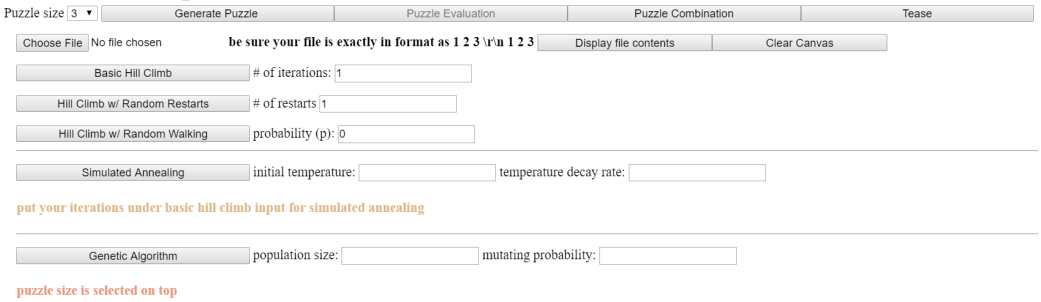
Assignment 1 Local Search Report
By Brandon Young and Ruicheng Wu

Task 1. Puzzle Representation

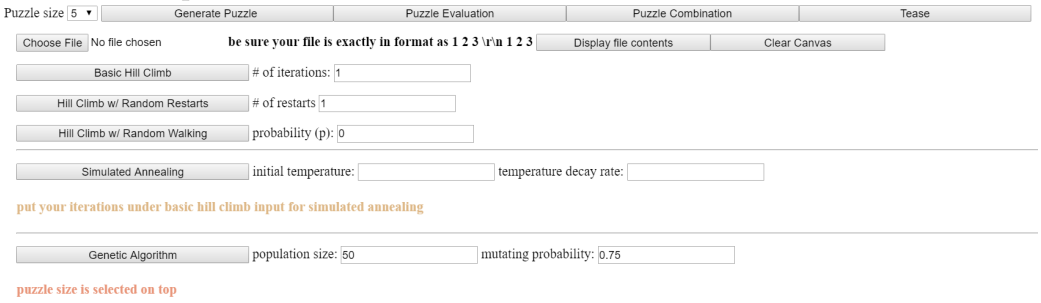
GUI Example 1:



1	2	1
1	1	1
1	1	0

0	1	4
1	2	3
2	2	3

GUI Example 2:



2	3	2	3	1
3	2	1	1	1
4	1	1	2	1
1	1	2	1	1
1	1	2	1	0

Task 2. Puzzle Evaluation

The puzzle is on the left, while the BFS output is on the right. The following shows 2 puzzles for each possible size, one that is solvable and one that is unsolvable

1. 5x5 (Solvable):

1	1	4	1	1
1	1	2	1	1
4	1	1	2	1
1	3	1	1	1
2	1	1	1	0

0	1	2	5	5
1	2	3	5	4
2	3	4	4	3
X	4	4	5	4
5	4	3	4	5

2. 5x5 (Unsolvable):

3	4	2	1	1
3	2	1	1	1
2	3	2	1	1
4	1	2	1	2
3	2	1	2	0

0	X	2	1	2
6	4	3	2	3
4	6	3	3	4
1	5	3	4	2
5	5	4	5	X

3. 7x7 (Solvable):

1	3	1	4	5	3	1
6	1	1	2	1	2	2
1	4	4	3	1	1	1
1	4	1	3	2	2	1
4	4	2	3	1	1	2
6	2	1	3	1	1	1
3	1	3	2	1	1	0

0	1	7	5	2	X	X
1	5	6	4	3	4	2
6	6	7	5	4	5	4
5	2	6	4	5	3	3
6	X	7	5	4	5	4
5	7	X	4	3	4	5
7	6	7	5	4	5	5

4. 7x7 (Unsolvable):

4	1	5	4	2	1	5
1	3	1	1	3	1	1
4	3	1	1	3	3	2
6	4	3	1	1	1	1
1	2	4	1	1	2	1
6	2	2	1	3	3	4
2	1	1	1	3	2	0

0	3	2	7	1	6	2
X	4	7	6	5	5	4
X	3	6	5	2	5	4
2	5	4	4	5	4	3
1	2	4	3	4	5	4
2	4	3	4	3	6	3
4	3	4	5	6	6	X

5. 9x9 (Solvable):

8	1	3	7	1	3	1	5	4
2	2	5	7	7	5	4	6	2
5	1	4	1	6	4	1	1	3
4	3	3	3	4	4	1	1	5
1	3	2	3	4	4	1	5	3
1	1	1	2	2	1	3	4	3
8	4	6	4	1	1	1	3	5
6	1	6	1	1	4	5	2	5
5	6	1	4	6	5	6	1	0

0	5	4	3	2	3	X	X	1
4	5	5	6	3	X	4	6	3
7	6	7	6	5	5	5	6	4
2	4	5	5	3	3	6	7	4
6	4	8	6	5	3	7	8	2
7	7	7	6	6	6	5	8	5
8	5	6	5	5	6	7	6	7
3	5	5	4	4	4	4	7	3
1	6	X	5	4	2	6	6	5

6. 9x9 (Unsolvable):

6	3	1	1	4	3	5	3	4
4	1	3	1	1	3	3	5	1
5	6	5	1	1	2	4	5	1
1	2	4	1	4	2	2	3	2
5	6	6	1	2	1	3	3	3
7	3	3	4	1	1	1	3	2
4	2	1	1	1	4	1	4	1
5	1	4	3	3	1	2	3	6
4	5	1	1	6	5	1	4	0

