Development of cooperative behavioral patterns for Swarm robotic scenarios

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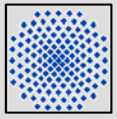



University of Stuttgart. Institute of Parallel and Distributed Systems (IPVS).

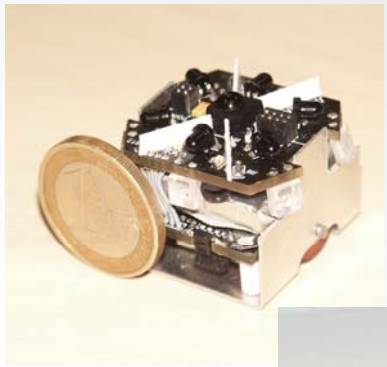
Two main goals

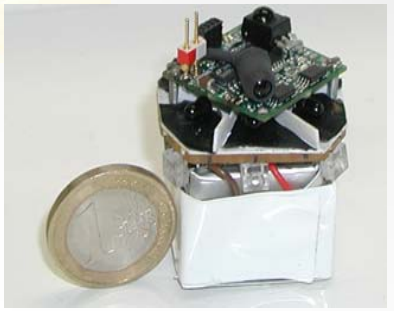
- Develop a simulation system for micro-robots (~3 Months)
  - For Jasmine-III model.
  - Potentially for other micro-robots.

- Create new behavioral patterns for Jasmine-III robot (~3 Months)
  - Try them in the simulation system.
  - Run them in the real world.

Simulation System

- 3D model for micro-robots
  - Thought for Jasmine-III but scalable for other robots.
  - Usable for ~100 robots.
  - Easy for new users.

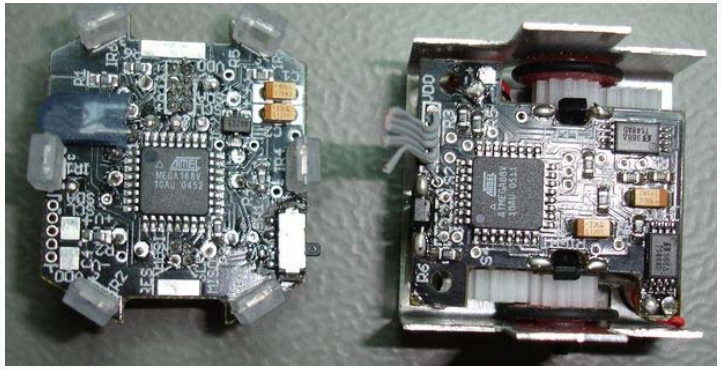




- Based on Breve (Steve language)
  - Open-source 3D simulation environment.
  - OpenGL display engine.
  - Easy to build 3D simulations and artificial life.

Why is important a simulation?

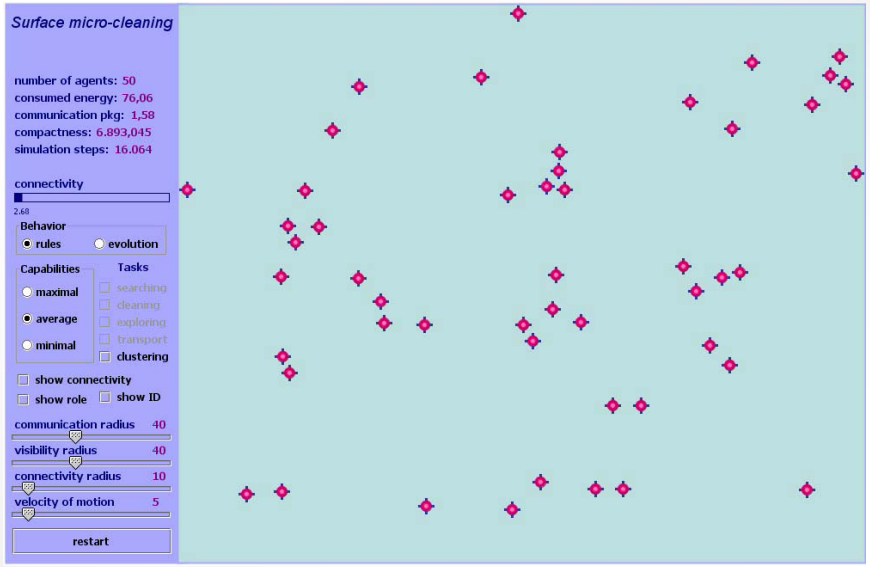
- The microcontroller life is limited (~10.000 times).



