An Evolutionary Optimization Approach for Disaster Relief Supplies Distribution

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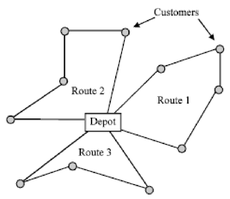
Case Study

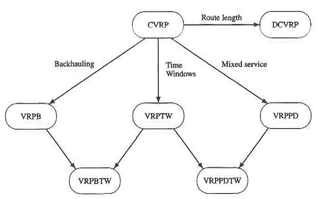
Peru is a country located in the west coast of South America. Since the Peruvian coast is located between the Nazca and South American tectonic plates, earthquakes in Peru are common occurrences. The last major earthquake, which measured 8.0 on the moment magnitude scale, hit the central coast of Peru causing 519 casualties. Despite the considerable relief effort, the response was unfortunately chaotic and marked with a lack of coordination and information.

Problems

- Facility location problems
- Scheduling problems
- Transportation problems
- **Routing problems**

Vehicle Routing Problem





$$\min \sum_{i \in V} \sum_{j \in V} c_{ij} x_{ij}$$

subject to

$$\sum_{i \in V} x_{ij} = 1 \quad \forall j \in V \backslash \{0\} \tag{1}$$

$$\sum_{j \in V} x_{ij} = 1 \quad \forall i \in V \backslash \{0\} \tag{2}$$

$$\sum_{i \in V} x_{i0} = K \tag{3}$$

$$\sum_{j \in V} x_{0j} = K \tag{4}$$

$$\sum_{i \notin S} \sum_{j \in S} x_{ij} \geq r(S) \quad \forall S \subseteq V \backslash \{0\}, S \neq \emptyset \tag{5}$$

$$x_{ij} \in \{0,1\} \quad \forall i,j \in V \tag{6}$$

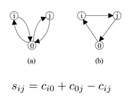
Exact Approaches

- Branch-and-Bound Algorithms
- Branch-and-Cut Algorithms
- Set-Covering-Based Algorithms

Heuristics

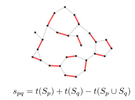
- Limited exploration of the search space
- Good quality solutions
- Modest computing times
- Can be extended to account for diverse constraints

Constructive Methods



$$s_{ij} = c_{i0} + c_{0j} - c_{ij}$$

Clarke and Wright Savings Algorithm



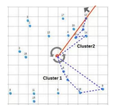
$$s_{pq} = t(S_p) + t(S_q) - t(S_p \cup S_q)$$

Matching-Based Savings Algorithms

$$\alpha(i,k,j) = c_{ik} + c_{kj} - \lambda c_{ij}$$
$$\beta(i,k,j) = \mu c_{0k} - \alpha(i,k,j)$$

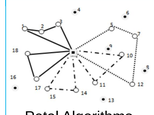
Sequential Insertion Heuristics

Two-Phase Methods

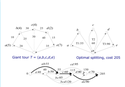


Clustering Methods

Truncated Branch-and-Bound



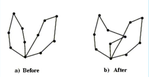
Petal Algorithms



Route-First, Cluster-Second Methods

Improvement Heuristics

Single-Route Improvements

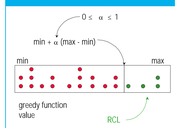


Multiroute Improvements

The Genetic Algorithm

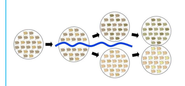
1. Generate initial population
2. Repeat
   1. For each species
      For i=1 to n
         Select two parents from current species
         Generate a new solution with the crossover operator
         Perform a local search with the mutation operator
         Add the new solution to the current species
      Remove the n worst individuals using the evaluation function
   2. Exchange the local best solutions across species
3. Until convergence criteria or maximum number of generations

Initialization



GRASP

Population



Speciation

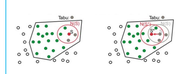
Selection

Tournament Selection

Mutation

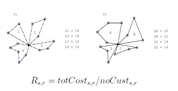
2-opt Procedure

Mutation



Tabu Search

Crossover



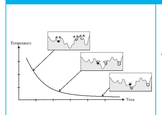
Uniform Crossover

$$f_s = \sum_{r \in s} cost_{s,r} + \alpha \cdot \frac{it}{IT} \sum_{r \in s} (max(0, totdem_{s,r} - cap))^2$$

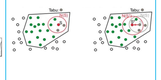
$$\alpha = \frac{best}{\frac{1}{IT}(\frac{mnv}{2} \cdot cap)^2}$$

$$mnv = \left\lceil \frac{\sum_{c \in s} dem_c}{cap} \right\rceil$$

Metaheuristics

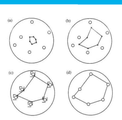


Simulated Annealing

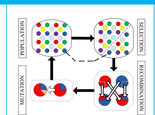


Tabu Search

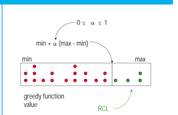
Ant Algorithms



Neural Networks

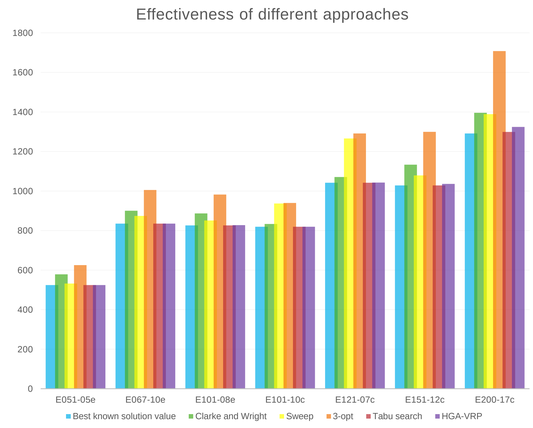


Genetic Algorithms

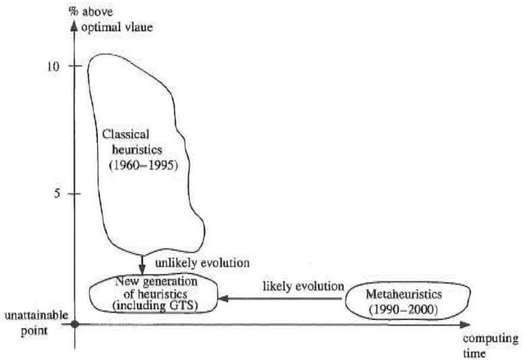


Greedy Randomized Adaptive Search Procedure

Evaluation



Discussion



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