Disaster Recovery Strategy Generation via Multi-Objective Heuristic Optimization

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Problem Statement

Following extreme (disaster) events, extensive restoration efforts are often required to return an affected area's infrastructure to its pre-disaster functionality. The rapidity demonstrated and cost incurred in completing this restoration can have significant impact on the long-term *health* of the impacted community.

Critical:

- Expedience
- Affordability

Community Impacts

Economic	Non-Economic*
• Restoration Costs • Lost Commerce • Outmigration • Resource Loss	• Mental Health Effects • Opportunity Loss • Resource Unavailability

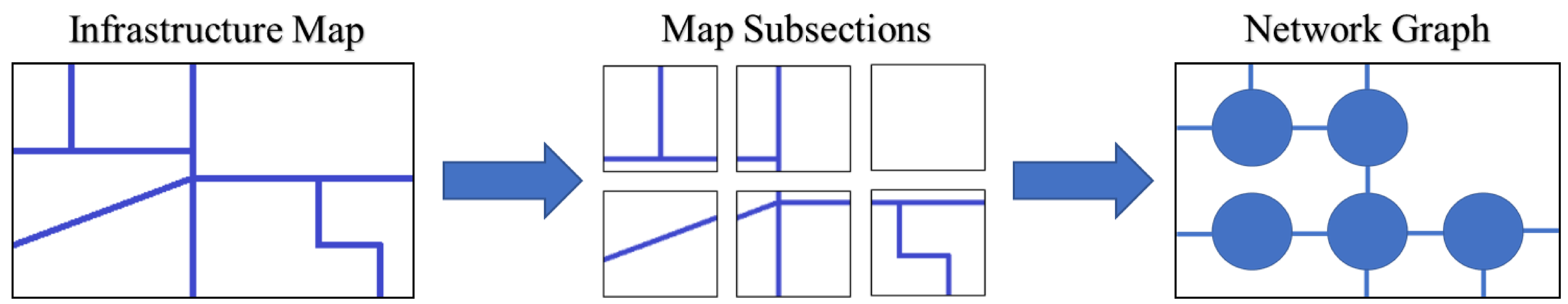
Challenges

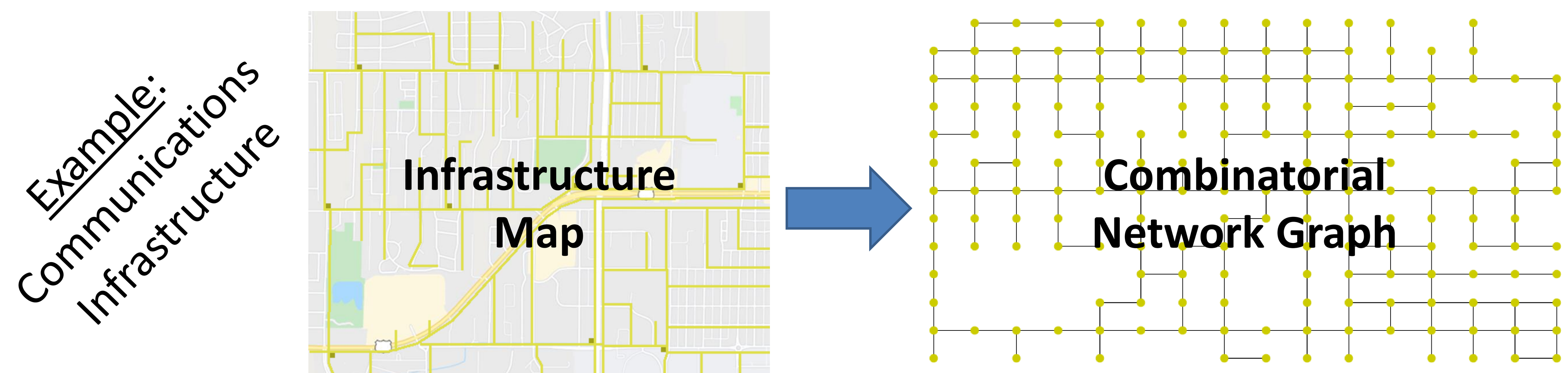
Many factors complicate the process of determining the best order to restore infrastructure elements to optimize restoration time and expense:

- Nature of infrastructure maps
- Rigor of mathematical formulation
- Highly dependent nature of infrastructure systems
- Competing objectives of time and cost
- Massive search space for even small areas

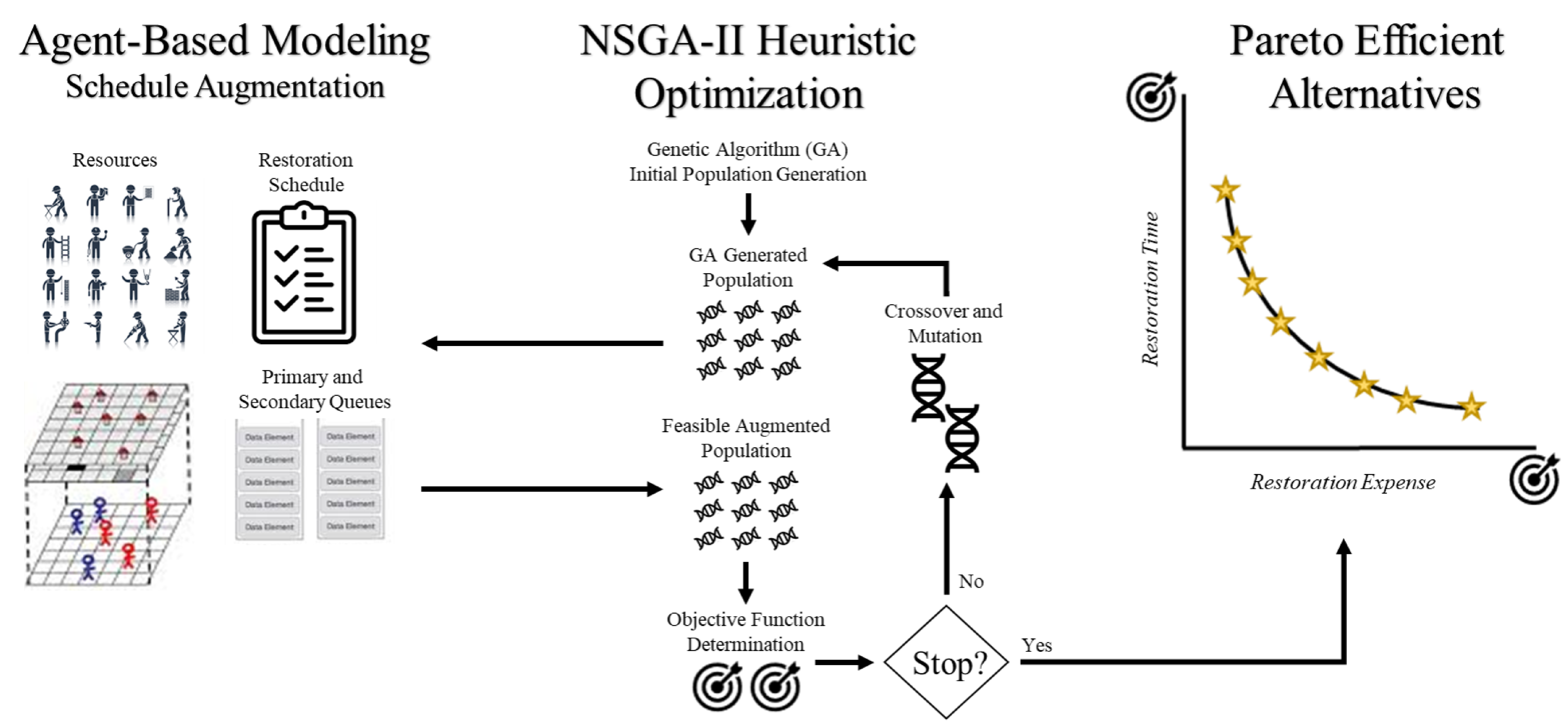
Automated Network Graph Construction

Using image processing, a basic infrastructure map can be automatically translated into a combinatorial graph about which network optimization techniques can be applied.



