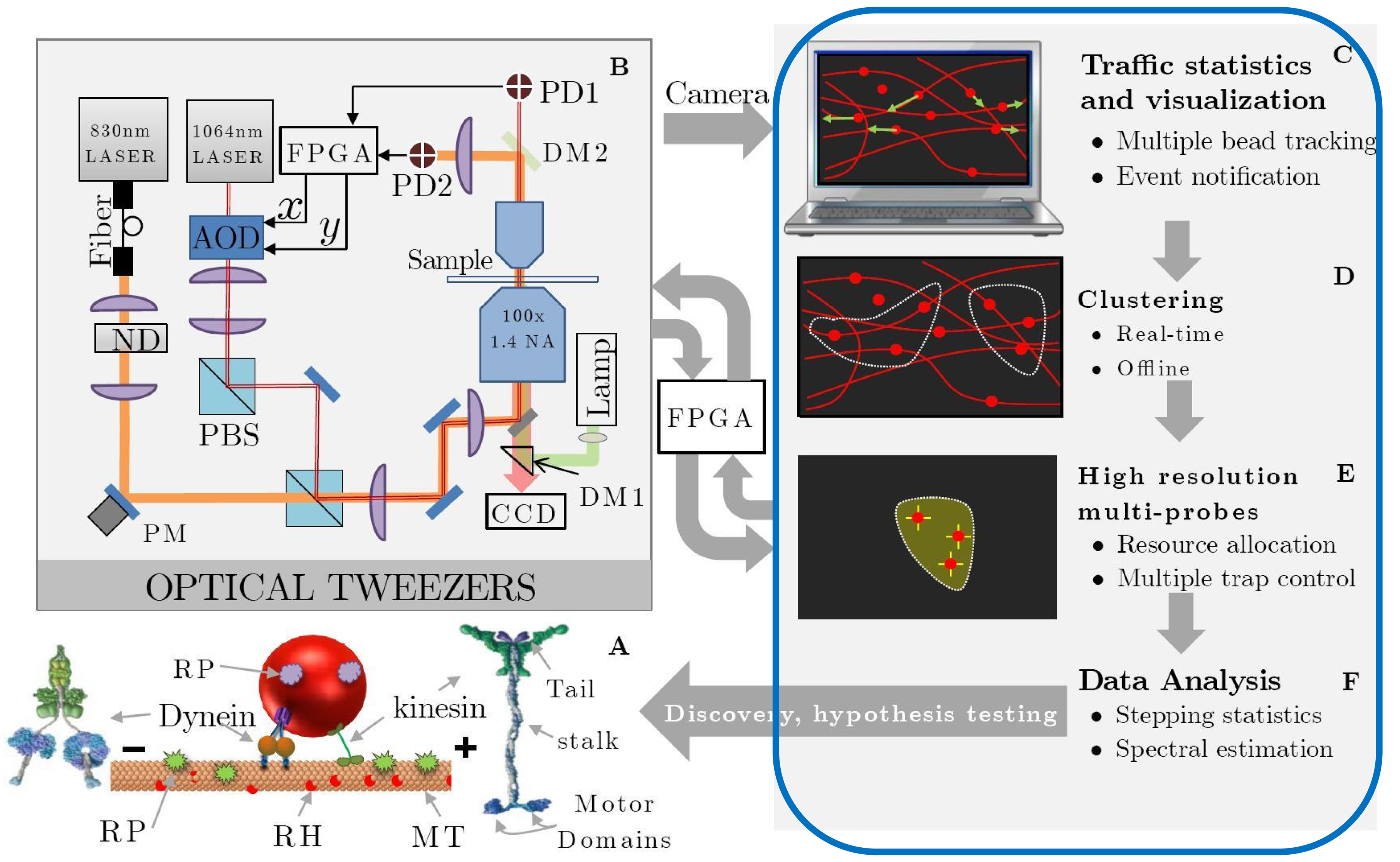
Resource Allocation For Traffic Modalities: Traveling-Salesman And Related Scheduling Problems

