ATILIM ÜNİVERSİTESİ

Faculty of Engineering

Computer Engineering Department

CMPE 462 – Introduction to Artificial Intelligence

HOMEWORK #2

Academic Year: Spring 2023-24
Due Date: 12.05.2024 (Sunday), Hr: 23:59
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Promotion of Cooperation Among Culturally Adaptive Agents in a Spatial Prisoner's Dilemma Game Environment

We want to investigate whether cooperation is promoted or not among culturally adaptive players situated in a Spatial Prisoner's Dilemma (PD) game environment. Each cell of the two-dimensional (NxN) game environment is occupied by one PD player. Initially, α ratio of the players (i.e. $(NxN)/2$) adopt strategy Defect (D) and $(1-\alpha)$ ratio of them adopts Cooperate (C) strategy. Strategy initialization is done randomly. In each iteration t, every player i plays PD game with each of its 8-nearest neighbors j one by one (see Fig. 1) and updates its individual budget B_i according to the pay-off matrix description in Fig. 2. In neighborhood description aasume that we adopt circular boundary counditions. For example in Fig. 1, 8-neigbors of cell j is numbered in clock-wise direction from 1 to 8.

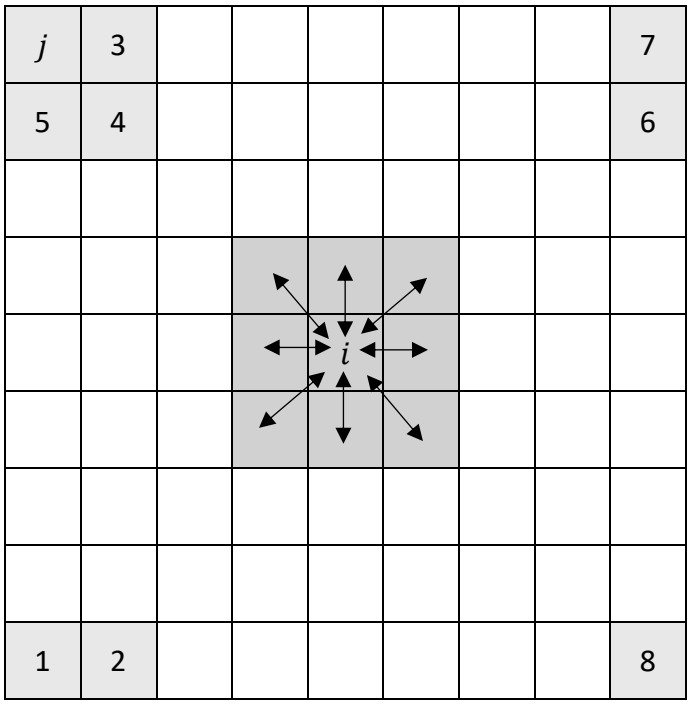

Fig. 1. A $9x9$ grid environment on which spatial PD game played in Moore neighborhood

For example, if player i prefers to play D and j prefers C, i gains 3 unit but j obtains nothing from the encounter. Similarly, if both players play C they both gain 2 units. Otherwise, if both of them play D, both players gain 1 unit.

		Player j	
		D	**C**
Player i	**D**	(1,1)	(3,0)
	C	(0,3)	(2,2)

Fig. 2. Payoff matrix for two-person (i/j) and two-strategy (D/C) PD game.

In every iteration t, each player i plays PD game 16 times and updates its budget $B_i(t)$. Following their 16 times played PD game and budget updates, our culturally adaptive player - inspired from Particle Swarm Optimization (PSO) algorithm revizes its current strategy $S_i(t)$ by considering 4 components: *Rationality* component, *Momentum* component, *Cognitive* component and *Social* component.

- In PD game, rational behavior requires to prefer strategy D. So, ***Rationality* component** is the rational strategy $S_r = D$ which is adopted as the next strategy with probability computed based on 16 encounters per iteration times expected budget change per encounter when D is played. So, $\Delta B_r = 16 * (0.5 * 1 + 0.5 * 3) = 32$.
- ***Momentum* component** is the current strategy $S_i(t)$ which is adopted as the next strategy $S_i(t+1)$ with probability computed based on budget change $\Delta B_i(t) = B_i(t) - B_i(t-1)$.
- ***Cognitive* component** is the strategy S_i adopted with probability computed based on the highest individual budget increment ΔB_i obtained so far.
- ***Social* component** is the strategy S_g adopted with probability computed based on the highest overall budget increment ΔB_g obtained among all 8-neighbors of the player i (including i itself), so far.

So, $S_i(t+1)$ is decided stochastically according to *Roulette-Wheel* like selection among strategies:

- S_r with probability $\Delta B_r/(\Delta B_r + \Delta B_i(t) + \Delta B_i + \Delta B_g)$
- $S_i(t)$ with probability $\Delta B_i(t)/(\Delta B_r + \Delta B_i(t) + \Delta B_i + \Delta B_g)$
- S_i with probability $\Delta B_i/(\Delta B_r + \Delta B_i(t) + \Delta B_i + \Delta B_g)$
- S_g with probability $\Delta B_g/(\Delta B_r + \Delta B_i(t) + \Delta B_i + \Delta B_g)$.

Do the following tasks:

1. Design and implement the above spatial PD game simulation environment (**75 pts**).
2. Do the simulations by taking grid size $N = 40$. Generate a single figure that summarizes the results by taking different α ratio values ranging from 0.0 to 1.0 in step size 0.1. In your

figure, *x-axis* shows iteration number and *y-axis* shows the ratio of players that adopts Cooperation as their current strategy (**10 pts**).

3. Analyze the results obtained in Tasks #2. Make discussions about promotion of cooperation sensitivity against different α ratio values (**15 pts**).

PS:

- You can work either alone or as a member of a two-person team.
- Submit your homework until May 12, 2024, Hr: 23:59 via Moodle.
- Do NOT submit your homework by e-mail.
- Use C/C++ or Python as your implementation language.
- Code-review date & time is planned to be announced later.
- You are required to attend code-review. Otherwise, you get 0 from whole HW #2.