- The robots are a limited resource.
- Difficult to reprogram a lot of robots.

Why another simulation?

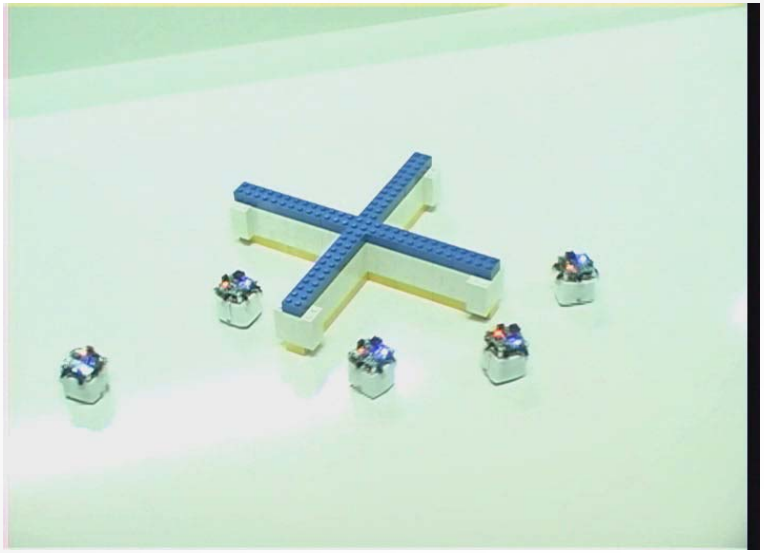
- Several attempts were not valid.



- We need a simulation which reflects the real world.
- Easy to insert new behavioral patterns.

Why another simulation?

- Strange behaviors in the real world.



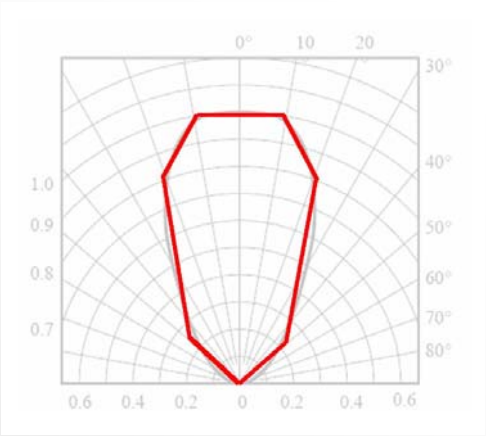
- Simulation must be equal to the real world.
- Even the strange effects.

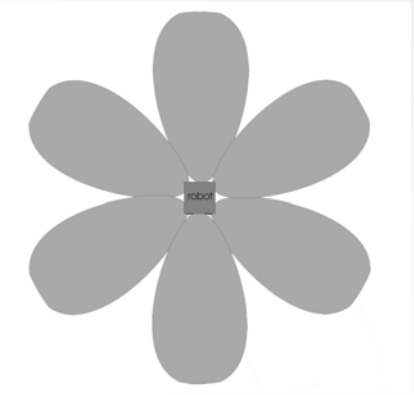
Simulation parts

- Physical sensors
  - Proximity sensors, distance sensors, touch sensors, communication sensors, color sensors…
- Body
  - Physical model vs. Logic model.
- Motion
  - Move, stop, rotate, ...
- Stage
- Communication between robots
  - Essential part in cooperative behaviors .

Physical sensors

- Different types: Infrared, ultrasound, RF, laser,…
- Infrared Sensors
- In Jasmine-III robot