0	2	5	6	3	4	1	7	4
5	4	5	5	6	6	4	6	6
2	5	5	4	5	3	X	4	7
6	3	5	4	5	5	6	6	6
7	5	5	4	4	4	3	5	5
6	4	5	4	3	3	2	3	7
1	4	4	3	2	3	3	4	X
3	4	5	4	3	4	4	4	5
6	5	6	5	6	5	6	4	X

7. 11x11 (Solvable):

4	9	7	7	4	1	7	10	9	9	1
3	5	5	1	6	1	7	1	2	5	9
4	5	3	1	4	1	3	2	3	7	8
1	5	6	6	7	3	4	3	1	5	5
10	1	2	5	1	6	4	1	1	1	6
10	3	5	2	2	1	2	1	5	1	7
1	5	8	7	3	5	1	1	4	1	6
3	2	1	5	3	1	4	4	1	1	7
1	2	2	7	1	3	4	1	6	1	1
1	7	6	3	5	3	6	1	7	6	6
4	7	1	5	7	4	6	1	3	5	0

0	X	5	9	1	7	7	7	2	6	7
X	8	9	8	7	6	7	10	11	X	8
7	5	8	7	6	5	6	11	4	7	X
X	6	6	7	3	6	5	6	5	6	6
1	X	7	3	2	3	6	5	4	5	2
7	6	4	6	3	7	4	5	5	6	7
6	7	7	5	7	5	7	6	7	7	6
7	5	6	6	4	X	5	5	7	8	6
6	7	7	8	8	9	7	10	8	7	7
5	4	6	4	8	X	5	9	3	7	8
6	5	5	6	4	4	9	8	6	5	3

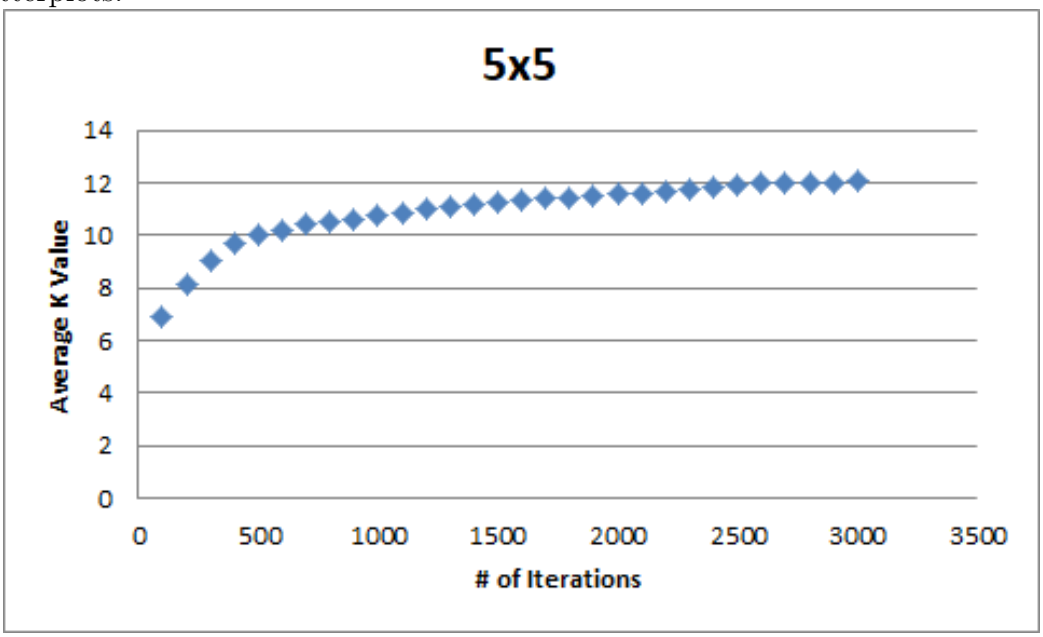
8. 11x11 (Unsolvable):

