SimpAI: Evolutionary Heuristics for the ColorShapeLinks Board Game Competition

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Purpose

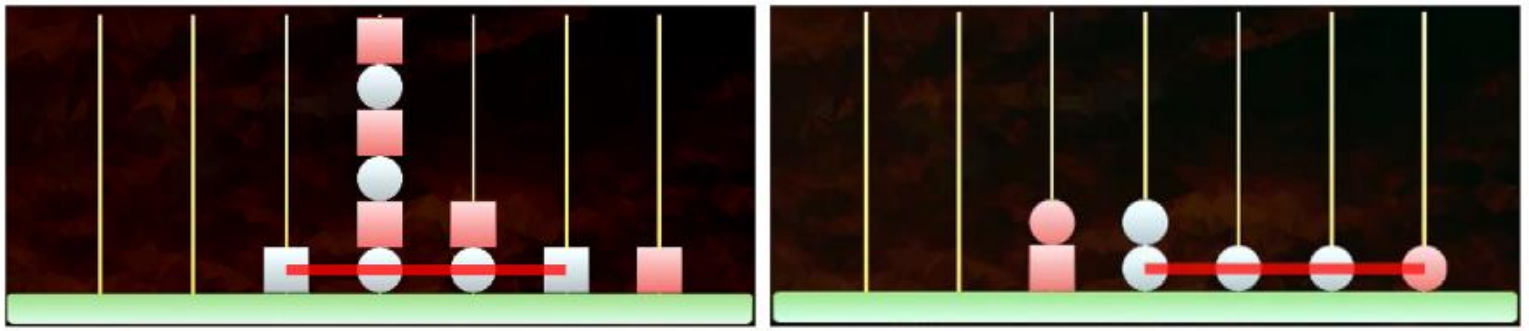
- To build an AI agent uses a highly efficient parallelized Mininmax-type search, with a heuristic function composed of several partial heuristics, the balance of which was optimized with an evolutionary algorithm.

Background -- ColorShapeLinks

- ColorShapeLinks is an AI board game competition framework specially designed for students and educators in videogame development, with openness and accessibility in mind.

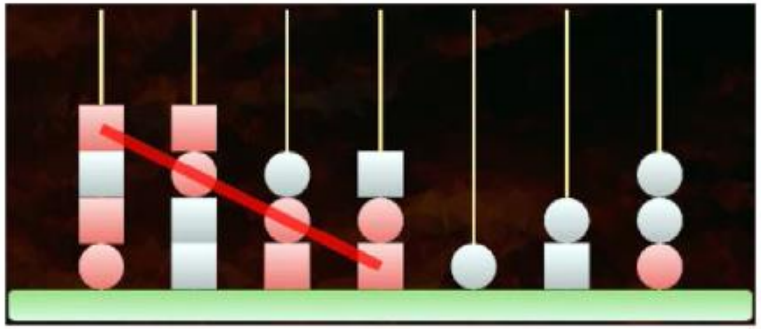
- Game - Simplexity

Background -- Simplexity

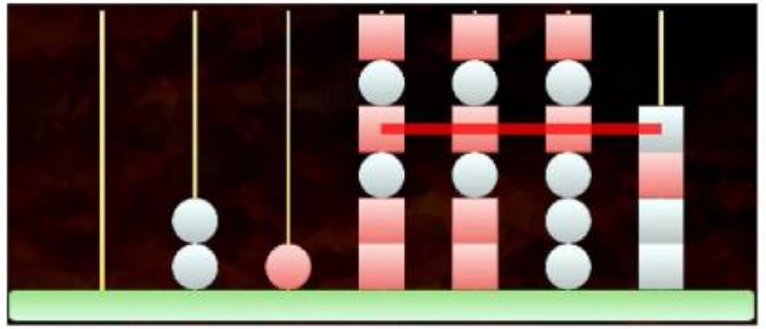


(a) White wins with white pieces.

(b) White wins with round pieces.