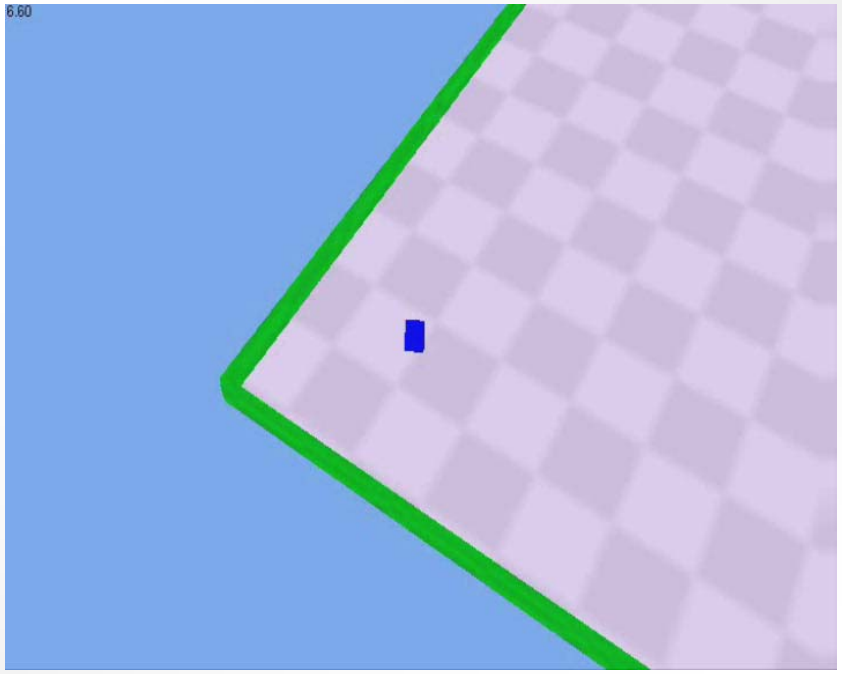




- We can model sensors as a ray, as a cone, etc.
- We must model them as realistic as possible.

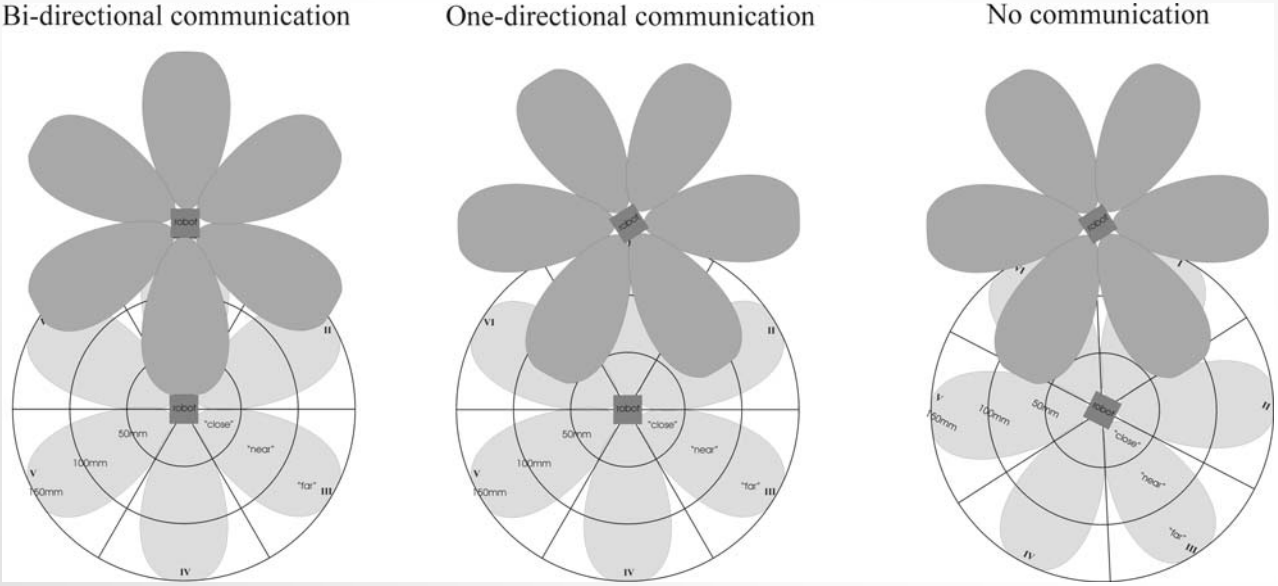
Simulated motion model

- Logic model
- Avoid physical simulation for motion
  - Wheels
  - Motors
  - Gravity center



Communication model

- Essential in cooperative behavioral patterns.
- In Jasmine-III: Based on IR sensors and confirmation protocol.
- Correct physical sensor model is extremely important.



Simulated communication model

- Requirements:
  · Communication model as realistic as possible.
  · Each robot has a queue with messages received.

- How does the communication work?
  · Establish a communication channel for bi-directional communication.
  · Each robot write in the queue of its neighbor.
  · Every message must be confirmed.

