SPP 1183 Organic Computing

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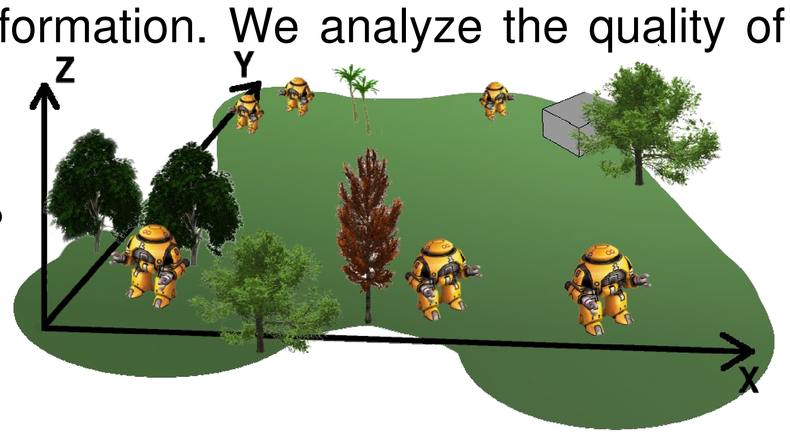
# Smart Teams

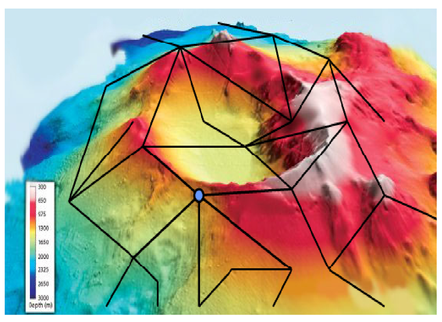
## Local Distributed Strategies for Self-Organizing Robotic Exploration Teams

We lay the algorithmic foundations for a scenario where an exploration team of robots (a Smart Team) self-organizes itself in order to explore an unknown terrain and execute work in this terrain. The work is guided by strategies for exploration, for finding important objects, and for assigning a subgroup of robots to such an object. All tasks have to be executed by local, distributed strategies that act on the mobile network of the moving robots, and have to result in a robust, effective self-organization of the team. No robot will have ever knowledge about the global state of the system. Decisions are solely based on local information. We analyze the quality of our strategies theoretically and experimentally.

### Challenges:

- How can the Smart Team organize itself to explore unknown terrain?
- How to keep the group connected?
- How to agree upon a fair resource assignment?
- How to minimize the overall energy consumption?



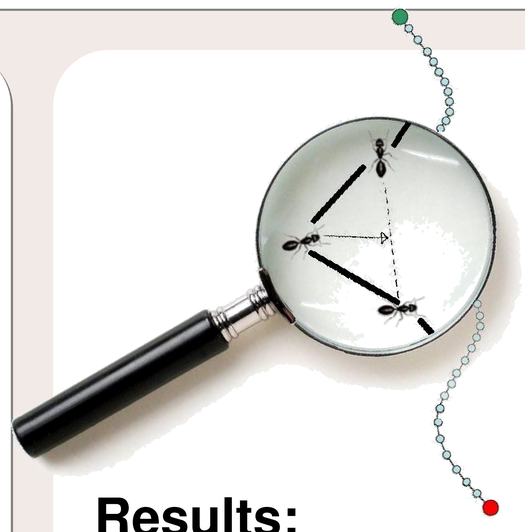



### Results:

- Unknown graph
- Simple, local strategies provided for both models
- Minimizing time is far more difficult than minimizing the energy used by a robot

### Exploration

We model the terrain by a graph. The group of *k* robots has to act locally in order to visit all interesting locations (nodes). Since the graph is unknown, they see only outgoing edges. The strategies minimize the maximal energy used by a robot, or the total time of the exploration. Our local, online and distributed strategies deliver provably good results.

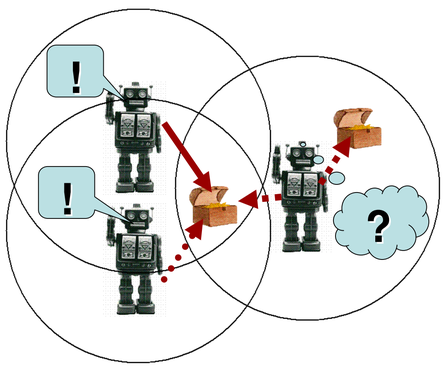


### Results:

- Mobile explorer and the static base station
- Robots serve as mobile relay stations
- Local strategies provided
- Go-To-The-Middle
- Chase-Explorer

### Communication

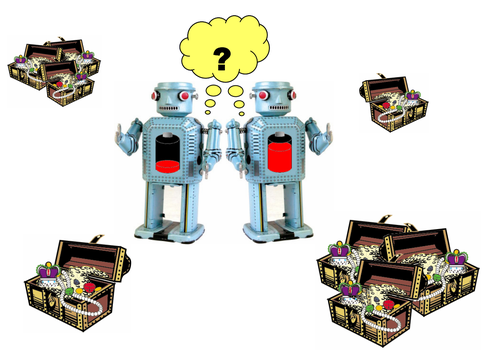
To maintain a communication structure between single members and the whole team without external infrastructure is crucial. The impact of local strategies like the Go-To-The-Middle is analyzed and improved by better but still local strategies. The analysis encompasses static cases and such with a moving explorer.




### Scheduling

- Tasks (treasures) appearing
- Specialized robots
- Coalition formation
- Local strategies required

Robots have special capabilities and tasks require a certain combination of them. Local strategies for proper assignments of robot-coalitions to treasures are required. Since treasures appear over time, we are dealing with online problems. Modeling locality, dynamics and online issues properly is a main aspect.




### Energy Consumption

- Communication cost
- Motion cost
- Optimized energy allocation
- Local strategies required

Mobile robots carry limited energy to fulfill assigned tasks. The energy of radio communication grows at least quadratically with the distance of two communicating robots while the mobility cost grows linearly. We want to optimize the energy consumption in each robot to maximize the lifetime of Smart Teams based on local strategies.

### Methods

- Local, distributed online algorithms
- Competitive analysis
- Marcov chains theory

### Applications

- Exploration of dangerous areas
- Exploration of oceans and outer planets
- Rescue actions in terrain, which is inaccessible to humans

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