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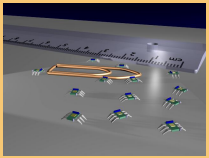

An Analytic and Spatial Model for the Foraging Scenario

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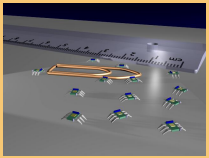

1. Motivation

1.1. Why model a swarm of robots?

- Explaining experimental and simulated results
- Saves resources (money and time)
- Exhaustive search of the parameter space is practical

1.2. State of the Art

- Macroscopic models
  - Rate Equations (probabilistic)
  - Assumption: Space is uniform.
- Microscopic models
  - Based on Brownian motion (big swarms possible) but simple behavior (no state transitions)
  - Complex model of a single agent (only tiny swarms possible)

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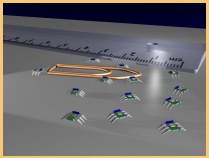

2. Step 1: Building the Simulation

2.1. Robot Model

- Very simpel
- Circumferential visibility
- Using virtual physics
- Ablility to distinct between: robot, nest, food, or wall.
- Perception of the pheromone gradients in two orthogonal directions (and absolute intensity)
- Deposition of pheromone(s)

2.2. Technical Notes concerning *breve*

- Pheromones implemented by Patches (not really supported yet)
- Evaporation and diffusion computationally intensive (interpreted language!)

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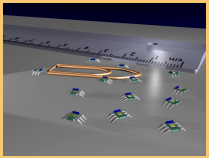

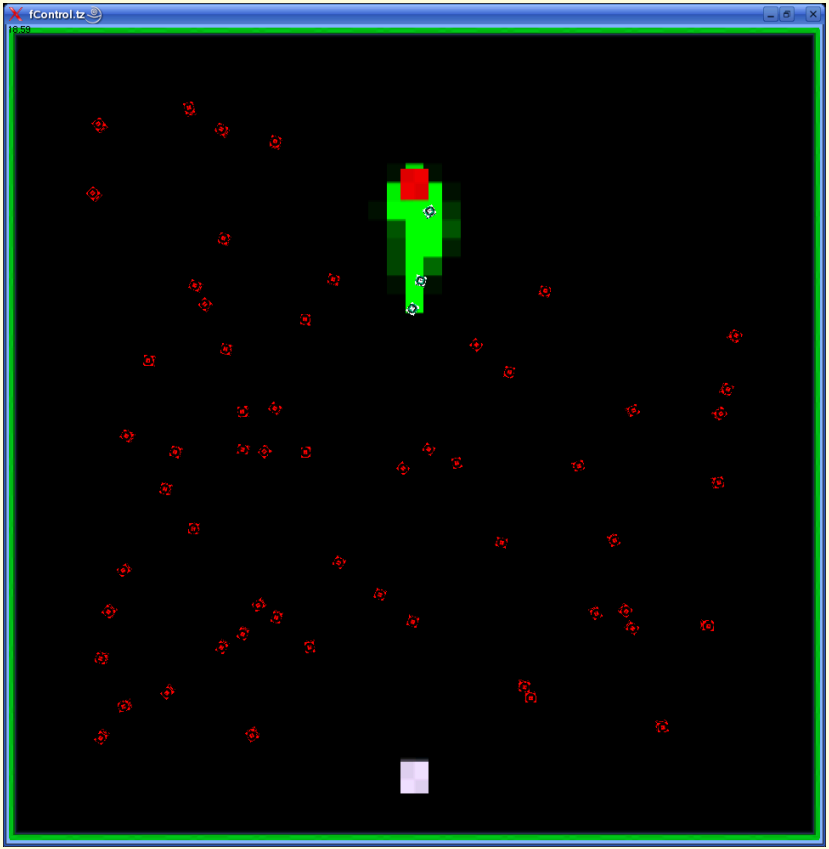

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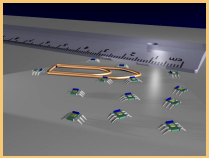