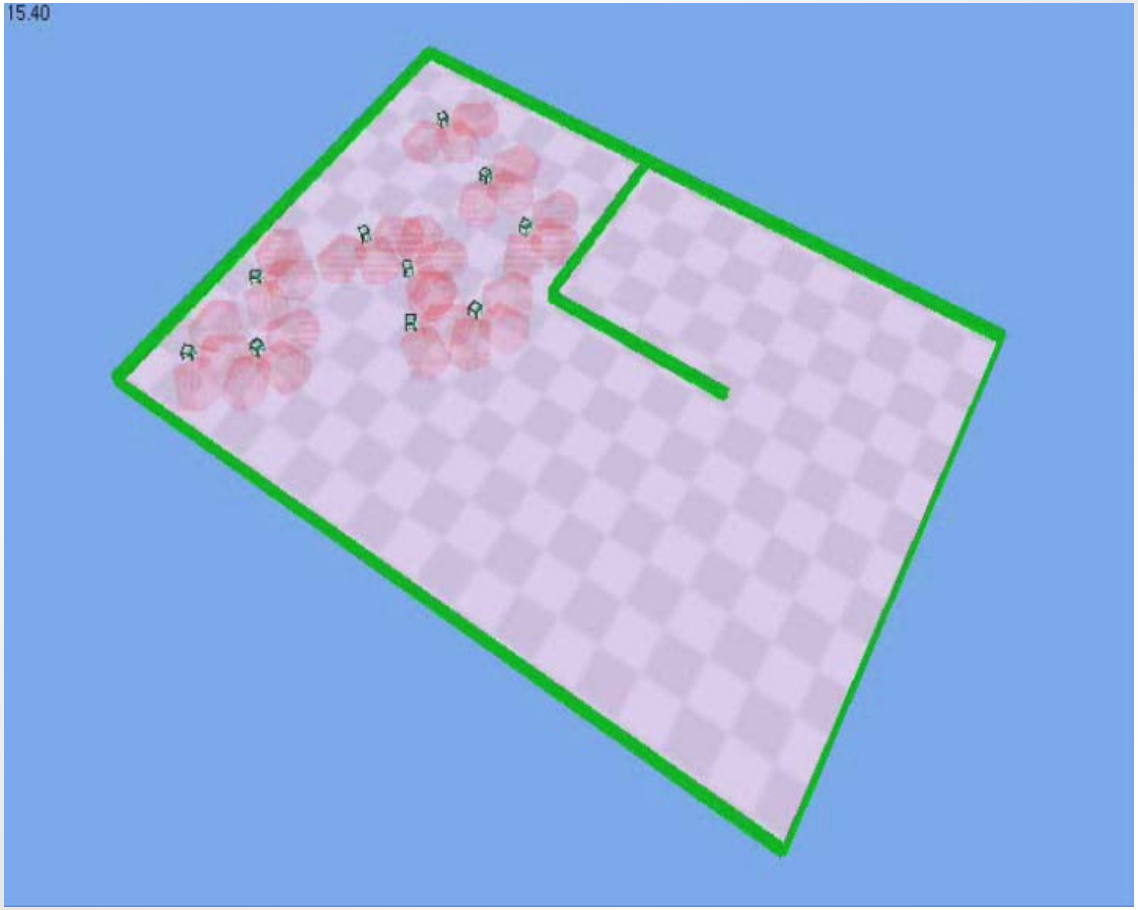
What is done?

- Stage model completed.
- Proximity sensor (infrared sensors) model.
- Basic motion.
- Random movement behavior.

What is to do?

- To unify different simulation implements.
- Add new sensor models (color sensor, light sensor,…).
- Communication between robots.

Simulation at the present time



To develop new behavioral patterns

- Different possibilities based on practical scenarios
  - New swarm game.
  - Cooperative perception.
  - Reach a common goal in a cooperative way.
- Minimal capabilities implemented in Jasmine-III
  - Motion.
  - Proximity Sensor.
  - Avoiding.
  - Communication.
- To make effort an behavioral (communication) part

How to make collective behavior?

- Five steps using Jasmine-III SDK.
  1. Create scenario. Real scenario or virtual scenario.
  2. Define roles. Who is who?
  3. Define communication signals.
  4. Describe roles. Graphical representation.
  5. Program roles. Write C/C++ code.

