**Polycraft AI Lab (PAL)**

**DARPA SAIL-ON Program**

**HUGA Task Specifications**

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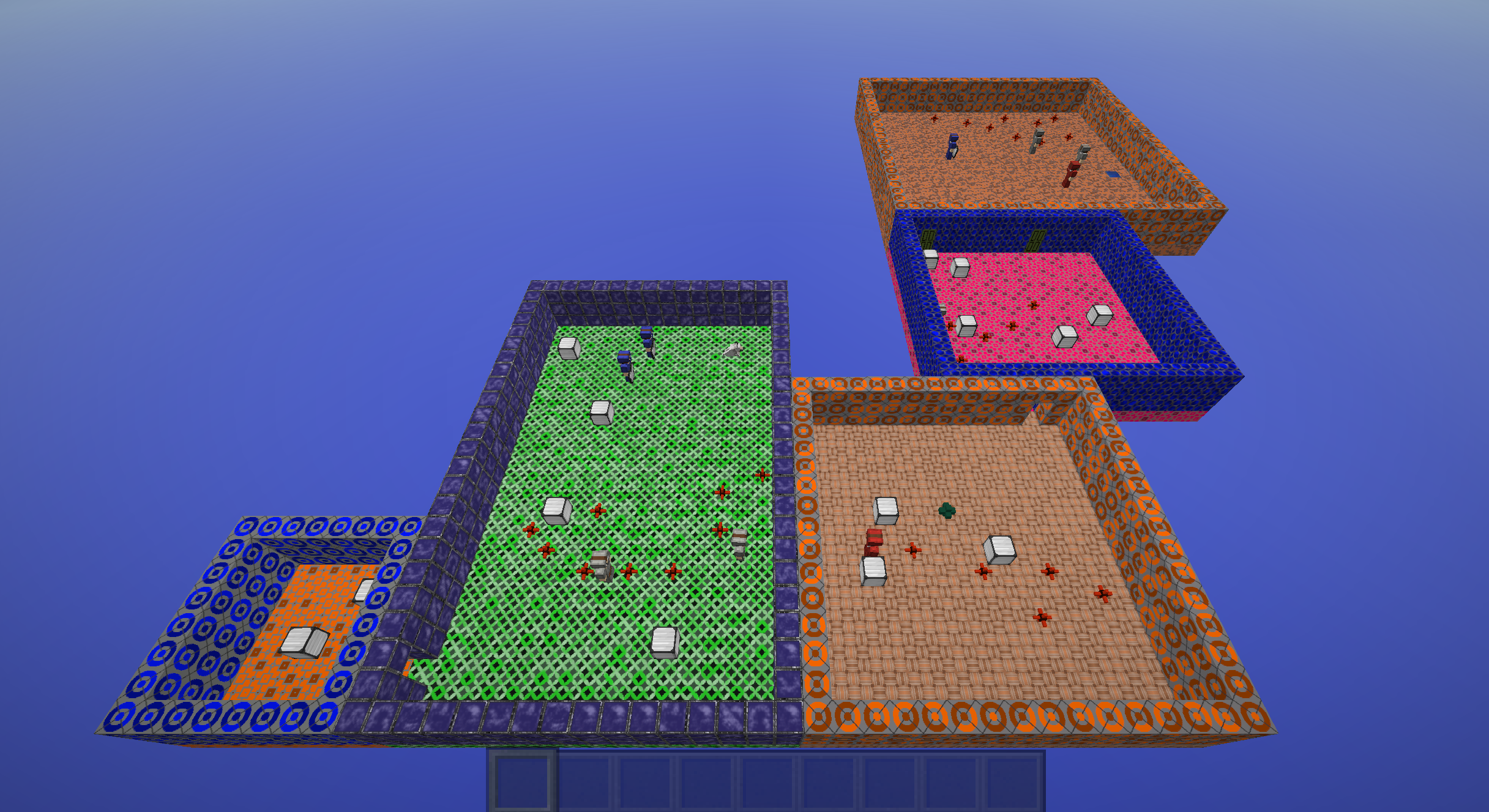
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# HUGA Task Visualizations:



