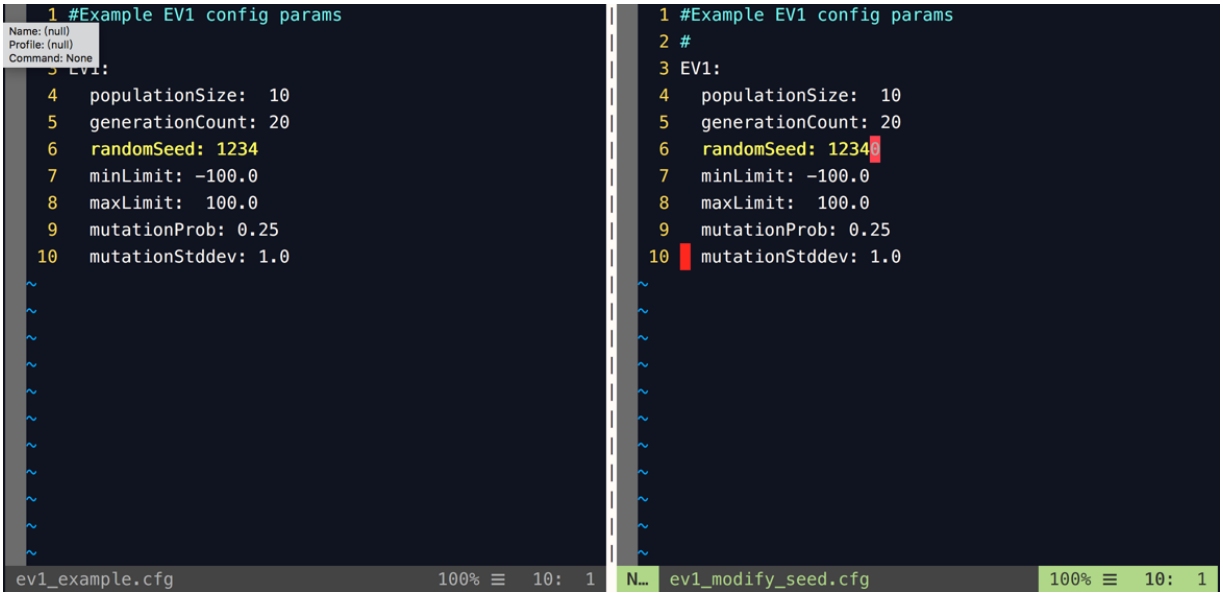
EC hw4 | 0416235 劉昱劭

Part I : experiment with parameters

1 Random seed

modify seed from 1234 to 12340.



1.1 Run ev1.py twice with same random seed (=1234) and output to a1 & a2 respectively.

1.2 Run ev1.py with another random seed (=12340) and output to b1

1.3 Use diff to see results. different random seed may cause different results.

```
~/2019S/GA2  master ●  p3 ev1.py --input ev1_example.cfg > a1
~/2019S/GA2  master ●  p3 ev1.py --input ev1_example.cfg > a2
~/2019S/GA2  master ●  p3 ev1.py --input ev1_modify_seed.cfg > b1
~/2019S/GA2  master ●  diff a1 a2
~/2019S/GA2  master ●  diff a1 b1 | head
7c7
< randomSeed: 1234
---
> randomSeed: 12340
10,21c10,21
< 93.29070713842776     -8653.156038387897
< -11.853480164929465   -90.50499202037625
< -98.50170598828257    -9652.586082602062
< 82.19519248982482     -6706.049668439355
< 87.8537994727528      -7668.29008179866
```

2 population size, generation count, mutation rate

2.1 Modify population size to 100

Many individuals still get poor fitness value. The max fitness is close to optimum because this function is too simple. From avg fitness, it seems not converge yet, so we need more iterations.

```
~/2019S/GA2  master ●  p3 ev1.py --input ev1_modify_popsize.cfg | tail
-10.665867148810477     -63.76072203607454
-0.7544687127740843     49.43077696144502
-20.95138994731009      -388.9607407242463
-14.818692312160266     -169.59364184247778
-42.77329921215449      -1779.555125492496
-45.18094900470729      -1991.3181529659603
Max fitness 49.97045300439886
Avg fitness -2102.5508258580026

EV1 Completed!
```