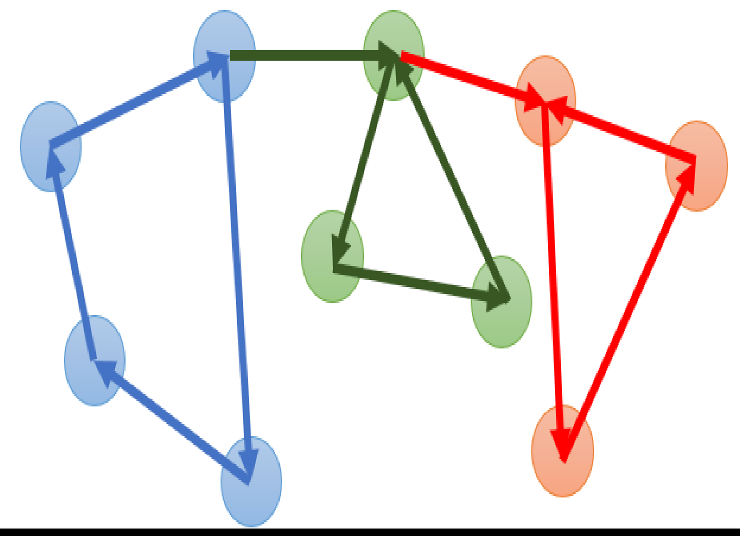
Srinivasa Salapaka (PI), Mayank Baranwal

University of Illinois, Urbana-Champaign

Overview



INFERENCE AND CONTROL ENGINE



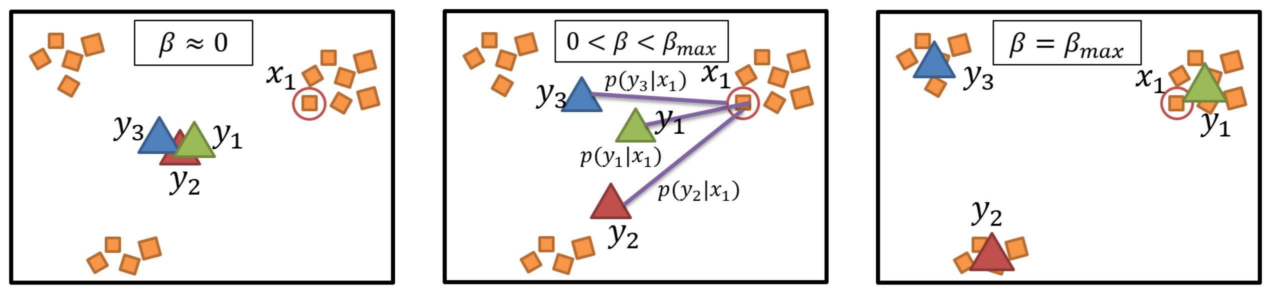
- Clustering of cargo based on measurements
- Traveling-salesman problem (TSP) with scheduling
  - High resolution sensing and manipulation resources are scarce
  - Optimal allocation needed

Deterministic Annealing (DA) algorithm

- Given N sities located at $\{x_i : 1 \le i \le N\}$, find K facility locations $\{y_j : 1 \le j \le K\}$ such that distance of a site i to its nearest facility j is minimized
- DA addresses optimal resource allocation as