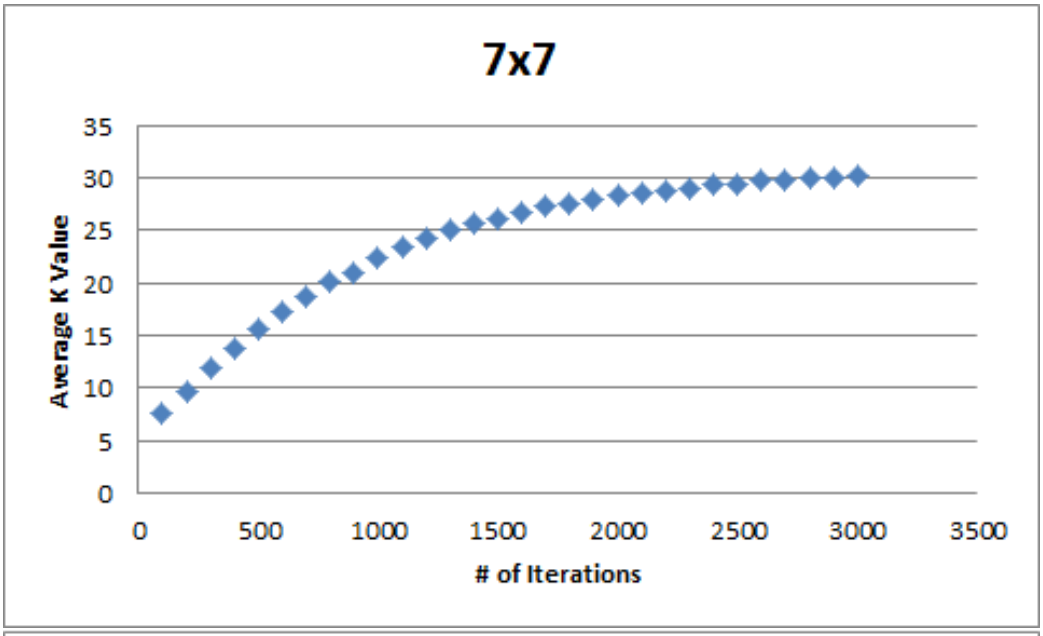
2	1	4	9	10	7	7	1	5	4	5
10	1	9	1	2	8	1	6	3	3	4
6	1	1	7	8	2	2	4	1	5	2
4	1	1	7	6	6	2	3	2	5	8
6	9	1	2	1	3	1	5	1	6	8
3	4	2	1	1	3	1	1	5	1	3
4	5	7	1	1	5	3	4	1	3	5
10	3	8	4	2	1	4	1	5	1	8
5	1	8	4	2	1	6	3	2	3	1
5	1	1	7	3	1	4	1	7	2	2
4	6	2	3	4	7	6	1	6	7	0

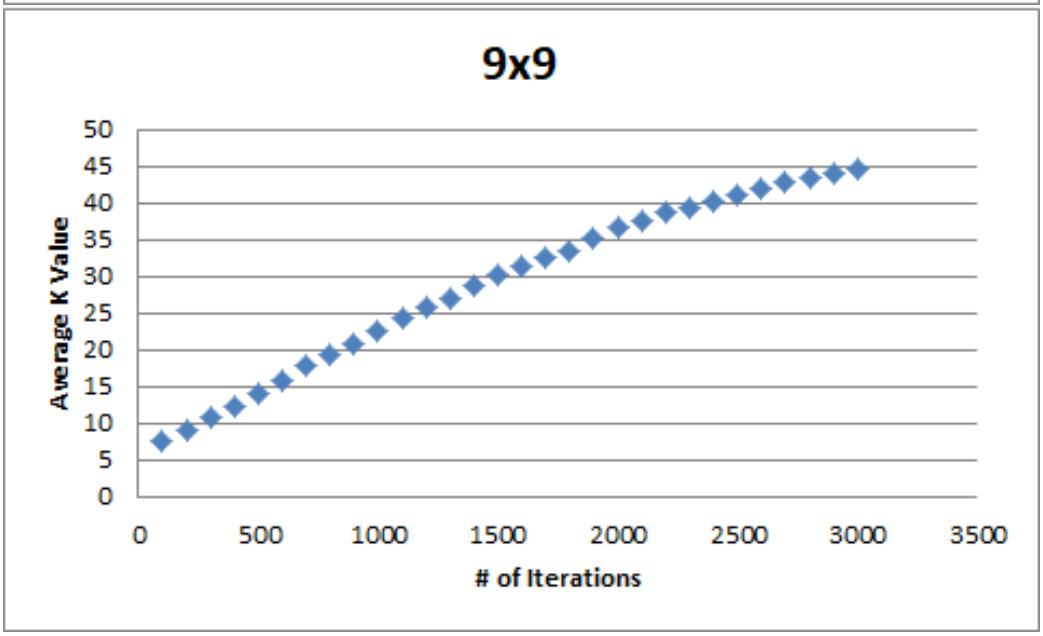
0	7	1	7	X	7	2	X	6	X	6
7	6	5	X	X	5	5	6	4	X	7
1	5	4	4	3	6	2	4	3	4	5
3	4	3	4	4	6	4	X	4	7	5
8	3	2	3	5	4	3	4	5	6	4
4	X	3	5	4	5	4	5	5	7	7
6	X	5	4	5	5	5	5	X	6	6
4	8	4	5	5	4	3	6	6	5	4
2	7	5	X	4	3	4	6	X	6	6
7	6	6	5	5	4	5	5	6	7	6
5	7	6	5	4	5	6	6	5	7	X

