**Homework #4**

1. My homework 4 was implemented using Python 3 scripts from command line. The minimax algorithm was implemented recursively. Alpha-beta pruning was also added to reduce the number of nodes expanded and significantly improve performance. The experiments were conducted on a Windows machine with Intel i5-6600K (3.50GHz, 4 Cores) CPU. No existing code was implemented.
2. Example Game (player 1 plays ‘1’, player 2 plays ‘2’):

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|  | 1 | 2 | 1 |  |  |
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|  | 1 | 2 | 1 |  |  |
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|  |  | 1 |  |  |  |
|  | **2** | **2** | **2** | **2** |  |
|  |  | 2 | 1 |  |  |
|  | 1 | 2 | 1 |  |  |
|  |  | 1 | 1 |  |  |
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For the above turns, the following are the number of nodes expanded and the execution time:

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| Turn | Player | Nodes Expanded | Execution Time (s) | Execution Time (ms) |
| 1 | 1 | 0 (start selection) | 0 | 0 |
| 2 | 2 | 596,475 | 166.32862 | 166,328.62 |
| 3 | 1 | 1,156 | 0.40724 | 407.24 |
| 4 | 2 | 433,993 | 143.84645 | 143,846.45 |
| 5 | 1 | 1,024 | 0.24078 | 240.78 |
| 6 | 2 | 207,529 | 50.26387 | 50,263.87 |
| 7 | 1 | 900 | 0.26306 | 263.06 |
| 8 | 2 | 142,987 | 44.18276 | 44,182.76 |
| 9 | 1 | 784 | 0.23423 | 234.23 |
| 10 | 2 | 75,837 | 10.10875 | 10,108.75 |
| 11 | 1 | 676 | 0.32112 | 321.12 |
| 12 | 2 | 135,726 | 10.21714 | 10,217.14 |

1. Multi-game experiments
   1. For an experiment of 20 games with Player 1 taking the first turn, Player 1 won no games, Player 2 won 12 games (60%), and there were 8 draws (40%).
   2. For an experiment of 20 games with Player 2 taking the first turn, Player 1 won no games, Player 2 won 20 games (100%), and there were no draws.