Assignment 1 Local Search Report By Brandon Young and Ruicheng Wu

Task 1. Puzzle Representation

Processes Files 1	GUI Example	e 1:			
Basic HI Climb W Random Restarts # of iterations: 1 HII Climb w Random Restarts # of restarts Simulated Arresiling initial temperature temperature decay rate: put your iterations under basic hill climb input for simulated amending Genetic Agorithm population size: mutuating probability: puzzle size is selected on top K is 3 The tree data structure is (*10.00*,***,****(1.0)*,***(1.2)*,***(1.2)*,***(1.2)*,***(1.2)*,***(2.1)*,***,***(2.1)*,****,***(2.0)**] 1			Puzzle Combination		Tease
Hill Climb w Random Restarts Hill Climb w Random Restarts Simulated Annealing Initial temperature temperature decay rate: put your Herations under basic hill climb lapar for simulated annealing Genetic Agorithm population size: mutating probability:	Choose File No file chosen	be sure your file is exactly in format as 1 2 3 \r\n 1 :	2 3 Display file contents	Clear Canvas	
Hill Clamb will Random Watering Probability (p): 0	Basic Hill Climb	# of iterations: 1			
Smulated Almeating Initial temperature: temperature decay rate:	Hill Climb w/ Random Restarts	# of restarts 1			
genetic Algorithm population size: mutating probability: puzzle size is selected on top K is 3 The tree data structure is: \(\frac{1}{2} \)(0.0)^*.\(\frac{1}{2} \).\(Hill Climb w/ Random Walking	probability (p): 0			
Genetic Algorithm population size: mutating probability: puzzle size is selected on top K is 3 The tree data structure is: \(\frac{1}{2} \) (0.0) \(\frac{1}{2} \) \(\fr		•	perature decay rate:		
puzzle size is selected on top K is 3 The tree data structure is: \(\begin{align*} \begin{align*} \cdot 0 & 1 & 4 & 1 & 2 & 3 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1	put your iterations under basic hill	l climb input for simulated annealing			
The tree data structure is: ["(0,0)"," ","(1,0)","(0,1)"," ","(1,2)","(1,1)","(0,2)"," ","(G,G)","(2,1)"," ","(2,0)"] 1	Genetic Algorithm	population size: mutation	ng probability:		
The tree data structure is :[^10,0)^*,^* ^*,^*(1,0)^*,^*(1,1)^*,^*(1,2)^*,^*(1,1)^*,^*(0,2)^*,^*(2,1)^*,^* ^*,^*(2,0)^*]	puzzle size is selected on top				
The tree data structure is :[^10,0)^*,^* ^*,^*(1,0)^*,^*(1,1)^*,^*(1,2)^*,^*(1,1)^*,^*(0,2)^*,^*(2,1)^*,^* ^*,^*(2,0)^*]	K is 3				
The state of the s					
GUI Example 2: Puzzle size [s v Generate Puzzle Puzzle Puzzle Puzzle Evaluation Puzzle Combination Tease Choose File No file chosen be sure your file is exactly in format as 123 'u' in 123 Display file contents Clear Canvas Basic Hill Climb # of iterations: [Hill Climb W Random Restarts # of restarts [Hill Climb W Random Restarts # of restarts [Hill Climb W Random Walking probability (p): [] Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: [0.75] puzzle size is selected on top	The tree data structure is :["(0,0)"," ","(1,0)","(0,1)"," ","(1,2)","(1,1)","(0,2)"," ","(G,G)","(2,1)"	'," ","(2,0)"]		
GUI Example 2: Puzzle size [s v Generate Puzzle Puzzle Puzzle Puzzle Evaluation Puzzle Combination Tease Choose File No file chosen be sure your file is exactly in format as 123 'u' in 123 Display file contents Clear Canvas Basic Hill Climb # of iterations: [Hill Climb W Random Restarts # of restarts [Hill Climb W Random Restarts # of restarts [Hill Climb W Random Walking probability (p): [] Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: [0.75] puzzle size is selected on top					