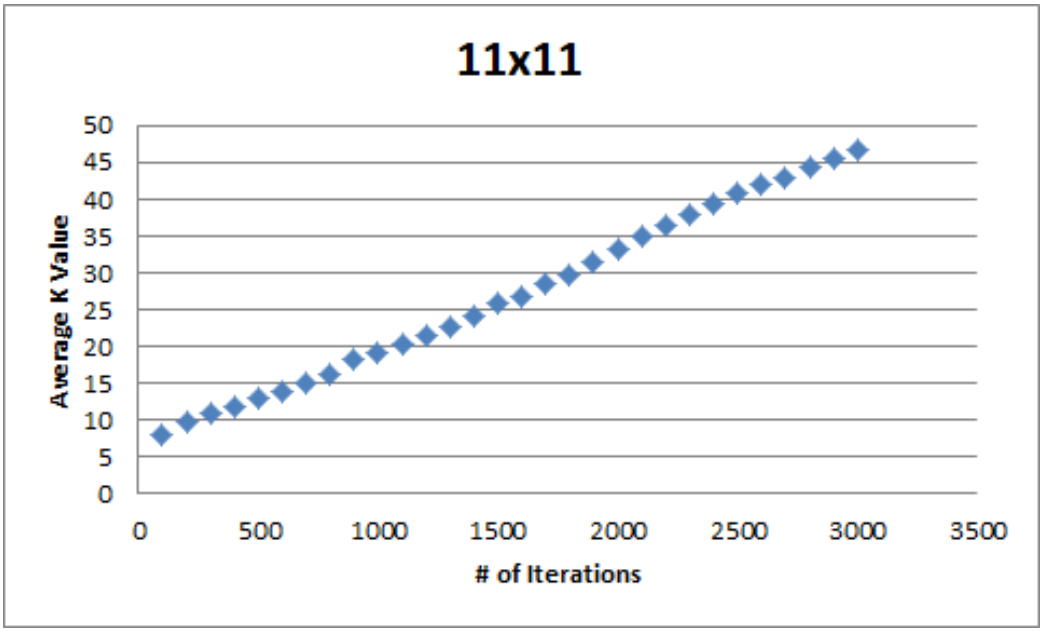
Task 3. Basic Hill Climb

To get the following plots we ran hill climb 50 times for 3000 iterations and at every 100th iteration we took the K value at that interval. Then we averaged the K values at each interval to get the data for the following scatterplots:



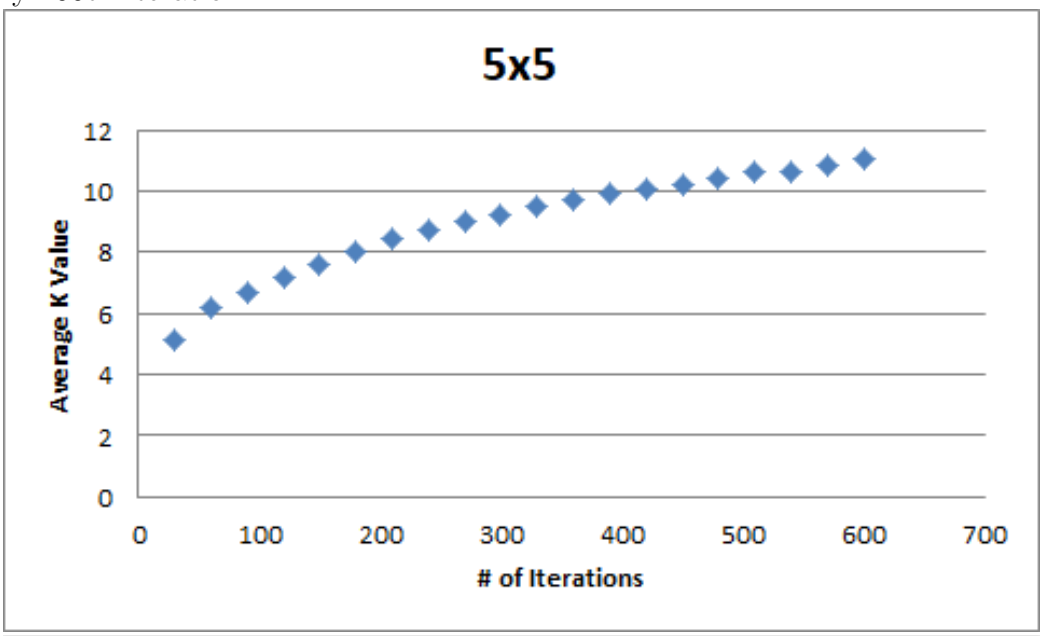

7x7
Average K Value
35
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500
# of Iterations

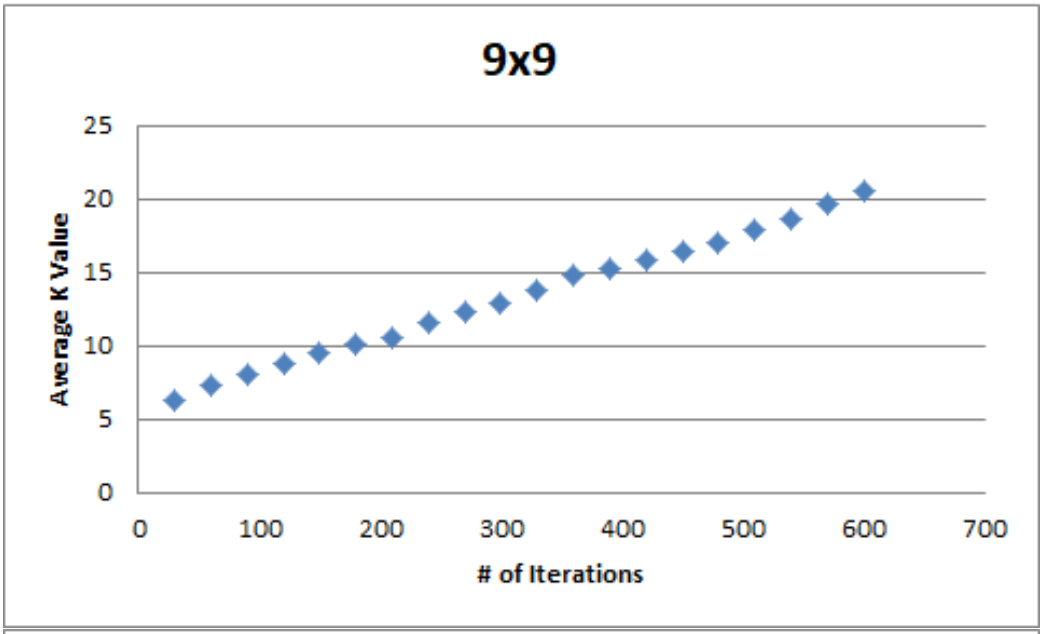

9x9
Average K Value
50
45
40
35
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500
# of Iterations