2.2 population size=100, generation count=200

```
~/2019S/GA2  master ●  p3 ev1.py --input ev1_modify_popsize_gcount.cfg | tail
-1.7224925733137115     47.03301933487911
-0.7544687127740843     49.43077696144502
-0.41050095828744126    49.83148896324509
2.604404036393941       43.21707961521495
0.2719301930395783      49.92605397011346
-2.933712954391786      41.39332830123382
Max fitness 49.99963954168537
Avg fitness 45.43706763765038

EV1 Completed!
```

With more generations, avg fitness converges more obviously.

2.3 population size=100, generation count=20, mutation rate=0.9

Increasing mutation rate could increase search space(or diversity), but this result shows we need more generations to constraint the search space.

2.4 population size=100, generation count=200, mutation rate=0.9

This max fitness value is higher than result of 2.2.

Increase mutation rate gives the best individual more chances to get better (or get worse, like result of 2.3).

Use more generations than 2.3, so that better individuals could get close to optimum more.

```
✘  ~/2019S/GA2  master ●  p3 ev1.py --input ev1_modify_popsize_gcount_mrate.cfg | tail
0.07458131054032102     49.994437628118085
-3.1158925101716215     40.29121386505639
3.698607489772931       36.32030263659558
0.5214544955748219      49.72808520904481
-1.112388033877487      48.76259286208618
-4.364987304003712      30.946885835886405
Max fitness 49.996839045738085
Avg fitness 43.8285577035029

EV1 Completed!
Avg fitness -2090.9875867190635

EV1 Completed!
```

3 Change fitness function to $f(x) = -\frac{1}{6}x^6 + \frac{1}{4}x^4 + 2x^2$

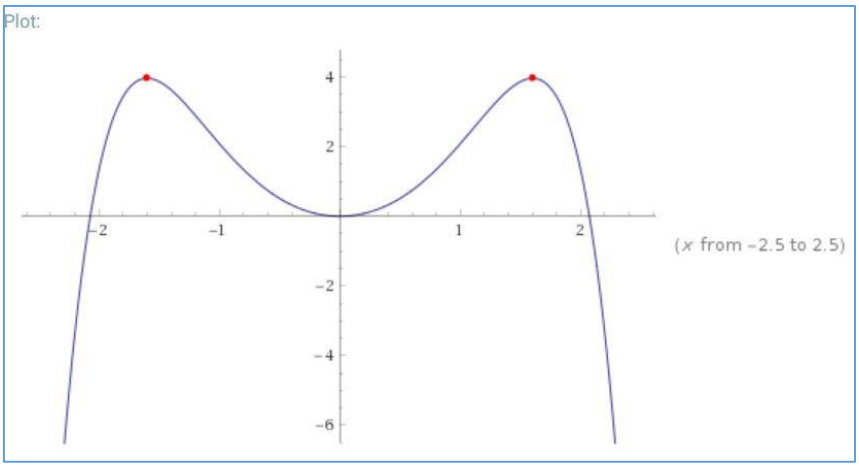
which has global maxima ≈ 3.9622:

Global maxima:

$$\max\left\{-\frac{x^6}{6}+\frac{x^4}{4}+2x^2\right\} = \frac{1}{24}\left(25+17\sqrt{17}\right) \text{ at } x = -\sqrt{\frac{1}{2}\left(1+\sqrt{17}\right)}$$

$$\max\left\{-\frac{x^6}{6}+\frac{x^4}{4}+2x^2\right\} = \frac{1}{24}\left(25+17\sqrt{17}\right) \text{ at } x = \sqrt{\frac{1}{2}\left(1+\sqrt{17}\right)}$$

It looks like



This function is interesting.

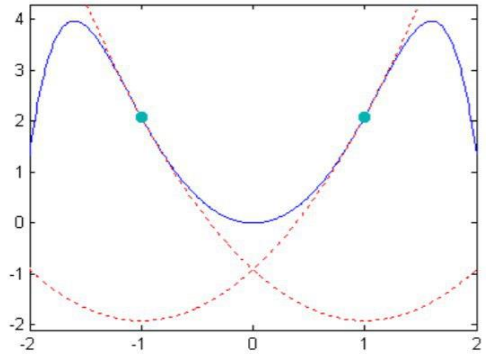
When we constraint its domain to this small interval $x \in (-2, 2)$, we can try to find its minimum.