*Aerial view of the Phase 2 HUGA Task Arena*

A picture containing diagram

Description automatically generated

*Schematic of the Phase 2 HUGA Task Arena*

# HUGA Novelties:

## Shared Novelties:

### 1-2-2 Objects – Type: Detritus

*Phase 2 Updates:*

1. The task is set in ‘Phase 2 light’ mode. In this mode, the harmful agents (Gray and Red Patrols) are removed. The Guide Dog and Blue Patrols can still spawn normally. ‘Phase 2 light’ mode is designed so used for some Phase 1 novelties so that i) the impact of the novelty in Phase 2 evaluations will be largely similar to the impact in Phase 1, and ii) the results of the evaluation are more likely to be consistent with Phase 1 evaluation results.
2. All other objects and entities should be spawned after the detritus so that they are not in the same location as the detritus.
3. If the detritus is blocking the only path to the next room, the Guide Dog will keep attempting to move to the next room until a path exists.

*Phase 1 Specifications:*

1. Glass blocks will surround the Player, MacGuffin, or Target spawn points at variable intensity.
2. There must be an option for the detritus to be up to 3 layers deep. The player would have to move to the detritus and break it multiple times to get through.
3. Detritus will spawn in full layers such that there is no path around the detritus. The detritus always spawns in at least all 8 blocks surrounding the Player, MacGuffin, or Target.
4. If the player attempts to move to a block of detritus, the action should fail and they should stay where they are.
5. Detritus is only 1 block tall.
6. Detritus should be breakable with a single BREAK\_BLOCK. stepCost should be moderate (~500-5,000)
7. If a player is facing 90 degrees and using MOVE commands, they must be able to move through a broken piece of detritus without ‘snagging’ on adjacent, unbroken pieces of detritus.
8. Detritus blocks should be obviously visible with both SENSE\_ALL and SENSE\_SCREEN (i.e., Glass).

|  |  |
| --- | --- |
| Easy | Detritus spawns around the Player 1-3 full layers deep (rng for layers). |
| Medium | Detritus spawns around the MacGuffin 1-3 full layers deep (rng for layers). |
| Hard | Detritus spawns around the Target 1-3 full layers deep (rng for layers). |

### 2-1-1 Attributes – Type: Wall Color

*Phase 2 Updates:*

1. All walls throughout the Phase 2 rooms are impacted similarly by this novelty.

*Phase 1 Specifications:*

1. The new color for wall blocks in this Tournament will be Green.
2. The color of some number of individual blocks in the wall changes to the new color.
3. Throughout the entire tournament, all blocks that change should change to the same new color.
4. Changes should occur throughout the arena in all four rooms and in the outer and inner walls.

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| --- | --- |
| Easy | 1-10% of wall blocks change to the new color (rng for percentage and which blocks). |
| Medium | 11-50% of wall blocks change to the new color (rng for percentage and which blocks). |
| Hard | 51-100% of wall blocks change to the new color (rng for percentage and which blocks). |

### 3-1-1 Representations – Type: Flip Screen

*Phase 2 Updates:*

1. No changes needed for the Phase 2 version.

*Phase 1 Specifications:*

1. SENSE\_SCREEN returns an upside-down screen.
2. There are no Easy, Medium, and Hard version for this novelty.
3. This is a static novelty where there are no novelty variations throughout the Tournament.

### 4-2-1 Agents – Type: Locksmith

*Novelty characteristics:*

1. Class, attribute, or representation change? New Class of agent.
2. Bonus, neutral, or hazard (maximum available score)? Bonus.
3. Ignorable or avoidable while still completing the task? No.
4. Requires accommodation? Yes, in all cases.
5. Paired novelty where a pre-novelty element is broken? Yes.

*Value as a shared novelty:*

1. The novelty illustrates what a new class of Actor looks like in post-novelty.
2. The novelty illustrates how a new class of impactful Actor can be added that only utilizes the Actions and Interactions already present for pre-novelty Actors.
3. This novelty illustrates a strict accommodation novelty.
4. This novelty illustrates a ‘Paired novelty’. The pre-novelty task is specifically broken where the color of the doors from Room 3 to Room 4 are a new color not seen in pre-novelty. This change is separate from the Locksmith itself and breaks the pre-novelty path to complete the task.
5. This novelty illustrates a Bonus novelty, meaning that the maximal achievable score is increased from pre-novelty. When solved optimally, the player can learn to skip the Guide and Chests and move straight to the Locksmith, saving stepCost and improving their final score.

