

# AI OFFLINE -2

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## 1 *A high-level description of each algorithm*

Here's a concise high-level description of each algorithm implemented for the Maximum Cut problem:

### **1. Randomized Heuristic:**

- Mechanism:

- Randomly assigns each vertex to partition X or Y with equal probability (50/50)
- Repeats this process multiple times (typically 100 iterations)
- Returns the average cut value across all trials

- Characteristics:

- Fast but low-quality solutions
- Provides a baseline for comparison
- No optimization - purely exploratory

### **2. Greedy Heuristic:**

- Mechanism:

- Starts by placing endpoints of the heaviest edge in opposite partitions
- Iteratively assigns each remaining vertex to the partition that maximizes its contribution to the current cut
- Makes irrevocable decisions at each step

- Characteristics:

- Tends to find decent solutions quickly
- Prone to getting stuck in local optima
- No randomness involved

### **3. Semi-Greedy Heuristic:**

- Mechanism:

- Begins like greedy heuristic (heaviest edge endpoints)
- For remaining vertices:
  - \* Calculates potential contribution to both partitions
  - \* Creates a Restricted Candidate List (RCL) of good options
  - \* Randomly selects from RCL using parameter  $\alpha$  (0=fully random, 1=fully greedy)
- Returns the average cut value across all trials

- Characteristics:

- Balances exploration and exploitation
- More diverse solutions than pure greedy
- $\alpha$  controls the randomness/greediness trade-off
- Construction phase for GRASP

### **4. Local Search :**

- Mechanism:

- Starts with an initial solution (from construction heuristics)
- Evaluates all possible single-vertex moves (flipping partition)
- Computes  $\phi(v) = (\text{edges to opposite partition}) - (\text{edges to same partition})$
- Executes the most improving move (steepest ascent)
- Repeats until no improving moves exist

- Characteristics:

- Guaranteed to find a local optimum
- Delta-based implementation avoids full cut recomputation
- Critical component of GRASP's improvement phase

### **5. GRASP (Greedy Randomized Adaptive Search Procedure) :**

- Mechanism:

- **Construction Phase:** Generates diverse starting solutions using semi-greedy heuristic
- **Improvement Phase:** Refines each solution via local search
- **Iteration:** Repeats for MaxIterations (typically 50-100)
- **Result:** Keeps the best solution found across all iterations

- Characteristics:

- Combines strengths of randomization and local search
- More thorough exploration than single-run methods
- Quality improves with more iterations
- Parameters:  $\alpha$  (RCL), MaxIterations
- State-of-the-art for many combinatorial problems

## 2 Comparison of algorithms

”Across the 54 benchmark graphs, GRASP with local search consistently produced the highest cut values, outperforming all other heuristics in both average and maximum cut size. While Greedy and Randomized methods were significantly faster, they were frequently trapped in poor-quality solutions. Semi-greedy heuristics offered a good middle ground, achieving competitive results in less time than GRASP.”

## 3 Plots

