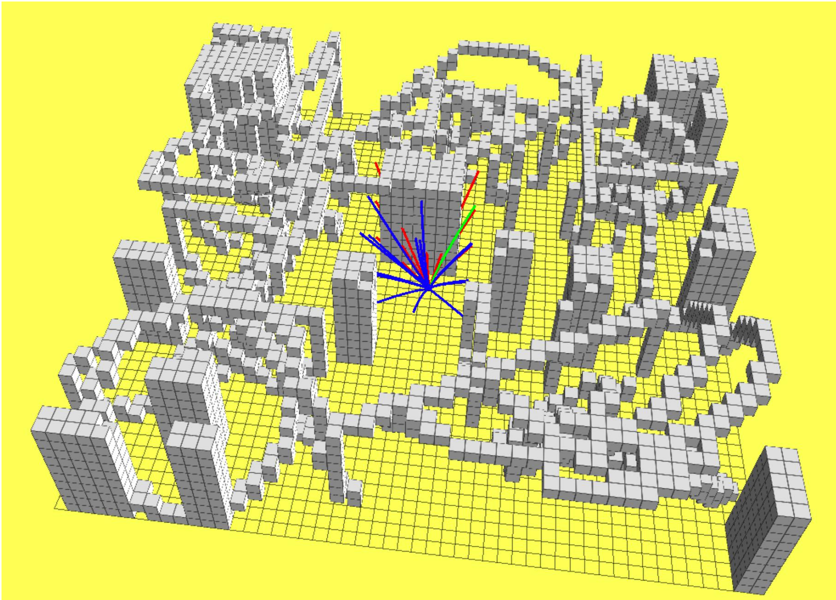
（一）结果截图



（二）实现流程

obvp 的实现：

（1）将 cost 仅依赖于 T 的表达式写出来；

（2）用 Matlab 将 cost 的导数表达式写出来，如下；

```
clear all;
clc;
syms p_x0 p_y0 p_z0;
syms p_xf p_yf p_zf;
syms v_x0 v_y0 v_z0;
syms v_xf v_yf v_zf;
syms a1 a2 a3 b1 b2 b3;
syms T J;

a1 = (-12) / (T^3) *(p_xf - v_x0 * T - p_x0) + 6 / (T^2) * (v_xf - v_x0) ;
a2 = (-12) / (T^3) *(p_yf - v_y0 * T - p_y0) + 6 / (T^2) * (v_yf - v_y0) ;
a3 = (-12) / (T^3) *(p_zf - v_z0 * T - p_z0) + 6 / (T^2) * (v_zf - v_z0) ;

b1 = 6 / (T^2) *(p_xf - v_x0 * T - p_x0) - 2 / T * (v_xf - v_x0) ;
b2 = 6 / (T^2) *(p_yf - v_y0 * T - p_y0) - 2 / T * (v_yf - v_y0) ;
b3 = 6 / (T^2) *(p_zf - v_z0 * T - p_z0) - 2 / T * (v_zf - v_z0) ;

J = T + (1/3 * a1^2 * T^3 + a1 * b1 * T^2 + b1^2 * T) + (1/3 * a2^2 * T^3 + a2 * b2 * T^2 + b2^2 * T) + (1/3 * a3^2 * T^3 + a3 * b3 * T^2 + b3^2 * T);

J_dot = diff(J,T);
pretty(J_dot)
```

结果为：

```
                                                                                                     3                              3
  2     2     2    2   2    2   2    2   2                                     2           2         T  #3 #11 2    2          2          T  #2 #9 2
#6  + #5  + #4  + T  #3  + T  #2  + T  #1  - T #6 #12 2 - T #5 #10 2 - T #4 #8 2 + T  #3 #12 + T  #6 #11 - ----------- + T  #2 #10 + T  #5 #9 - ----------
                                                                                                          3                                  3

                    3
    2          2    T  #1 #7 2
  + T  #1 #8 + T  #4 #7 - ---------- - T #6 #3 2 - T #5 #2 2 - T #4 #1 2 + 1
                        3

where
```

$$\#1 == \frac{(v\_z0 - v\_zf)\,6}{T^2} - \#13$$

$$\#2 == \frac{(v\_y0 - v\_yf)\,6}{T^2} - \#14$$

$$\#3 == \frac{(v\_x0 - v\_xf)\,6}{T^2} - \#15$$

$$\#4 == \frac{(v\_z0 - v\_zf)\,2}{T} - \frac{6\,\#16}{T^2}$$

$$\#5 == \frac{(v\_y0 - v\_yf)\,2}{T} - \frac{6\,\#17}{T^2}$$

$$\#6 == \frac{(v\_x0 - v\_xf)\,2}{T} - \frac{6\,\#18}{T^2}$$

$$\#7 == \frac{12\,v\_z0}{T^3} + \frac{(v\_z0 - v\_zf)\,12}{T^3} - \frac{36\,\#16}{T^4}$$

$$\#8 == \frac{6\,v\_z0}{T^2} + \frac{(v\_z0 - v\_zf)\,2}{T^2} - \#13$$

$$\#9 == \frac{12\,v\_y0}{T^3} + \frac{(v\_y0 - v\_yf)\,12}{T^3} - \frac{36\,\#17}{T^4}$$

$$\#10 == \frac{6\,v\_y0}{T^2} + \frac{(v\_y0 - v\_yf)\,2}{T^2} - \#14$$

$$\#11 == \frac{12\,v\_x0}{T^3} + \frac{(v\_x0 - v\_xf)\,12}{T^3} - \frac{36\,\#18}{T^4}$$

$$\#12 == \frac{6\,v\_x0}{T^2} + \frac{(v\_x0 - v\_xf)\,2}{T^2} - \#15$$

$$\#13 == \frac{12\,\#16}{T^3}$$

$$\#14 == \frac{12\,\#17}{T^3}$$

$$\#15 == \frac{12\,\#18}{T^3}$$

$$\#16 == p\_z0 - p\_zf + T\,v\_z0$$

$$\#17 == p\_y0 - p\_yf + T\,v\_y0$$

$$\#18 == p\_x0 - p\_xf + T\,v\_x0$$

（3）将 T 分割为很小的间隔，代入 cost 的导数表达式中，若 $J'(T_i)<0$ 且 $J'(T_{i+1})>0$ 则找到一个零点，也就是局部最小点；将所有的局部最小和始末两种情况一起比较找到全局最小。