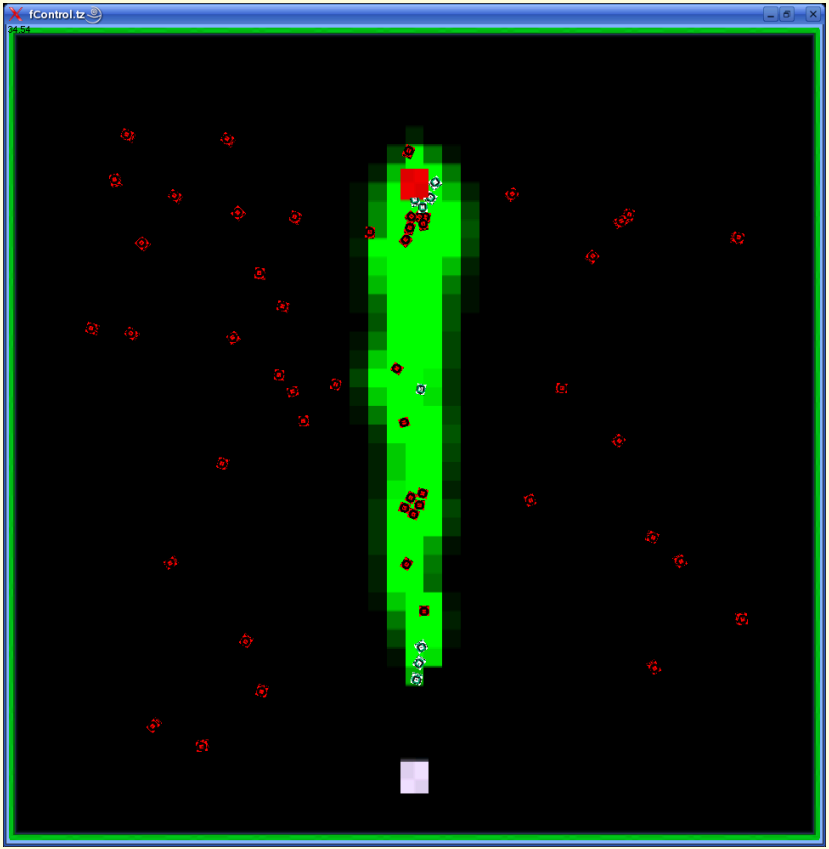

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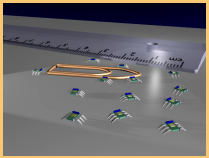

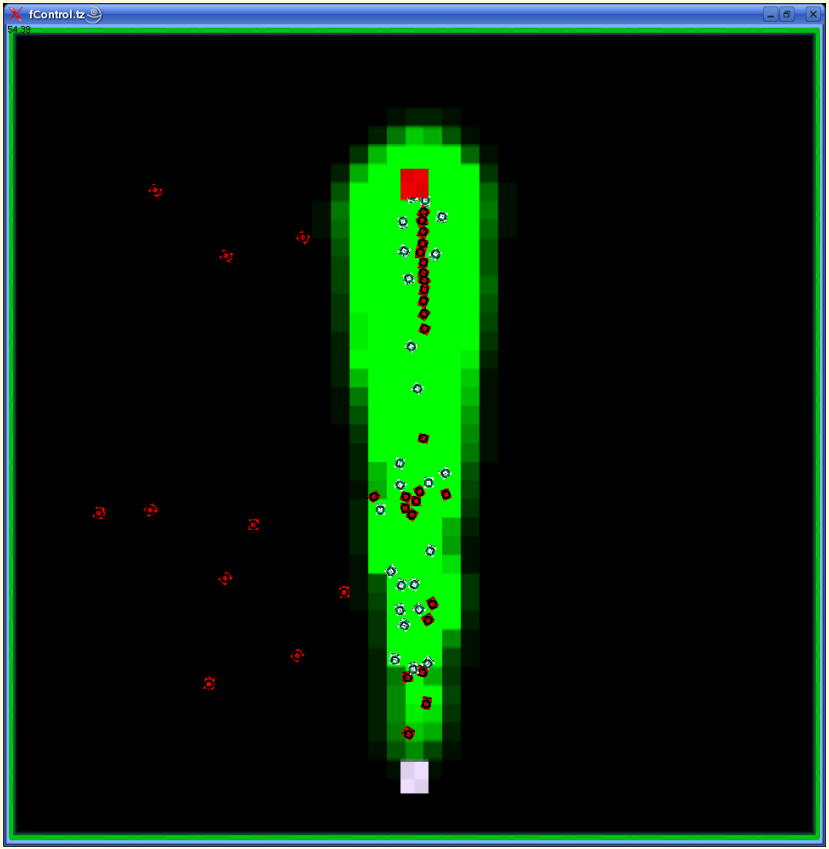

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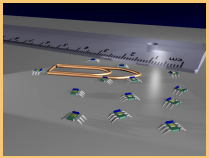

