HW4

March 29, 2023

1 Exercise Set 4

1.1 Stationary checking:

[ ]:
```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.optimize import curve_fit
sns.set()
```

[ ]:
```
def sigma(x, tau):
    """calculate stationary

    Args:
        x (array): timeseris data
        tau (int):

    Returns:
        float: stationary for timeseries
    """
    N = len(x)
    M = int(N/tau)
    sigma_i = np.zeros(M)
    for i in range(M):
        sigma_i[i] = np.sqrt(np.mean((x[i*tau:(i+1)*tau] - np.mean(x[i*tau:
 ↪(i+1)*tau]))**2))
    return np.mean(sigma_i)
```

[ ]:
```
A = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/FBM.
 ↪txt")
B = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/FGN.
 ↪txt")
Tau = range(1,len(A)//2 +100)
```

[ ]:
```
SigmaA = []
SigmaB = []
for t in Tau:
```

```
    SigmaA.append(sigma(A,t))
    SigmaB.append(sigma(B,t))
```

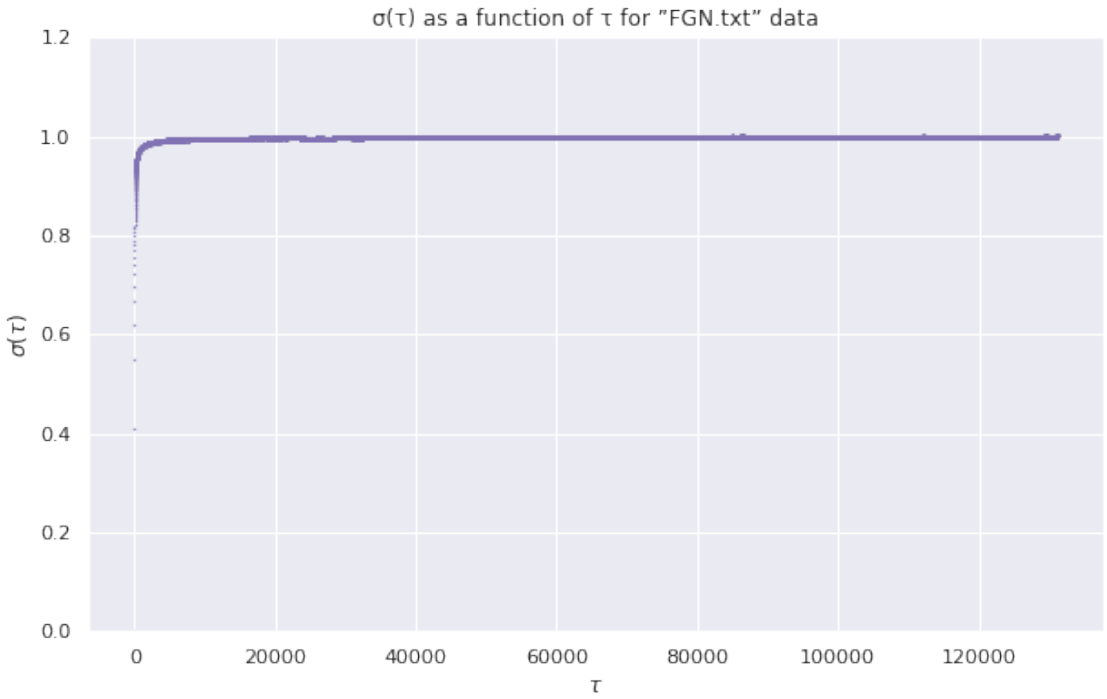
1.2 A:

[ ]:
```
plt.figure(figsize=(10,6))
plt.scatter(Tau, SigmaA, s=0.2, c="r")
plt.xlabel(r"$\tau$")
plt.ylabel(r"$\sigma(\tau)$")
plt.ylim(0,1)
plt.title(" ( ) as a function of  for "FBM.txt" data")
plt.show()
```

As we can see the FBM data is non-stationary data.

1.3 B:

[ ]:
```
plt.figure(figsize=(10,6))
plt.scatter(Tau, SigmaB, s=0.2, c="m")
plt.xlabel(r"$\tau$")
plt.ylabel(r"$\sigma(\tau)$")
plt.ylim(0,1.2)
plt.title(" ( ) as a function of  for "FGN.txt" data")
plt.show()
```