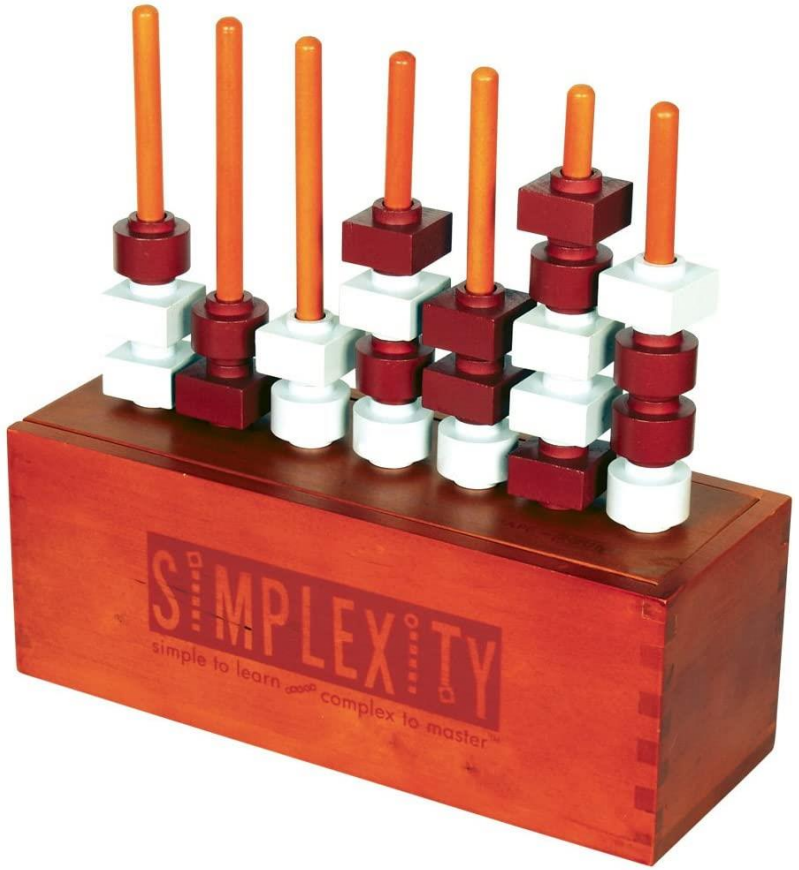


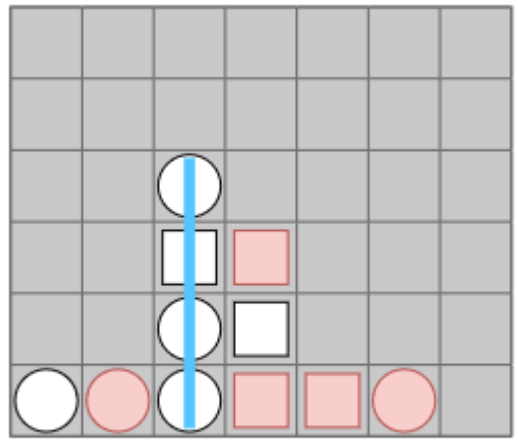
(c) Red wins with red pieces.



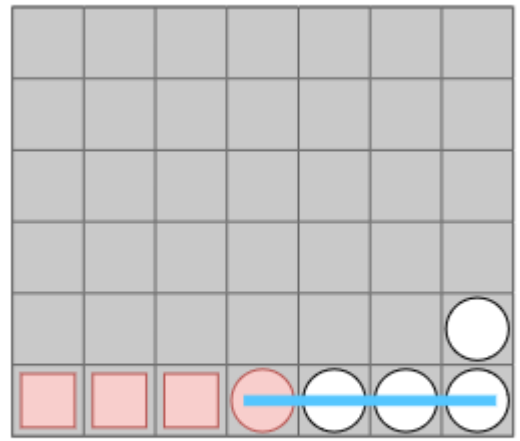
(d) Red wins with square pieces.

Fig. 1. Possible victory conditions in ColorShapeLinks using standard Simplexity rules.

