1 Methods description

1.1 global optimization of sequences

First, three constraints are implemented to filter the entire set of asteroids, which are given below:

- \( 2.83 \leq \text{semimajor axis} \leq 2.94 \)
- \( 0 \leq \text{eccentricity} \leq 0.1 \)
- \( 0 \leq \text{inclination} \leq 3.5^\circ \)

In Fig. 1, the selected points are marked by red color.

Second, suppose the mothership launch from Earth and rendezvous an asteroid in the red region illustrated above, a set of feasible transfer trajectories are determined by solving lambert problems.

Third, branch and bound method is used to generate sequences respect to 3 probes.
1.2 local optimization of each segment

The low-thrust trajectory optimization problem can be described by Optimal Control Problem (OCP), with
the knowledge of calculus of variation theory, the OCP is converted to Two-Point Boundary Value Problem
(TPBVP). In each segment, once given the missing part of initial costates, the final states and costates can
be obtained by integrating canonical equations and the implicit control law. The related shooting process
consist in finding 7 unknown initial costates in order to satisfy 7 equality constraints. In order to cope with
convergence problem coming from the fuel-optimal problem, homotopy method is implemented by starting
from the easier energy-optimal problem. In addition, bisection methods is used to accurately detect the
switching points together with a fixed step 4th-order Runge-Kutta integrator.

2 Summary of the solution

Mother ship launch epoch: 60865
Mother ship launch $v_\infty$: 6.92139733767501 (km/s)
Mother arrival epoch at asteroid 16030: 61405

Epoch of release probe 1: 61541
Epoch of release probe 2: 61819
Epoch of release probe 3: 63105

Number of visited asteroids by probe 1: 11
Number of visited asteroids by probe 2: 8
Number of visited asteroids by probe 3: 8

Epoch of mothership collects probe 1: 63726
Epoch of mothership collects probe 2: 64004
Epoch of mothership collects probe 3: 65245

Time of flight of probe 1: 5.98220396988364 years
Time of flight of probe 2: 5.98220396988364 years
Time of flight of probe 3: 5.8590006844627 years

Final mass of probe 1: 817.390584180638 kg
Final mass of probe 2: 877.19073682399 kg
Final mass of probe 3: 842.958076102345 kg
Final mass of mothership: 6488.25883856573 kg

First performance index: 27
Second performance index: 2537.53939710697 kg
total mission time: 11.9917864476386 years

3 Simulation figures

3.1 probe 1

1. From Mother ship to Asteroid 7390 (epoch from 61541 to 61621)
2. From Asteroid 7390 to Asteroid 14158 (epoch from 61651 to 61821)
3. From Asteroid 14158 to Asteroid 16038 (epoch from 61851 to 62051)
4. From Asteroid 16038 to Asteroid 14215 (epoch from 62081 to 62221)
5. From Asteroid 14215 to Asteroid 8456 (epoch from 62251 to 62401)
6. From Asteroid 8456 to Asteroid 7405 (epoch from 62431 to 62581)
7. From Asteroid 7405 to Asteroid 14225 (epoch from 62611 to 62776)
8. From Asteroid 14225 to Asteroid 6581 (epoch from 62806 to 62961)
9. From Asteroid 6581 to Asteroid 12481 (epoch from 62991 to 63201)
10. From Asteroid 12481 to Asteroid 5693 (epoch from 63231 to 63396)
11. From Asteroid 5693 to Asteroid 16030 (epoch from 63426 to 63696)

3.2 probe 2
1. From Mother ship to Asteroid 10973 (epoch from 61819 to 62049)
2. From Asteroid 10973 to Asteroid 2346 (epoch from 62079 to 62321)
3. From Asteroid 2346 to Asteroid 10992 (epoch from 62351 to 62479)
4. From Asteroid 10992 to Asteroid 3884 (epoch from 62509 to 62704)
5. From Asteroid 3884 to Asteroid 1399 (epoch from 62734 to 62824)
6. From Asteroid 1399 to Asteroid 2332 (epoch from 62854 to 62989)
7. From Asteroid 2332 to Asteroid 2326 (epoch from 63019 to 63179)
8. From Asteroid 2326 to Asteroid 1270 (epoch from 63209 to 63389)
9. From Asteroid 1270 to Asteroid 16030 (epoch from 63419 to 63974)

3.3 probe 3
1. From Mother ship to Asteroid 4453 (epoch from 63105 to 63365)
2. From Asteroid 4453 to Asteroid 2660 (epoch from 63395 to 63615)
3. From Asteroid 2660 to Asteroid 16038 (epoch from 63645 to 63875)
4. From Asteroid 16038 to Asteroid 2323 (epoch from 63905 to 64045)
5. From Asteroid 2323 to Asteroid 2100 (epoch from 64075 to 64265)
6. From Asteroid 2100 to Asteroid 6557 (epoch from 64295 to 64465)
7. From Asteroid 6557 to Asteroid 1144 (epoch from 64495 to 64655)
8. From Asteroid 1144 to Asteroid 2336 (epoch from 64685 to 64815)
9. From Asteroid 2336 to Asteroid 1265 (epoch from 64845 to 65005)
10. From Asteroid 1265 to Asteroid 16030 (epoch from 65035 to 65215)
Figure 2: Transfer trajectory of mothership

Figure 3: Transfer trajectory of probe 1
Figure 4: Thrust and mass profile of probe 1

Figure 5: Transfer trajectory of probe 2
Figure 6: Thrust and mass profile of probe 2

Figure 7: Transfer trajectory of probe 3
Figure 8: Thrust and mass profile of probe 3

Figure 9: Transfer trajectories of mothership and 3 probes