# Lecture 12 - Swarm intelligence

## Particle Swarm Optimization

- A population (or swarm) of solutions (or particles) is moving in the solution space to find the optimum
- Each particle has its own velocity (set randomly at the beginning) and remembers its own best solution in time
- The velocity of a particle is updated as a weighted average of:
    - Its previous velocity
    - The velocity towards its best solution so far
    - The velocity towards the best solution of the swarm
- PSO usually converges faster than evolutionary algorithms.

## Ant Colony Optimization

- ACO is applied often to such problems like TSP where we need to find the shortest path, however it is still possible to use this algorithm for other problems by mapping them into a construction graph.
- Each ant moves at random unless they fell the pheromone. When they feel the pheromone they are more likely to choose that path. Once they go thorough some path they leave more pheromone.
- Communication through environment - stigmergy
- The probability of moving from the city x to city y by ant k is:

$$p_{xy}^k = \frac{\tau_{xy}^\alpha \cdot \eta_{xy}^\beta}{\sum_{x \in allowed_x} \tau_{xz}^\alpha \cdot \eta_{xz}^\beta}$$

- $\tau_{xy}$ is the amount of pheromone
- $\eta_{xy}$ is the desirability of moving from x to y (in case of TSP it is 1/distance)

- $\alpha$, $\beta$ are the parameters (in some versions $\beta$ is assumed to be 1)

# Applying ACO to TSP

- At any given time, each city has a certain number of ants, which choose another unvisited city with a probability that is proportional to the distance and the amount of pheromone between the cities.
- There are several mechanisms for leaving the pheromone
    - ant density
    - ant quantity
    - ant cycle
- Pheromone also evaporates