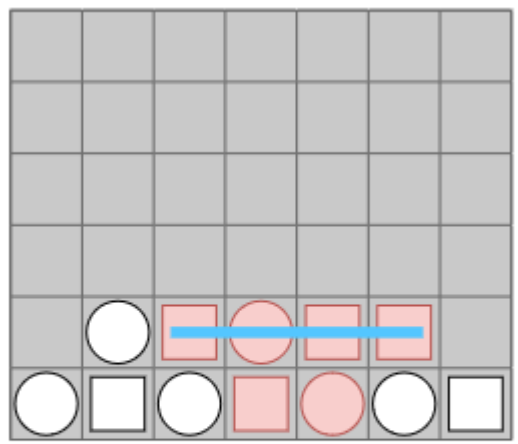




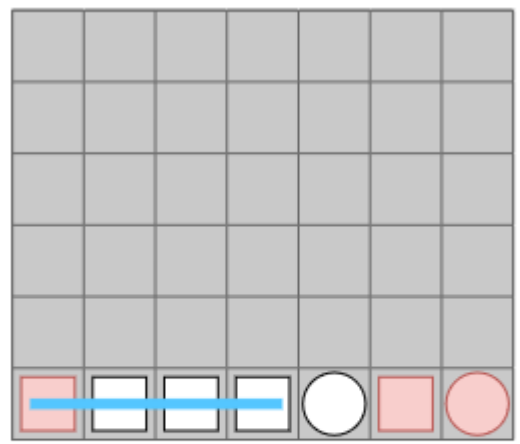
(a) Color victory for white player.



(b) Shape victory for white player.



(c) Color victory for red player.

