MaxCut Approximation Algorithm Comparisons

Jeremy McMahan

August 2019

1 Introduction

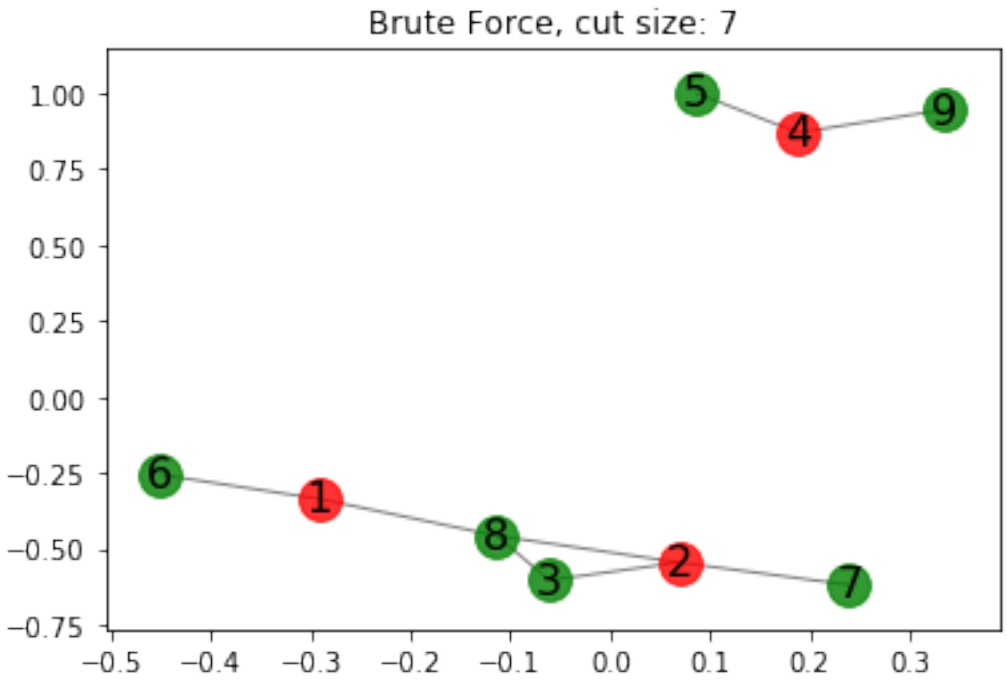
The goal of this project is to compare how simulated annealing and hill climbing with random restarts perform when dealing with NP-complete problems. In particular, for the problem MaxCut, which can be viewed as a two player game similarly to how SAT can be. The program given takes as input a graph, then computes the max cut by brute force. Afterwards, an implementation of Hill Climbing with random restarts is used to find an approximate max cut and similarly for simulated annealing, with a very slowly cooling rate chosen experimentally. Also, we implement the well known greedy 2 approximation algorithm for the Max Cut problem to give an idea of whether the local search algorithms are indeed giving a good approximation when not optimal. Lastly, the networkx package is used to visualize the cuts on the given graph and the value of the cut associated with each algorithm is written to a text file, 'output.txt'.

