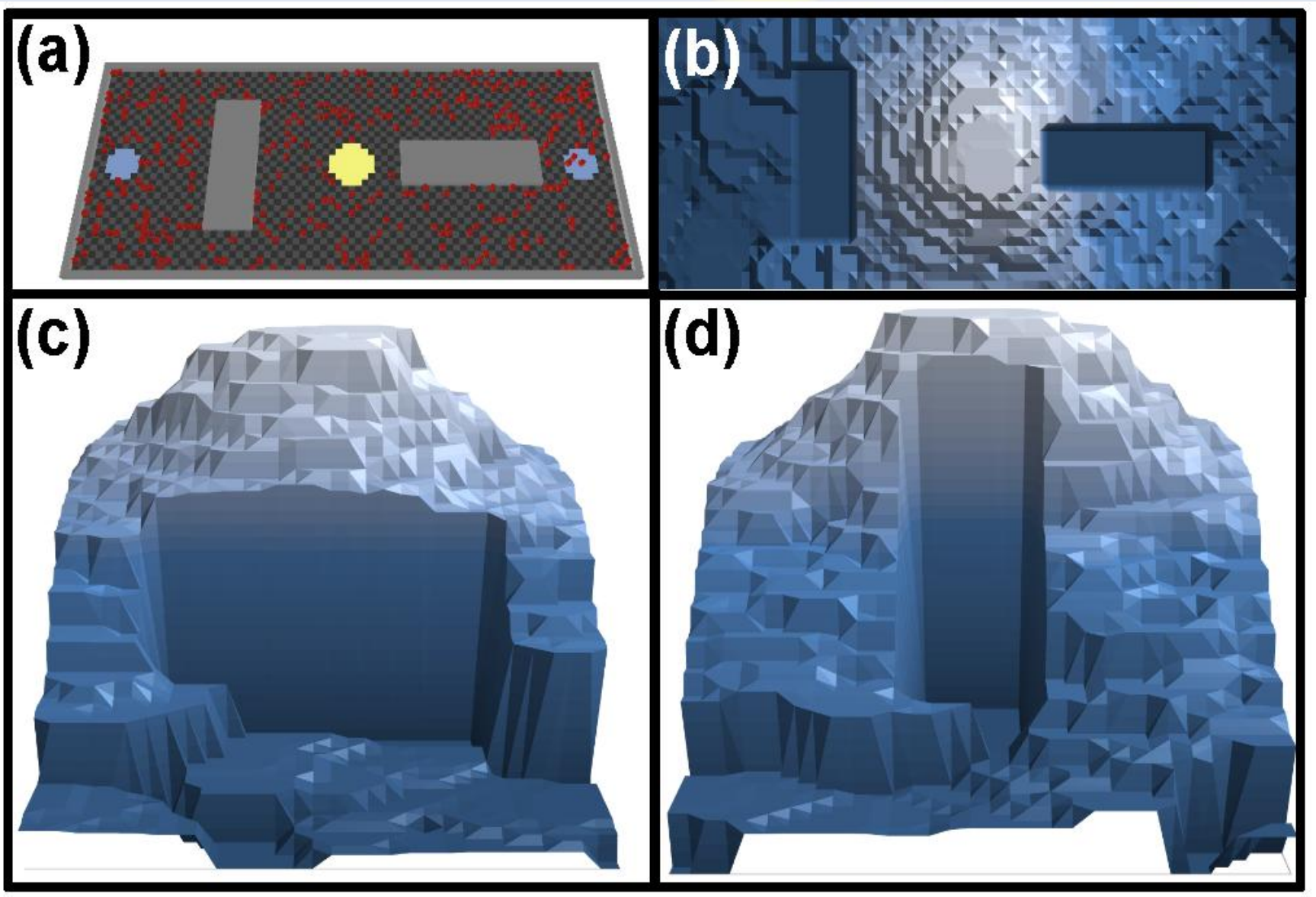
Robotic collective cognition

- Robots build a distributed map of the environment.
- If robots get lost, the map becomes just a bit more coarse



