blatt6_aufgabe2

June 12, 2024

```python
[1]: import cma
     import numpy as np

     # Definition der Zielfunktion
     def funktion(x):
         return x[0]**3 - x[1]**3 + x[1]**2 + 1000 * np.cos(x[0]) * np.sin(x[1])


     Upperbound=10
     Lowerbound=-10


     wiederholung=5 #Rechenzeit viel zu groß für 10 Wiederholungen

     # Funktion zur Optimierung mit CMA-ES und fmin()
     def optimize_cma_es(mu, lambda_,wiederholung):
         all_opt_result=[]

         for i in range(wiederholung):
             x_wert=np.linspace(-10,10,20) #x-Startwerte gleichverteilt auf -10 bis
      ↪10
             y_wert=np.linspace(-10,10,20) #y-Startwerte analog
             start_values = np.transpose([np.tile(x_wert, len(y_wert)), np.
      ↪repeat(y_wert, len(x_wert))])
             opt_results=[]

             for start_value in start_values:
                 options = {
                     'popsize': lambda_,
                     'CMA_mu': mu,
                     'tolfun': 1e-11,  # Stoppkriterium für die Änderung des
      ↪Zielfunktionswerts
                     'maxfevals': 500,  #Budget von 500 Auswertungen
                     'bounds': [-10, 10],
                     'verb_disp': 0,  # Um die Konsolenausgabe zu minimieren
                 }
                 result = cma.fmin(funktion, start_value, 0.5, options=options)
                 opt_results.append(result[1])
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```python
        all_opt_result.extend(opt_results)

    return all_opt_result

# Verschiedene Parameterkombinationen testen
results = []
for mu in [2,4]: #range(2,10)
    #print(mu)
    for lambda_ in [4,8]: #range(2,10)  #Lamda muss größer gleich als mu sein
        if mu<=lambda_:
            #print(lambda_)
            result = optimize_cma_es(mu, lambda_,wiederholung)
            evals_used = result[4]   # Anzahl der Funktionsevaluationen
            deviation = evals_used - 500   # Abweichung vom Soll-Wert
            results.append((mu, lambda_, result, evals_used, deviation))
        else:
            print(f'Mu muss kleiner als Lamda sein')

# Beste Kombination basierend auf dem niedrigsten Zielfunktionswert finden und
 ↪kleinste Abweichung zu Soll-Wert
best_result = min(results, key=lambda x: (x[2][1], abs(x[4])))
#print(best_result)
#print(results)
print(f"Beste Parameterkombination: mu = {best_result[0]}, lambda =
 ↪{best_result[1]}")
print(f"Minimaler Zielfunktionswert: {best_result[2][1]}")
print(f"Anzahl der Funktionsevaluationen: {best_result[3]}")
print(f"Abweichung vom Soll-Wert: {best_result[4]}")
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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
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np.exp(1.0165666883927527) = 2.763689848197535 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=5)
  warnings.warn(msg + ' (' +
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packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.034634129411156) = 2.8140764594418743 clipped to np.exp(+-1)
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    warnings.warn(msg + ' (' +
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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.016254301891017) = 2.7628266436277222 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=1)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0459510500724947) = 2.8461040243532123 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=11)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0786560260627178) = 2.940724636741434 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=2)
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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0567490310025534) = 2.8770027228894395 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=47)
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packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.1805028446624481) = 3.2560110590949156 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=60)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.2073680536875537) = 3.3446700658317288 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=95)
  warnings.warn(msg + ' (' +

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packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.1774737498999375) = 3.24616321560454 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=47)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.1959534741706015) = 3.3067091296379587 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=66)
  warnings.warn(msg + ' (' +
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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.1950318185215838) = 3.3036628864982043 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=4)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0475913281718692) = 2.85077625728602 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=40)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0072849730385525) = 2.738156744506213 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=68)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.2260595381856623) = 3.4077748382153543 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=6)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0872204495661404) = 2.966018406609401 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=116)
  warnings.warn(msg + ' (' +

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packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.1881800146399346) = 3.2811042083834976 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=3)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0344598017682765) = 2.8135859308834026 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=15)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0757937159785032) = 2.9323194058858535 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=96)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.1876445532422781) = 3.2793477740315833 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=28)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0674864701473616) = 2.908060808300229 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=80)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0087085518947991) = 2.7420575024122553 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=4)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0331716527183556) = 2.8099639461685877 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=10)
  warnings.warn(msg + ' (' +

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packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.05359835144285) = 2.8679524739210907 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=95)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
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np.exp(1.0637729452434848) = 2.897281678736909 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=29)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.040195221885215) = 2.829769393347264 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=8)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0007230995432925) = 2.720248127637086 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=18)
  warnings.warn(msg + ' (' +

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packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.1263190266885286) = 3.0842824178557255 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=27)
  warnings.warn(msg + ' (' +
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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.026108116014172) = 2.7901855974776253 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=105)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.013363727562741) = 2.7548520190333505 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=5)
  warnings.warn(msg + ' (' +

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/home/adrian/.local/conda/lib/python3.10/site-
packages/cma/utilities/utils.py:343: UserWarning: sigma change
np.exp(1.0828439071943616) = 2.9530658657239433 clipped to np.exp(+-1)
(class=CMAAdaptSigmaCSA method=update iteration=2)
  warnings.warn(msg + ' (' +

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Beste Parameterkombination: mu = 4, lambda = 4
Minimaler Zielfunktionswert: -356.47262536381385
Anzahl der Funktionsevaluationen: -681.1920133323786
Abweichung vom Soll-Wert: -1181.1920133323786
```

Die Berechnungszeit war trotz reduzierter Anzahl der Wiederholungen (von 10 auf 5) immernoch so hoch, dass auch die Anzahl an mu und lambda reduziert werden musste.