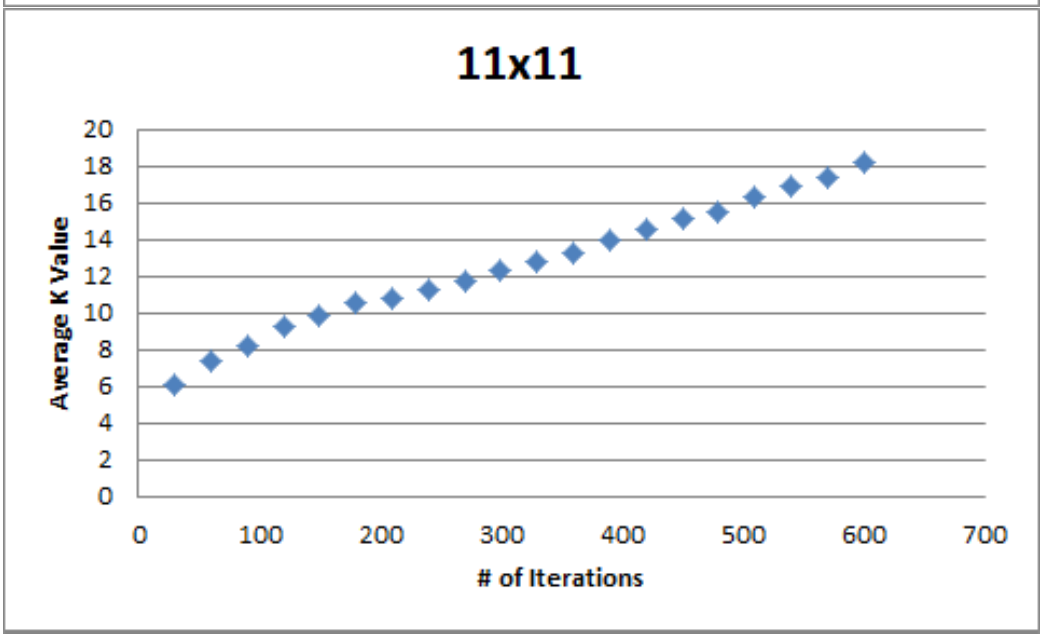

11x11
Average K Value
50
45
40
35
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500
# of Iterations

Task 4. Hill Climbing with Random Restarts

For hill climbing with random restarts, using 600 iterations and 5 restarts, the best individual hill climb was picked and its K values were recorded at every 100th iteration:







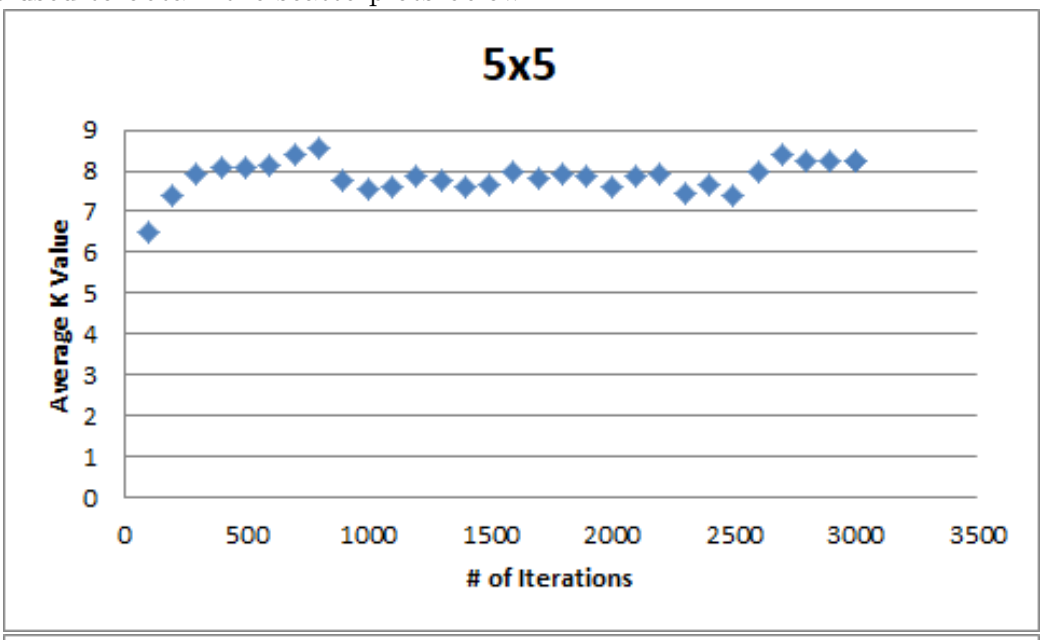
Compared to basic hill climbing, hill climbing with restarts appears to do worse. On the 5x5 plots, for example, restarts only reaches K = 11 at most, but basic hill climb reaches K = 12.