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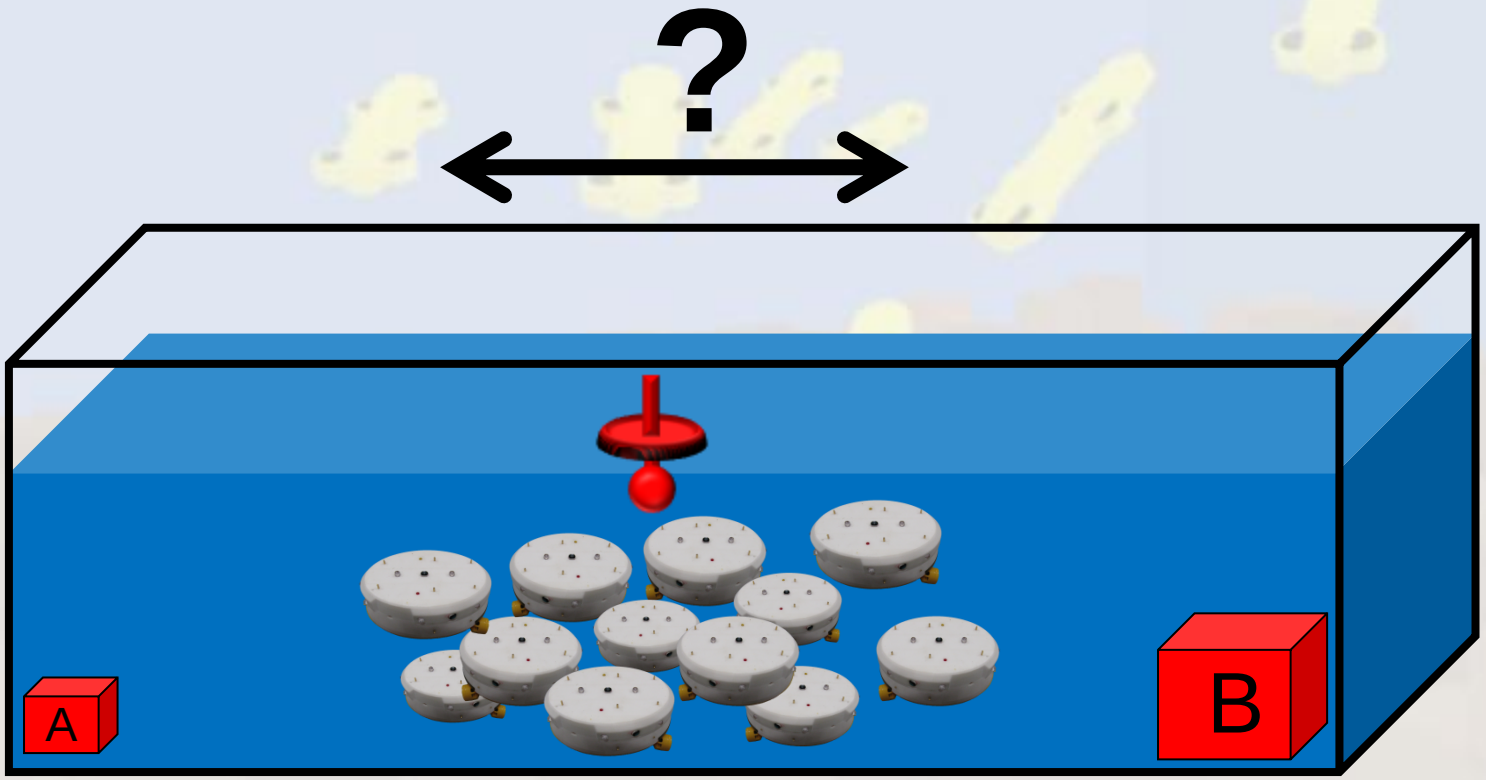
Experimentation

Choosing one solution from several options:

- **Collective** decision making
- Select „**optimal**" target
- Consider also the **swarm size**
- **Inspired by** / **Comparable to** experiments with cockroach, honeybees …



