The Coverage Control in the Multi-agent systems by the Aid of Evolutionary Game Theory

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Problem Statement:

We study the self-organization of mobile agents who are randomly distributed in two dimensions, by which the resulting distribution can realize the largest sensor coverage on the surrounding environment. Importantly, the system should be always connected. The game theory is employed here for designing the distributed control algorithm. For each agent, she needs to stay away from her neighbors to increase the coverage, meanwhile, she also needs to ensure that communications are not interrupted. Thus, theses goals of agents are conflicted, and the control process here can be seen as a continuous game. At each time step, each agent decides the next move direction by games. Key elements are: (1) the players of the game. (2)the strategy is the direction of migration. The strategy spaces can be defined as 20 average angles in $[0,2\pi)$: $S_i = \{\frac{n\pi}{10} | n = 0, 1, \ldots, 19\}$. (3) $f_i(a_1, a_2, \ldots, a_n)$ is the payoff of agent i. Rational agents will choose the strategy that maximizes their payoffs. (4) only the information about herself and her neighbors is known. The communication range and sensory range are centered on their own, respectively, with communication radius R_C and sensory radius R_S. Next, coverage is defined as:$Coverage = \frac{(Areacoveredbythesystem)}{N\pi R^2}$. Two agents are defined neighbors of each other if the distance between them is less than or equal to the communication radius. So, agent i's equations of migration are: $x_i(t+1) = x_i(t) + p_i \cdot \cos\theta_i(t)$, $y_i(t+1) = y_i(t) + p_i \cdot \sin\theta_i(t)$. The relation between coverage area and number of agents N is: $S(k=2) = \pi R^2 + (N-1) \cdot [\pi R^2 - 2(\frac{\pi R^2}{3} - \frac{\sqrt{3}R^2}{4})]$. The payoff of each agent is given by: $f_i(\theta_i(t), \theta_{-i}(t)) = \sum_{j \in N_i(t)} \hat{d}_{ij}(t+1)$.

Main Results:

After setting the sensory radius to be 20, our analysis is performed based on $k = 2$ and $k = 3$ for comparison. 20 randomly distributed agents finally realize the coverage control of the target environment to a certain extent, as shown in Figs.2-3. The dots describe the location of agents, and the circles denote their coverage range. Green lines are the neighboring relation of the involved agents. Red lines denote that who are not neighbors but could connect each other.

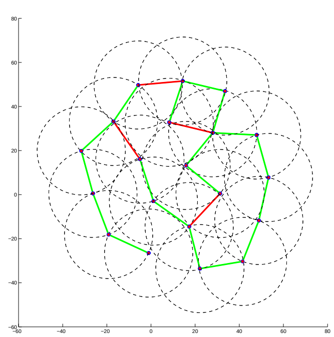

Figure 1: Coverage effect of 20 agents: k=2

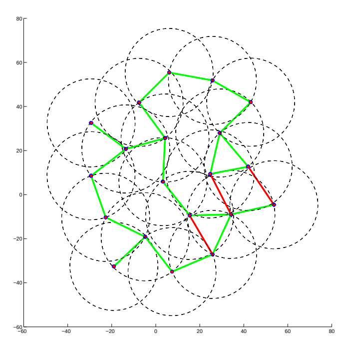

Figure 2: Coverage effect of 20 agents: k=3