



Tecnológico de Monterrey

Tecnológico de Monterrey - Campus Monterrey
School of Engineering and Sciences
Engineering in Computational Technologies
Analysis and Design of Advanced Algorithms

Class Activity 10: Hill Climb

Group: 607
Team #3

Luis Salomón Flores Ugalde

Santiago Quintana Moreno A01571222
Miguel Ángel Álvarez Hermida a01722925

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Act10_HillClimb.py U X

HillClimb > Act10_HillClimb.py > ...
1 # Analysis and Design of Advanced Algorithms
2 # Group #607
3 # Team 1
4 # Luis Salomón Flores Ugalde
5
6 # Santiago Quintana Moreno A01571222
7 # Miguel Ángel Álvarez Hermida A01722925
8
9 # ----- Class Activity 10 - Hill climber_ISL_SA -----
10
11 import random
12 import math
13 import matplotlib.pyplot as plt
14 import os
15
16 def load_graph(filename):
17 n = None
18 edges = []
19
20 with open(filename, "r", encoding="utf-8") as f:
21 for line in f:
22 line = line.strip()
23 if not line:
24 continue
25
26 parts = line.split()
27 if len(parts) < 2:
28 continue
29 try:
30 a = int(parts[0])
31 b = int(parts[1])
32 except ValueError:
33 continue
34 if n is None:
35 n = a
36 else:
37 u, v = a, b
38 edges.append((u, v))
39
40 if n is None:
41 raise ValueError("Could not find a valid 'n m' header line in the fil
42

python X

python
Loaded graph with 85 vertices and 219 edges from d:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advan
ced Algorithms\HillClimb\ash85.txt
Running Hill-Climber...
HC run 1/50: cost = 17
HC run 2/50: cost = 18
HC run 3/50: cost = 16
HC run 4/50: cost = 18
HC run 5/50: cost = 17
HC run 6/50: cost = 19
HC run 7/50: cost = 20
HC run 8/50: cost = 19
HC run 9/50: cost = 18
HC run 10/50: cost = 16
HC run 11/50: cost = 18
HC run 12/50: cost = 17
HC run 13/50: cost = 17
HC run 14/50: cost = 17
HC run 15/50: cost = 19
HC run 16/50: cost = 20
HC run 17/50: cost = 16
HC run 18/50: cost = 18
HC run 19/50: cost = 21
HC run 20/50: cost = 19
HC run 21/50: cost = 22
HC run 22/50: cost = 16
HC run 23/50: cost = 16
HC run 24/50: cost = 19
HC run 25/50: cost = 17
HC run 26/50: cost = 17
HC run 27/50: cost = 22
HC run 28/50: cost = 17
HC run 29/50: cost = 19
HC run 30/50: cost = 17
HC run 31/50: cost = 25
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HC run 38/50: cost = 19
HC run 39/50: cost = 19
HC run 40/50: cost = 18
HC run 41/50: cost = 17
HC run 42/50: cost = 22
HC run 43/50: cost = 18

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30 a = int(parts[0])
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HC run 6/50: cost = 19
HC run 7/50: cost = 20
HC run 8/50: cost = 19
HC run 9/50: cost = 18
HC run 10/50: cost = 16
HC run 11/50: cost = 18
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HC run 14/50: cost = 17
HC run 15/50: cost = 19
HC run 16/50: cost = 20
HC run 17/50: cost = 16
HC run 18/50: cost = 18
HC run 19/50: cost = 21
HC run 20/50: cost = 19
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HC run 31/50: cost = 25
HC run 32/50: cost = 20
HC run 33/50: cost = 17
HC run 34/50: cost = 17
HC run 35/50: cost = 17
HC run 36/50: cost = 22
HC run 37/50: cost = 19
HC run 38/50: cost = 19
HC run 39/50: cost = 19
HC run 40/50: cost = 18
HC run 41/50: cost = 17
HC run 42/50: cost = 22
HC run 43/50: cost = 18

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Act10_HillClimb.py U X

HillClimb > Act10_HillClimb.py > ...

```
66 def local_search_hc(perm, edges, max_evals, evals_used, no_improve_limit_factor):
67
68     if neighbor_cost <= current_cost:
69         current_perm = neighbor
70         current_cost = neighbor_cost
71
72     if current_cost < best_cost:
73         best_cost = current_cost
74         best_perm = current_perm[:]
75
76     no_improve = 0
77     else:
78         no_improve += 1
79
80     return best_perm, best_cost, evals_used
81
82 def hill_climber(n, edges, max_evals=100_000):
83     perm = list(range(1, n + 1))
84     random.shuffle(perm)
85
86     evals_used = 0
87     best_perm, best_cost, evals_used = local_search_hc(
88         perm, edges, max_evals, evals_used, no_improve_limit_factor=10
89     )
90
91     return best_cost
92
93 def perturb_solution(perm, num_swaps=3):
94     perturbed = perm[:]
95     n = len(perturbed)
96     for _ in range(num_swaps):
97         i, j = random.sample(range(n), 2)
98         perturbed[i], perturbed[j] = perturbed[j], perturbed[i]
99     return perturbed
100
101 def iterated_local_search(n, edges, max_evals=100_000):
102     current = list(range(1, n + 1))
103     random.shuffle(current)
104
105     evals_used = 0
106     current, current_cost, evals_used = local_search_hc(
```