(Due to this constraint, we know there is a global minimum f(0)=0)

This image shows the result of using quadratic Newton's method to approximate the minimum, starting point is x=1 or x=-1.

x will get stuck in 1, -1, 1, … , as an alternating sequence, and converge to

$$f(1) = f(-1) = -\frac{1}{6} + \frac{1}{4} + 2 \approx 2.083$$



$f(x) = \frac{-1}{6}x^6 + \frac{1}{4}x^4 + 2x^2$

$g(x) = f(x^i) + f'(x^i)(x - x^i) + \frac{1}{2}f''(x^i)(x - x^i)^2$

It can not converge to the optimal solution.

The following I directly use this function as fitness function to get maximum without constraints.

3.1 Population size=10, generation count=20

```
~/2019S/GA2  master ●  p3 ev2.py --input ev1_example.cfg | tail
3.5888724567022905      -288.8867892370169
1.7148069900526481      3.805056038662984
4.052503197023818       -637.9528286474238
-0.32897004873157165    0.21915930276074727
-4.132303854113587      -722.8062861372777
-2.9019493244696997     -64.96548671399417
Max fitness 3.805056038662984
Avg fitness -1191.973490066396

EV1 Completed!
```

3.2 Population size=100, generation count=20

```
~/2019S/GA2  master ●  p3 ev2.py --input ev1_modify_popsize.cfg | tail
-10.665867148810477     -241909.53606833922
-0.7544687127740843     1.1887103394346341
-20.95138994731009      -14047920.907072889
-14.818692312160266     -1752356.422867826
-42.77329921215449      -1019829283.8573753
-45.18094900470729      -1416642757.764365
Max fitness 3.957921296607312
Avg fitness -6881284087.847003

EV1 Completed!
```

3.3 Population size=100, generation count=200

```
~/2019S/GA2  master ●  p3 ev2.py --input ev1_modify_popsize_gcount.cfg | tail
-1.7224925733137115     3.7816624893182964
-0.7544687127740843     1.1887103394346341
-0.41050095828744126    0.3433235601766203
2.604404036393941       -26.94360061808881
0.2719301930395783      0.14919167393617094
-2.933712954391786      -70.52420137281032
Max fitness 3.957921296607312
Avg fitness -54.68508687063623
```

Part2: Modification

Configuration is same as professor's advice.

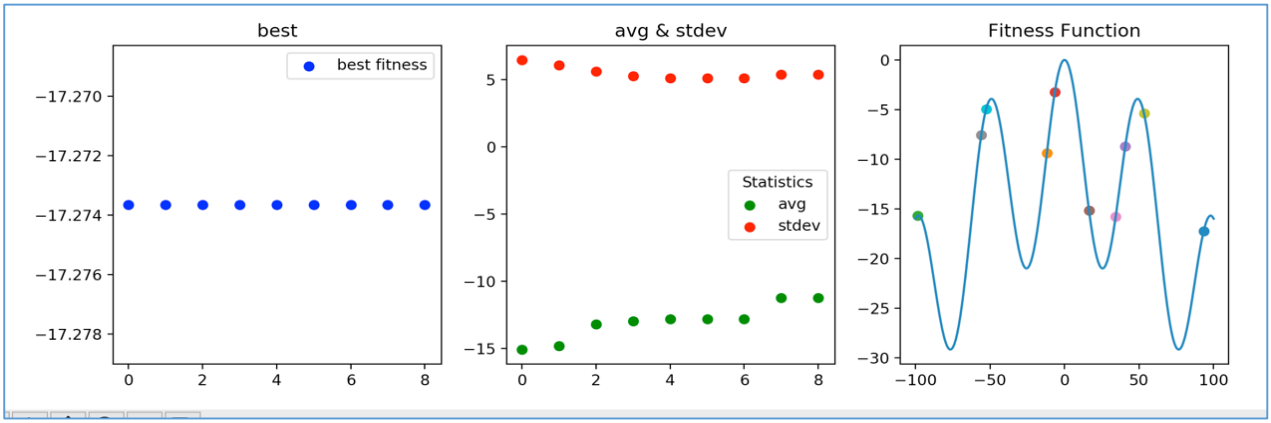
```
~/2019S/GA2  master ●  cat 0416235.cfg
#Example EV1 config params
#
EV1:
  populationSize:  10
  generationCount: 50
  randomSeed: 1234
  minLimit: -100.0
  maxLimit:  100.0
  mutationProb: 0.25
  mutationStddev: 1.0
```