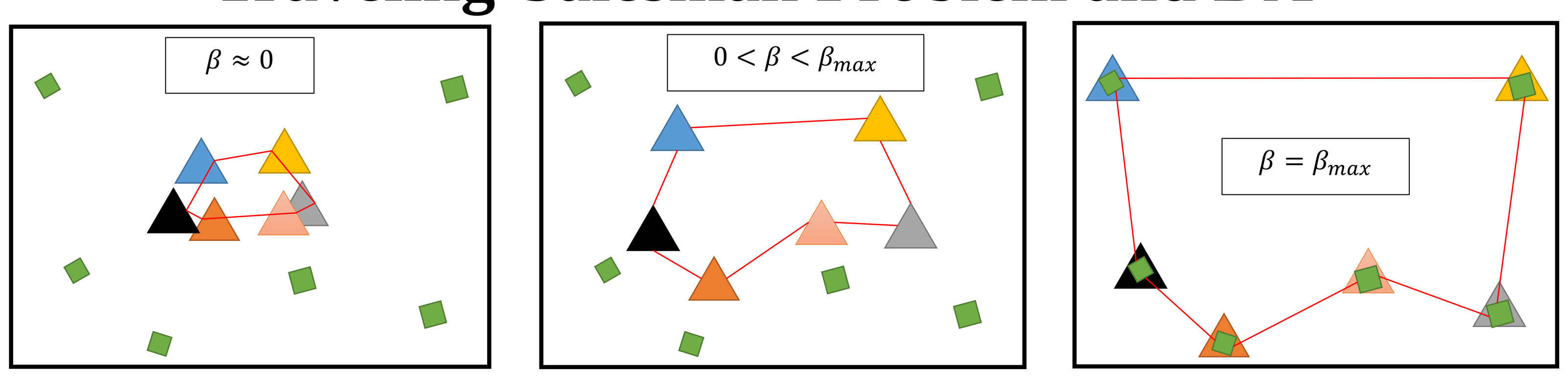
$$\min_{\{y_j, p_{j|i}\}} D - \frac{1}{\beta} H = \min_{\{y_j\}} \; -\frac{1}{\beta} \sum_{i=1}^{N} p_i \log\left(\sum_{j=1}^{K} e^{-\beta d(x_i, y_j)}\right), \text{ where,}$$

$$D = \sum_{i=1}^{N} \sum_{j=1}^{K} p_i p_{j|i} d(x_i, y_j); \quad H = -\sum_{i=1}^{N} p_i \sum_{j=1}^{K} p_{j|i} \log p_{j|i}; \; p_{j|i} = \frac{e^{-\beta d(x_i, y_j)}}{\sum_k e^{-\beta d(x_i, y_k)}}; \; p_i = \frac{1}{N}$$



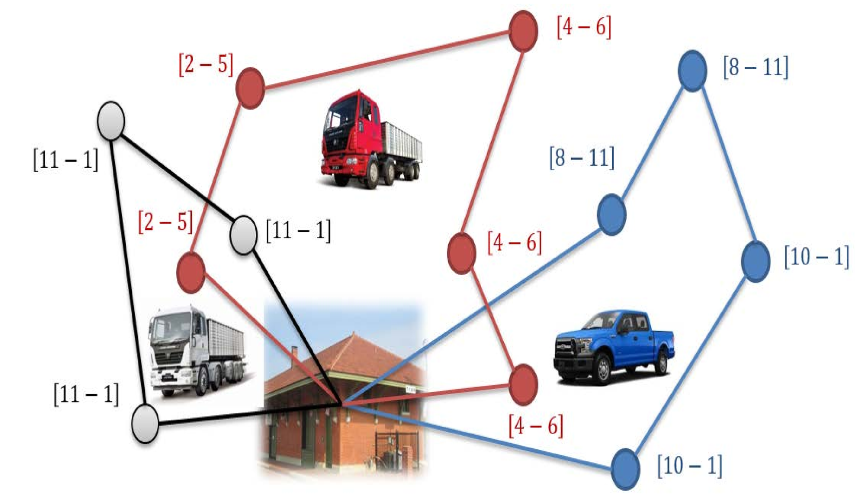
Working methodology of DA

Traveling-Salesman Problem and DA



$$\min_{\{y_j\}} \; -\frac{1}{\beta} \sum_{i=1}^{N} \log\left(\sum_{j=1}^{N} e^{-\beta d(x_i, y_j)}\right) + \left(\sum_{j=1}^{N} d(y_j, y_{j+1})\right)$$