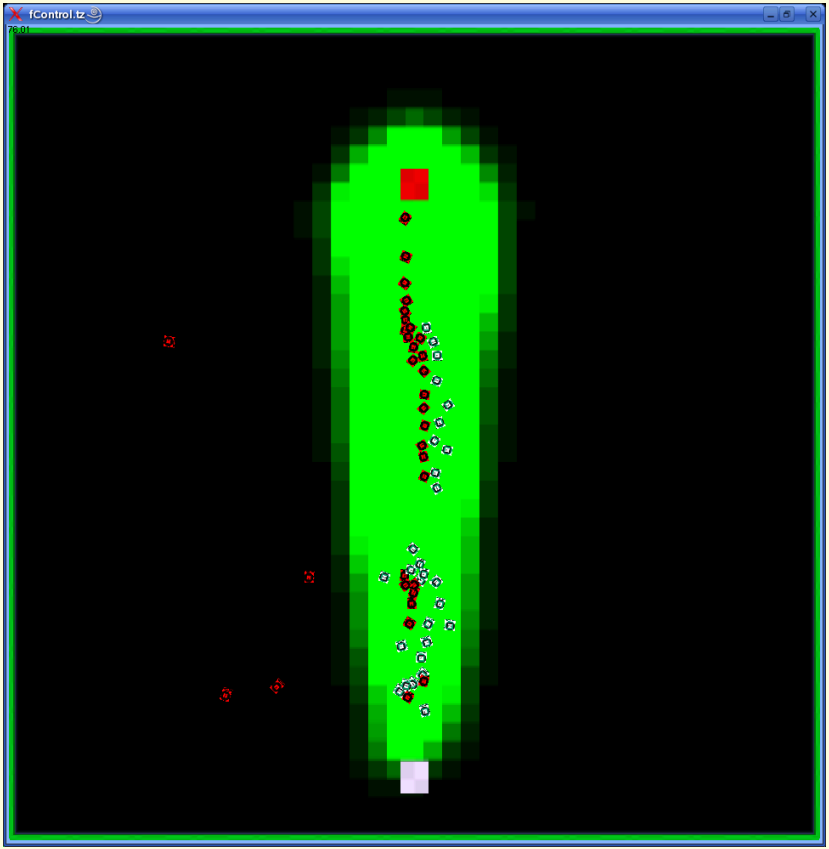

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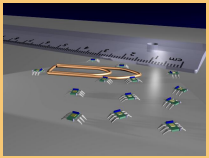

Warning!

The next slide may contain parts,
that are dangerous for people
susceptible to “math phobia”.
;-)

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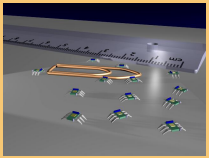

3. Step 2: Building the Model

3.1. Brownian Agents by F. Schweitzer et al.:

$$\frac{\partial}{\partial t}s(\mathbf{r},t) = D\frac{\partial^2 s(\mathbf{r},t)}{\partial^2 \mathbf{r}} - \alpha\frac{\partial^2 p(\mathbf{r},t)}{\partial^2 \mathbf{r}}s(\mathbf{r},t) = D\Delta s(\mathbf{r},t) - \alpha\Delta p(\mathbf{r},t)s(\mathbf{r},t).$$

- $s(\mathbf{r},t)$ is the density of ants at position $\mathbf{r}$ at time t
- $p(\mathbf{r},t)$ is the intensity of the pheromone at position $\mathbf{r}$ at time t

3.2. States, nest, and food

- two states: s_f and s_h (food search and homing)
- two pheromones: p_n and p_f (increasing towards nest / food)
- nest and food are punctual
- state transitions at the nest:
  $\frac{\partial}{\partial t}s_f(\mathbf{r}_{nest},t) =$
  $D\Delta s_f(\mathbf{r}_{nest},t) - \alpha\Delta p_f(\mathbf{r}_{nest},t)s_f(\mathbf{r},t) + \frac{\partial}{\partial t}s_h(\mathbf{r}_{nest}+\epsilon,t)$
- $s_h(\mathbf{r}_{nest},t) = 0$

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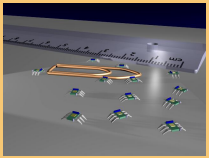

