Combinatorial Optimization

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1. Affine independence, positive scalar multiple and linear independence.

2. Piotr's question.

3. Not covering polytope theory. Something of everything or everything of something.

4. Matroids after shortest paths.

5. Directed graphs and undirected graphs.

6. Representation of digraphs.

7. Diwalk, Dipath, interior vertex, dicycle.

8. The minimum dipath problem (Shortest path problem). Can it have cycles?

9. Presence of negative cost cyles.

10. Shortest paths in the presence of negative weight cycles.

11. No negative cycles.

12. The relax operation. The difference between d and δ. d represents the cost of an actual path.

13. Optimal substructure property.

14. Triangle inequality $\delta(s, v)$.

15. Convergence property.

16. Bellman-Ford Algorithm. Two different dynamic programs.

$$
\begin{aligned}
d[v] &= \delta(s, v) \\
&\leq \delta(s, u) + w(u, v) \\
&= d[u] + w(u, v)
\end{aligned}
$$

17. Extracting the shortest path.

18. All-Pairs Shortest path problem. Floyd-Warshall algorithm.

$$
\begin{aligned}
d_{ij}^{k} &= w_{ij}, \; if \; k = 0 \\
&= d_{ik}^{k-1} + d_{jk}^{k-1}, \; otherwise.
\end{aligned}
$$