Analyses of Experimental Heuristics for Package-Handoff Type Problems

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Chapter 1

Overview

How do you get a package from point A to point B with a fleet of drones each capable of various maximum speeds? This is the question we try to answer in all its various avatars by developing algorithms, heuristics, local optimality heuristics and lower-bounds.

To be more specific, we are given as input the positions P_i of n drones (labelled 1 to n) in the plane each capable of a maximum speed of u_i. Also given is a package present at S that needs to get to T. Each drone is capable of picking up the package and flying with speed u_i to another point to hand the package off to another drone.

The challenge is to figure how to get the drones to cooperate to send the package from S to T in the least possible time i.e. minimize the makespan of the delivery process.

To solve the problem we need to be able to do several things

- Figure out which subset $S = \{i_1, i_2, \ldots i_k\}$ of the drones are used in the optimal schedule.
- Find the order in which the handoffs happend between the drones used in a schedule.
- Find the "handoff" points when drone i_m hands over the package to drone i_{m+1} for all $m \leq k-1$ [1]

This category of problems is a generalization of computing shortest paths in $\mathbb{R}^2$ between two points. As far as we know such problems have not been considered before in the operations research or computational geometry literature; it is, however, reminescent of the Weighted Region Problem [Mitchell and Papadimitriou, 1991] (henceforth abbreviated as `WRP`) where one needs to figure out how to compute a shortest *weighted* path between two points in the plane that has been partitioned into convex polygonal regions, each associated with a constant multiplicative weight for scaling the euclidean distance between two points *within* that region.

The distinctive feature of this problem and its generalizations is figuring out how to make multiple agents of *varying* capabilities located at different points in $\mathbb{R}^2$ (such as maximum capable speed, battery capacity, tethering constraints etc.) *cooperate* in transporting one or more packages most efficiently from their given sources to their target destinations.

Each chapter in this document is devoted to developing algorithms for a specific variant of the package handoff problem (henceforth abbreviated as `PHO`), beginning with the plain-vanilla single package handoff problem described above. For most algorithms we will also be giving implementations in Python described in a literate-programming style [2] [Knuth, 1984] using the NuWeb literate programming tool [Briggs et al., 2001] for weaving and tangling the code-snippets.

You can check out the Package Handoff code from the following GitHub repository:

`https://github.com/gtelang/PackageHandoff_Python`

The `README` file gives instructions on how to run the code and any of the associated experiments.

[1] The drone i_k flies with the package to the target site T

[2] which essentially means you will see code-snippets interleaved with the actual explanation of the algorithms. The code snippets are then extracted using a literate programming tool (using a so called a "weaver" and "tangler") into an actual executable Python program

Chapter 2

Single Package Handoff

Chapter Index of Fragments

None.

Chapter Index of Identifiers

Bibliography

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Appendices