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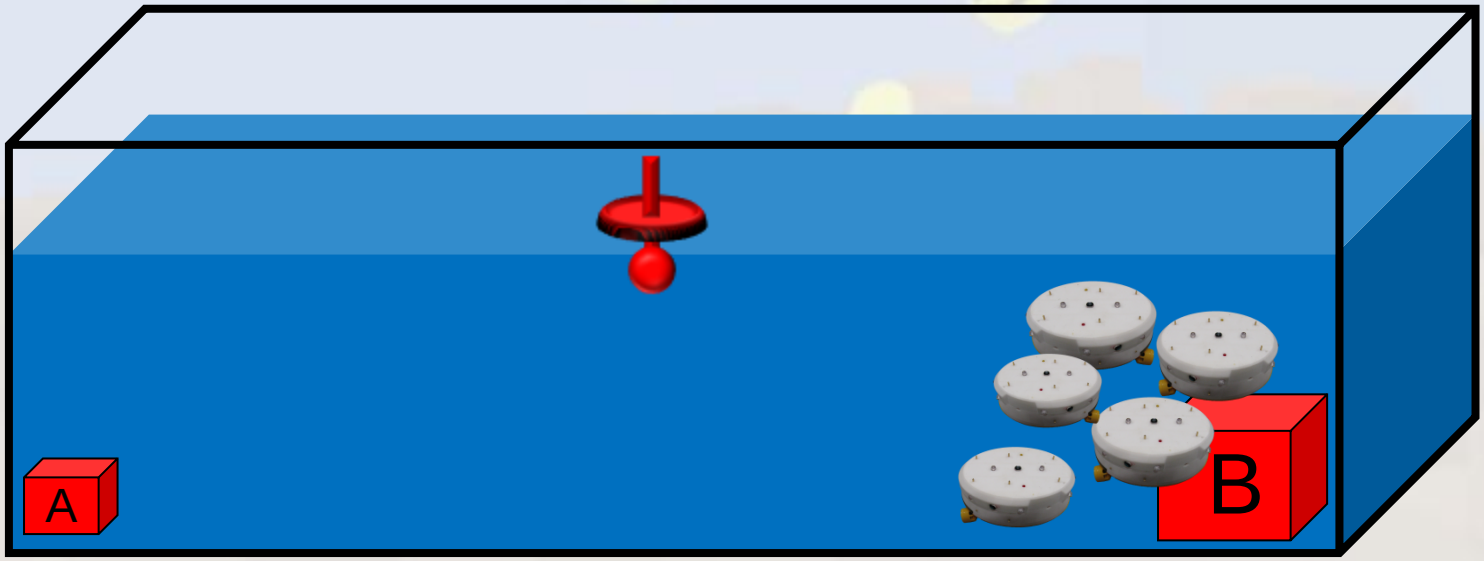
small swarm



