Applied Optimization: Location Planning – Exercises Part I

10th October 2020

Imagine the following decision problem. The Danish Ministry of Defense plans to use a substantial number of new surveillance drones in order to improve control and surveillance of critical infrastructure in the country. The drones are completely autonomous, can be made ready within 2 minutes, have a maximum flight time of 110 minutes, can be controlled online, are equipped with real-time aerial surveillance cameras and data gathering sensors, and can send videos back online in real-time within a radius of 50 km.

The ministry plans to install a number of runways and charging stations (including a small control office) for these drones in every of Denmark's five regions. For the region of Mid Jutland ("Midtjylland"), the ministry believes that about 5–10 of these kind of "drone base stations" could be sufficient. For deciding on the drones' base stations' locations, the ministry wants to divide the region of Mid Jutland into non-overlapping sub-regions and to place a "drone base station" somehow centrally in each sub-region. It is thereby expected that the number of drones required for surveillance as well as the number of times a drone is employed per month for surveillance of a particular location or village in Mid Jutland is approximately proportional to the village's population.

1. The file `midt.txt` contains population data for all villages of Mid Jutland at the 1st of January 2022. The data were taken from bolius.dk, which in turn extracted the data from Danmarks Statistik befolkningsstatistik, BY1. Use these data to provide possible solutions for the drone stations' locations in case that the total distance flown by all employed drones should be minimized. Analyze "key figures" of the solutions you found, in particular in dependence on the number of "drone stations" located.

2. A critical point is that a drone can only send back video data in real-time within a distance of 50 km. Also the maximal flight time of 110 minutes could be an issue. Additionally, it can be important to have small "reaction times", so that a drone can quickly reach a place to survey. The head of the planning staff therefore suggests to locate the drone stations such that the

maximal distance to be covered by a drone is smallest. Provide solutions to this problem of minimizing the maximal distances for the case that again 5 to 10 drone stations have to be located. Analyze again "key figures" of the solutions and compare them in particular to those obtained when minimizing total distances flown.

3. Model the problem of minimizing the maximal drone distance as a quadratically constrained mixed integer program.

4. Suzuki and Drezner (1996) consider the *p-center location problem in an area*, where it is assumed that "demand" is continuously distributed over an area and cannot be represented as a finite set of points. Read the paper and discuss pros and cons of this model compared to the model(s) employed in the previous points. Summarize also the solution procedure suggested by Suzuki and Drezner (1996).

Please, hand in your answers until 7th of November, 2020.

References

Suzuki, A. and Drezner, Z. (1996). The p-center location problem in an area. *Location Science*, **4**(1), 69–82.