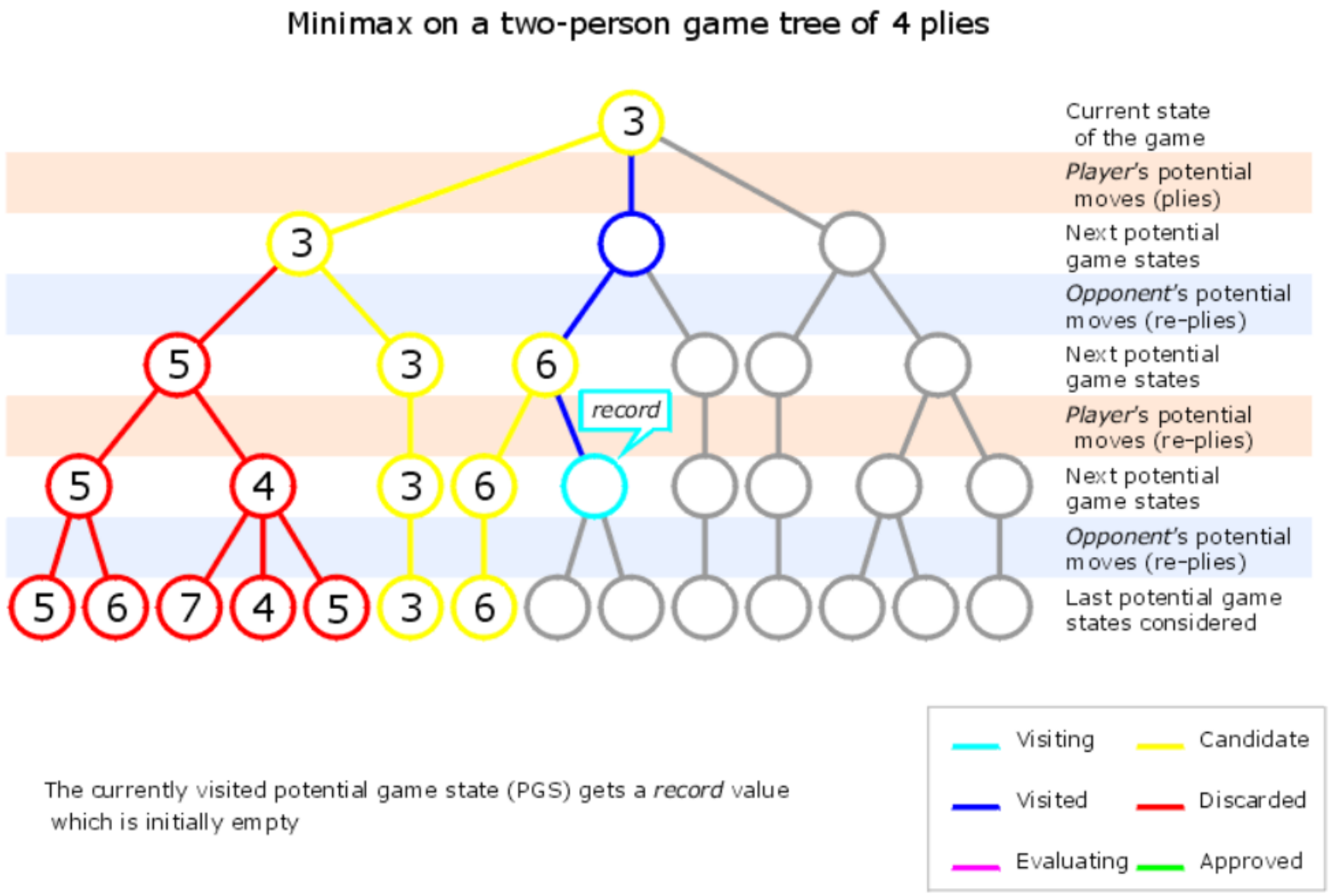


(d) Shape victory for red player.