GUI Example 2: Puzzle size [s v Generate Puzzle Puzzle Puzzle Puzzle Evaluation Puzzle Combination Tease Choose File No file chosen be sure your file is exactly in format as 123 'u' in 123 Display file contents Clear Canvas Basic Hill Climb # of iterations: [Hill Climb W Random Restarts # of restarts [Hill Climb W Random Restarts # of restarts [Hill Climb W Random Walking probability (p): [] Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: [0.75] puzzle size is selected on top	1 2 1 0 1	4			
GUI Example 2: Puzzle size 5 Generate Puzzle Puzzle Puzzle Puzzle Evaluation Puzzle Combination Tease Choose File No file chosen	+++				
GUI Example 2: Puzzle size 5 T Generate Puzzle Puzzle Puzzle Evaluation Puzzle Combination Tease Choose File No file chosen be sure your file is exactly in format as 1 2 3 \(\text{vin 1 2 3} \) Display file contents Clear Canvas Basic Hill Climb # of iterations: 1 Hill Climb w/ Random Restarts # of restarts 1 Hill Climb w/ Random Walking probability (p): 0 Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: 0.75 puzzle size is selected on top	——	<u> </u>			
Puzzle size 5 Generate Puzzle Puzzle Puzzle Evaluation Puzzle Combination Tease Choose File No file chosen be sure your file is exactly in format as 1 2 3 \text{ \text{in 1 2 3}} Display file contents Clear Canvas Basic Hill Climb # of iterations: 1 Hill Climb w/ Random Restarts # of restarts 1 Hill Climb w/ Random Walking probability (p): 0 Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: 0.75 puzzle size is selected on top 2 3 2 3 1 1 1 1 4 1 1 2 1 1 1 1 1 2 1 1 1 1 1 1	1 1 0 2 2	3			
Puzzle size 5 Generate Puzzle Puzzle Evaluation Puzzle Combination Tease Choose File No file chosen be sure your file is exactly in format as 1 2 3 \tau \tau 1 2 3 \tau 1 2 3 \tau 1 2 3 \tau 1 1 1 1 2 1 1 1 1 1 2 1 1 1 1 1 1 1 1	GIII Evample	. 2.			
Choose File No file chosen be sure your file is exactly in format as 1 2 3 \(\text{in} \) 1 2 3 \(\text{Display file contents} \) Basic Hill Climb # of iterations: 1 Hill Climb w/ Random Restarts # of restarts 1 Hill Climb w/ Random Walking probability (p): 0 Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: 0.75 puzzle size is selected on top 2 3 2 3 1			Puzzle Combination		Tease
Basic Hill Climb # of iterations: 1 Hill Climb w/ Random Restarts # of restarts 1 Hill Climb w/ Random Walking probability (p): 0 Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: 0.75 puzzle size is selected on top 2 3 2 3 1 3 2 1 1 1 1 4 1 1 2 1 1 1 2 1 1		·	·	Clear Canvas	
Hill Climb w/ Random Restarts # of restarts 1 Hill Climb w/ Random Walking probability (p): o Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: 0.75 puzzle size is selected on top 2					
Hill Climb w/ Random Walking probability (p): 0 Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: 0.75 puzzle size is selected on top 2 3 2 3 1					
Simulated Annealing initial temperature: temperature decay rate: put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: 0.75 puzzle size is selected on top 2 3 2 3 1					
put your iterations under basic hill climb input for simulated annealing Genetic Algorithm population size: 50 mutating probability: 0.75 puzzle size is selected on top 2 3 2 3 1					
Comparison Page 1 Page 2 Page 3 Page 3 Page 3 Page 4 Page 3 Page 4			perature decay rate:		
2 3 2 3 1 3 2 1 1 1 4 1 1 2 1 1 1 2 1 1	put your iterations under basic hill	climb input for simulated annealing			
2 3 2 3 1 3 2 1 1 1 4 1 1 2 1 1 1 2 1 1	Genetic Algorithm	population size: 50 mutatir	ng probability: 0.75		
2 3 2 3 1 3 2 1 1 1 4 1 1 2 1 1 1 2 1 1	puzzle size is selected on top				
3 2 1 1 1 4 1 1 2 1 1 1 2 1 1					
3 2 1 1 1 4 1 1 2 1 1 1 2 1 1					
3 2 1 1 1 4 1 1 2 1 1 1 2 1 1					
4 1 1 2 1 1 1 2 1 1					
1 1 2 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	(Solva	able)

