Organisation and Control of Self-Organizing Systems in Technical Compounds

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Research Topic

Develop and investigate **technically realizable self-organising systems**, that use principles of natural self-organising systems.

→ Focus: systems from social insect societies

2. Study how **compounds of self-organizing systems** can be created that
   - do not exists in nature in this form
   - that are technically realizable and manageable

3. Develop **methods for the organisation and control** of such compounds of self-organizing systems

Concepts

Test OC-System

Worker:

- different types of requirements for service exist
- worker that needs help searches for a helper

Helper:

- can perform different **servicing tasks**
- time depends on amount of resources reconfigured for corresponding task type
- decides at a request whether its **accepted** and if so, whether it **reconfigure itself** before performing the task
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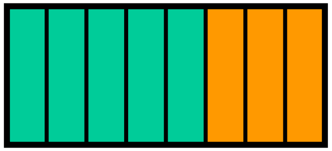
Self Organisation

Worker-Helper Model :

- 2 (or more) types of servicing tasks
- probability that worker needs help per time step for task type i
- search for helper = select helper randomly
- helper is FPGA with q slices, each slice for one type of tasks different **reconfiguration strategies**



1-slice strategy = reconfigure one more slice for type of the next task

- **stimulus** S_j for task type j: #request for j - #requests for other task type
- **threshold** of helper H_i for task type j: T_{ij}=T
- probability that helper accepts a task for which it is not specialized depends on threshold, stimulus and configuration

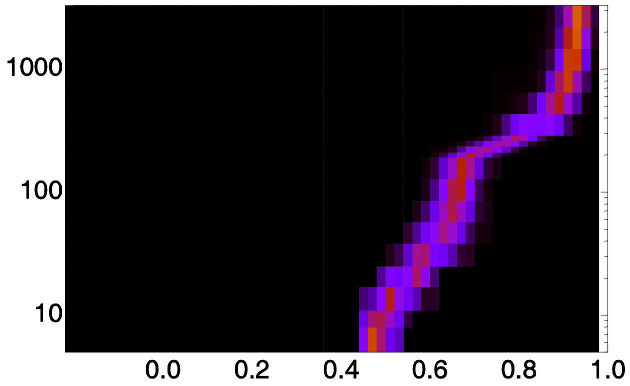
Emergence Phenomena

Colony size dependent polyethism [Merkle,Middendorf,2002]

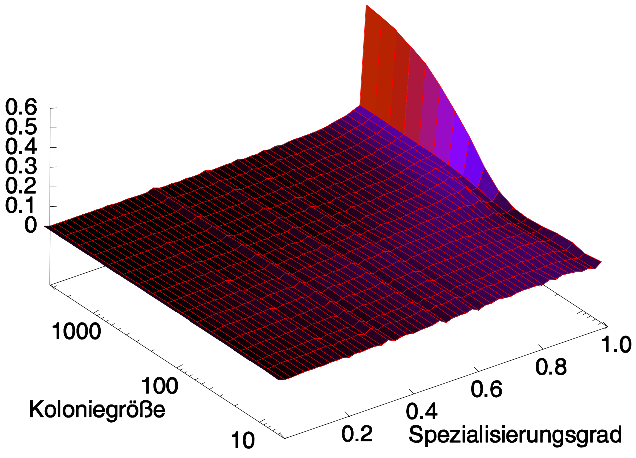
Competition: only a fraction of the individuals that have decided to work for a task is allowed to work for the task

→ selected are the individuals with the lowest threshhold

Specialization of individuals depending on demand for work and colony size:



infinite lifespan



finite lifespan

Infinite lifespan: colony size dependent specialization

Finite lifespan: colony size dependen specialization and differentiation

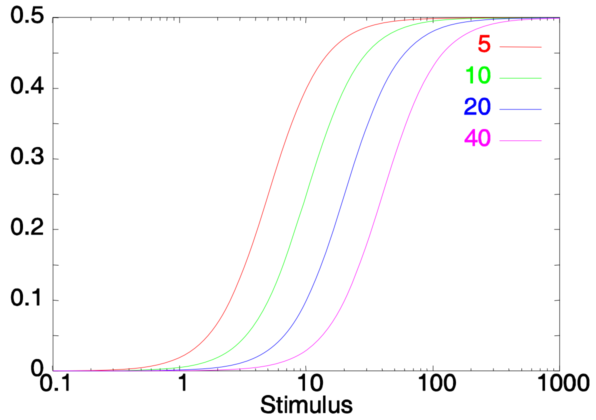
Nature Inspired Methods

Task selection in ant colonies:

Response-Threshold-Reinforcement-Model [Theraulaz,1998; Gautrais et al.2002]

- 2 tasks, each has its own stimulus value S_j
- n individuals, each has a threshold value for each task $\Phi_{i,j} \leq \Phi_{max}$
- probability that non-working individual I_i engages in Task T_j

$$\frac{1}{2}\frac{S_j^2}{S_j^2 + \Phi_{i,j}^2}$$



- if individual I_i works for a task T_j threshold is $\Phi_{i,j}$ decreased (learning) otherwise it is increased (forgetting)
- stimuli are changed every time step $$S_j = S_j + \delta \cdot W_{\max} - E_j$$

  where W_{max} is the maximal average amount of work and D is a demand parameter