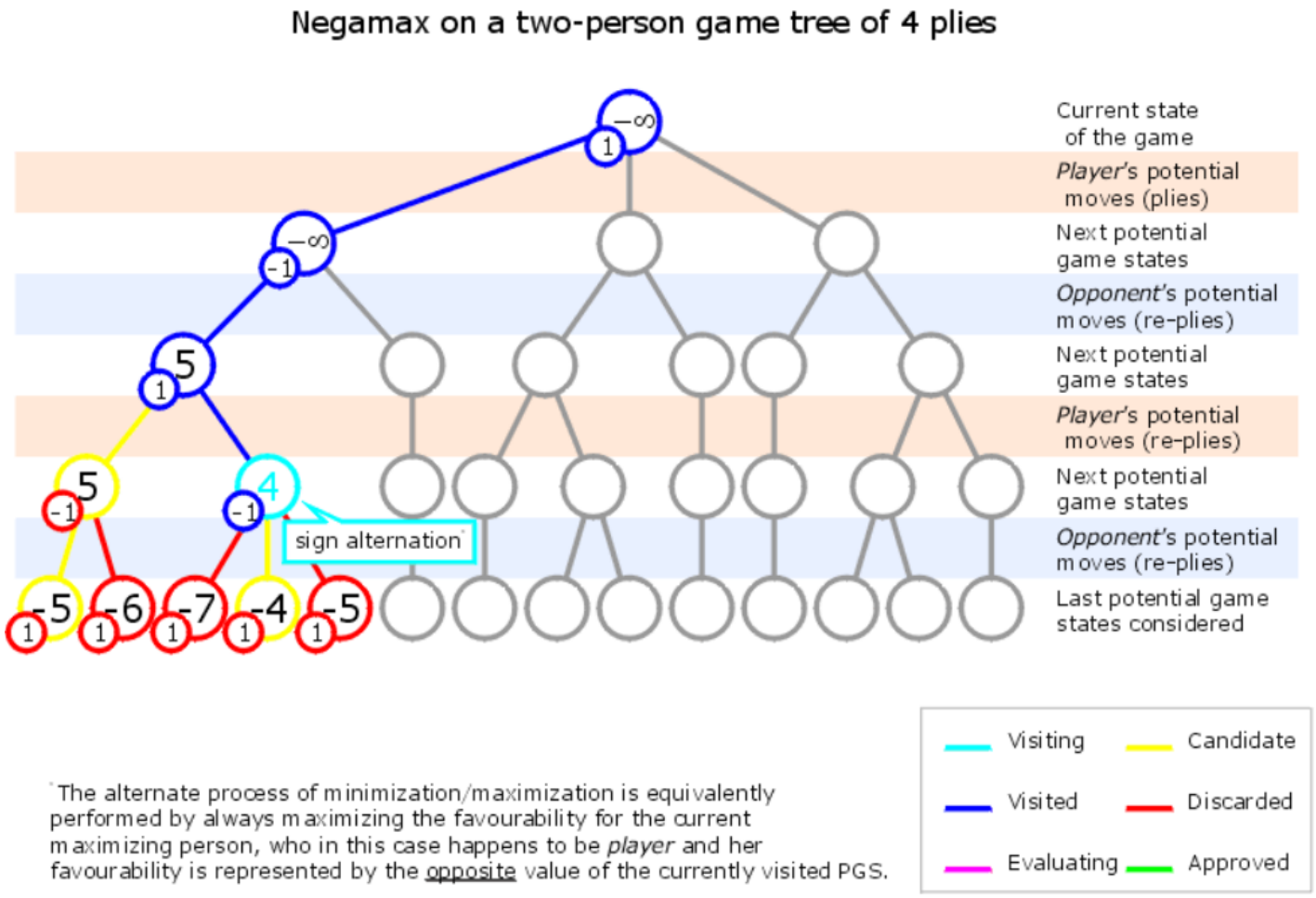
Method

- The implementation is divided into two different parts, which work together to form SimpAI:
- The search algorithm, used to search for promising future moves in the time it has available to think
- The heuristic, used to classify future board states according to their strategic value, thus guiding the search algorithm towards finding the best move.
- In practice, the heuristic is a combination of several partial heuristics. These are weighted in order to give the final heuristic value for each board state. The optimized weights were obtained using an evolutionary algorithm.

The search algorithm - Negamax algorithm

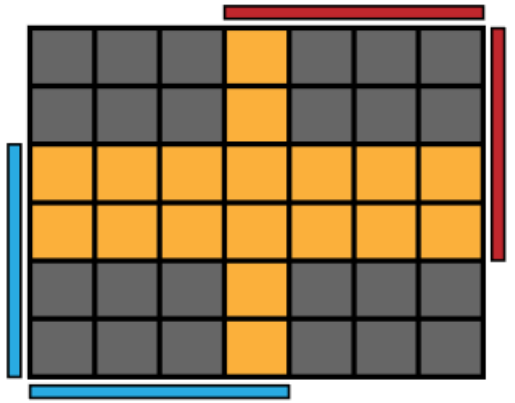


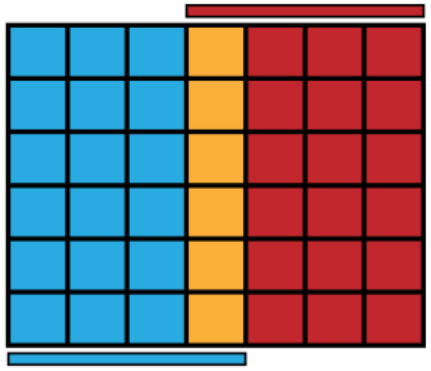
The search algorithm - Negamax algorithm