*Specifications:*

1. A new Actor type is added with a unique appearance that is called a ‘Locksmith’ in SENSE\_ALL returns.
2. The visual appearance of the Locksmith is significantly different than the Patrols. It appears as the Minecraft character ‘Alex’.
3. The Locksmith is holding a key in its hand that is clearly visible, like the armor held by the Blue Patrol.
4. The key is color-coded and a different color than the original 3 keys present in pre-novelty.
   1. Multiple other colors are available that are clearly distinct from Red/Green/Blue and are randomly chosen from for each instance:
      1. Black, Brown, Purple, Gray, Pink, Silver, Yellow, Magenta, Orange, White
5. The door between Room 3 and Room 4 is a new color that matches the color of the key provided by the Locksmith.
6. When the TA2 uses the INTERACT command with the Locksmith, the TA2 receives the key in the same way that it gets the armor from the Blue Patrol.
7. The remainder of the task is identical to pre-novelty, meaning that the Guide Dog, chests with color-coded keys, etc. all remain as they are. This will allow us to test if the TA2 keeps attempting to do the pre-novelty task or if they learn that they can ignore the Guide Dog and other non-Locksmith keys.

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| Easy | Locksmith spawns in Room 1. |
| Medium | Locksmith spawns in Room 2 or 3. |
| Hard | Locksmith spawns in Room 0. |

### 5-1-1 Actions – Type: Throw

*Novelty characteristics:*

1. Class, attribute, or representation change? New Class of action.
2. Bonus, neutral, or hazard (maximum available score)? Neutral.
3. Ignorable or avoidable while still completing the task? Possibly, but unlikely.
4. Requires accommodation? Probably in most cases.
5. Paired novelty where a pre-novelty element is broken? No.

*Value as a shared novelty:*

1. The novelty illustrates what a new class of Action looks like in post-novelty.
2. This novelty illustrates a novelty that may or may not require accommodation depending on i) how many Red Patrols are present in the instance and ii) what strategy the TA2 uses to detect and avoid traps.
3. This novelty illustrates a novelty that negatively impacts the score without adaptation but can be overcome to return to essentially the same optimal score as pre-novelty.

*Specifications:*

1. The Red Patrol can now use the command ‘THROW’.
2. Every time the Red Patrol would place a trap with the pre-novelty PLACE command, it should instead use THROW.
3. The THROW command causes a trap to be placed at a variable distance away from the Red Patrol.
4. The Red Patrol should THROW the trap toward the current location of the TA2 Agent.
5. If the TA2 Agent is within the throw radius, the trap should appear directly next to the player.

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| Easy | Traps are THROWN up to 2-3 blocks toward the TA2, determined by RNG. |
| Medium | Traps are THROWN up to 4-5 blocks toward the TA2, determined by RNG. |
| Hard | Traps are THROWN up to 6-7 blocks toward the TA2, determined by RNG. |

### 6-1-1 Relations – Type: Sequential Doors

*Novelty characteristics:*

1. Class, attribute, or representation change? New Attribute of an existing relation.
2. Bonus, neutral, or hazard (maximum available score)? Neutral.
3. Ignorable or avoidable while still completing the task? No.
4. Requires accommodation? Yes, in all cases.
5. Paired novelty where a pre-novelty element is broken? No.

*Value as a shared novelty:*

1. The novelty illustrates what an attribute change novelty can look like in a Phase 2 novelty category.
2. This novelty illustrates a sequential relationship in addition to spatial relationships.
3. This novelty illustrates a novelty that requires accommodation in all cases without requiring a paired novelty.

*Specifications:*

1. Colored doors should be added to every walkway using the same color options present in pre-novelty (Red, Green, Blue).
2. All of the doors for a given room transition (e.g., Room 1 to Room 2 walkways, Room 2 to Room 3 walkways, etc.) should have the same color. This will mean that 1 specific key is needed to progress out of every room.
3. By default, there should only be one chest per room that has the correct key in every room. All other chests should be empty.
4. There should be a Room 1 key, Room 2 key, and Room 3 key.
5. The color-matched doors should only open when the color-matched key is used to unlock them.
6. If a door is blocking the only path to the next room, the Guide Dog will keep attempting to move to the next room until a path exists.

