AI for Games and Puzzles – Assignment 1

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I wrote a method that builds a tree with the 5 specified parameters of branching factor, horizon, desired value, approximation and interestingness threshold.

The tree is constructed in a breadth first fashion, building out daughter nodes level by level, until the horizon is reached.

I then work backwards and add noise to the values stored in the node, to simulate having a proper static evaluation function rather than using the true search based value.

Daughter nodes are created to fit the negamax style of the search algorithms. One daughter has the negated value of its parent node, while its siblings have values

The tree has a non-uniform branching factor, with the variance coming the chance values given in the assignment specification.

To create a tree of non-uniform depth, when generating daughter nodes I made it so that there is a 10% chance that for any node, no daughters will be created.

Each node is considered and marked interesting based on the formula given in the specification, which takes into account a node's depth relative to the root node.

For the Negamax-style alpha-beta algorithm I basically just translated the pseudocode given in the lecture slides into Java.

As well as this I added a counter to keep track of the number of evaluations performed during a search.

Similarly, the algorithm for Selective Quiescence Search is also essentially just translated pseudocode.

Note 1: Due to the manner in which I built my trees, tree building stops once the horizon point has been reached. As such, even if quiescence search deems a node interesting and worth continuing searching, there is nothing for it to search and so it doesn't improve on the alpha beta search that I implemented.

Note 2: Due to an OutOfMemoryError in Java, I was not able to compute results for a tree with a branching factor of 11 and a horizon of 7. It seems the most my computer could handle was about 15 million nodes, compared to the 20 million needed for such a game tree.

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After analysing the results below, I concluded that alpha beta greatly reduces the computational load of searching a game tree, removing redundant paths of exploration.

If my quiescence search was able to produce results that properly improved on alpha beta search, I would have seen how selective quiescence search can avoid the horizon effect and produce more accurate results. As my quiescence search didn't improve over my alpha beta search implementation, I did not include the results of said search in this report.

Below you will find the raw data dealing with the number of evaluations performed per search of each of the 12 generated game trees. The data is there to see but is not of all that much value overall.

Where a search conducted 0 evaluations, due to the way I created my trees with a 10% chance of a node not producing any daughters, occasionally, a root node would not produce any daughters.

And so we are left with a tree that consists solely of a root node.

I realise that this is not a proper representation of a game (in what game from the outset could there be no possible moves?) but left these results in anyway in the interest of fairness and transparency.

Experimentation:

AlphaBeta Search:

h= 4, b=3, approx. = 100

Evals at h: 38	Evals at h-1: 20	Evals at h-2: 10
Evals at h: 33	Evals at h-1: 16	Evals at h-2: 8
Evals at h: 69	Evals at h-1: 28	Evals at h-2: 10
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 75	Evals at h-1: 31	Evals at h-2: 11
Evals at h: 26	Evals at h-1: 15	Evals at h-2: 8
Evals at h: 39	Evals at h-1: 23	Evals at h-2: 10
Evals at h: 48	Evals at h-1: 24	Evals at h-2: 10
Evals at h: 64	Evals at h-1: 30	Evals at h-2: 12
Evals at h: 30	Evals at h-1: 14	Evals at h-2: 6
Evals at h: 26	Evals at h-1: 10	Evals at h-2: 4
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0

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h= 5, b=3, approx. = 100

Evals at h: 120	Evals at h-1: 63	Evals at h-2: 29
Evals at h: 167	Evals at h-1: 75	Evals at h-2: 32
Evals at h: 85	Evals at h-1: 46	Evals at h-2: 24
Evals at h: 140	Evals at h-1: 68	Evals at h-2: 32
Evals at h: 127	Evals at h-1: 56	Evals at h-2: 27
Evals at h: 129	Evals at h-1: 60	Evals at h-2: 26
Evals at h: 77	Evals at h-1: 38	Evals at h-2: 19
Evals at h: 46	Evals at h-1: 26	Evals at h-2: 17
Evals at h: 108	Evals at h-1: 48	Evals at h-2: 21
Evals at h: 94	Evals at h-1: 45	Evals at h-2: 23
Evals at h: 133	Evals at h-1: 65	Evals at h-2: 31
Evals at h: 90	Evals at h-1: 43	Evals at h-2: 21

