Game theory

Hide And Seek

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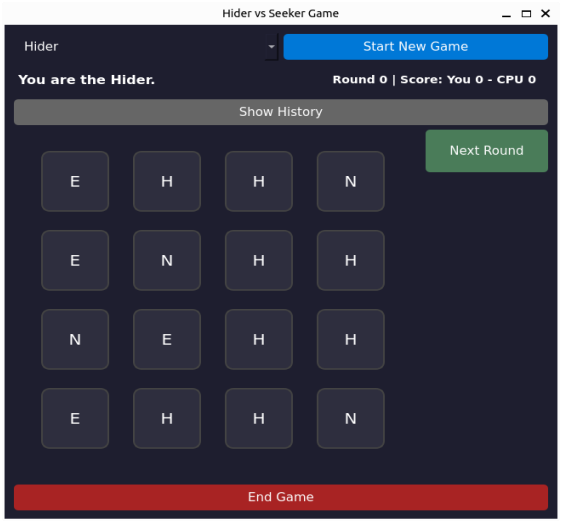
Introduction :

Hide and Seek game based on game theory principles it models a competitive scenario between two players—a hider and a seeker— where each player's objective is to optimize their own strategy to win, The game introduce fundamental concepts of **zero-sum games**, **payoff matrices**, and **optimal mixed strategies** using **linear programming**. The computer uses the **simplex method** to determine the best probabilistic strategy for either hiding or seeking, depending on the human player's choice of role.

Game description :



The Hide and Seek game is a two-player strategic game where one player acts as the **Hider** and the other as the **Seeker**. The game world is structured as a

2D grid, and each location in the world is assigned a specific type: **Easy (E)**, **Hard (H)**, or **Neutral (N)**—affecting how points are awarded based on the outcome. At the beginning of the game, the human player selects a role (Hider or Seeker), and the computer takes the opposite role. The player and the computer then take turns hiding or seeking on a board filled with randomly assigned place types. Each type influences the payoff when the Seeker finds or fails to find the Hider**.**

Implementation details :

1. Game Setup

- Initialize 4X4 grid (our world) each cell assigned randomly to either hard H easy E or N neutral (with respect to hider).
- Make player choose a role to play with either hider or seeker.

2 .Payoff Matrix Generation

- Based on the generated grid we build payoff matrix (16 X 16) which represent all possible relative places between hider and seeker and the point add to hider in case of escape from hider and points sub from hider in case of being caught .
- We have also implemented the **bonus feature of proximity-based scoring**, which adjusts the hider's score based on how close the seeker was:
  1. If the seeker is **one cell away**, the hider's score is multiplied by **0.5**.
  2. If the seeker is **two cells away**, the score is multiplied by **0.75**.
  3. Otherwise, the score remains unchanged

  Note :

  We intergerate the **bonus feature of proximity-based scoring in** the payoff matrix make it affect the produced probability from simplex

3 Linear programming formulation :

to determine the optimal mixed strategy for both players (Hider and Seeker), we formulate the game as a linear program. Let the payoff matrix *A [i][j]* represent the hider's gain (and seeker's loss). The matrix has:

- m rows (strategies for the Hider)
- n columns (strategies for the Seeker)
- Used formulas :

Row Player's LP

$$\max z = v$$

$$\text{s.t.} \quad v \le a_{11}x_1 + a_{21}x_2 + \cdots + a_{m1}x_m \quad \text{(Column 1 constraint)}$$
$$v \le a_{12}x_1 + a_{22}x_2 + \cdots + a_{m2}x_m \quad \text{(Column 2 constraint)}$$
$$\vdots$$
$$v \le a_{1n}x_1 + a_{2n}x_2 + \cdots + a_{mn}x_m \quad \text{(Column } n \text{ constraint)}$$
$$x_1 + x_2 + \cdots + x_m = 1$$
$$x_i \ge 0 \quad (i = 1, 2, \ldots, m);\ v \text{ urs}$$