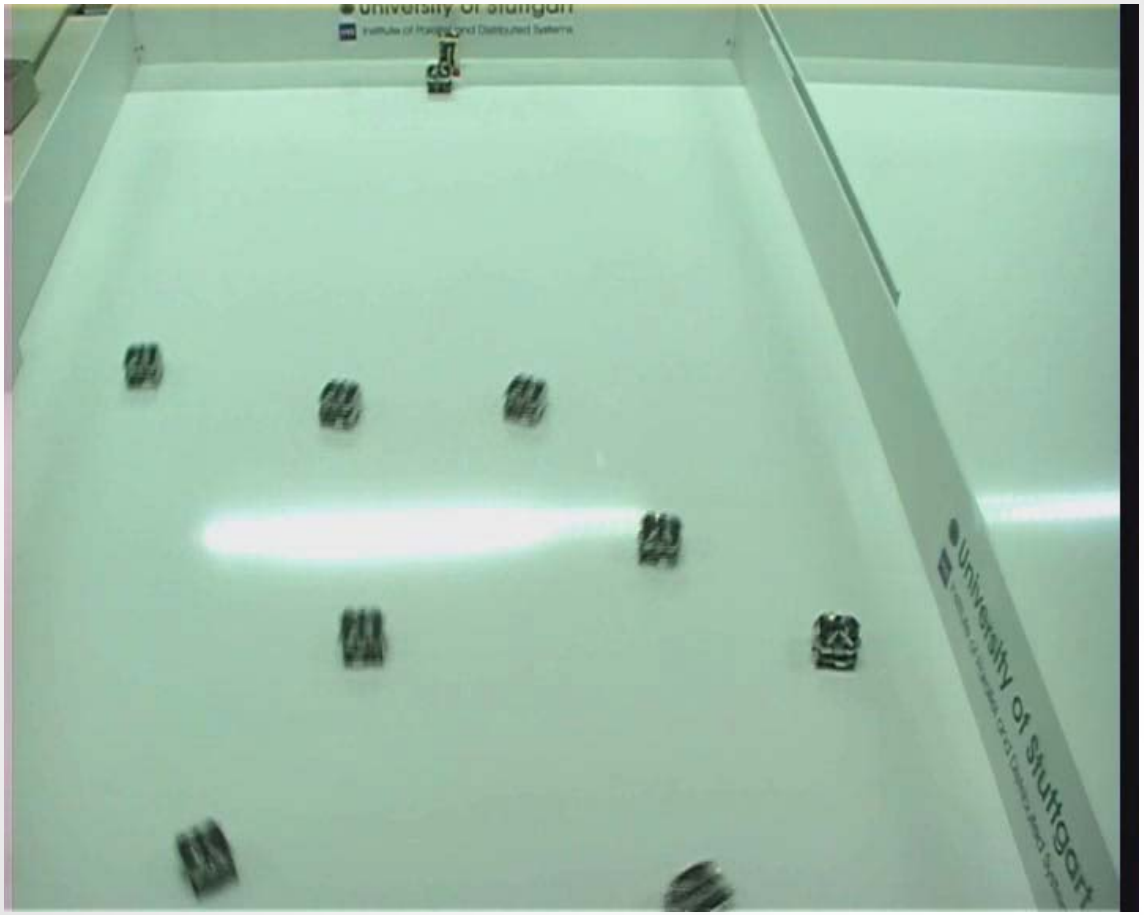
Test new patterns

- First in the simulation system
  - Prove all the basics.
  - Debug the main problems: communication between robots, the robots must follow the roles, etc.
- After, few of them in the real world
  - Check and fix real problems.
  - Feedback for the simulation system.

Example collective behavior

- Communication street
  1. Scenario: link between two points for transmitting messages from one point to other or for moving along the street.
  2. Define roles: three roles.
     - Landmark that indicates the start point of the street.
     - Communication agents.
     - Scout agent.
  3. Define communication signals:
     - During building the street.
     - Street is finished.
     - Navigation along the street.
  4. Describe roles: graphics to put logic into behavior.
  5. Program roles: translate the graphics in C/C++ code.

Communication street



What is done?

- Random movement behavior (simulation and real world)
- More complex patterns are made or are being developed by other Master Thesis.

What is to do?

- Create new collective behaviors following the Jasmine-III SDK.
- Open ideas.

Questions

- Questions (?)