h= 6, b=3, approx. = 100

Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 167	Evals at h-1: 86	Evals at h-2: 44
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 272	Evals at h-1: 144	Evals at h-2: 70
Evals at h: 268	Evals at h-1: 134	Evals at h-2: 60
Evals at h: 186	Evals at h-1: 98	Evals at h-2: 46
Evals at h: 185	Evals at h-1: 102	Evals at h-2: 50
Evals at h: 217	Evals at h-1: 112	Evals at h-2: 54
Evals at h: 140	Evals at h-1: 70	Evals at h-2: 33
Evals at h: 119	Evals at h-1: 67	Evals at h-2: 36
Evals at h: 240	Evals at h-1: 120	Evals at h-2: 54
Evals at h: 219	Evals at h-1: 102	Evals at h-2: 45

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h= 7, b=3, approx. = 100

Evals at h: 321	Evals at h-1: 171	Evals at h-2: 98
Evals at h: 148	Evals at h-1: 78	Evals at h-2: 44
Evals at h: 343	Evals at h-1: 171	Evals at h-2: 90
Evals at h: 576	Evals at h-1: 295	Evals at h-2: 151
Evals at h: 458	Evals at h-1: 227	Evals at h-2: 113
Evals at h: 653	Evals at h-1: 329	Evals at h-2: 158
Evals at h: 319	Evals at h-1: 163	Evals at h-2: 75
Evals at h: 144	Evals at h-1: 72	Evals at h-2: 39
Evals at h: 385	Evals at h-1: 200	Evals at h-2: 108
Evals at h: 129	Evals at h-1: 71	Evals at h-2: 40
Evals at h: 272	Evals at h-1: 143	Evals at h-2: 75
Evals at h: 1	Evals at h-1: 1	Evals at h-2: 1

h= 4, b=7, approx. = 100

Evals at h: 544	Evals at h-1: 145	Evals at h-2: 32
Evals at h: 399	Evals at h-1: 112	Evals at h-2: 24
Evals at h: 485	Evals at h-1: 139	Evals at h-2: 38
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 467	Evals at h-1: 150	Evals at h-2: 30
Evals at h: 301	Evals at h-1: 98	Evals at h-2: 21
Evals at h: 410	Evals at h-1: 119	Evals at h-2: 29
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 485	Evals at h-1: 133	Evals at h-2: 31
Evals at h: 462	Evals at h-1: 134	Evals at h-2: 29
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 484	Evals at h-1: 134	Evals at h-2: 33

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h= 5, b=7, approx. = 100

Evals at h: 2260	Evals at h-1: 587	Evals at h-2: 167
Evals at h: 2749	Evals at h-1: 741	Evals at h-2: 208
Evals at h: 3153	Evals at h-1: 855	Evals at h-2: 244
Evals at h: 1944	Evals at h-1: 544	Evals at h-2: 171
Evals at h: 1748	Evals at h-1: 491	Evals at h-2: 145
Evals at h: 1267	Evals at h-1: 340	Evals at h-2: 101
Evals at h: 1833	Evals at h-1: 490	Evals at h-2: 144
Evals at h: 1518	Evals at h-1: 402	Evals at h-2: 110
Evals at h: 1376	Evals at h-1: 405	Evals at h-2: 120
Evals at h: 1452	Evals at h-1: 445	Evals at h-2: 136
Evals at h: 1626	Evals at h-1: 455	Evals at h-2: 122
Evals at h: 1382	Evals at h-1: 344	Evals at h-2: 102

h= 6, b=7, approx. = 100

Evals at h: 3106	Evals at h-1: 1017	Evals at h-2: 261
Evals at h: 7986	Evals at h-1: 2398	Evals at h-2: 673
Evals at h: 7302	Evals at h-1: 2101	Evals at h-2: 592
Evals at h: 6466	Evals at h-1: 1874	Evals at h-2: 552
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 5223	Evals at h-1: 1635	Evals at h-2: 467
Evals at h: 7009	Evals at h-1: 2197	Evals at h-2: 599
Evals at h: 8037	Evals at h-1: 2389	Evals at h-2: 726
Evals at h: 3338	Evals at h-1: 1162	Evals at h-2: 328
Evals at h: 4832	Evals at h-1: 1548	Evals at h-2: 409
Evals at h: 6573	Evals at h-1: 1983	Evals at h-2: 556
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0