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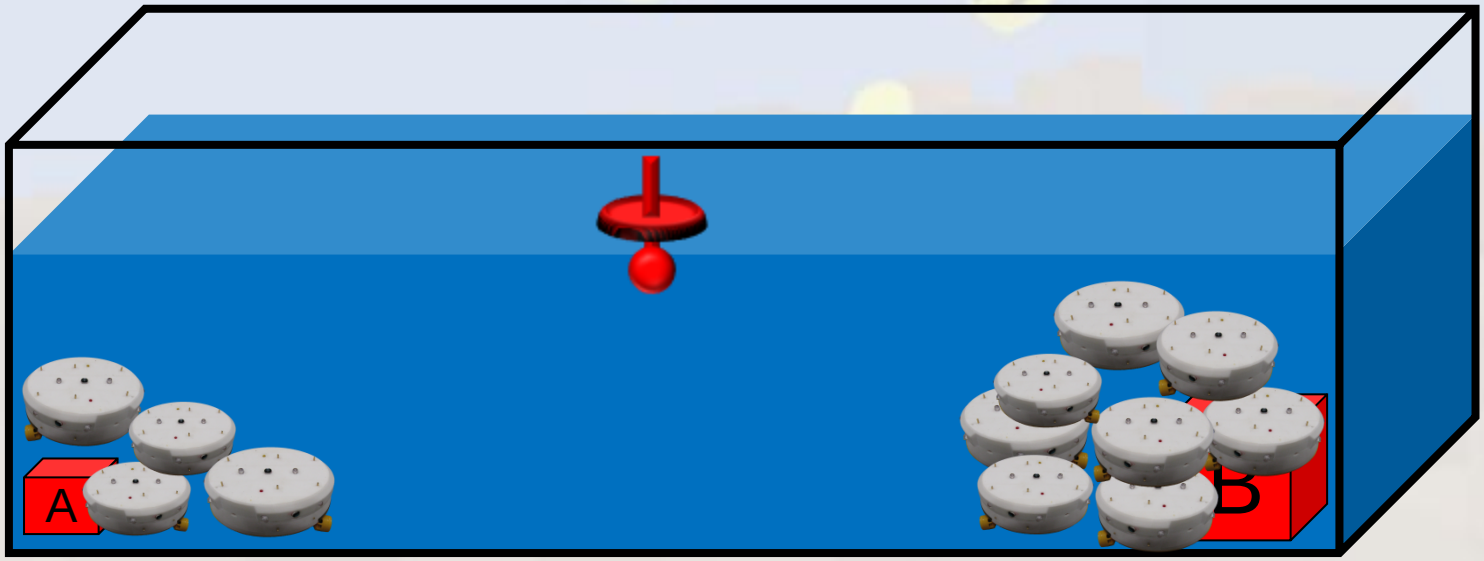
Big swarm



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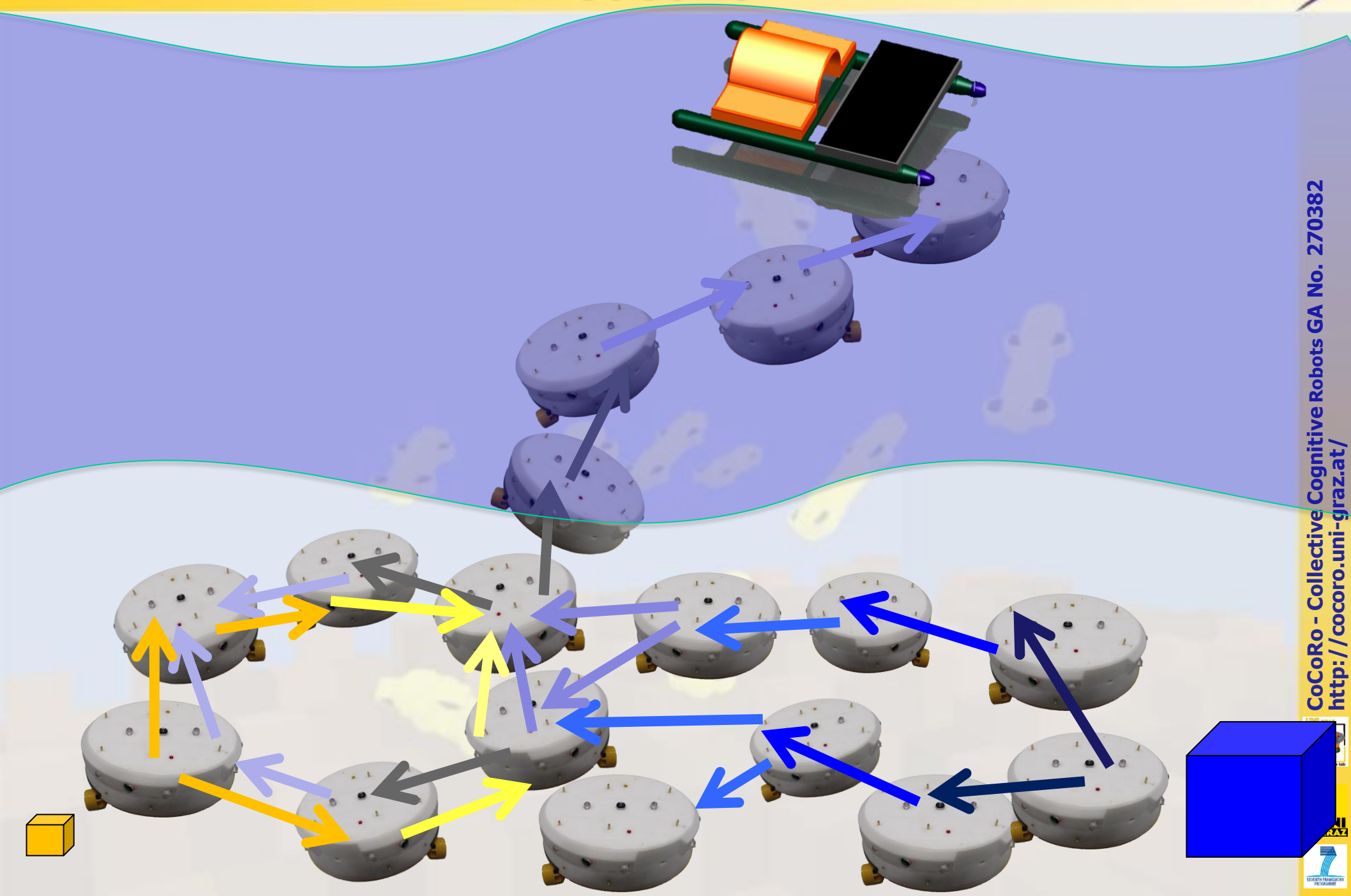
Bio-inspired cognition-generating algorithms in CoCoRo