Press any key could start the computation

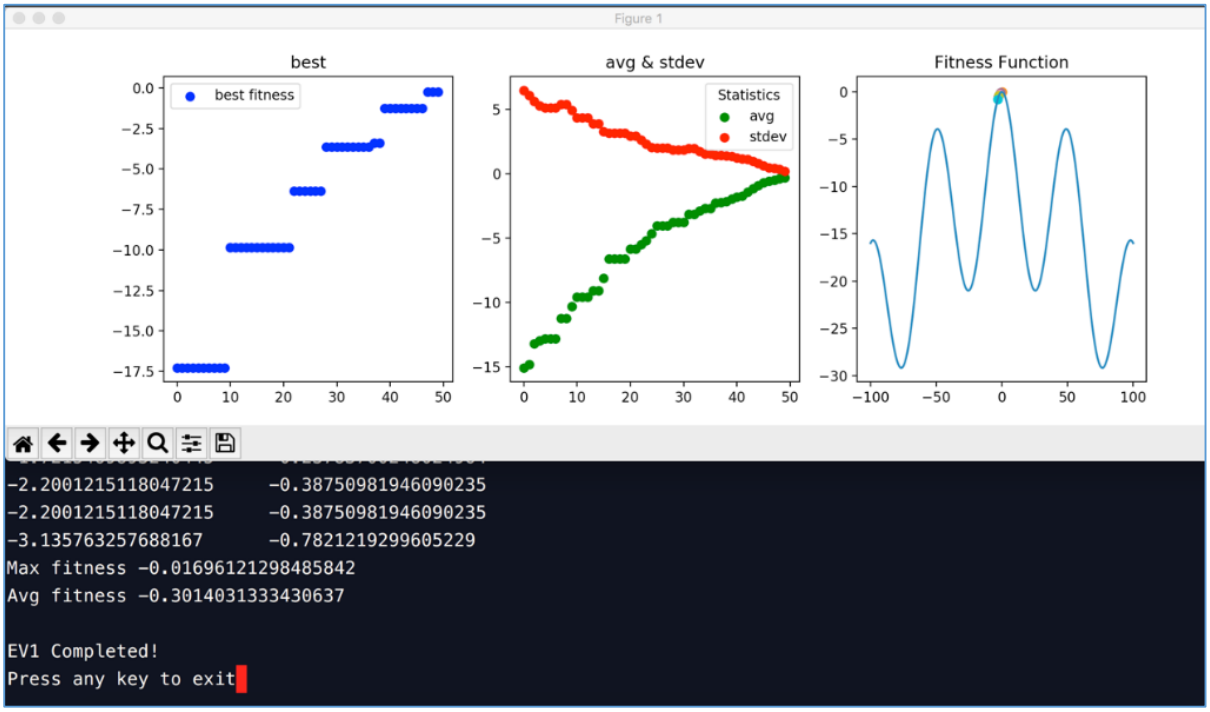
```
~/2019S/GA2  master ●  p3 hw4_0416235.py --input 0416235.cfg
generationCount: 50
maxLimit: 100.0
minLimit: -100.0
mutationProb: 0.25
mutationStddev: 1.0
populationSize: 10
randomSeed: 1234

Press any key to start
```

You'll see plots to show best, mean, and stdev of fitness value, and fitness function.



When the computation is done, press any key to exit this program.




```
-2.2001215118047215     -0.38750981946090235
-2.2001215118047215     -0.38750981946090235
-3.135763257688167      -0.7821219299605229
Max fitness -0.01696121298485842
Avg fitness -0.3014031333430637

EV1 Completed!
Press any key to exit
```