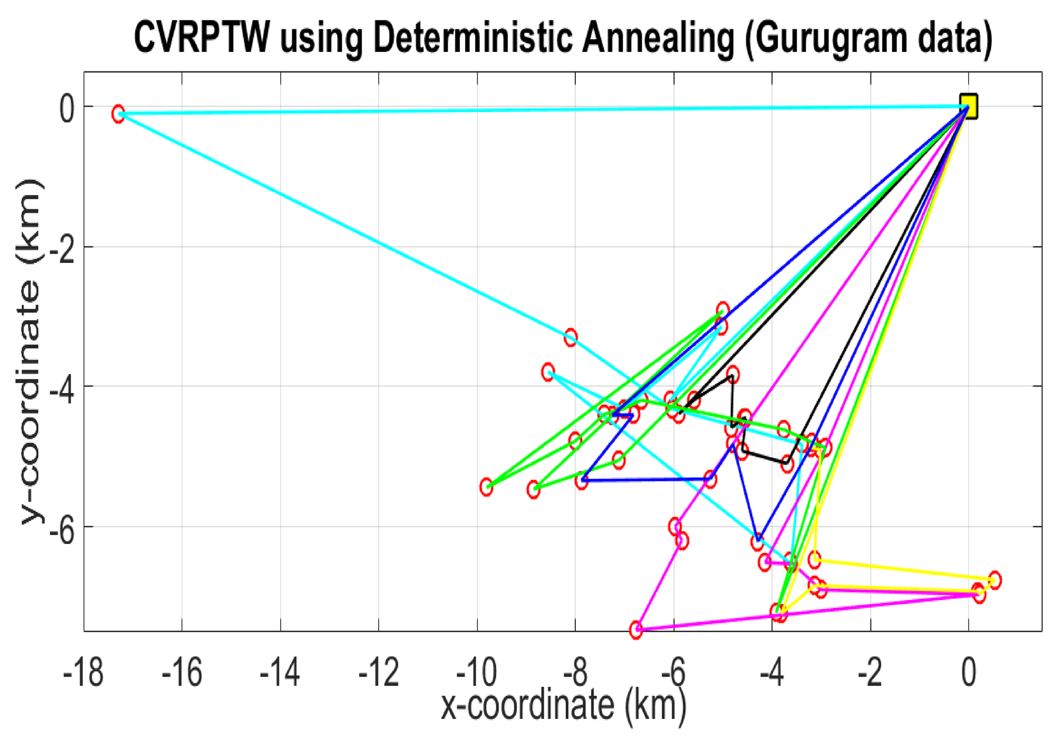
TSP with Time-Windows

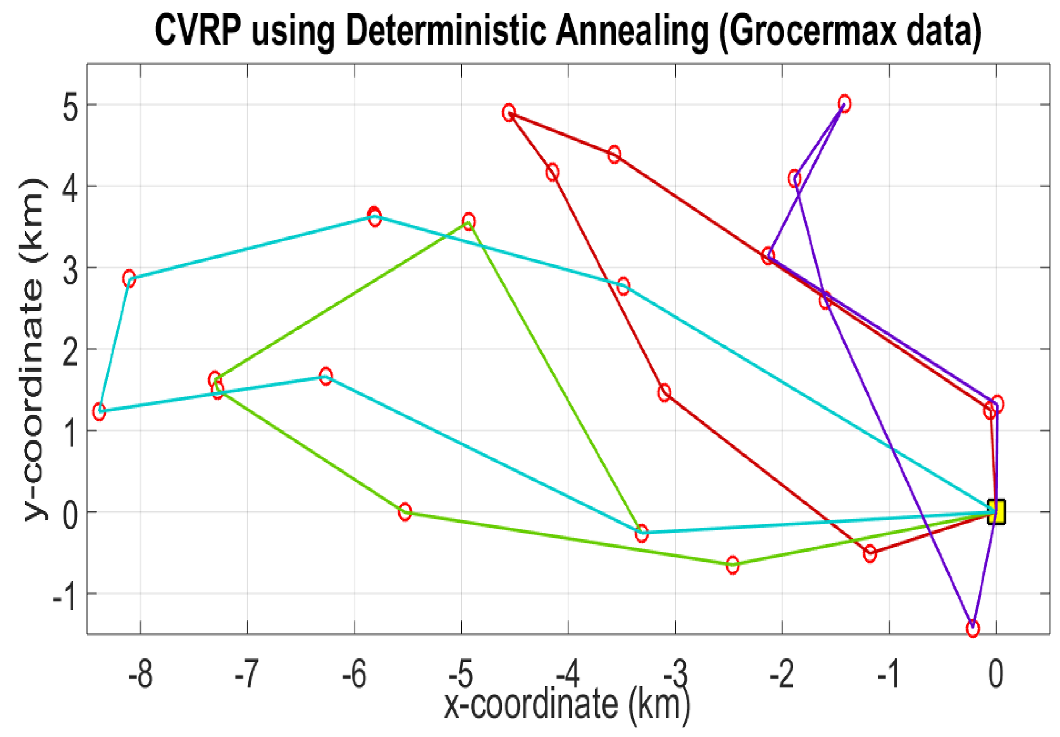


- Each customer is equipped with a service time-window $[t_i^s - t_i^f]$
- $d(x_i, y_j)$ in DA is as