Ich hätte gerne mehr Paramterkombinationen von mu und lambda getestet, aber bereits mit nur 4 Möglichkeiten und 5 Wiederholungen hat der Algorithmus knapp eine Stunde gebraucht.

[13]:
```python
#print(results)

#Berechnung der Median der Zielfunktionswerte
for res in results:
    mu, lambda_, opt_results, evals_used, deviation = res
    median_val = np.median(opt_results)
    print(f"Parameterkombination: mu = {mu}, lambda = {lambda_}, Median der
    ↪Zielfunktionswerte = {median_val}")
```

```
Parameterkombination: mu = 2, lambda = 4, Median der Zielfunktionswerte =
-993.7117738741703
Parameterkombination: mu = 2, lambda = 8, Median der Zielfunktionswerte =
-993.7117738741679
Parameterkombination: mu = 4, lambda = 4, Median der Zielfunktionswerte =
-993.7117738741703
Parameterkombination: mu = 4, lambda = 8, Median der Zielfunktionswerte =
-993.7117738741703
```

[10]:
```python
#Berechnung Median der 5 Zielfunktionswerte


all_opt_results = [res[2] for res in results] #Enthält alle Zielfunktionswerte
    ↪für jede Parameterkombination
combined_results = [val for sublist in all_opt_results for val in sublist]
    ↪#Kombinierte Liste

median_val = np.median(combined_results)
print(f"Median der Zielfunktionswerte der Multi-Starts: {median_val}")
```

```
Median der Zielfunktionswerte der Multi-Starts: -993.7117738741701
```

```
[12]:  #Visualisierung als Streudiagramm
       import matplotlib.pyplot as plt

       mu_values = [res[0] for res in results]
       lambda_values = [res[1] for res in results]
       median_values = [np.median(res[2]) for res in results]

       plt.figure(figsize=(10, 6))
       plt.scatter(mu_values, lambda_values, c=median_values, cmap='viridis', s=100,␣
         ↪edgecolors='k', alpha=0.7)
       plt.colorbar(label='Median der Zielfunktionswerte')
       plt.xlabel('mu')
       plt.ylabel('lambda')
       plt.title('Median der Zielfunktionswerte für verschiedene␣
         ↪Parameterkombinationen')
       plt.grid(True)
       plt.show()
```
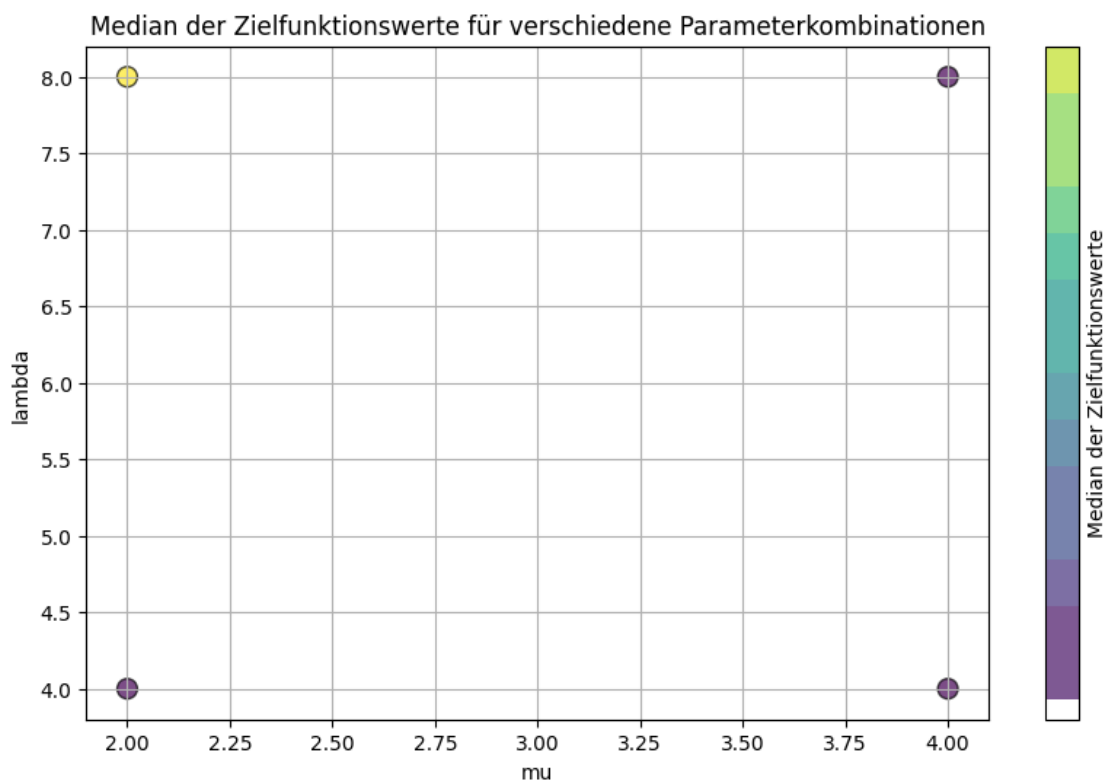

Die Grafik zeigt, dass eine Kombination von mu=2 mit lamda=8 , einen kleinen Median der Zielfunktionswerte ergibt.

Die Andern Parameterkombinationen erzeugen einen ähnlichen Median-Wert , welcher schlechter ist.