# Ant System & Travelling Salesman Problem (TSP)

Metaheuristics for Optimization

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# The Inspiration

- **Swarm Intelligence** → Collective behaviour makes the group perform *better* than the sum of the individula parts
- **Heterarchy** → The absence of a centralized control
  Local behaviours that produce coherent global one
- **Auto – Organisation** → Ants don’t depend on one individual
- **Pheromone** → Gives the ability to solve a global problem with only a *local* appreciation of it

# Ant System Algorithm

→ Adapt the pheromone trail behaviour to solve the TSP

**Parameters**

- **Visibility:** $\eta_{ij} = \frac{1}{d_{ij}}$
- **Trail intensity:** $\tau_{ij}(t)$
- **# of ants:** $m$

**Algorithm 1**

**for all** $t = 1, ..., t_{max}$ **do**
  **for all** ant $k = 1, ..., m$ **do**
    **choose** a city at random
    **while** there exists a city not visited **do**
      **choose** a city $j$ according to (1)
    **end while**
    **mark** a path according to (3)
  **end for**
  **update** all paths according to (2)
  **Keep** the best of solutions obtained at last iteration
**end for**

$$p_{ij}^k(t) = \begin{cases} \frac{(\tau_{ij}(t))^\alpha (\eta_{ij})^\beta}{\sum_{l \in J} (\tau_{il}(t))^\alpha (\eta_{il})^\beta} & \text{if } j \in J \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

$$\tau_{ij}(t+1) = (1-\rho)\tau_{ij}(t) + \sum_{k=1}^{m} \Delta\tau_{ij}^k(t) \tag{2}$$

$$\Delta\tau_{ij}^k(t) = \begin{cases} \frac{Q}{L^k(t)} & \text{if ant } k \text{ used edge } (i,j) \text{ in its tour} \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

# Tunable Parameters

- $\alpha = 1$
- $\beta = 5$
- $\rho = 0.1$

- $Q = L_{nn}$
- $\tau_0 = \frac{1}{L_{nn}}$

- $m$
- $t_{max}$