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| Easy | 1. All the doors in the instance are the same color. Meaning that the R1-0, R1-2, R2-3, and R3-4 doors will all be the same color.  2. A key of this color will be present in each room, but the TA2 could complete the task just by getting the key in Room 1. |
| Medium | 1. All of the doors except for R3-4 are the same color.  2. The R3-4 doors are a different color and the relevant key is only found in Room 3. |
| Hard | 1. All of the room transitions have a different color. The doors out of Room 1 (both to R2 and to R0) will randomly be one of the three colors, R2-3 doors will be a second color, and the R3-4 doors will be the third color chosen at random. |

### 7-1-1 Interactions – Type: Patrols Pursue

*Novelty characteristics:*

1. Class, attribute, or representation change? New Class of interaction.
2. Bonus, neutral, or hazard (maximum available score)? Neutral/Hazard.
3. Ignorable or avoidable while still completing the task? Sometimes, but not often.
4. Requires accommodation? Yes, in most cases.
5. Paired novelty where a pre-novelty element is broken? No.

*Value as a shared novelty:*

1. The novelty illustrates what a new class of interaction can look like in a novelty.
2. This novelty illustrates an impactful novelty that will often be solvable with a similar optimal score as pre-novelty.
3. This novelty illustrates a novelty that does not strictly require accommodation but will not be ignorable in most cases.
4. The novelty illustrates how necessary strategies and difficulty may change significantly across easy, medium, and hard difficulty levels.

*Specifications:*

1. The Red Patrols should now sometimes move toward the TA2 player, instead of only moving randomly.
2. Once the TA2 player leaves a room, the Red Patrols should return to fully random movement so they don’t bunch up at the walkway entrances near the room perimeter.
3. The density of Red Patrols and frequency of how often the Red Patrols move toward the player will be determined by difficulty, as follows:

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| Easy | 1. Every Room 2-4 should have 2 Red Patrols. Gray and Blue Patrols can still be determined randomly.  2. Every time the Red Patrol moves, it should have a 50% chance to move toward the TA2 Agent and a 50% chance to move randomly. |
| Medium | 1. Every Room 2-4 should have 3 Red Patrols. Gray and Blue Patrols can still be determined randomly.  2. Every time the Red Patrol moves, it should have a 75% chance to move toward the TA2 Agent and a 25% chance to move randomly. |
| Hard | 1. Every Room 2-4 should have 4 Red Patrols. Gray and Blue Patrols can still be determined randomly.  2. Every time the Red Patrol moves, it should have a 100% chance to move toward the TA2 Agent and a 0% chance to move randomly. |

# HUGA Task Design:

## Arena Layout:

1. The HUGA task includes 4-5 individual rooms generated in random locations relative to the starting room. Rooms are generated in a specific sequence (i.e., Room 2 with the MacGuffin will always be generated immediately adjacent to Room 1 with the TA2 Agent Spawn).
   1. Room 1 will no longer always be connected to Room 4 (as it was in Phase 1).
   2. The MacGuffin is in Room 2 (as in Phase 1).
   3. The Target is in Room 4 (as in Phase 1).
   4. Room 0 is a small room off of Room 1 in a different direction from Room 2.
2. All adjacent rooms have walkways connecting them that are open (no doors).
3. The walkways from Room 3 to Room 4 are blocked by doors of a single color. These doors can be unlocked with the color-matched key.

## Example steps to complete the HUGA Task:

1. Typical steps to complete the pre-novelty task will be as follows:
   1. Interact with the Guide,
   2. Follow the Guide to a Chest while avoiding traps and Red Patrols,
   3. Open the Chest to obtain a key,
   4. Continue this sequence until you have the key that matches the doors from Room 3 to Room 4,
   5. Obtain the MacGuffin,
   6. Unlock a door to Room 4,
   7. Move into Room 4, and
   8. Place the MacGuffin on the Target.
2. Place MacGuffin on the Target.
   1. As in Phase 1, the goal of the HUGA task is to place the MacGuffin on the Target, at which point the task ends and the TA2 agent achieves the goal.