Column Player's LP

$$\min z = w$$

$$\text{s.t.} \quad w \ge a_{11}y_1 + a_{12}y_2 + \cdots + a_{1n}y_n \quad \text{(Row 1 constraint)}$$
$$w \ge a_{21}y_1 + a_{22}y_2 + \cdots + a_{2n}y_n \quad \text{(Row 2 constraint)}$$
$$\vdots$$
$$w \ge a_{m1}y_1 + a_{m2}y_2 + \cdots + a_{mn}y_n \quad \text{(Row } m \text{ constraint)}$$
$$y_1 + y_2 + \cdots + y_n = 1$$
$$y_j \ge 0 \quad (j = 1, 2, \ldots, n);\ w \text{ urs}$$

- LP from the **Hider's perspective**, trying to **maximize** the expected value v
- From the **Seeker's perspective**, we try to **minimize** the expected value w

4 .Simulation Mode

In simulation mode, the game is played automatically for **100 rounds** between two computer-controlled players: one acting as the **Hider** and the other as the **Seeker**. Unlike random play, each computer uses its **optimal mixed strategy**, computed via **linear programming (LP)**, to make decisions.

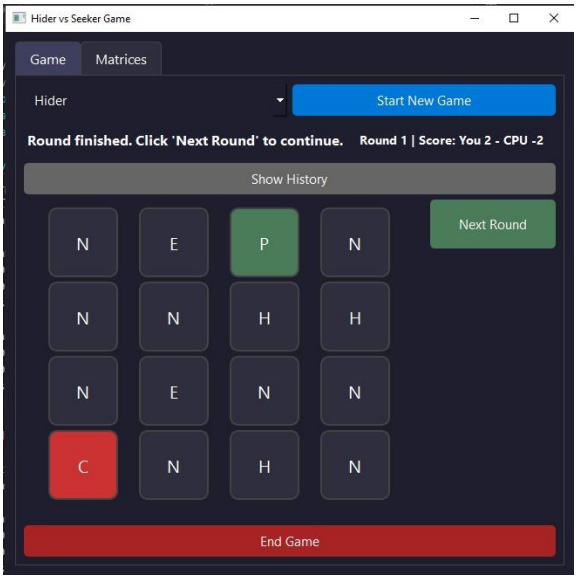
Optimal Strategy-Based Play

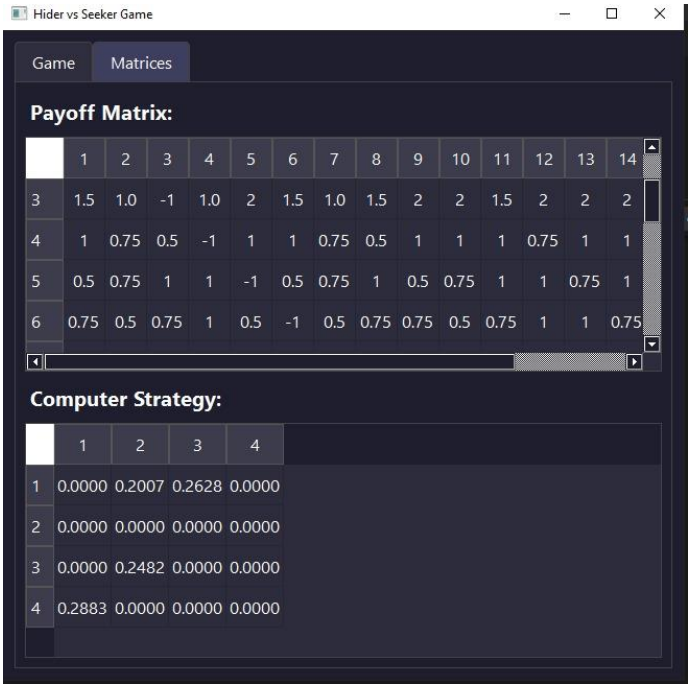
- Both players first calculate their **probability distributions** over all possible positions using the LP solver.
- In each round, the Hider selects a hiding spot and the Seeker selects a seeking spot **based on these probabilities**. The selection is made using a **weighted random choice**, ensuring that strategies reflect the optimal solution but retain stochastic variation.
- The round result is determined by checking whether the seeker found the hider and applying the scoring rules
- Scores for each player are updated accordingly after each round.

Code repo:

- https://github.com/ShahdMohamed-11/Hide-SeekGame

5 .Screen shots from the game :





6-Reference:

Winston, W. L. (2004). *Operations Research: Applications and Algorithms* (4th ed.). Brooks/Cole – Thomson Learning.