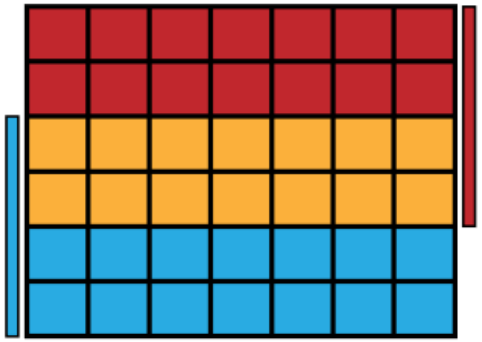


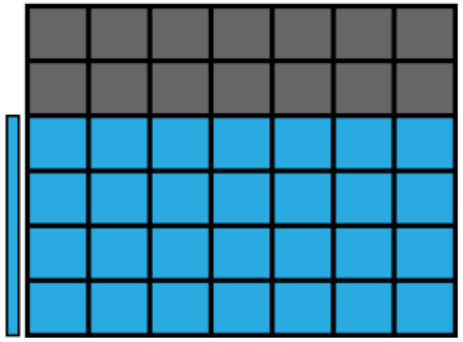
Heuristics

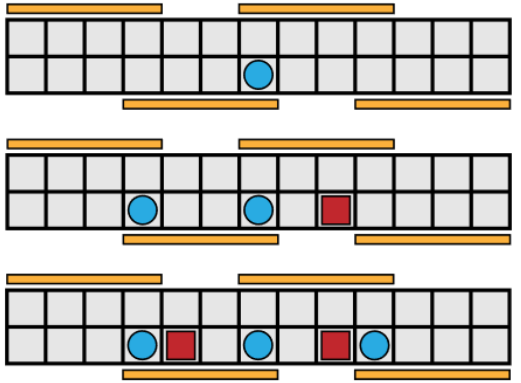
- The heuristic value for each board state is determined by the weighted sum of five partial heuristics
  - HorizCenterHeuristic
  - VertCenterHeuristic
  - VertDiscHeuristic
  - BuildFromAfarHeuristic
  - DumpFromAfarHeuristic











Heuristic Weight Optimization with Evolutionary Algorithms

Individual				
HorizCenterHeuristic weight	*VertCenterHeuristic* weight	*VertDiscHeuristic* weight	*BuildFromAfarHeuristic* weight	*DumpFromAfarHeuristic* weight

- The algorithm population is composed of n individuals representing SimpAI agent instances, with various partial heuristic weights
- Individuals in the first generation are initialized with random weights
- The fitness of individuals in each generation is given by their score in a ColorShapeLinks competition between them.

Heuristic Weight Optimization with Evolutionary Algorithms

Table 1: Parameters used for the evolutionary algorithm runs.

Param.	Value	Description
n	50	Population size
l	500	Number of generations
p_c	0.4	Crossover probability for pairs of individuals
p_{c_a}	0.5	Crossover probability for each attribute
p_m	0.2	Mutation probability per individual
p_{m_a}	0.5	Mutation probability for each attribute
μ	0.0	Mean of normal distribution used for mutation
σ	0.25	Standard deviation of normal distribution used for mutation

Table 2: Weights of the partial heuristics for the best individuals in five runs of the evolutionary algorithm. Position (Pos.) refers to the position of the individual in a final competition between these individuals.

Heuristic \ Pos.	1st	2nd	3rd	4th	5th
HorizCenter	0.5386	0.8322	1.0383	0.9882	0.7913
VertCenter	4.5551	8.0820	0.1755	6.9733	5.4766
VertDisc	-0.9044	-0.5215	8.4260	0.2584	0.0797
BuildFromAfar	2.9906	2.2055	3.4491	2.3593	5.5618
DumpFromAfar	4.9090	6.7064	3.3461	6.7073	4.1143

Result - The ColorShapeLinks Competition

Table 3: Configurations for the two competition tracks.

Parameter	Value	
	Base Track	*Unknown Track*
Rows	6	8
Columns	7	13
Win Sequence	4	4
Round Pieces	10	26
Square Pieces	11	26
Time Limit (ms)	200	325

Base Track : 6th position. Last position
Unknown Track: 2nd position

The Base Track, was run on Simplexity's default board configuration. Here, agents were limited to one CPU core.

The second session, the Unknown Track, was held in a configuration to be defined by the results of that week's EuroMillions draw, after the final submission deadline. This way, the AI agents were unable to specifically prepare for this configuration. There were no limits in the access to the CPU cores, with the AIs being able to take full advantage of the available computing power, provided multithreading was implemented.

Discussion

- The poor result of SimpAI in the Base Track can most likely be attributed to the track's technical restrictions, which limited computing power to one CPU processor

- They talked a bout the heuristics factors a lot but I won't put it here.