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Test for collective self-awareness

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What to be aware of:

- "Am I in a group or alone ?"
- "Do I belong to this group ?"
- "How big is our group ?"
- "Is this another group or a reflection of our own group ?"
- ...

The mirror experiment

1. Will the swarm to discriminate another swarm from its own mirror image?
2. Never has a robot passed the mirror test.
3. We plan to perform this experiment with a whole robot swarm.

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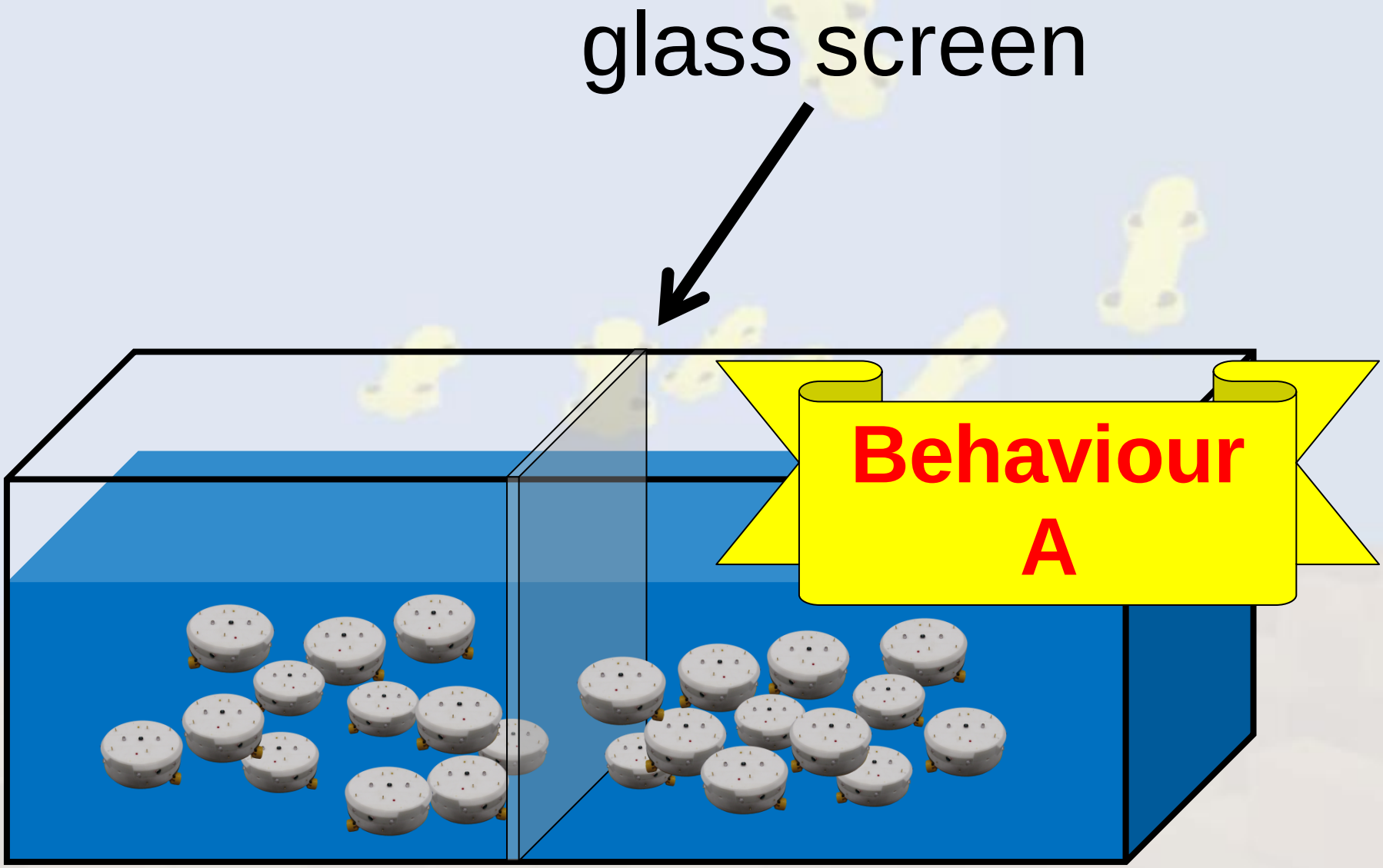
Experimentation: Mirror



