

Homework2 Solution (V1.0)

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因为 ROS 不能在 macOS 平台运行，所以用 **Matplotlib-for-C++** 重写了可视化模块。

编译和运行

```
$ cd gcopter_homework
$ cmake -B build
$ cmake --build build
$ ./build/curve_gen
```

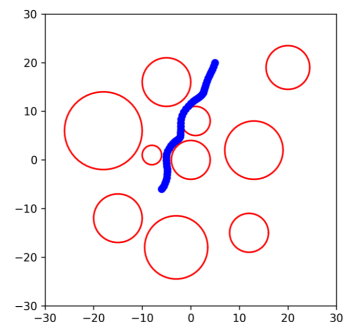
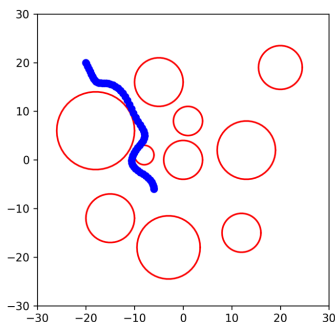
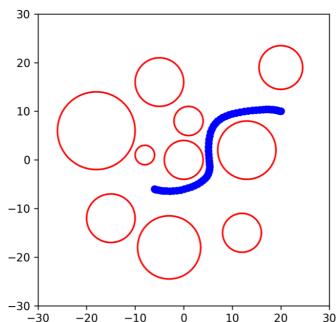
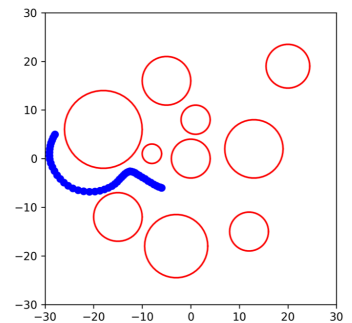
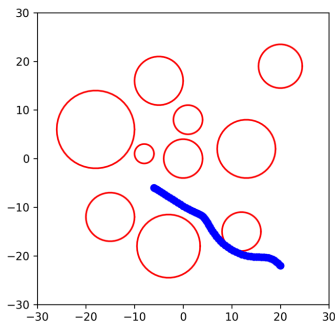
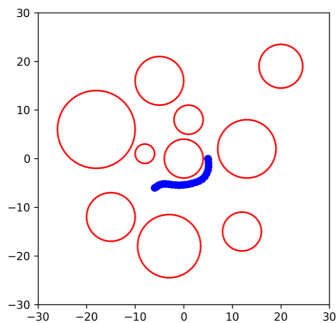
结果分析

Workflow and Result

Workflow

1. 初始化优化变量 (用 A* 或者直线)
2. 计算代价 $\text{Cost} = \text{Energy} + \text{Potential}$
3. 用链式法则计算梯度 $\text{Grad} = \text{GradEnergy} + \text{GradPotential}$
4. 调用 L-BFGS 优化直到收敛

Result



Analysis

观察发现，轨迹优化结果**不够平滑**，推测与优化过程过早结束有关，需要助教给点Debug的思路

Suggestion

1. 用 Matplotlib 实现跨平台，希望课程组这边提供跨平台的框架 (ROS 不支持 macOS 和 Windows)
2. 用 SymPy 自动求解梯度和代价

```
import symforce
symforce.set_symbolic_api("sympy")
symforce.set_log_level("warning")
from symforce.notebook_util import display
import symforce.symbolic as sf
```

计算 Energy

```
a = sf.Symbol("a")
b = sf.Symbol("b")
c = sf.Symbol("c")
d = sf.Symbol("d")
s = sf.Symbol("s")
p = a + b * s + c * s ** 2 + d * s ** 3
display(p)
pd = p.diff(s)
display(pd)
pdd = p.diff(s).diff(s)
display(pdd)
display(pdd ** 2)
```

```
from sympy import *
energy = integrate(pdd ** 2, (s, 0, 1))
display(energy)
```

$$4c^2 + 12cd + 12d^2$$

计算 Potential 及其梯度

```
x = sf.Symbol("x")
y = sf.Symbol("y")
ox = sf.Symbol("o_x")
oy = sf.Symbol("o_y")
potential = sqrt((x - ox) ** 2 + (y - oy) ** 2)
display(potential)
```

$$\sqrt{(-o_x + x)^2 + (-o_y + y)^2}$$

```
display(potential.diff(x))
display(potential.diff(y))
```

$$\frac{-o_x + x}{\sqrt{(-o_x + x)^2 + (-o_y + y)^2}}$$

$$\frac{-o_y + y}{\sqrt{(-o_x + x)^2 + (-o_y + y)^2}}$$