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1  import numpy as np
2  import matplotlib.pyplot as plt
3
4  # initialize tridiagonal matrix A
5  A = np.zeros((150,150))
6  for i in range(np.shape(A)[0]):
7      for j in range(np.shape(A)[0]):
8          if i == j:
9              A[i][j] = -2
10         if i == j+1:
11             A[i][j] = 1
12         if i == j-1:
13             A[i][j] = 1
14
15
16  # Perform QR factorization
17  def QRfactorization(A,N,i=0):
18      Q,R = np.linalg.qr(A)
19      A = R.dot(Q)
20      i+=1
21      if(i<N):
22          return QRfactorization(A,N,i)
23      else:
24          # compute diagonal and sort the list (something weird
25          • happens where the last eigenvalues are swapped in position)
26          x = np.array(np.diagonal(A))
27          return np.sort(x)
28
29  # plot results and sort the theoretical values because of the reason
30  • given aboveself.
31  linalgfunc = np.sort(np.linalg.eig(A)[0])
32  QR10 = QRfactorization(A,10)
33  QR100 = QRfactorization(A,100)
34  QR500 = QRfactorization(A,500)
35  x = np.arange(0,np.shape(A)[0],1)
36  plt.scatter(x,QR10,color = "r",s=12, label="10 QR iterations")
37  plt.scatter(x,QR100, color = "g",s=12, label="100 QR iterations")
38  plt.scatter(x,QR500, color = "b",s=12, label="500 QR iterations")
39  plt.plot(x,linalgfunc,color = "k",label = "np.linalg.eig")
40  plt.xlabel("Eigenvalue no.",fontsize=20)
41  plt.ylabel("Eigenvalues",fontsize=20)
42  plt.tick_params(axis='both', labels=15)
43  plt.legend()
44  plt.title("Excercise 4 eigenvalue comparison",fontsize=30)
45  plt.show()

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45 # compute the error compared to the np.linalg.eig function and plot
    • them
46 error10 = abs(linalgfunc-QR10)
47 error100 = abs(linalgfunc-QR100)
48 error500 = abs(linalgfunc-QR500)
49 plt.scatter(x,error10,color ="r",s=12, label="error on QR 10")
50 plt.scatter(x,error100, color = "g",s=12, label="error on QR 100")
51 plt.scatter(x,error500, color = "b",s=12, label="error on QR 500")
52 plt.axhline(0,color = "k",label = "zero line")
53 plt.xlabel("Eigenvalue no.",fontsize=20)
54 plt.ylabel("Absolute eigenvalue error",fontsize=20)
55 plt.tick_params(axis='both', labels=15)
56 plt.legend()
57 plt.title("Excercise 4 error of QR compare to
    • np.linalg.eig",fontsize=30)
58 plt.show()
59
```