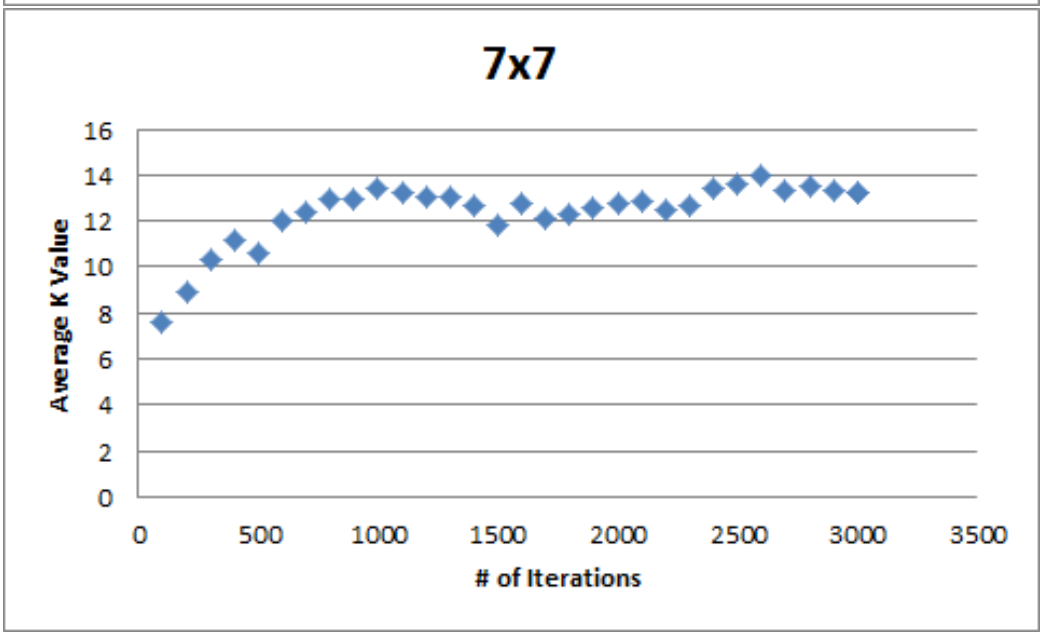
For the number of restarts, more than 2 restarts are preferred, to differentiate from basic hill climb. Yet the number of restarts should not be too

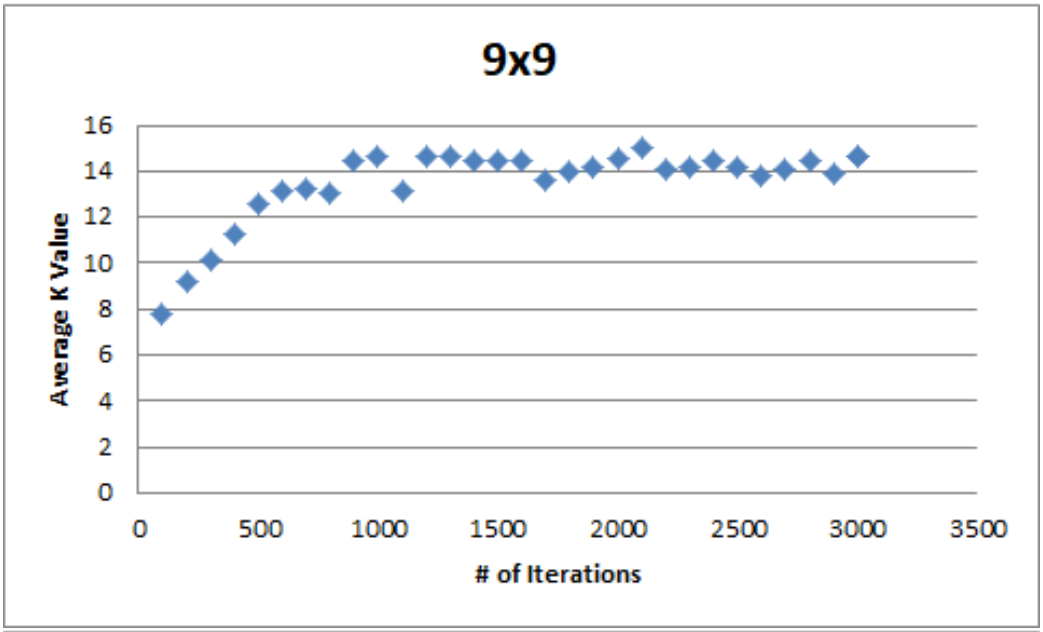
high, or the hill climb process will be too short to be effective compared to basic hill climb. So 5 restarts was chosen for the plots above.

