Report Project 1 Part 3

Student: Maria Alejandra Zapata Montano

1)Problem formulation

Terrain and resource tiles in a 5x5 grid. Players A and B take turns moving up, down, left, and right by one step. Every participant gets a fixed capacity backpack that holds two items. If a player steps onto a resource tile and has space, they pick it up; if they step onto their own base, they deliver everything they're carrying. Game ends when all resources have been delivered. Whoever delivered more is the winner.

State:

- Positions of A and B
- Backpack contents for A and B
- Delivered counters for A and B, plus a global delivered total
- Remaining resources
- Whose turn it is

Actions:

- Legal actions are the 4 neighborhood moves that stay on the board.
- The transition does, in order:
  1. move to target cell
  2. collect if a resource is present and bag has room
  3. deliver if standing on the player's base
  4. switch turn

Utility:

$$Utility = delivered(A) - delivered(B)$$

Zero sum from A's perspective.

- Terminal states: all resources delivered. We use the exact utility.
- Non terminal states: we use a heuristic score.

2)Heuristic design

We wanted to design a zero-sum estimate of who's ahead right now.

Signals we used:

- Possession (delivered + in bag): nearest to actual points; should dominate.
- closest needed resource (when empty): be closer to something you can actually pick up.
- Distance to base (when carrying).
- Opponent pressure (cheap): subtract the opponent's versions of the two proximity terms.
- Tiny step penalty: To breaks ties and discourages stalling.

Final heuristic:

$$Eval(s) = POSSESSION\_W * [(del\_A + bag\_A) - (del\_B + bag\_B)]$$

$$+ (NearRes\_A - NearRes\_B)$$

$$+ (HomePull\_A - HomePull\_B)$$

$$- STEP\_PENALTY$$

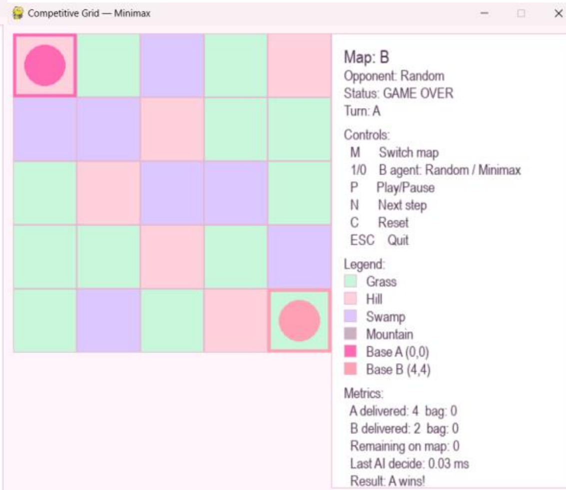
The formula **Eval(s)** estimates who is ahead. **del_A/del_B** are items already delivered by A/B (banked points). **bag_A/bag_B** are items currently carried, valuable because they're close to becoming points. **POSSESSION_W** is a large weight so this (delivered + carried) score dominates. **NearRes_A/NearRes_B** measure closeness to the **nearest remaining resource**, and **HomePull_A/HomePull_B** measure closeness to each player's **own base when carrying**. **STEP_PENALTY** is a small penalty per step to break ties and discourage stalling. Each component is taken as A minus B,making the score **zero sum**: positive favors A; negative favors B. We used heuristic with depth 5.

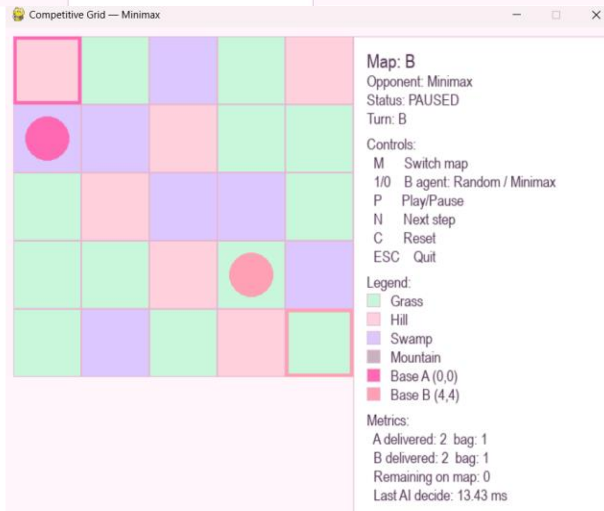
3)Results

- **Map A**

In the screenshots, the alpha beta/Minimax agent behaves as intended: against Random (top-right) it finishes the game cleanly with A 4–0 deliveries and 0 remaining tiles, with sub-millisecond last-move time, evidence that alpha–beta is giving the same choices as plain minimax while expanding fewer nodes and running faster. The Minimax vs Minimax match (bottom) is a sensible endgame: A has 3 delivered, B has 2 delivered and 1 in the bag, and no resources remain on the map, so it's purely a race to base; the heuristic drive both agents to cash out rather than oscillate. Overall, results match the analysis: alpha beta improves efficiency without changing decisions.

- **Map B**





On Map B we see the same pattern as Map A but with tougher terrain: the top-left is a fresh start (A vs Minimax, 6 resources on board), while the top-right shows GAME OVER vs Random with A wins and 0 remaining**,** again confirming the alpha–beta/Minimax agent converts pickups into deliveries quickly. The bottom snapshot is a Minimax vs Minimax: A delivered 3 B delivered 3 and no resources remain**;** Overall, Map B results reinforce the analysis: alpha–beta yields the same choices as plain minimax but faster, dominates Random.

- **Map C**

On Map C, we see the same behavior: the start screen (top-left) shows a fresh board vs Random, and the finish (top-right) shows GAME OVER with A 4–2 B deliveries and 0 remaining, so the alpha beta agent still converts quickly even on harder terrain. In self-play (bottom), the game also ends cleanly with A 4–2 over a Minimax opponent. Overall, Map C reinforces the pattern: alpha–beta yields fast decisions, dominating Random and producing decisive results in Minimax-vs-Minimax.

4)Discussion

The heuristic used was so good because of how solid and simple it is:

- The **possession** term (delivered + carried) gives a strong direction.
- The **home pull** when carrying removes indecision.
- The **context aware proximity** avoids fighting between two goals.
- The **step penalty** push game to finish.

Also, across Maps A, B, and C, we met the goal of implement a computer search agent using minimax with alpha–beta pruning: it consistently beats Random cleanly (4–0 with zero tiles remaining), while minimax vs minimax produces stable endgames that hinge on who can bank first. Alpha–beta delivers the same choices as plain minimax but with far fewer nodes and lower latency.

Regarding the depth of heuristic: the deeper you search, the smarter the moves, but the tree blows up fast. With alpha beta and good move ordering, **d=5** was the best for us: noticeably better play, **d=3–4** is super fast and “good enough” for most boards. Pushing to **d≥6** helps in tricky endgames, but costs a lot more nodes. Thus, more depth is better quality, but it depends on your resources. For this game, our best option was d=5.