powershell X


ILS run 50/50: cost = 22
Running Simulated Annealing...

Run	Cost
1/50	18
2/50	18
3/50	18
4/50	17
5/50	20
6/50	19
7/50	19
8/50	20
9/50	16
10/50	18
11/50	17
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29/50	19
30/50	18
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32/50	20
33/50	18
34/50	17
35/50	18
36/50	18
37/50	18
38/50	19
39/50	20
40/50	17
41/50	18
42/50	17

main

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1. **Introduction**
 2. **Background**
 3. **Methodology**
 4. **Results**
 5. **Discussion**
 6. **Conclusion**
 7. **References**
 8. **Appendix**
 9. **Figure 1**
 10. **Figure 2**
 11. **Figure 3**
 12. **Figure 4**
 13. **Figure 5**
 14. **Figure 6**
 15. **Figure 7**
 16. **Figure 8**
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 217. **Figure 209**

```
=== Summary (final bandwidth costs over runs) ===
```

Hill-Climber: min = 16, mean = 18.62, max = 25

```
ILS: min = 15, mean = 18.16, max = 22
```

SA: min = 16, mean = 18.14, max = 21

```
d:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms\HillClimb\Act10_HillClimb.py:229:
MatplotlibDeprecationWarning: The 'labels' parameter of boxplot() has been renamed 'tick_labels' s
ince Matplotlib 3.9; support for the old name will be dropped in 3.11.
```

```
plt.boxplot([hc costs, ils costs, sa costs],
```

```
(.jupy) PS D:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms>
```



HillClimb

HillClimb > Act10_HillClimb.py > ...

```

121 def iterated_local_search(n, edges, max_evals=100_000):
122     current, current_cost, evals_used = local_search_hc(
123         current, edges, max_evals, evals_used, no_improve_limit_factor=5
124     )
125
126     best_perm = current[:]
127     best_cost = current_cost
128
129     while evals_used < max_evals:
130         candidate = perturb_solution(best_perm, num_swaps=3)
131
132         candidate, candidate_cost, evals_used = local_search_hc(
133             candidate, edges, max_evals, evals_used, no_improve_limit_factor=
134         )
135
136         if candidate_cost < best_cost:
137             best_cost = candidate_cost
138             best_perm = candidate[:]
139
140     return best_cost
141
142
143 def simulated_annealing(n, edges, max_evals=100_000,
144                         T0=10.0, alpha=0.995, Tmin=1e-6):
145     current_perm = list(range(1, n + 1))
146     random.shuffle(current_perm)
147
148     current_cost = bandwidth(current_perm, edges)
149     evals_used = 1
150
151     best_cost = current_cost
152     best_perm = current_perm[:]
153
154     T = T0
155
156     while evals_used < max_evals:
157         neighbor = random_swap_neighbor(current_perm)
158         neighbor_cost = bandwidth(neighbor, edges)
159         evals_used += 1
160
161         delta = neighbor_cost - current_cost
162
163         if delta <= 0:

```

 powershell X

```
(.jupyter) PS D:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms> python3 Act10_Hillclimb.py
SA run 41/50: cost = 18
SA run 40/50: cost = 17
SA run 41/50: cost = 18
SA run 42/50: cost = 19
SA run 43/50: cost = 16
SA run 44/50: cost = 17
SA run 45/50: cost = 18
SA run 46/50: cost = 18
SA run 47/50: cost = 21
SA run 48/50: cost = 18
SA run 49/50: cost = 18
SA run 50/50: cost = 17

=== Summary (final bandwidth costs over runs) ===
Hill-Climber: min = 16, mean = 18.62, max = 25
ILS: min = 15, mean = 18.16, max = 22
SA: min = 16, mean = 18.14, max = 21
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MatplotlibDeprecationWarning: The 'labels' parameter of boxplot() has been renamed 'tick_labels' since
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  plt.boxplot([hc_costs, ils_costs, sa_costs],
(.jupyter) PS D:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms>
```