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h= 7, b=7, approx. = 100

Evals at h: 30831	Evals at h-1: 9302	Evals at h-2: 2709
Evals at h: 18210	Evals at h-1: 5286	Evals at h-2: 1649
Evals at h: 16419	Evals at h-1: 4657	Evals at h-2: 1524
Evals at h: 16361	Evals at h-1: 4470	Evals at h-2: 1452
Evals at h: 24416	Evals at h-1: 7010	Evals at h-2: 2204
Evals at h: 24101	Evals at h-1: 6969	Evals at h-2: 2212
Evals at h: 17585	Evals at h-1: 5022	Evals at h-2: 1522
Evals at h: 15062	Evals at h-1: 4447	Evals at h-2: 1328
Evals at h: 18238	Evals at h-1: 5596	Evals at h-2: 1627
Evals at h: 14576	Evals at h-1: 4387	Evals at h-2: 1318
Evals at h: 21210	Evals at h-1: 6026	Evals at h-2: 1735
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0

h= 4, b=11, approx. = 100

Evals at h: 899	Evals at h-1: 214	Evals at h-2: 37
Evals at h: 1634	Evals at h-1: 355	Evals at h-2: 64
Evals at h: 1671	Evals at h-1: 390	Evals at h-2: 63
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 1379	Evals at h-1: 313	Evals at h-2: 53
Evals at h: 1777	Evals at h-1: 372	Evals at h-2: 67
Evals at h: 2129	Evals at h-1: 499	Evals at h-2: 73
Evals at h: 1177	Evals at h-1: 292	Evals at h-2: 42
Evals at h: 1835	Evals at h-1: 421	Evals at h-2: 71
Evals at h: 1190	Evals at h-1: 253	Evals at h-2: 52
Evals at h: 1399	Evals at h-1: 318	Evals at h-2: 61
Evals at h: 2030	Evals at h-1: 402	Evals at h-2: 78

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h= 5, b=11, approx. = 100

Evals at h: 6332	Evals at h-1: 1228	Evals at h-2: 298
Evals at h: 5384	Evals at h-1: 1052	Evals at h-2: 255
Evals at h: 7028	Evals at h-1: 1530	Evals at h-2: 364
Evals at h: 5324	Evals at h-1: 1053	Evals at h-2: 273
Evals at h: 8567	Evals at h-1: 1790	Evals at h-2: 404
Evals at h: 5540	Evals at h-1: 1064	Evals at h-2: 272
Evals at h: 7805	Evals at h-1: 1721	Evals at h-2: 394
Evals at h: 6586	Evals at h-1: 1455	Evals at h-2: 322
Evals at h: 8821	Evals at h-1: 1791	Evals at h-2: 418
Evals at h: 7952	Evals at h-1: 1635	Evals at h-2: 345
Evals at h: 8721	Evals at h-1: 1916	Evals at h-2: 401
Evals at h: 9570	Evals at h-1: 2052	Evals at h-2: 428

h=6, b=11, approx. = 100

Evals at h: 14245	Evals at h-1: 3787	Evals at h-2: 720
Evals at h: 38241	Evals at h-1: 8965	Evals at h-2: 1890
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 0	Evals at h-1: 0	Evals at h-2: 0
Evals at h: 32251	Evals at h-1: 7412	Evals at h-2: 1559
Evals at h: 24612	Evals at h-1: 5844	Evals at h-2: 1209
Evals at h: 24102	Evals at h-1: 5559	Evals at h-2: 1235
Evals at h: 38158	Evals at h-1: 8738	Evals at h-2: 1896
Evals at h: 35311	Evals at h-1: 7900	Evals at h-2: 1749
Evals at h: 30284	Evals at h-1: 6925	Evals at h-2: 1564
Evals at h: 28521	Evals at h-1: 6717	Evals at h-2: 1450
Evals at h: 32055	Evals at h-1: 7425	Evals at h-2: 1560

Note 3: To avoid an overly long report, I only documented here the results with the approximation value=100. When I conducted experiments with said approx. value=200 and 300, the results produced were by and large the same as with approx.=100 and so I didn't think merited taking up another 12 or so pages of report.