$$d(x_i, y_j) = \left\| \begin{matrix} x_i^{(1)} - y_j^{(1)} \\ x_i^{(2)} - y_j^{(2)} \\ \lambda\left(0.5\left(t_i^s + t_i^f\right) - y_j^3\right) \end{matrix} \right\|^2$$

Implementation on Real Datasets from a Logistics Startup

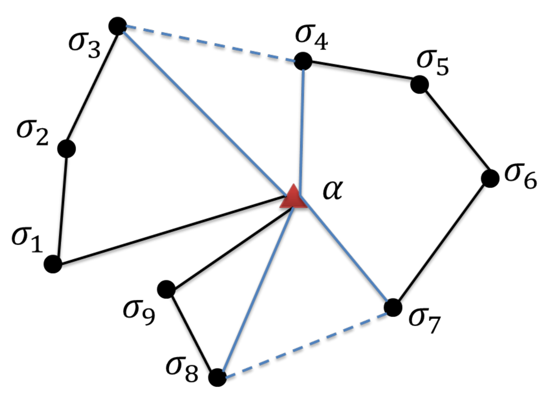




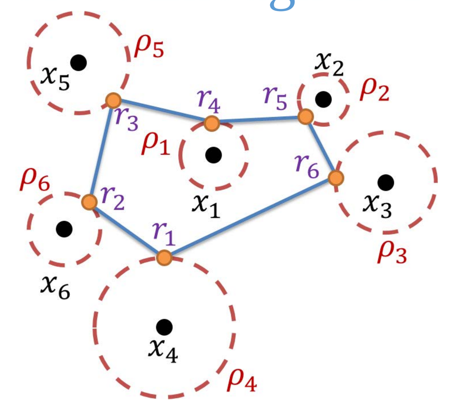
Variants of TSP and Extensions to other related problems

