Solution to exercises from lecture 3 (Swarm intelligence) TEK5010 Multiagent systems 2020

Question 1

Could you explain the differences between swarm intelligence and game theory as applied to multiagent systems?

1) Definitions:
a. Swam intelligence (SI) is the emergent collective intelligence of groups of simple agents, typically based on the social insect metaphor.
b. Game theory (GT) is the modeling of intelligent agents engaging in strategic interaction, typically inspired by utility-based models in the social sciences and the humanities.

2) Some key similarities in terms of MAS:
a. Both SI and GT model autonomous agents (this is the only requirement in MAS).
b. Both SI and GT employ distributedness (not central control but distributed control)

3) Some key differences in relation to MAS:
a. SI use simple, reactive agents vs. strategic agents of GT (that are proactive and social; negotiation, competition, bargaining, cooperation, etc.)

b. Emergence is important in SI
The understanding of the simple and individual behaviour of each single agent is not sufficient to explain the complexity of what agents can do in terms of coordinated collective behavior, or the emergent collective intelligence originates from the many interactions between many simple agents (and not the agent itself).
Typically, GT agents are modelled more explicit in their capabilities and their direct contribution to the overall system performance is more quantifiable.

c. Stigmergy is unique to SI
Stigmergy is indirect interaction, non-symbolic form of interaction, mediated by the environment, or stigmergy is when agents exchange information by modifying their environment.
Typically, GT assumes direct communication between agents.

d. Self-organization (scalability, flexibility and robustness)
The scalability of swarm systems is typically better than the complicated structure of a strategic system modelled by GT. The reason for this is the low complexity of the reactive agents in SI agents. Furthermore, the specialization and division of labour exhibits a high degree of plasticity in swarm systems making them flexible in adaption to changes in the environment. The scalability, flexibility and low need for communication, i.e. stigmergy, makes SI systems fairly robust in term of agent drop out and communication failure, often breaking down gracefully as number of agents decrease. GT systems are often thought to be more vulnerable to agent malfunction and communication drop out, often breaking down completely if system is not working 100%.

Question 2

First, a summary of problem:

Search area (100, 100) to (-100, -100) for a hidden RF (Radio Frequency) emitter.

$$A = \frac{1}{4\pi r^2} + kN(0,\sigma)$$

is the A detected amplitude of the signal at distance r from RF emitter with added noise given by the kN-part.

a) Explain the canonical PSO

This is the original PSO of [Kennedy and Eberhart, 1995].

$$v'_{id} = \underbrace{\omega \cdot v_{id}}_{\text{Inertia term}} + \underbrace{\omega_1 \varphi_1 (p_{id} - x_{id})}_{\text{Cognitive term}} + \underbrace{\omega_2 \varphi_2 (p_{gd} - x_{id})}_{\text{social term}}$$

where $\omega, \omega_1, \omega_2$ are parameters that needs to be tuned

$\varphi_1, \varphi_2 \in [0,1]$ uniform random distribution

x_{id} is position of particle i in dimension d

p_{id} is best position of particle i in dim d

p_{gd} is global best position of all particles in dim d

Random position of particles and dim d velocities at initialization.

b) Given the 4 particles in PSO

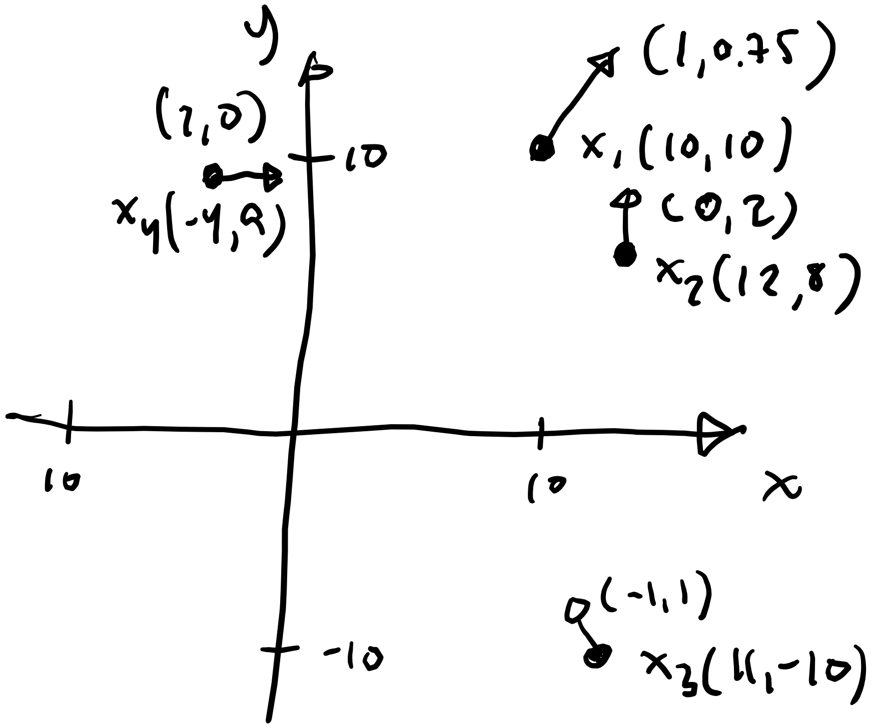
$x_1 = (10,10)$ $\quad v_1 = (1, 0.75)$

$x_2 = (12,8)$ $\quad v_2 = (0,2)$

$x_3 = (11,-10)$ $\quad v_3 = (-1,1)$

$x_4 = (-4,9)$ $\quad v_4 = (2,0)$

Calculate one iteration of particle 1 assuming $w = 0.98$, $w_1 = 0.04$, $w_2 = 0.02$, $k = 0$, emitter is at $(0,0)$



lets calculate the global best particle

$r_1 = \sqrt{10^2 + 10^2} = \sqrt{200} = 14,14$

$r_2 = \sqrt{12^2 + 8^2} = \sqrt{144 + 64} = \sqrt{208} = 14.42$

$r_3 = \sqrt{11^2 + (10)^2} = \sqrt{121 + 100} = \sqrt{221} = 14.87$

$r_4 = \sqrt{(-4)^2 + 9^2} = \sqrt{16 + 81} = \sqrt{97} = 9.85$

$\Rightarrow P_g = x_4$ Particle 4 is global best position since it is closest to emitter.

$v_{11}' = \omega v_{11} + \omega_1 \varphi_1 (x_{11} - x_{11}) + \omega_2 \varphi_2 (x_{41} - x_{11})$

$= 0.98 \cdot 1 + 0.04 \cdot 0,3 (10 - 10) + 0.02 \cdot 0.9 (-4 - 10)$

$= 0.98 + 0 - 0,252 = 0,728$

$v_{12}' = \omega \cdot v_{12} + \omega_1 \varphi_1 (x_{12} - x_{12}) + \omega_2 \varphi_2 (x_{42} - x_{12})$

$= 0.98 \cdot 0,75 + 0.04 \cdot 0,75 (10 - 10) + 0,02 \cdot 0.1 (9 - 10)$

$= 0,735 + 0 - 0,002 = 0,733$

$x_{11}' = x_{11} + v_{11}' = 10 + 0,73 = 10,73$

$x_{12}' = x_{12} + v_{12}' = 10 + 0.73 = 10.73$

c) Simulate the next particle iterations using NetLogo.