Building simple formations in large societies of tiny mobile robots

**Vision:** Mathematical foundations of swarm robotics

- Tiny robot
  - Small
  - Limited sensing
  - Limited computational power
  - Limited communication capabilities
  - Limited energy
- Large society of tiny robots
  - Accomplish difficult tasks
  - Adapt to changing environment
  - Are robust against failures
  - Adapt to different tasks

How do we achieve good global behaviour? → Which formations can the robots build?

**Challenge:** Design and rigorous mathematical analysis of local strategies for robotic swarm formation

- Correctness
- Time efficiency
- Energy efficiency

**Example:** Line between two stations

- Start
  - Robots already organized in a chain
  → each robot knows two neighbours
  - Chain is arbitrarily long and winding
- Goal
  - Each robot is between two neighbours
  - The robots form a straight line between the two stations

→ Spend as little energy as possible!
  - Sense environment
  - Movement

**A Strategy:** δ-Go-To-The-Middle

- Model assumptions
  - Discrete time
  - Synchronous execution of the strategy
  - n robots

- Results
  - Energy spent for sensing environment: proportional to $n^2 \log n + \frac{n}{\delta}$
  - Energy spent for moving: proportional to $\delta n^2 + n$

→ Choose $\delta = \frac{1}{n}$:
  - Energy for sensing proportional to $n^2 \log n$
  - Energy for moving proportional to $n$

**Conclusion:** Exploring the step size can be helpful for energy reduction

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