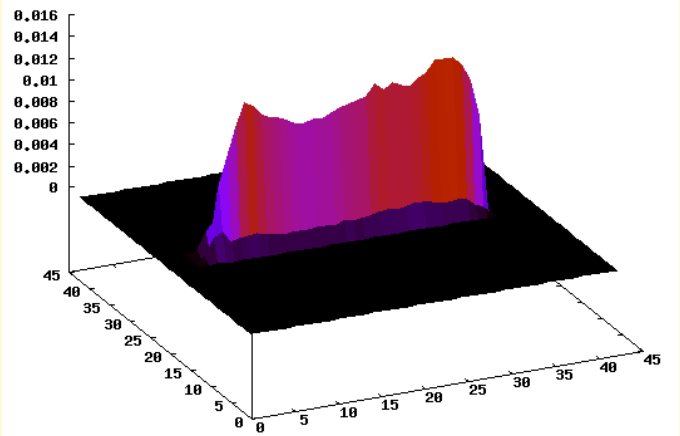

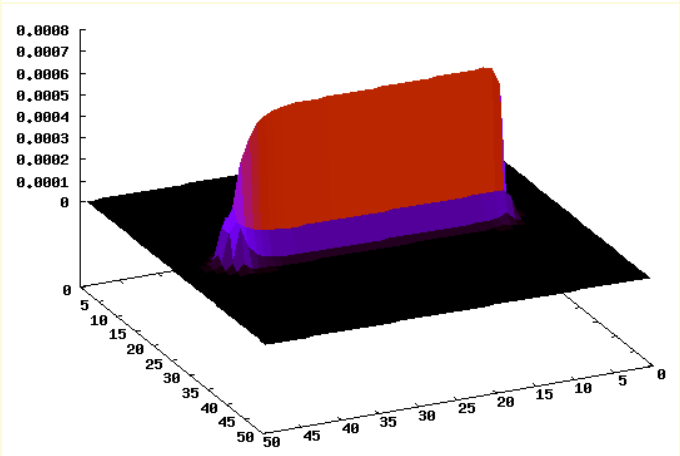

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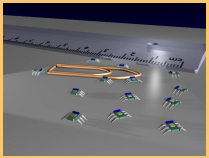

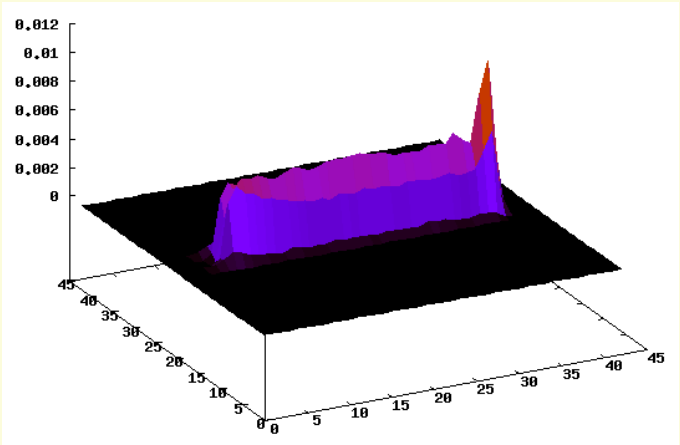

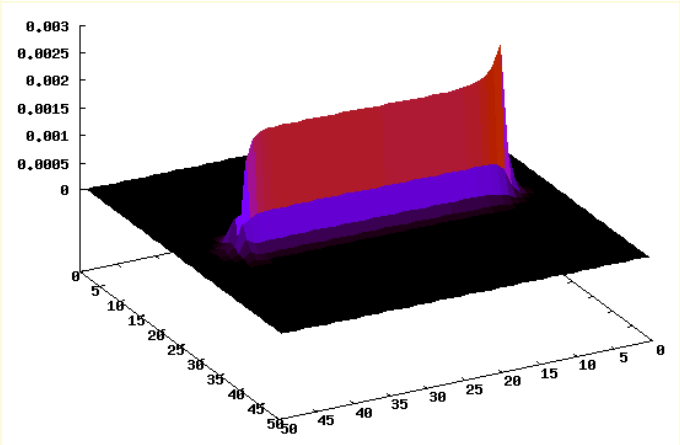

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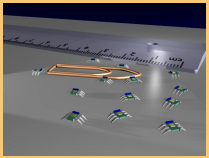

4. Future Work

- Comparison of simulation and model
- Further improvements of both model and simulation
- Measurement of the ant flow (state transitions)
- Simpler model for flow only, to determine a minimum damping constant

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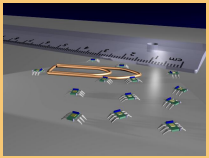

Questions?