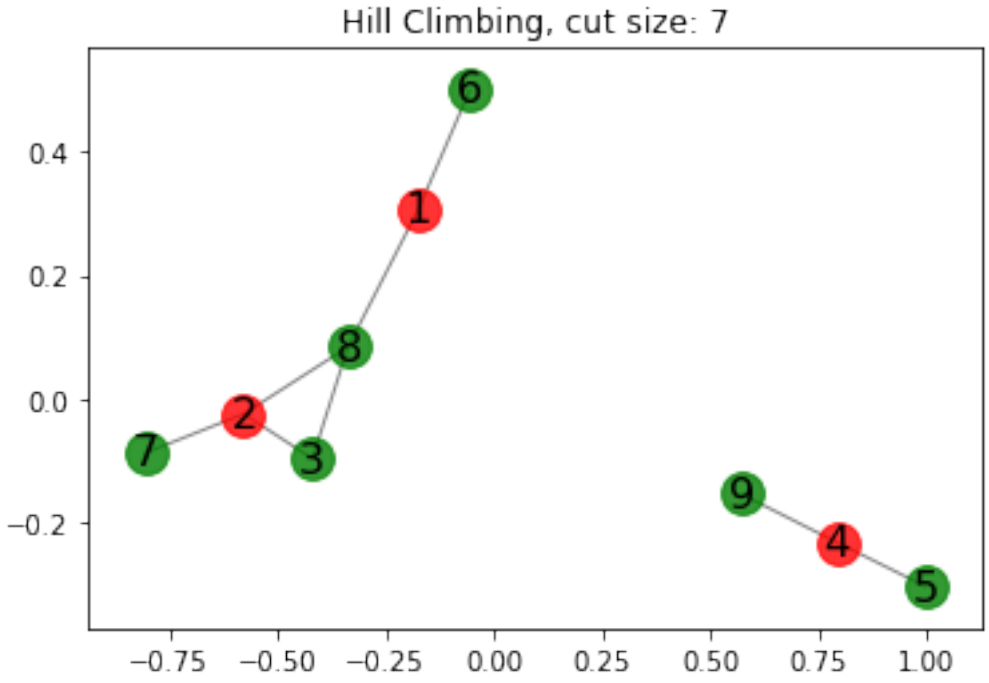
2 Results

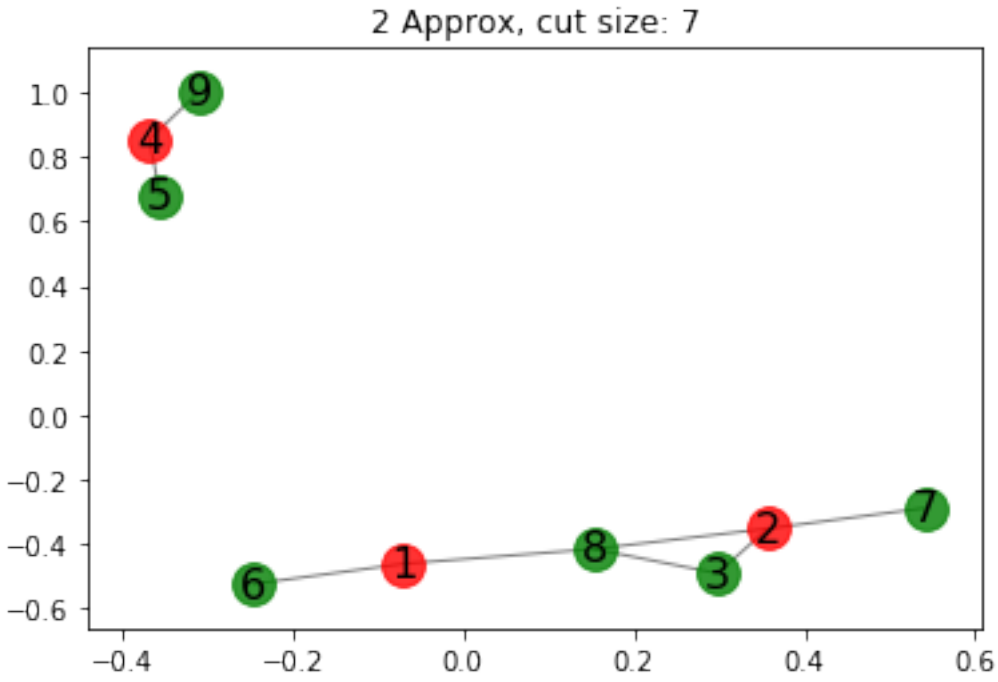
Overall, Hill Climbing seemed to do best when given plenty of random restarts, around 100, and simulated annealing performed rather well as long as the cooling rate was small enough. Specifically, a multiplicative factor of smaller than .001 did well. Also, an interesting artifact of the two algorithms is Hill Climbing tended to output cuts whose number of vertices on the 'left side' was small and the simulated annealing algorithm tended to output large numbers of vertices on the left side. Both algorithms performed much faster than brute force even with many restarts or slower cooling rates, and found an optimal cut for most small graphs. They also produced cuts at least as good as the 2 approximation algorithm in all cases tested. Note the performance for the 2 approximation algorithm varied wildly depending on the ordering of the vertices, for the ordering used in the example, this algorithm was optimal.

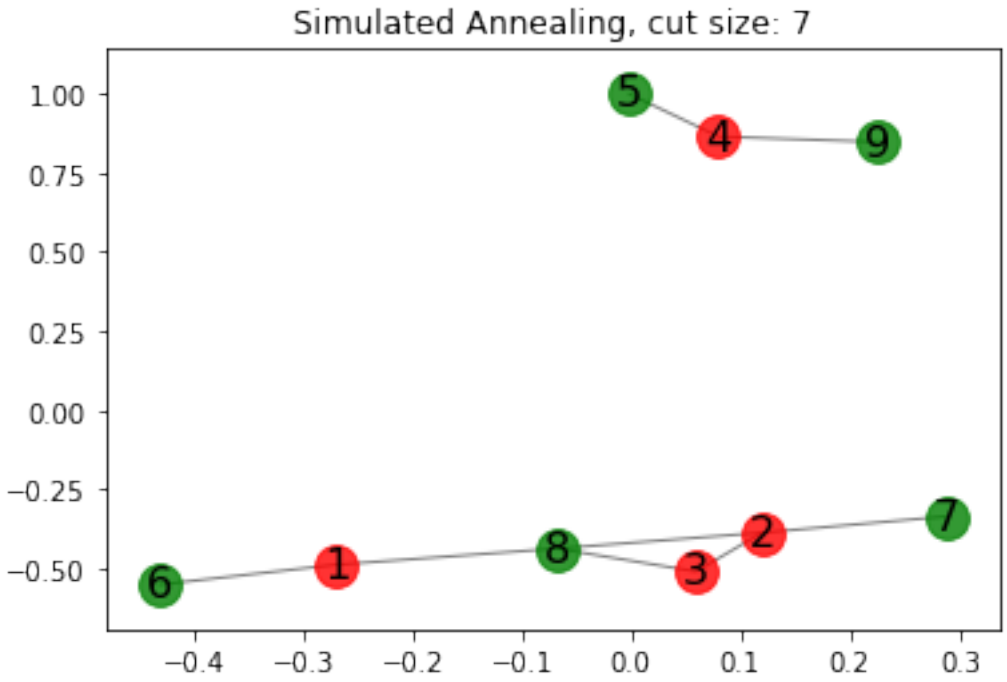
3 Output

Here is a sample output for the algorithm on a given graph with the vertices in the set defining the cut highlighted in red and the complementary vertices in green:




Hill Climbing, cut size: 7
6
1
8
2
7
3
9
4
5
0.4
0.2
0.0
−0.2
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00


2 Approx, cut size: 7
9
4
5
6
1
8
2
3
7
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6


Simulated Annealing, cut size: 7
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.4
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3
5
4
9
7
2
8
1
3
6