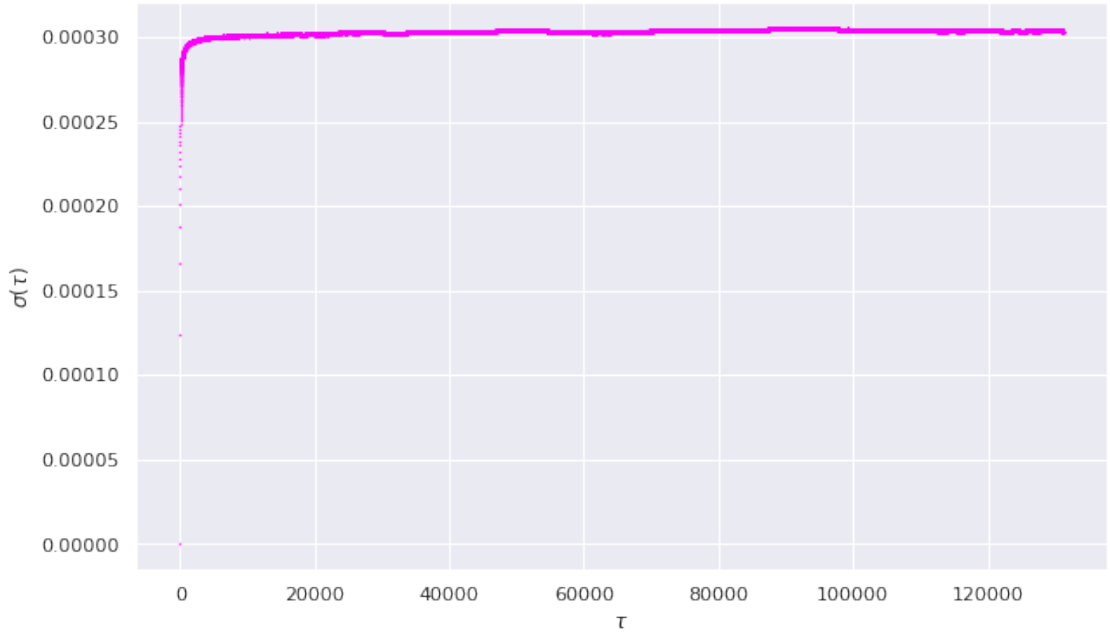
As we can see the FBM data is stationary data.

1.4 C:

[ ]:
```
C = np.zeros(len(A))
for i in range(len(A)-1):
    C[i] = A[i+1] - A[i]
```

[ ]:
```
SigmaC = []
for t in Tau:
    SigmaC.append(sigma(C,t))
```

[ ]:
```
plt.figure(figsize=(10,6))
plt.scatter(Tau, SigmaC, s=0.2, c="magenta")
plt.xlabel(r"$\tau$")
plt.ylabel(r"$\sigma(\tau)$")
plt.show()
```



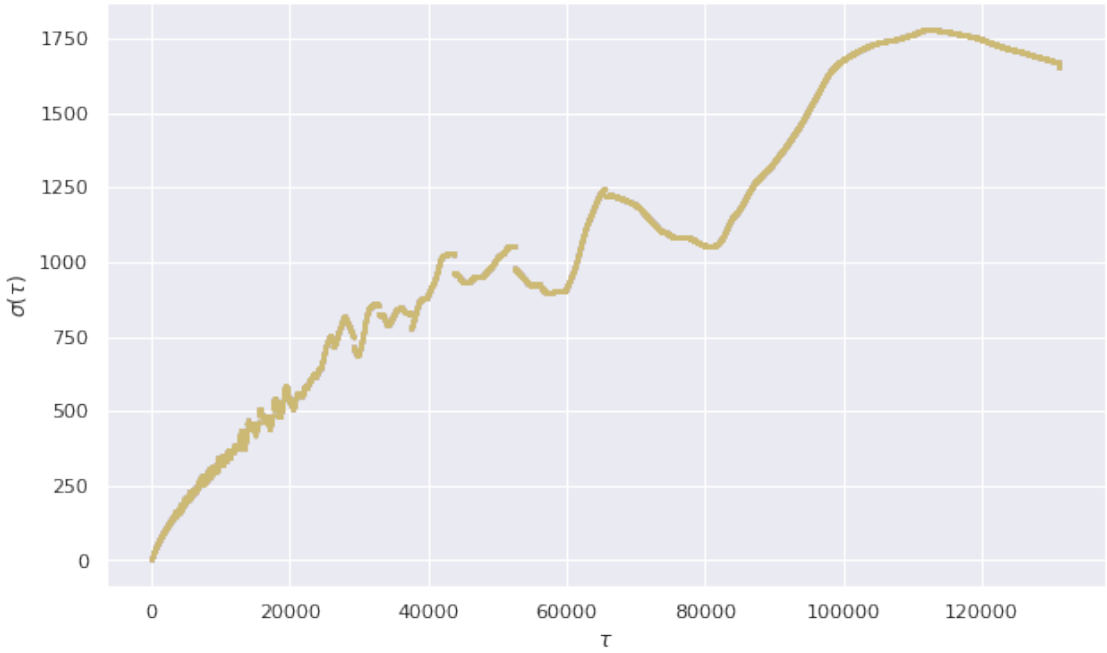
The constructed signal is stationary data.

1.5 D:

[ ]:
```
D = np.zeros(len(B))
for i in range(len(B)):
    D[i] = np.sum(B[:i])
```

[ ]:
```
SigmaD = []
for t in Tau:
    SigmaD.append(sigma(D,t))
```

[ ]:
```
plt.figure(figsize=(10,6))
plt.scatter(Tau, SigmaD, s=0.2, c="y")
plt.xlabel(r"$\tau$")
plt.ylabel(r"$\sigma(\tau)$")
plt.show()
```



The constructed signal is non-stationary data.