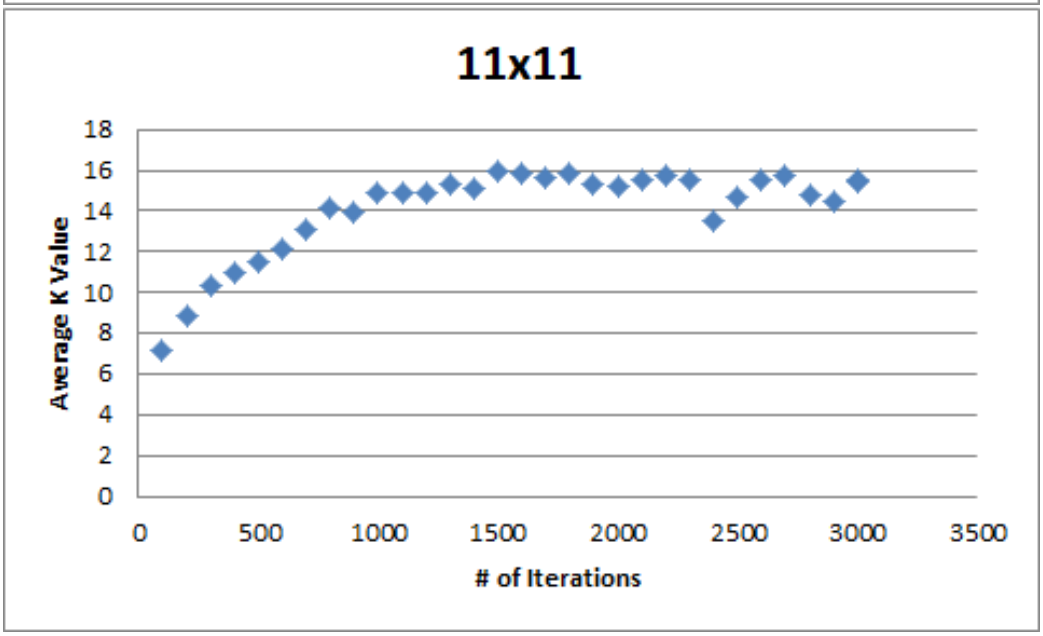
Task 5. Hill Climbing with Random Walking

For hill climbing with random walking, p = 0.01, where p is the probability of allowing downhill movement. A similar process with basic hill climbing was used to obtain the scatterplots below:









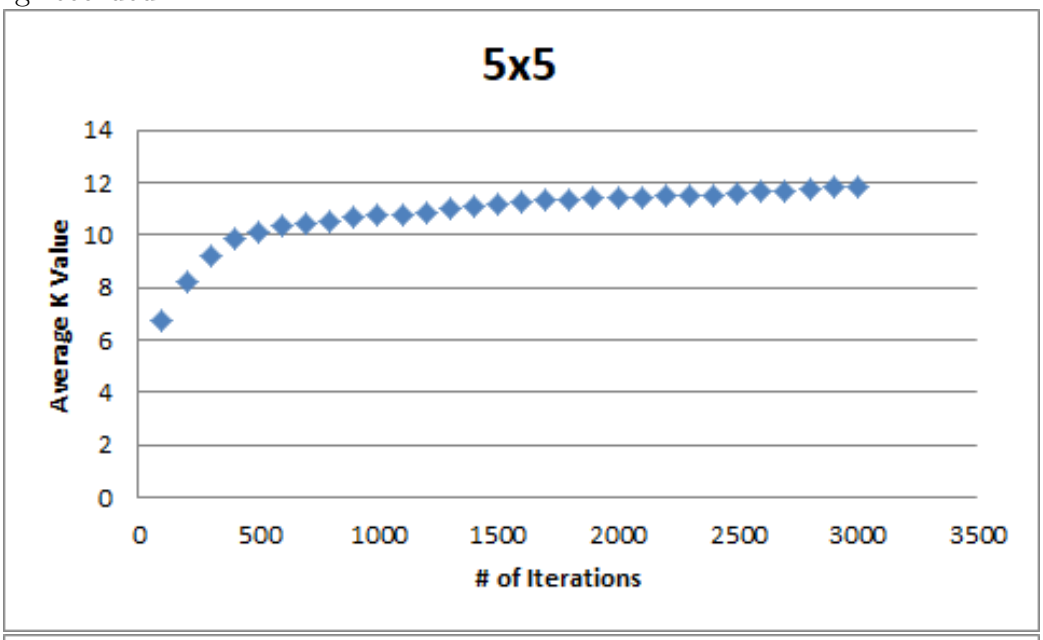
Random walk does appear to work, however, the dips caused by downhill movement can be too severe to recover from. This is why p was set to 0.01, but it looks like it could be set even lower to retain the effectiveness of basic hill climbing.

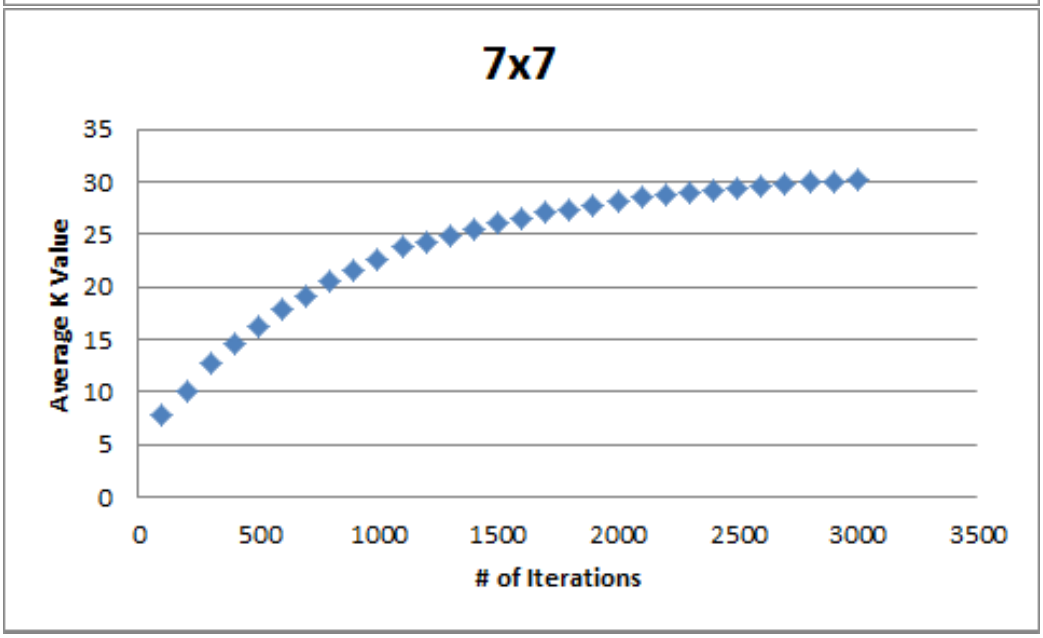
Compared to plain hill climbing and climbing with restarts, random walk