## Objects:

1. Chests:
   1. Chests spawn with 1-6 chests per room in Rooms 0-3.
      1. In general, there will be few chests in Room 0 and the most chests in Rooms 1-3.
2. Color-coded keys:
   1. Key objects can be used to unlock doors. If a door is Red, Green, or Blue, then it will be locked by default and using the matching key on it will unlock it.
   2. To use a key first equip the key with ‘SELECT\_ITEM polycraft:key metadata’ and then open the door with the USE command.
   3. The 3 keys (Red, Green, Blue) will spawn randomly in chests in Room 1-3, often with one key in each room.
3. Doors:
   1. The walkways between Rooms 0-3 do not have doors.
   2. The walkways from Room 3 to Room 4 are blocked by doors.
   3. Doors from Room 3 to Room 4 are all the same color.
   4. Doors can be unlocked by selecting the color-matched key and using the USE command on the door.
   5. Unlocked doors can be opened using the USE command with the agent’s hand (i.e., null).
4. MacGuffin
   1. The MacGuffin spawns randomly in Room 2.
5. Target:
   1. The Target spawns randomly in Room 4.
6. Traps:
   1. Traps have a clear and easily distinguished appearance. They look like red undersea mines.
   2. If the player steps onto the same block as a trap, then the following happens:
      1. The player loses points from their stepCost (e.g., 10,000 points).
      2. The player is teleported back to their original spawn location in Room 1.
      3. The trap will disappear/de-spawn.
7. Armor:
   1. An Armor item can be acquired from the Blue Patrol agent. If the TA2 agent has ‘Armor’ equipped when they step on a trap, then the following happens:
      1. The trap is removed.
      2. They do not get teleported to the spawn point.
      3. They do not lose any points.
      4. The Armor is destroyed/removed.
   2. SENSE commands include information on if the armor is equipped on the TA2 agent.
   3. The Armor can be equipped to the TA2 agent by using the SELECT\_ITEM command on the armor followed by the USE command.

## Actors:

1. **Guide:**

*Appearance and Spawning:*

* 1. In each pre-novelty instance, 1 Guide will spawn in Room 1.
  2. The Guide has the appearance of a Dog that can be in either a ‘sitting’ state or a ‘standing’ state.
  3. SENSE return includes a state attribute (e.g., the Guide could start as state = ‘sitting’).

*Movement and Actions:*

1. The Guide does not move until the TA2 agent interacts with it using the Interact command. Upon interaction its state changes from ‘sitting’ to ‘standing’.
2. Once the TA2 interacts with the Guide, the Guide begins moving 1 step for every time-advancing action the TA2 takes. The Guide walks directly to the chest with the closest key.
   1. Actions such as SENSE, CHECK\_COST, and TURN do not advance time and thus do not trigger Actors to take actions.
3. Once the Guide gets within 1 block of the appropriate chest, it sits and its state changes from ‘standing’ to ‘sitting’.
4. When the TA2 agent interacts with the Guide again, it walks to the next nearest chest with a key and does the same sequence of behaviors. If there are no more keys, the Guide will not move following further interactions.
5. **Patrol:**