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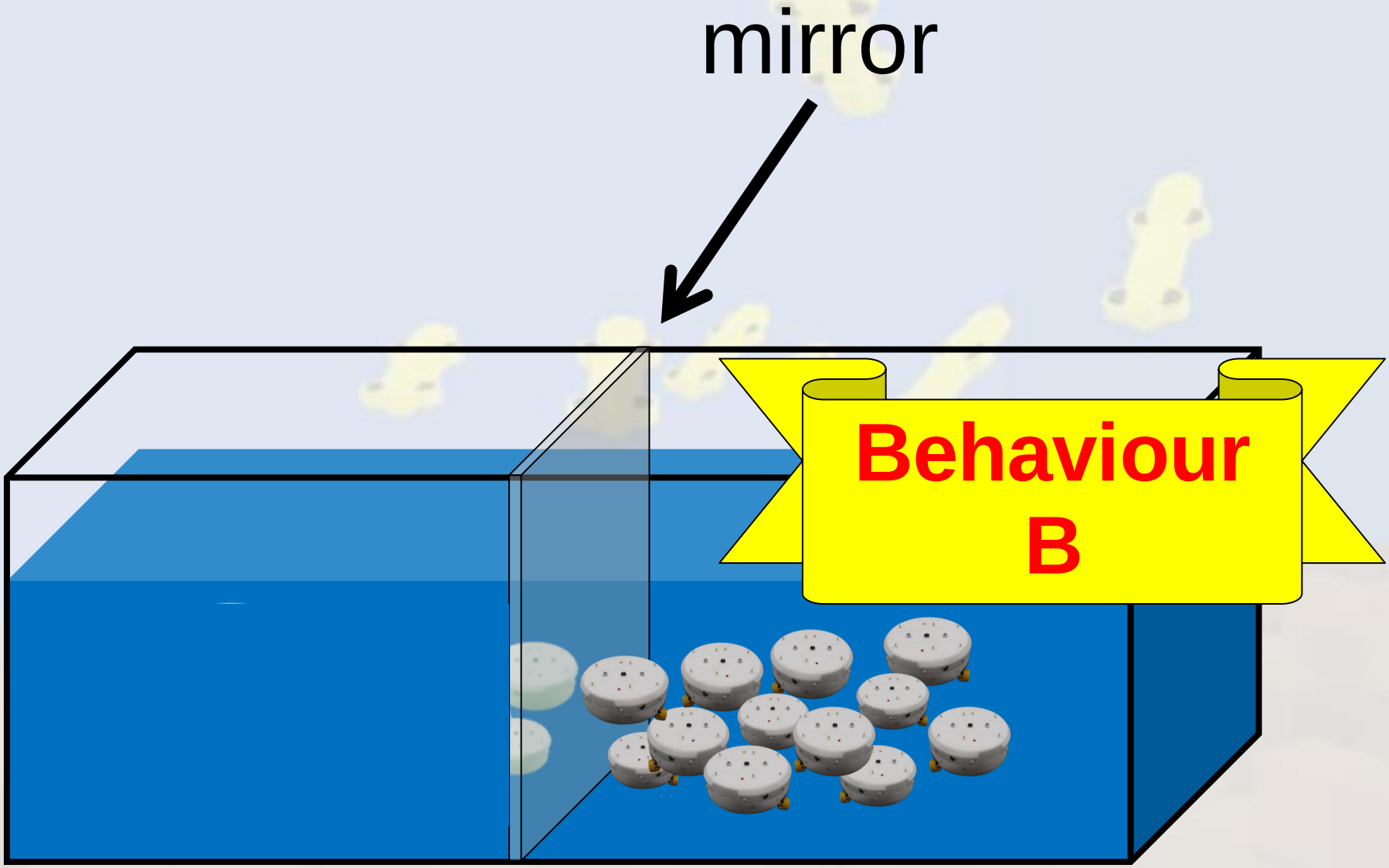
Experimentation: Mirror