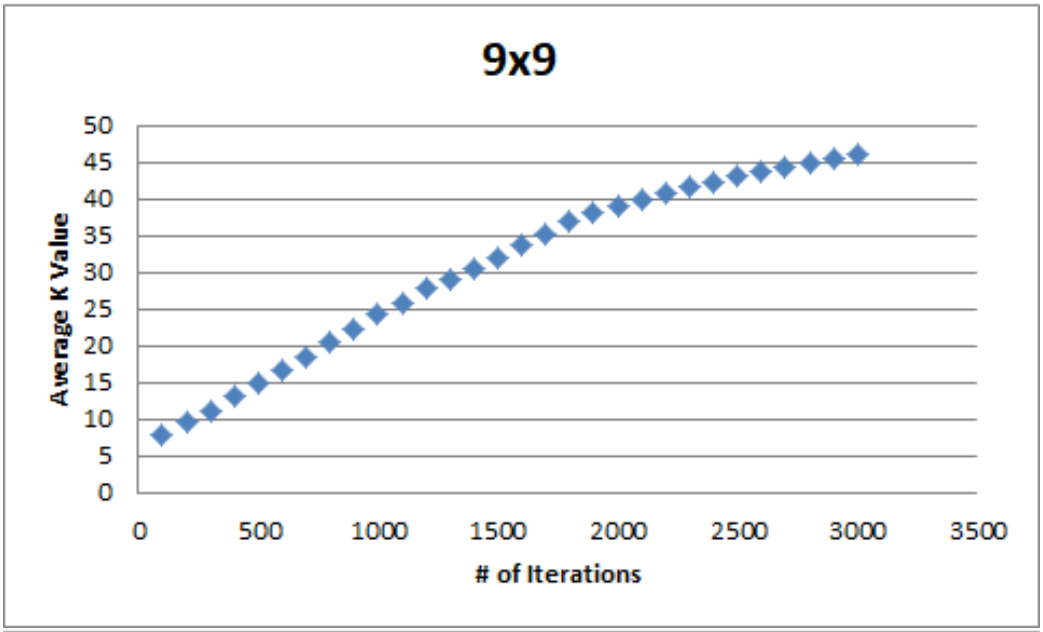
performs much worse, reaching a high of about K = 8.5 for 5x5 puzzles while the other 2 methods surpassed 10. However, this may be caused by the averaging of data points, since at some points in the plots, there can be a jump in K values (such as from iterations 800 to 900 on the 9x9 plot).

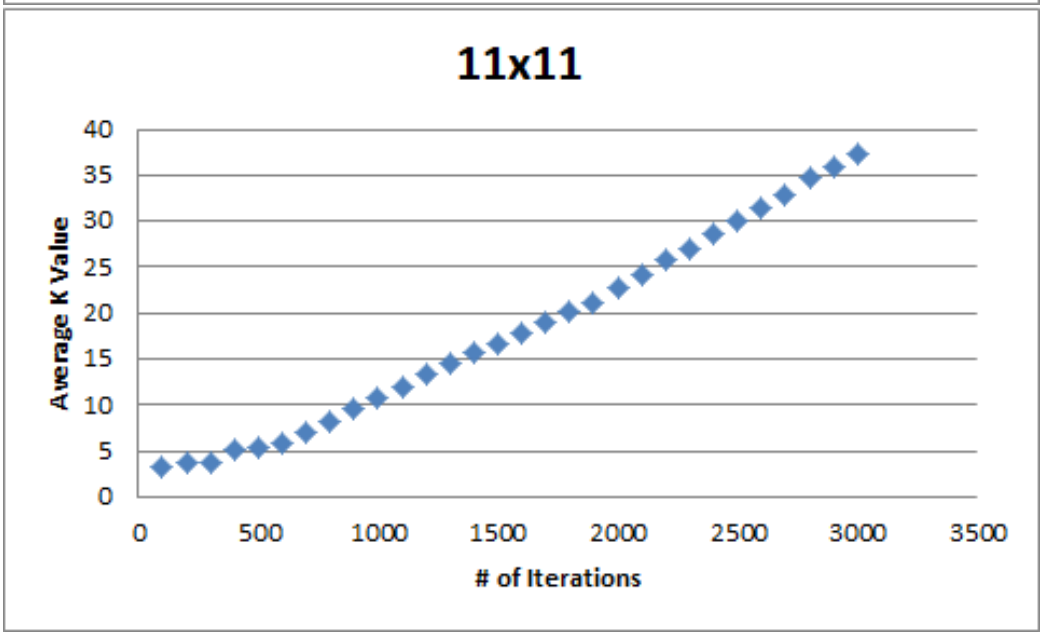
Task 6. Simulated Annealing

The parameters used for simulated annealing were: T (initial temperature)= 1000, decay rate = 0.99 with 3000 iterations and every 100th iteration being recorded.









Compared to basic hill climbing...
Compared to hill climbing with restarts...

Task 7. Genetic Algorithms