AIRLINE PLANNING ALGORITHM

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Future Work

1 Solution Improvements

The formulation of this routing problem has a very high branching factor and complexity level which makes it difficult to apply to real-world scenarios.

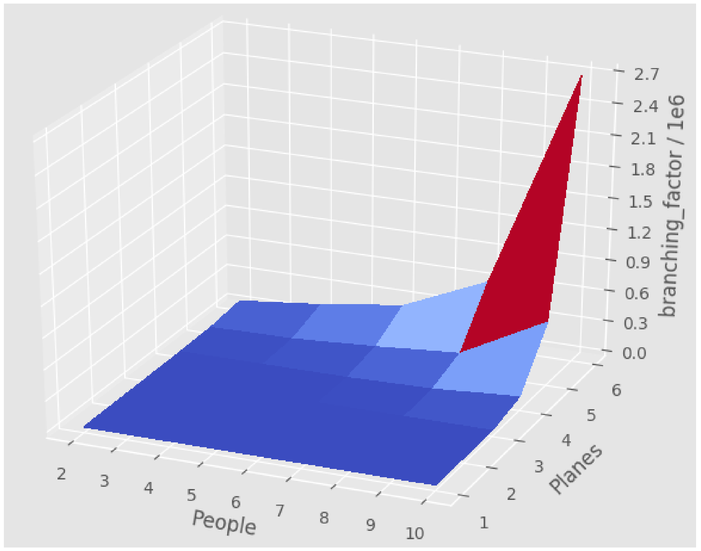

Fig. 1: **Problem 2** Branching Factor as a function of Passengers and Planes

Scalability in the Vehicle routing problem, which is NP-hard, is currently an unsolved problem. To manage this branching factor and allow for increased scalability, the next steps would be to implement the following:

- Different heuristic algorithms such as the Clarke-Wright Algorithm [12] which is commonly implemented in the VRP to find quicker feasible solutions
- Deep Q Learning with Reinforcement Learning [11] to optimize the learning time

Both of these solutions would limit the branching factor and allow for solving larger problems.

2 Additional Considerations

To transform this problem to real world data, there are additional constraints that could be explored. These variations include the following:

- Adding costs, such as fuel, manteinance, crew, taxes
- Adding stochasticity for delays or equipment malfunctions
- Modeling competing airline routes to understand how the increase in supply would impact ticket prices
- Taking into account the optimal scheduling of flight crews
- Considering how seasonality impacts ticket prices

This additional data would increase the effectiveness of the plan, transforming it to a real-world solution.

References

[1] Sohaib Afifi, Duc-Cuong Dang, and Aziz Moukrim. “A Simulated Annealing Algorithm for the Vehicle Routing Problem with Time Windows and Synchronization Constraints”. In: *7th International Conference, Learning and Intelligent Optimization (LION 7)*. Vol. 7997. Catania, Italy, Jan. 2013, pp. 259–265. DOI: 10.1007/978-3-642-44973-4_27. URL: https://hal.archives-ouvertes.fr/hal-00916972.

[2] J. Bailey. *How Do Airlines Actually Plan Routes?* 2019. URL: https://simpleflying.com/how-do-airlines-plan-routes/.

[3] Marshall Fisher. *Handbooks in Operations Research and Management Science*. 1995. Chap. Vehicle routing.

[4] *Flight-UI: A Flight Application in Flutter*. Available at https://github.com/ajay1706/Flight-UI?files=1 (Accessed: 2019-10-03).

[5] Anders Forsgren and Margaret H. Wright. “An elementary proof of linear programming optimality conditions without using Farkas’ lemma”. In: 2014.

[6] Maria Fox and Derek Long. “PDDL2.1: An Extension to PDDL for Expressing Temporal Planning Domains”. In: *CoRR* abs/1106.4561 (2011). arXiv: 1106.4561. URL: http://arxiv.org/abs/1106.4561.

[7] *HomePage - Fast Downward Homepage*. Available at http://www.fast-downward.org/ (Accessed: 2019-10-03).

[8] M Kefi and K Ghedira. “A multi-agent model for the Vehicle Routing Problem with Time Windows”. In: *WIT Transactions on The Built Environment* 75 (2004).

[9] Gilbert Laporte. “The vehicle routing problem: An overview of exact and approximate algorithms”. In: *European Journal of Operational Research* (1992).

[10] Abdul Kadar Muhammad Masum et al. “Solving the Vehicle Routing Problem using Genetic Algorithm”. In: *International Journal of Advanced Computer Science and Applications* 2.7 (2011). DOI: 10.14569/IJACSA.2011.020719. URL: http://dx.doi.org/10.14569/IJACSA.2011.020719.

[11] MohammadReza Nazari et al. “Deep Reinforcement Learning for Solving the Vehicle Routing Problem”. In: *CoRR* abs/1802.04240 (2018). arXiv: 1802.04240. URL: http://arxiv.org/abs/1802.04240.

[12] Petrică Claudiu Pop et al. “Heuristic Algorithms for Solving the Generalized Vehicle Routing Problem”. In: *International Journal of Computers Communications Control* 6.1 (2011), pp. 158–165. ISSN: 1841-9844. DOI: 10.15837/ijccc.2011.1.2210. URL: http://univagora.ro/jour/index.php/ijccc/article/view/2210.

[13] Stuart J Russell and Peter Norvig. *Artificial intelligence: a modern approach*. Malaysia; Pearson Education Limited, 2016.

[14] *Skyscanner Flight Search API: How To Use the API | RapidAPI*. Available at https://rapidapi.com/skyscanner/api/skyscanner-flight-search/details (Accessed: 2019-10-03).

[15] Paolo Toth and Daniele Vigo. *The vehicle routing problem*. SIAM, 2002.

[16] Antonio A Trani. *Applications of Linear Programming Associate Professor of Civil Engineering*. Available at http://www.fast-downward.org/ (Accessed: 2019-10-03).

[17] Sedighe Zibaei, Ashkan Hafezalkotob, and Seyed Sajad Ghashami. “Cooperative vehicle routing problem: an opportunity for cost saving”. In: *Journal of Industrial Engineering International* 12.3 (2016), pp. 271–286.