ARL Battlespace v1.2

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[*https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11746/1174615/Battlespace--using-AI-to-understand-friendly-vs-hostile-decision/10.1117/12.2585785.full?SSO=1*](https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11746/1174615/Battlespace--using-AI-to-understand-friendly-vs-hostile-decision/10.1117/12.2585785.full?SSO=1)

*J. Zachary Hare, B. Christopher Rinderspacher, Sue E. Kase, Simon Su, Chou P. Hung, "Battlespace: using AI to understand friendly vs. hostile decision dynamics in MDO," Proc. SPIE 11746, Artificial Intelligence and Machine Learning for Multi-Domain Operations Applications III, 1174615 (12 April 2021); https://doi.org/10.1117/12.2585785*

**These instructions are for Python game and AI development only.**

**Due to COVID restrictions, and consistent with the ARL 20-119 Exemption Determination Letter, any game play with people outside your household (friends or co-workers) must be remote or via Teams (e.g. by telephone or an online app).**

This is a strategy game called ARL Battlespace, which is similar to Axis and Allies and Battleship. Please download and print the game and instructions to play. The printable instructions in /boardgame/battlespace\_gameboard\_8.5x11paper.v1.2.pdf are for a 2-humans-versus-2-AIs game. You must install the folder dfvc2HareFork on a Linux system to play. You can play as both humans by starting 1 server and 2 clients (i.e. 3 terminals).

The goal of this project is to develop novel AIs as decision aids. The AIs in this game take random actions, either from a uniform distribution or from a human-derived distribution. The focus of this project is to modify the AIs based on reinforcement learning, and in particular to tackle multiplayer decision-making.

After playing, please contact Chou Hung ([chou.p.hung.civ@army.mil](mailto:chou.p.hung.civ@army.mil)) if you have any questions. We would be interested in your comments on 1) What were the hard decisions in your game? Were there any scenarios with game theory, especially involving 3 or more players? 2) Can you suggest how to change the game, to increase the number of hard decisions?

[For examples of game theory, please see slides 10-12 of http://www.maths.lse.ac.uk/personal/stengel/gt-politics.pdf]

**Game description:**

The game is for 2 human players vs 2 AI players. The objective of the game is to defeat the opposing team, either by destroying their pieces or capturing their flags (capturing a flag destroys all pieces of that color). Players are grouped into 2 teams.

Team 0 (AIs): black (Agent 0), black (Agent 1)

Team 1 (humans): red (Agent 2, NW quadrant), yellow (Agent 3, NE quadrant)

**Game setup:**

* Each player gets 1 game board with air and land grids
* Each player’s pieces consist of:
  + 1 Truck (1 square)
  + 1 Soldier (1 square)
  + 1 Tank (1 square)
  + 1 Airplane (1 square; airborne early warning and control, AEW&C)
  + 1 Flag (1 square)
  + Missiles (1 square; long range precision fires, LRPF)
* Each player’s game board is visible to only himself/herself and his/her teammates during initial placement, and remains visible to teammates during the game. Each piece has a visibility of 1 square in any direction.
* Each player places his/her flag and pieces within his/her quadrant.
  + Red (Human 1): Northwest
  + Yellow (Human 2): Northeast
  + Black (AI Agent 0): Southwest
  + Black (AI Agent 1): Southeast
* The flag and piece locations are initially hidden to opposing players. Pieces are initially oriented facing the opposing team. On each turn, a piece may be reoriented in any direction horizontally (East-West), vertically (North-South), or diagonally. Ground pieces are at z=0 and may not overlap each other or the flag, as collisions result in mutual destruction. Ground pieces are also destroyed if they collide with the wall (mines). The airplane may start anywhere within the player’s color zone, at z=1. Teammates should coordinate their flag, piece placements, and strategy. Capturing a player’s flag removes all of his/her pieces from the game and the player may not continue to play, even in an advisory role, once all of his/her ground pieces are lost.

**Piece descriptions:**

* **Airplane:** 
  + Health: The airplane has 1 health.
  + Movement: The Airplane may move up to 2 squares in any direction (2 up/2 down/2 left/2 right, 1 diagonal). They may also remain in their current location.
  + Orientation: The orientation of the airplane does not matter for movements but matters for firing missiles.
  + Observations: The airplane can view any opposing player’s ground piece within 1 square of their location, including diagonal squares.
  + Attacks: On each turn, an airplane can fire one missile, or drop one bomb on the square below.
  + Defense: None
* **Truck/Tank/Soldier (for now, all ground units are identical):**
  + Health: Each ground unit has 1 health.
  + Movement: Each unit may turn towards any direction, or advance by 1 square, or advance and attack simultaneously by 1 square (‘ram’). They may also remain in their current location.
  + Orientation: The orientation matters for both advancing and for shooting/firing missiles.
  + Observations: Each unit can view any opposing player’s ground piece within 1 square of their location, including diagonal squares.
  + Attacks: On each turn, the unit can fire one missile, or ram the square ahead, or capture the flag in the square ahead. If two units ram the same square, both units are destroyed.
  + Defense: None
* **Missiles:** Missiles continue advancing 1 square per turn, until they collide with another unit or missile, or until they exit the gameboard.
* **Flag:**
  + Health: The flag does not have health.
  + Movement: The flag cannot move and must remain in its initial location throughout the entire game.
  + Orientation: The orientation does not matter.
  + Observations: The flag does not observe opposing players pieces.
  + Attacks: None
  + Defense: None. Flags can only be captured by moving a ground piece to their square. They cannot be captured by airplanes or missiles.

**Game play:**

The game consists of the following two steps:

1. **Step 0 (Initial Placement):** After both human players have started their clients, each player places his/her units on the gameboard in the yellow highlighted area by left-clicking with a mouse. Ground pieces are at z=0, airplane is at z=1. Pieces are oriented facing the opposing force (i.e. facing South).
2. **Step 1 (Actions):** After both players have placed their pieces, play alternates from player to player. At the start of each turn, the player is updated on the status of the game board, including the locations of missiles and whether any pieces have been destroyed. Note that the missile orientation of the opposing team is intentionally wrong to incorporate uncertainty and deception. The player should communicate this information to his teammate. The player then selects from a set of actions for each unit. Upon completing the choice of actions, it is the next player’s turn. Play continues until one team loses all of its ground pieces, and/or all of its flags.

**Winners:**

The team with ground pieces still on the board.