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

О	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	O

О	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					
6	1	1	2	1	2	2
1	4	4	3	1	1	1
1	4	1	3	2	2	1
	4					2
6	2	1	3	1	1	1
3	1	3	2	1	1	0

О	1	7	5	2	X	X
1	5	6	4	3	4	2
6	6	7	5	4	5	4
5	2	_				
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	О

О	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	5	6	6	Χ

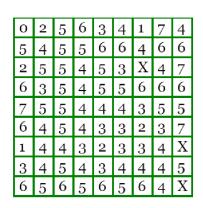
5. 9x9 (Solvable):

or one (servasie).								
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

О	5	4	3	2	3	Χ	X	1
	5							
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):

o. oxo (Choorvabic).										
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		
	3									
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		



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

o	X	5	9	1	7	7	7	2	6	7
Χ	8	9	8	7	6	7	10	11	X	8
7	5	8	7	6	5	6	11	4	7	Χ
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

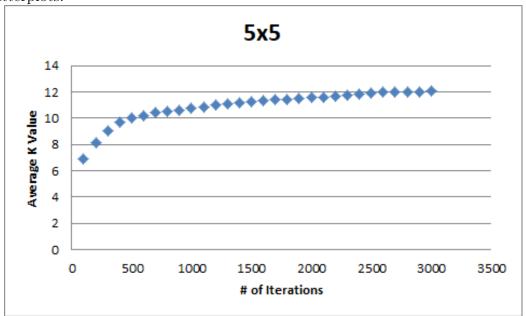
8. 11x11 (Unsolvable):

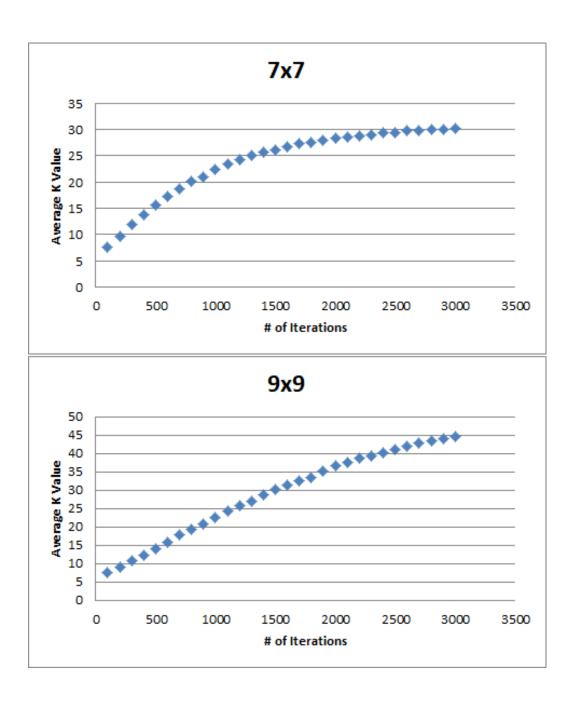
				(Chisorvasie):						
2	1	4	9	10	7	7	1	5	4	5
10	1	9	1	2	8	1	6	3	3	4
6	1	1	7	8	2	2	4	1	5	2
4	1	1	7	6	6	2	3	2	5	8
6	9	1	2	1	3	1	5	1	6	8
3	4	2	1	1	3	1	1	5	1	3
4	5	7	1	1	5	3	4	1	3	5
10	3	8	4	2	1	4	1	5	1	8
5	1	8	4	2	1	6	3	2	3	1
5	1	1	7	3	1	4	1	7	2	2
4	6	2	3	4	7	6	1	6	7	О