*Appearance and Spawning:*

* 1. In each pre-novelty instance, Rooms 1-4 have 1-4 Patrols spawn randomly. Red Patrols do not spawn in Room 1.
  2. For the Patrols and Guide, the TA2 has to be within 1 space (including corners) to successfully interact. If the TA2 is 2 or more spaces away, interact commands return “Fail” with an appropriate message (e.g., “You are not close enough to interact”).
  3. Patrol types spawn with the following frequency:
     1. Red Patrol = 50% (except in Room 1)
     2. Gray Patrol = 30%
     3. Blue Patrol = 20%
  4. There are three versions of the Patrol denoted by armor color.
     1. Red Patrol:
        1. Threat Status: Enemy.
        2. Places traps.
           1. The Red Patrol only starts placing traps once the TA2 Agent is in the same room as the Red Patrol.
        3. If the TA2 agent is ever within 1 space (including corners) of the Red Patrol, then the TA2 agent loses points as stepCost (e.g., 10,000 points) and is immediately teleported back to their original spawn location in Room 1.
        4. The TA2 agent is unable to ‘Interact’ with the Red Patrol because they will be teleported back to spawn before having the opportunity.
     2. Gray Patrol:
        1. Threat Status: Neutral.
        2. Places traps.
           1. The Gray Patrol places traps from the start of the instance, even if the TA2 Agent is in another room.
        3. If the TA2 agent comes near the Gray patrol, nothing happens.
        4. If the TA2 agent interacts with the Gray patrol, it will send a message (e.g., “Hello”).
     3. Blue Patrol:
        1. Threat Status: Friendly.
        2. Does not place traps.
        3. If the TA2 agent comes near the Blue patrol, nothing happens.
        4. If the TA2 agent interacts with the Blue patrol, they receive the item ‘Armor’ in their inventory and the Blue patrol will send a message stating if they do or do not have armor to give (e.g., “Here, take this armor.”).
        5. Each Blue patrol only has one piece of armor to give out, if the TA2 interacts to get a second piece of armor the Blue Patrol will send a message indicating it has no more armor to give.
        6. The armor is clearly visible as an item being held by the Blue Patrol when the Blue Patrol has armor to give.

*Actions:*

1. Speed: The Patrol takes a single action for every 2 actions the TA2 agent takes.
   1. This excludes SENSE commands, CHECK\_COST commands, TURN, and other commands that do not advance time.
2. Movement:
   1. The Patrols do not pass between rooms and stay in their spawn room.
3. Place trap:
   1. The Red and Gray patrols place traps one block away from their current location in either the X or Z direction. Traps are placed approximately 25-33% of actions for the Red and Gray patrols as long as they have remaining traps. Each Red and Gray patrol has 4-6 traps total. After placing all of their traps, the Red and Gray patrols will continue moving and will not place more traps.

## API:

1. NOP
   1. The command NOP can be sent to advance time by one turn without taking an action for the TA2 agent. This could be useful if the Agent wants to wait for a specific future state without changing location. NOP does not have a stepCost.
2. DELETE [block/item name] [integer/how many to delete]
   1. This is to prevent edge cases where an agent may fill their inventory with seeds, logs, etc. and be unable to proceed.
   2. API Command: DELETE [block/item name]
   3. StepCost: Free
3. SELECT\_ITEM [block/item name]
   1. You can now pass no parameters to deselect the current item
4. USE
   1. Previously USE\_HAND
   2. This will perform the “USE” action with the currently selected item as a parameter.
5. PLACE [block/item name]
   1. Previously “PLACE\_BLOCK”
   2. Used to attempt to place a block or item
6. COLLECT
   1. Replaces “EXTRACT\_RUBBER”
      1. Step cost for extracting rubber will remain the same
   2. Collecting from other objects has a much lower step cost of 1200
7. TRADE [entityID] [item 1] [qty] [item 2] [qty] [item 3] [qty] [item 4] [qty] [item 5] [qty]
   1. Similar to craft but used for trading. Trades have up to 5 slots in and 5 slots out. But we are only using one slot in and one slot out currently.
8. INTERACT [entityID]
   1. This command is similar to SENSE\_RECIPES in that it returns the list of available trades with the Trading Villager.
9. Partial Observability with SENSE commands:
   1. SENSE commands only sense objects in the same room as the player
      1. This includes the edge wall blocks of the room, but not adjacent rooms.

## Task Goal and Steps:

1. Typical steps to complete the pre-novelty task will be as follows: Interact with the Guide, Follow the Guide to a Chest while avoiding traps and enemies, Open the Chest to obtain a key, Continue this sequence until you have the key that matches the doors from Room 3 to Room 4, Obtain the MacGuffin, Unlock a door to Room 4, Move into Room 4 and place the MacGuffin on the Target.
2. Place MacGuffin on the Target.
   1. As in Phase 1, the goal of the HUGA task is to place the MacGuffin on the Target, at which point the task ends and the TA2 agent achieves the goal.

# Appendix A: Change Log

- An up-to-date change log for Polycraft AI Lab can be found on GitHub in the ChangeLog.txt file.