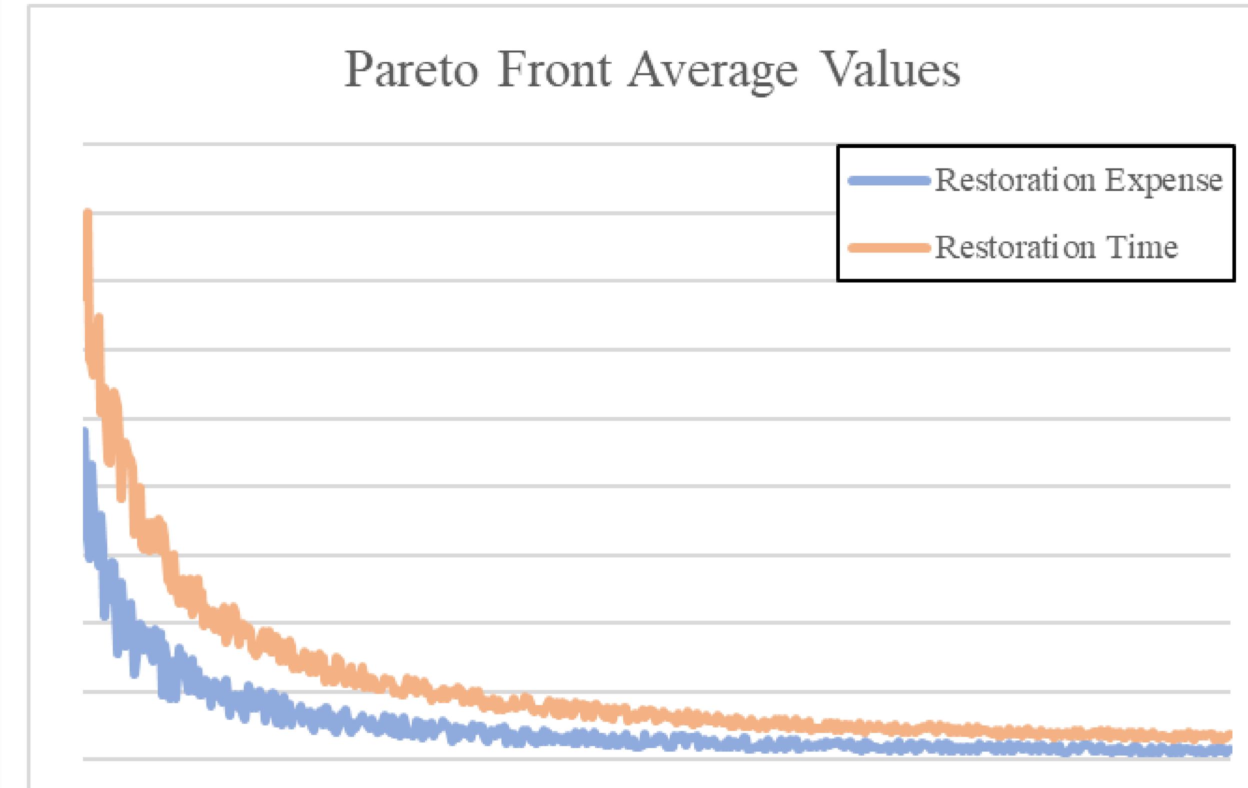


Two-Stage Heuristic Optimization



A multiobjective genetic algorithm develops restoration schedules seeking to simultaneously optimize the restoration time and restoration cost. An agent-based simulation is used in-place of a standard fitness function to overcome the arduous task of mathematical formulation.

Simulation Results



Above: Average restoration times and expense seen dropping as genetic algorithm generations progress

Below: Average restoration time and expense of final generation's (500th) Pareto front compared to best values upon initiation.

Population	Objective Measure	Minimum Exhibited Value	Average Exhibited Value
Initial Feasible Population	Recovery Cost	$1,980,090	$2,998,845
	Recovery Time	42 Days	49.6 Days
Final Pareto Front	Recovery Cost	$761,130	$1,410,310
	Recovery Time	21 Days	29.1 Days

Contributions

Primary contributions of this research include:

- Presents a method enabling the automated creation of combinatorial network graphs enabling network optimization
- Uses heuristic optimization to allow multiobjective investigation without extensive mathematical formulation
- Easily handles precedence constraints and other infrastructure dependencies
- Demonstrated capable of autonomously improving restoration time and cost in a simulated disaster