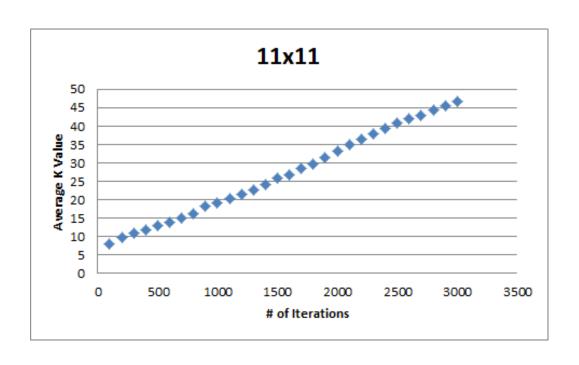
0	7	1	7	X	7	2	X	6	X	6
7	6	5	X	X	5	5	6	4	X	7
1	5	4	4	3	6	2	4	3	4	5
3	4	3	4	4	6	4	X	4	7	5
8	3	2	3	5	4	3	4	5	6	4
4	Χ	3	5	4	5	4	5	5	7	7
6	Х	5	4	5	5	5	5	X	6	6
4	8	4	5	5	4	3	6	6	5	4
2	7	5	X	4	3	4	6	X	6	6
7	6	6	5	5	4	5	5	6	7	6
5	7	6	5	4	5	6	6	5	7	Χ

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:

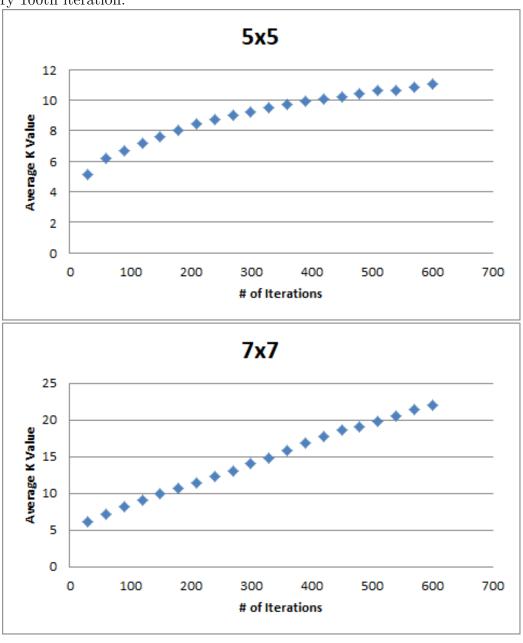


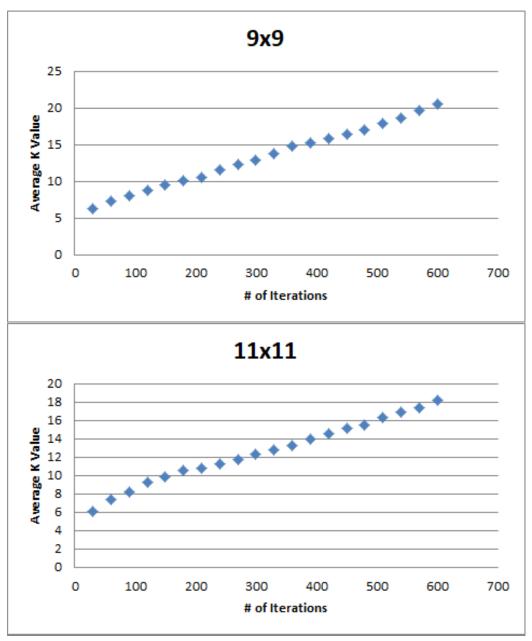




Task 4. Hill Climbing with Random Restarts

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:





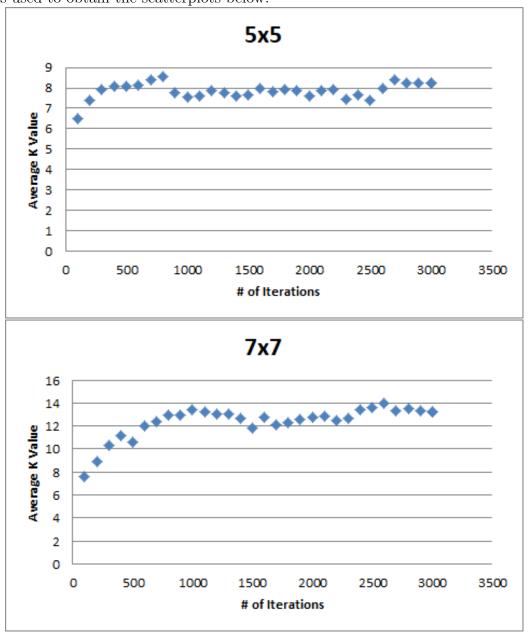
Compared to basic hill climbing, hill climbing with restarts appears to do worse. On the 5x5 plots, for example, restarts only reaches K=11 at most, but basic hill climb reaches K=12.

