Small Project

December 1, 2025

Problem description

A consulting company uses drones to analyze the external surfaces of arbitrary buildings by means of cameras and various types of sensors. The company has been tasked with analyzing a specific building, and the set of points at which the drone must stop to perform measurements is known. Each point in the given set is identified by its three spatial coordinates; we can instead neglect the issue of the drone orientation at each point.

The measurement team for the building has $k = 4$ drones. At the beginning of the measurement, the team positions itself at a point (x_0, y_0, z_0) and launches all drones simultaneously. Each drone explores a subset of the points and returns to the starting point. The speeds of each drone are:

- 1 m/s when moving upward;
- 2 m/s when moving downward;
- 1.5 m/s for purely horizontal movements;
- a combination for oblique movements: for a segment with lateral movement of length a and vertical (upward) movement of length b, the travel time is

$$\max\left\{\frac{a}{1.5\ \mathrm{m/s}},\ \frac{b}{1\ \mathrm{m/s}}\right\}.$$

We may assume that the drones are either stationary or moving at the speeds listed above; that is, we can neglect the computation of acceleration and deceleration when moving from one point to another.

We must decide the trajectories of each of the k drones so that every point in the given grid is visited by exactly one drone. Since time is money, we must find trajectories that minimize the time taken by the last drone to return to the base point.

Two points A and B of the grid are *connected* (i.e., a drone can travel from A to B and vice versa) if and only if:

- the Euclidean distance between A and B is at most 4 m, *or*
- the Euclidean distance between A and B is at most 11 m and *two* among the coordinates x, y, and z differ by at most 0.5 m.

This connectivity condition does *not* apply to the segments between the base point and the "entry" points of the grid, specified below, which are the only points that are accessible to all drones when they depart from the base and when they return from the grid to the base. Each drone may travel along the segments between the base point and any of these entry points (we also neglect the possibility of collisions between drones), regardless of the distance.

Two instances of the problem are given in the attached files `Edificio1.csv` and `Edificio2.csv` (CSV format), which contain the spatial coordinates (x, y, z) of the points to be visited. The coordinates (x_0, y_0, z_0) of the starting point are as follows:

- for `Edificio1.csv`: $(0, -16, 0)$; the entry points are all grid points (x, y, z) with $y \leqslant -12.5$;
- for `Edificio2.csv`: $(0, -40, 0)$; the entry points are the grid points (x, y, z) with $y \leqslant -20$

Operational instructions for submission

Upload a file named `Cognome_Nome_IDpersona.zip`, using your surname, name, and personal ID (not your student number). This must be a `.zip` archive containing a folder called `Cognome_Nome_IDpersona` with the following files:

- the two files `Edificio1.csv` and `Edificio2.csv`;
- one or more Python files that use the `mip` module to model and solve the problem; there may be multiple Python scripts, but the Python script to be executed *must* be named `main.py`.

The script `main.py` *must* accept one input argument, which must be a file with the same format as `Edificio1.csv` and `Edificio2.csv`.

The person evaluating your project *must* be able to run it by executing the following two commands from the terminal:

```
unzip Cognome_Nome_IDpersona.zip
python Cognome_Nome_IDpersona/main.py Cognome_Nome_IDpersona/Edificio1.csv
```

After solving the problem, the program *must* produce an output in which, for each drone i with $i = 1, \dots, k$, the string `Drone i` is printed, followed by the sequence of points visited by drone i from the base point (which can be assumed to have index 0) until it returns to the base point, as in the following example:

```
Drone 1: 0-4-11-17-...-2-0
Drone 2: 0-5-6-3-...-7-0
Drone 3: 0-9-...-0
Drone 4: 0-12-...-0
```

Any error encountered by your evaluator in executing the steps described above will result in penalties to your score.

The submission can be done until **December 10th 23:59 hrs** on Webeep (assignment Small Project).