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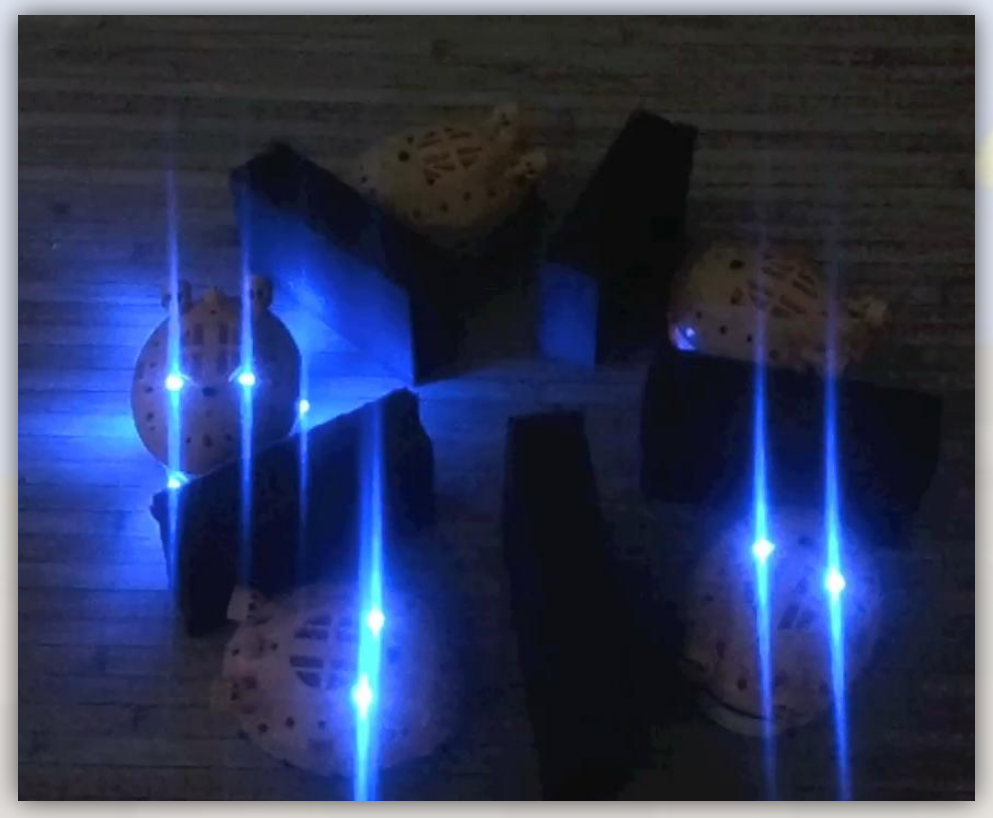
Progress towards this big vision