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Act10_HillClimb.py U X

HillClimb > Act10_HillClimb.py > ...
188 def run_experiments(filename, runs=50, max_evals=100_000):
196
197 # Hill-Climber runs
198 print("Running Hill-Climber...")
199 for r in range(runs):
200 cost = hill_climber(n, edges, max_evals=max_evals)
201 hc_costs.append(cost)
202 print(f" HC run {r + 1}/{runs}: cost = {cost}")
203
204 # ILS runs
205 print("Running Iterated Local Search...")
206 for r in range(runs):
207 cost = iterated_local_search(n, edges, max_evals=max_evals)
208 ils_costs.append(cost)
209 print(f" ILS run {r + 1}/{runs}: cost = {cost}")
210
211 # SA runs
212 print("Running Simulated Annealing...")
213 for r in range(runs):
214 cost = simulated_annealing(n, edges, max_evals=max_evals)
215 sa_costs.append(cost)
216 print(f" SA run {r + 1}/{runs}: cost = {cost}")
217
218 def summarize(name, values):
219 avg = sum(values) / len(values)
220 print(f"{name}: min = {min(values)}, mean = {avg:.2f}, max = {max(values)}")
221
222 print("\n=== Summary (final bandwidth costs over runs) ===")
223 summarize("Hill-Climber", hc_costs)
224 summarize("ILS", ils_costs)
225 summarize("SA", sa_costs)
226
227 # Boxplot
228 plt.figure()
229 plt.boxplot([hc_costs, ils_costs, sa_costs],
230 labels=["HC", "ILS", "SA"])
231 plt.ylabel("Bandwidth (cost)")
232 plt.title(f"Bandwidth comparison over {runs} runs\n(max_evals = {max_evals})")
233 plt.grid(True, axis="y", linestyle="--", alpha=0.7)
234 plt.tight_layout()
235 plt.show()
236

powershell X

```
(.jupyter) PS D:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms> python Act10_HillClimb.py  
SA run 41/50: cost = 18  
SA run 40/50: cost = 17  
SA run 41/50: cost = 18  
SA run 42/50: cost = 19  
SA run 43/50: cost = 16  
SA run 44/50: cost = 17  
SA run 45/50: cost = 18  
SA run 46/50: cost = 18  
SA run 47/50: cost = 21  
SA run 48/50: cost = 18  
SA run 49/50: cost = 18  
SA run 50/50: cost = 17  
  
=== Summary (final bandwidth costs over runs) ===  
Hill-Climber: min = 16, mean = 18.62, max = 25  
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(.jupyter) PS D:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms>
```

main

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Act10_HillClimb.py U X

HillClimb > Act10_HillClimb.py > ...

188 def run_experiments(filename, runs=50, max_evals=100_000):

210

211 # SA runs

212 print("Running Simulated Annealing...")

213 for r in range(runs):

214 cost = simulated_annealing(n, edges, max_evals=max_evals)

215 sa_costs.append(cost)

216 print(f" SA run {r + 1}/{runs}: cost = {cost}")

217

218 def summarize(name, values):

219 avg = sum(values) / len(values)

220 print(f"{name}: min = {min(values)}, mean = {avg:.2f}, max = {max(val

221

222 print("\n== Summary (final bandwidth costs over runs) ==")

223 summarize("Hill-Climber", hc_costs)

224 summarize("ILS", ils_costs)

225 summarize("SA", sa_costs)

226

227 # Boxplot

228 plt.figure()

229 plt.boxplot([hc_costs, ils_costs, sa_costs],

230 labels=["Hc", "ILS", "SA"])

231 plt.ylabel("Bandwidth (cost)")

232 plt.title(f"Bandwidth comparison over {runs} runs\n(max_evals = {max_eval

233 plt.grid(True, axis="y", linestyle="--", alpha=0.7)

234 plt.tight_layout()

235 plt.show()

236

237

238 if __name__ == "__main__":

239 script_dir = os.path.dirname(os.path.abspath(__file__))

240 FILENAME = os.path.join(script_dir, "ash85.txt")

241 run_experiments(FILENAME, runs=50, max_evals=100_000)

242

powershell X

(.jupyter) PS D:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms> d:\1.SQM\1.UNIVERS

SA run 41/50: cost = 18

SA run 40/50: cost = 17

SA run 41/50: cost = 18

SA run 42/50: cost = 19

SA run 43/50: cost = 16

SA run 44/50: cost = 17

SA run 45/50: cost = 18

SA run 46/50: cost = 18

SA run 47/50: cost = 21

SA run 48/50: cost = 18

SA run 49/50: cost = 18

SA run 50/50: cost = 17

=== Summary (final bandwidth costs over runs) ===

Hill-Climber: min = 16, mean = 18.62, max = 25

ILS: min = 15, mean = 18.16, max = 22

SA: min = 16, mean = 18.14, max = 21

d:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms\HillClimb\Act10_HillClimb.py:229:

MatplotlibDeprecationWarning: The 'labels' parameter of boxplot() has been renamed 'tick_labels' s

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plt.boxplot([hc_costs, ils_costs, sa_costs],

(.jupyter) PS D:\1.SQM\1.UNIVERSIDAD\5. QUINTO SEMESTRE\2.Advanced Algorithms>

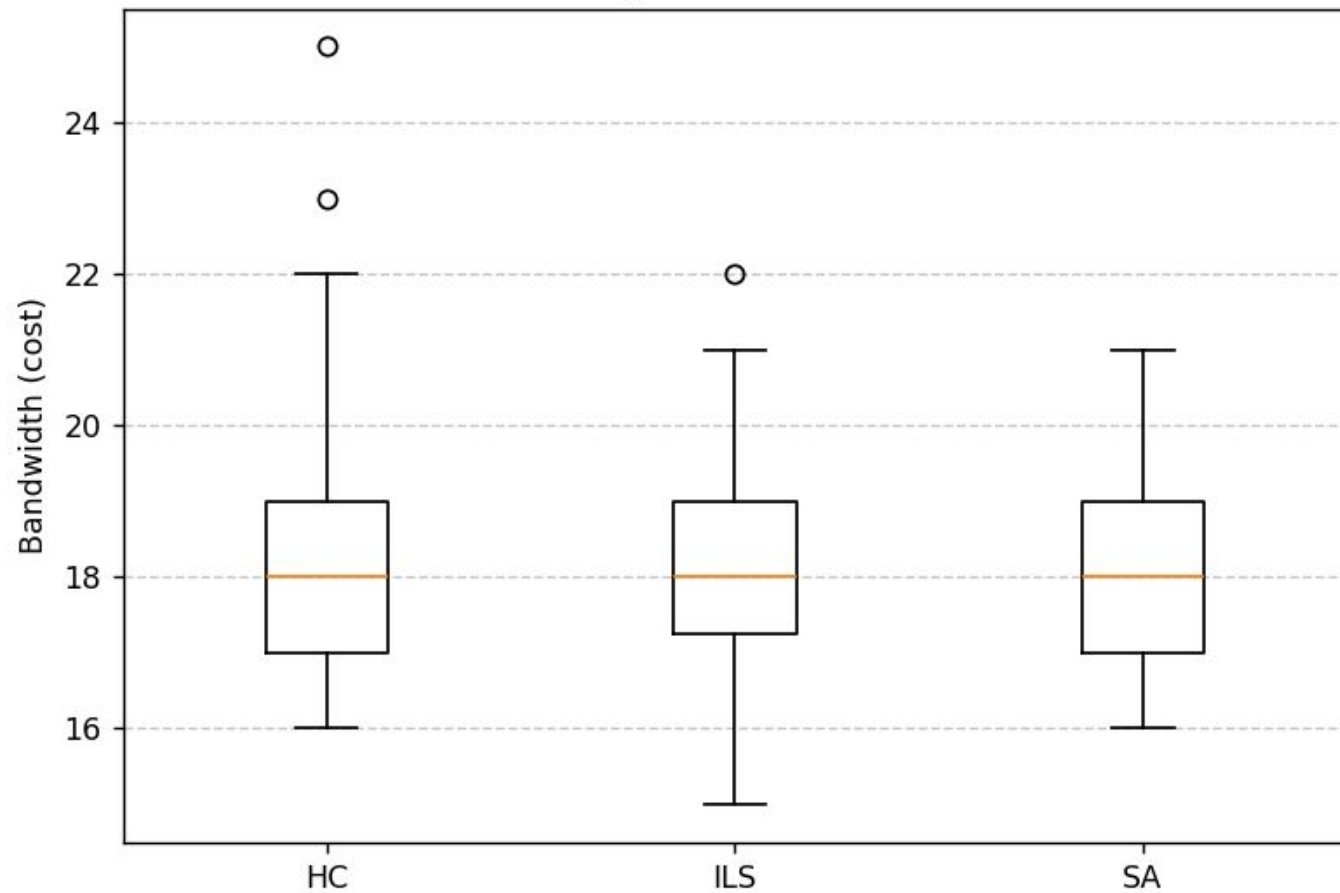
< main*

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Bandwidth comparison over 50 runs
(max_evals = 100000)



<https://colab.research.google.com/drive/1PABqw6sBAD4zyjQsSc7sWASRUbfKVyZa?usp=sharing>