- DA is successfully applied to many NP-hard graph problems

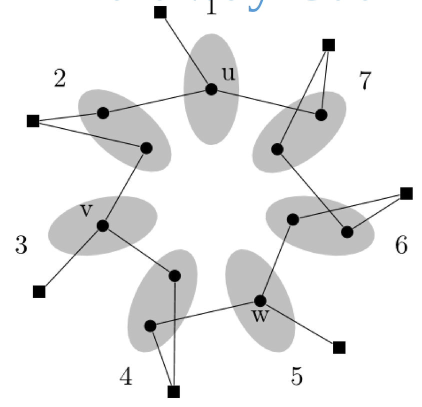
*m*TSP



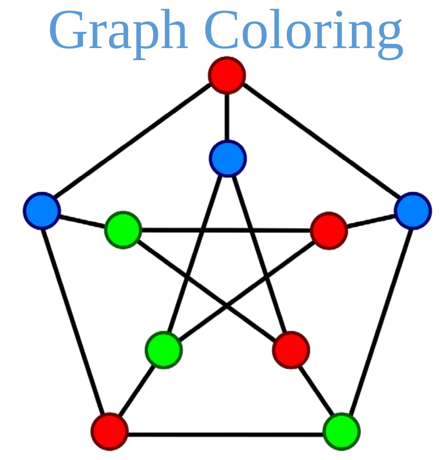
Close Enough TSP



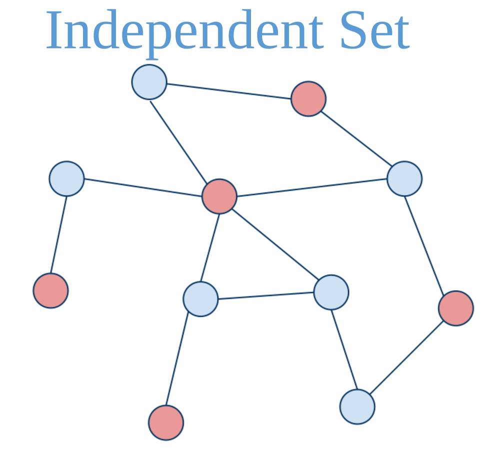
Multiway Cut



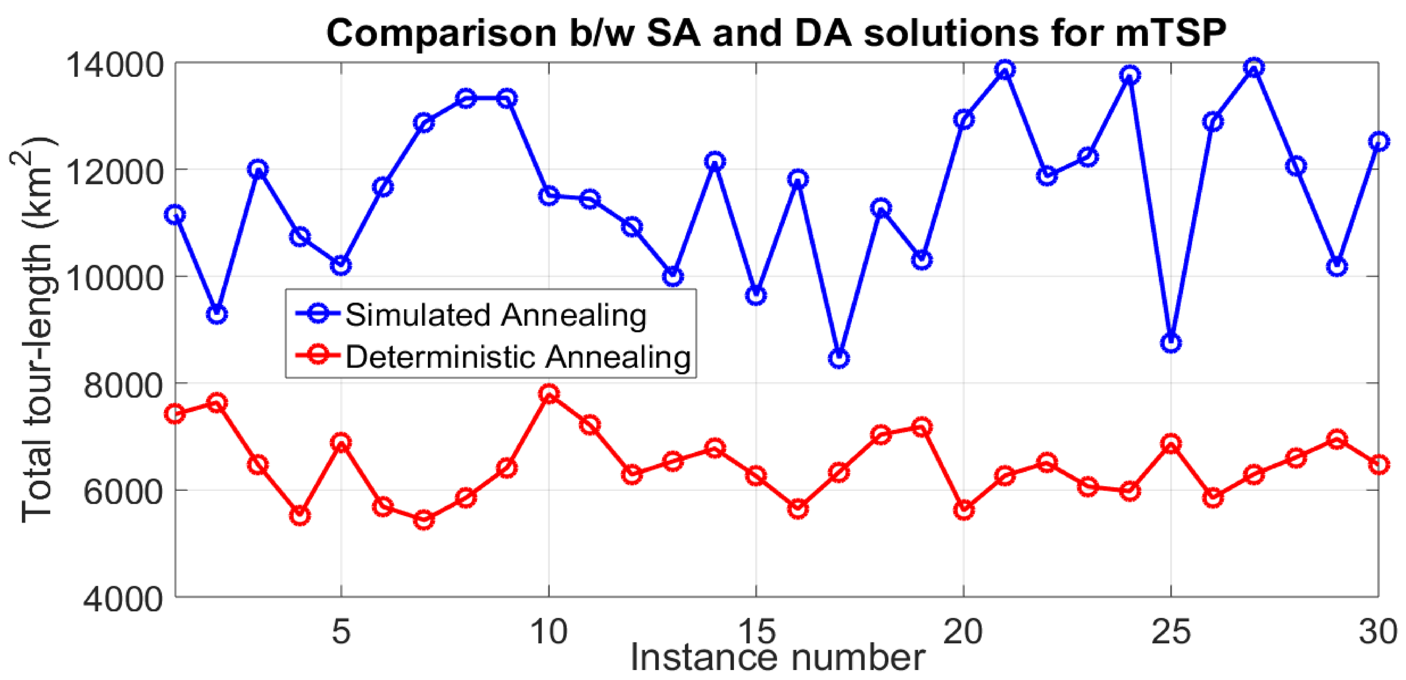
Graph Coloring



Independent Set



Results and Comparisons



- Run-time comparisons:
  1. Gurugram data
     a) DA: 19.91s
     b) SA: 55.40s
  2. Grocermax data
     a) DA: 5.51s
     b) SA: 42.3s

SUMMARY

1. Manipulation and sensing using optical fields demand control with resource allocation constraints
2. The control problems are studied in the spirit of the TSP with time-windows and its variants thereof
3. A Deterministic Annealing (DA) based algorithm is proposed to incorporate several resource allocation constraints

Lead Institution: University of Minnesota, Twin Cities

Lead PI: *Dr. Murti Salapaka*