Autonomy By Design

Multi-Agent Systems Theorie

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1.1 Distributed Programming in the Context of Hide and Seek

This chapter explores the application of Distributed Programming to more complex problems, such as playing a simulation of the game of Hide and Seek. Distributed programming is a method of solving problems by distributing tasks across multiple processes or computers, which can improve efficiency and scalability.

In the context of Hide and Seek, we can define the game as follows: there are several seekers (search agents) and one or more hidden objects on a two-dimensional playing field. The searchers' goal is to find the hidden objects as quickly as possible by working together and calculating the shortest routes to the objects' probable locations.

Important concepts in this chapter are:

Distributed Dynamic Programming: A technique for solving problems by breaking them down into overlapping sub-problems and solving them step-by-step. In the context of path planning, this is used to find the shortest route between nodes in a weighted directed graph. Custom pseudo code for Hide and Seek with Distributed Dynamic Programming:

Algorithm 1 ASYNCHDP_HIDE_AND_SEEK algorithm for Hide and Seek

```
1:  procedure ASYNCHDP_HIDE_AND_SEEK(agent, grid)
2:      if agent is at the goal node then
3:          report_found_object()
4:      else
5:          initialize h(agent) arbitrarily (e.g., to ∞ or 0)
6:          repeat
7:              for all neighboring nodes j do
8:                  f(j) ← w(agent, j) + h(j)
9:              h(agent) ← min_j f(j)
10:             move_to_min_cost_neighbor(h)
11:         until object_found or time_limit_reached
```

This modified ASYNCHDP algorithm pseudocode can be used to direct a search agent in the Hide and Seek simulation. Each agent calculates the cost to go to the neighboring nodes, chooses the node with the lowest cost and moves there. This process is repeated until the hidden object is found or a time limit is reached.

Combining this approach with communication between the search agents allows them to work together to find the locations of the hidden objects more efficiently thus playing the Hide and Seek game.

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2.1 Agent communication

In a Hide and Seek simulation, there are two types of agents: Hiders and Seekers. Hiders aim to hide from the Seekers, while Seekers aim to find the Hiders. We can analyze agent communication in this simulation using speech act theory, allowing agents to share information, coordinate, and negotiate with each other.

Algorithm :

a) Initialize the environment, agents, and their positions.

b) Assign roles to agents (Hider or Seeker).

c) While the simulation is running:

   (a) Agents perform their respective roles (Hiders hide, Seekers seek).

   (b) Agents communicate using speech acts (e.g., inform, request, propose, accept-proposal, reject-proposal).

   (c) Update the environment and agent positions.

d) Terminate the simulation once all Hiders are found or a predetermined time limit is reached.

Algorithm 2 Hide and Seek with Communication

```
procedure HideAndSeek
    initialize_environment()
    initialize_agents()
    assign_roles_to_agents()
    while simulation_is_running() do
        for agent in agents do
            if agent.role == "Hider" then
                agent.hide()
            else if agent.role == "Seeker" then
                agent.seek()
            agent.communicate_with_other_agents()
        update_environment()
        update_agent_positions()
        if all_hiders_found() or time_limit_reached() then
            break
    terminate_simulation()
```

To incorporate agent communication using speech act theory, we can define a set of communicative acts that agents can perform:

- Inform: An agent shares information about its position or the position of other agents.

- Request: An agent requests information from other agents, such as the location of a Hider or a suitable hiding spot.

- Propose: An agent proposes a plan or action to coordinate with other agents (e.g., splitting the search area, moving to a new location).

- Accept-Proposal: An agent agrees to another agent's proposed plan or action.

- Reject-Proposal: An agent disagrees with another agent's proposed plan or action.

Agents can use these communicative acts to share information and coordinate their actions to achieve their goals (i.e., Hiders hiding effectively, and Seekers finding Hiders efficiently). By employing speech act theory in the Hide and Seek simulation, agents can improve their performance and adapt to the changing environment and agent positions.

Rules of Conversation: Agents can follow Grice's maxims to ensure cooperative and efficient communication. These maxims include Quantity, Quality, Relation, and Manner.

Signaling Games: Agents can play signaling games to convey information indirectly. For example, a Hider might convey its position using a coded message, which Seekers must interpret to find the Hider.

Algorithm 3 Hide and Seek with Communication and Signaling Games

```
procedure HideAndSeek
    initialize_environment()
    initialize_agents()
    assign_roles_to_agents()
    while simulation_is_running() do
        for agent in agents do
            if agent.role == "Hider" then
                agent.hide()
            else if agent.role == "Seeker" then
                agent.seek()
            agent.communicate_with_other_agents()
            agent.follow_rules_of_conversation()
            agent.play_signaling_games()
        update_environment()
        update_agent_positions()
        if all_hiders_found() or time_limit_reached() then
            break
    terminate_simulation()
```

By integrating the Rules of Conversation and Signaling Games into the Hide and Seek simulation, agents can communicate more effectively and use strategies to convey or interpret

information indirectly, adding an extra layer of complexity and challenge to the simulation.