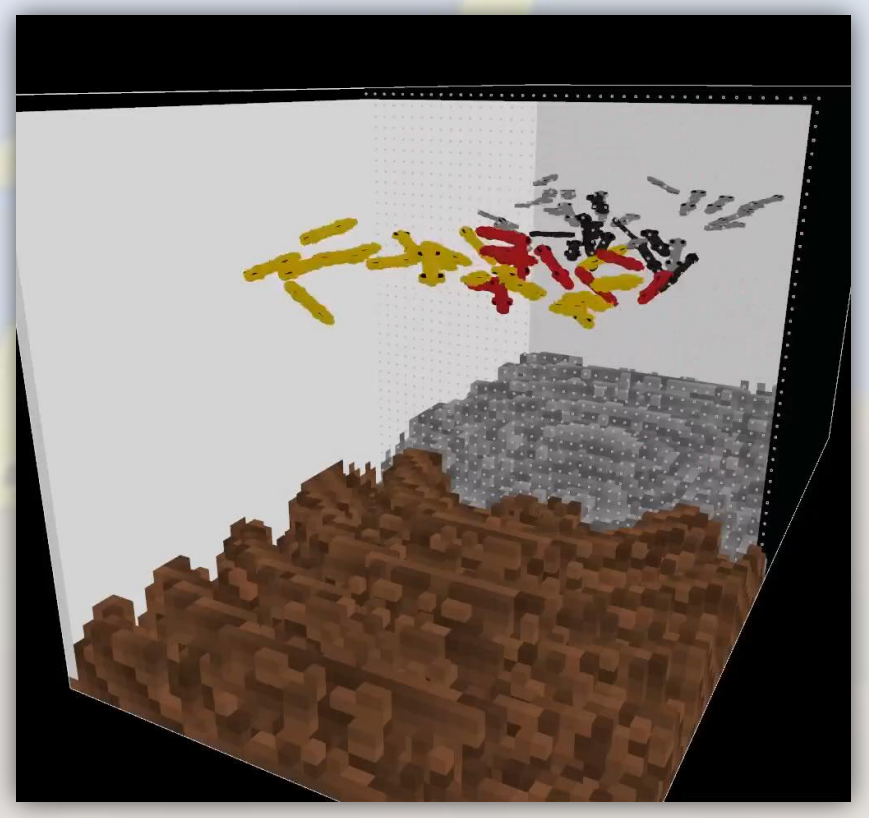
Coupled oscillators:

(light, sound, electric; 1 bit channel)

Swarm size measurement:



Mirror test:



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Summary

- In CoCoRo we will develop the hardware & software of a self-aware AUV swarm.
- CoCoRo will be a controllable, autonomous, distributed & heterogeneous system.
- Our concepts fuse/merge several bio-inspired algorithms that produce motion principles and self-awareness.
- Experimentation of the swarm will follow the lines of experimentation used in biology and psychology.

The CoCoRo consortium

UNIVERSITY OF GRAZ Artificial Life Lab	Coordination, bio-inspired algorithms, experimentation
Universität Stuttgart	Hardware, electronics, sensors, algorithms
The University of York	Electronics, operating system, artificial immune systems
Scuola Superiore Sant'Anna	Hardware design, sensors, actuators
ULB Université Libre de Bruxelles	Bio-inspired algorithms, experimentation

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THANK YOU FOR LISTENING!

QUESTIONS?

FURTHER INFO & MOVIES: HTTP://COCORO.UNI-GRAZ.AT

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