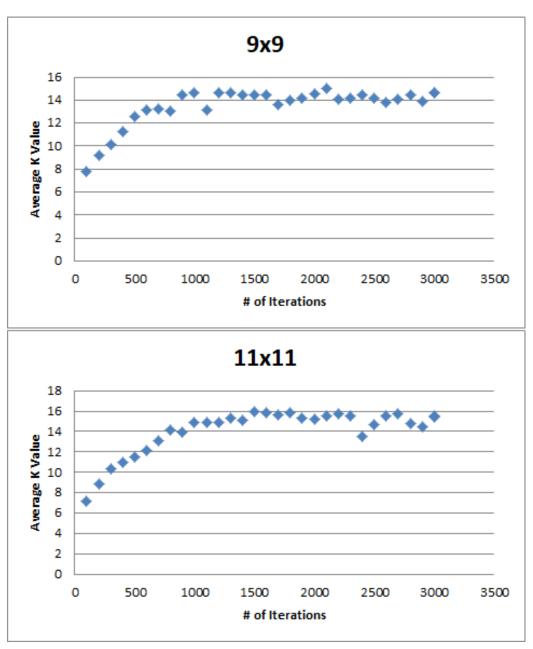
For the number of restarts, more than 2 restarts are preferred, to differentiate from basic hill climb. Yet the number of restarts should not be too

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:





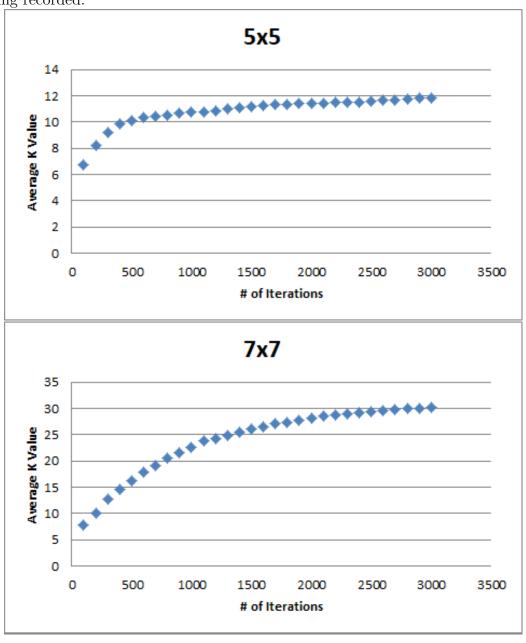
Random walk does appear to work, however, the dips caused by downhill movement can be too severe to recover from. This is why p was set to 0.01, but it looks like it could be set even lower to retain the effectiveness of basic hill climbing.

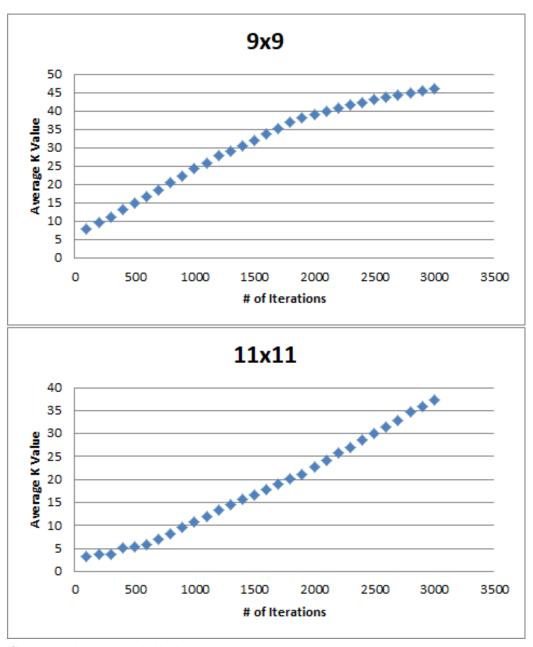
Compared to plain hill climbing and climbing with restarts, random walk

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...

 ${\bf Task~7.~Genetic~Algorithms}$