2 E:

2.1 The stationary intensity:

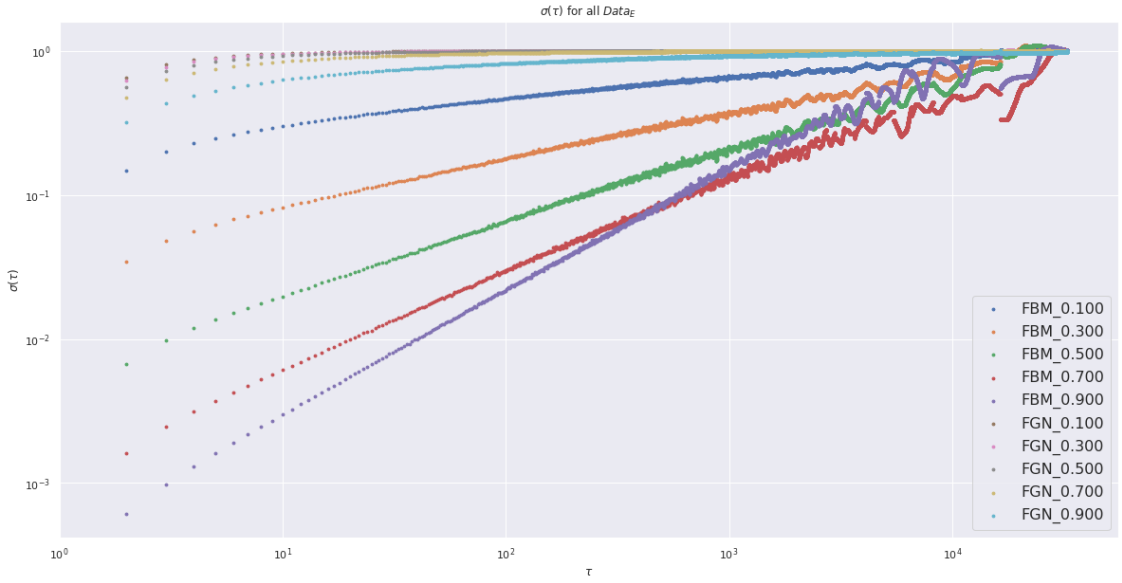
```
[ ]: x0 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FBM_0.100")
     x1 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FBM_0.300")
     x2 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FBM_0.500")
     x3 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FBM_0.700")
     x4 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FBM_0.900")
     x5 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FGN_0.100")
     x6 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FGN_0.300")
     x7 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FGN_0.500")
     x8 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
       ↪FGN_0.700")
```

```
x9 = np.loadtxt("/home/mohaddeseh/Documents/Programing/Computational/HW4/Data_E/
↪FGN_0.900")
```

[ ]:
```
tau = range(1, len(x0))
```

[ ]:
```
sigma0, sigma1, sigma2, sigma3, sigma4, sigma5, sigma6, sigma7, sigma8, sigma9␣
↪= [], [], [], [], [], [], [], [], [], []
for t in tau:
    sigma0.append(sigma(x0, t))
    sigma1.append(sigma(x1, t))
    sigma2.append(sigma(x2, t))
    sigma3.append(sigma(x3, t))
    sigma4.append(sigma(x4, t))
    sigma5.append(sigma(x5, t))
    sigma6.append(sigma(x6, t))
    sigma7.append(sigma(x7, t))
    sigma8.append(sigma(x8, t))
    sigma9.append(sigma(x9, t))
```

[ ]:
```
plt.figure(figsize=(20,10))
plt.scatter(tau, sigma0, s=8, label="FBM_0.100")
plt.scatter(tau, sigma1, s=8, label="FBM_0.300")
plt.scatter(tau, sigma2, s=8, label="FBM_0.500")
plt.scatter(tau, sigma3, s=8, label="FBM_0.700")
plt.scatter(tau, sigma4, s=8, label="FBM_0.900")
plt.scatter(tau, sigma5, s=8, label="FGN_0.100")
plt.scatter(tau, sigma6, s=8, label="FGN_0.300")
plt.scatter(tau, sigma7, s=8, label="FGN_0.500")
plt.scatter(tau, sigma8, s=8, label="FGN_0.700")
plt.scatter(tau, sigma9, s=8, label="FGN_0.900")
plt.xlabel(r"$\tau$")
plt.ylabel(r"$\sigma(\tau)$")
plt.legend(fontsize="16")
plt.title(r"$\sigma(\tau)$ for all $Data_E$ ")
plt.loglog()
plt.xlim(1,)
plt.show()
```



Since we cannot find the stationary regime for all FBM data, we only find $\tau_{stationary}$ for FGN data.

[ ]:
```
def line(x,b):
    """function of horizontal line"""
    return b
```

[ ]:
```
parameter5, _ = curve_fit(line, tau, sigma5)
parameter6, _ = curve_fit(line, tau, sigma6)
parameter7, _ = curve_fit(line, tau, sigma7)
parameter8, _ = curve_fit(line, tau, sigma8)
parameter9, _ = curve_fit(line, tau, sigma9)
```

[ ]:
```
def find_t(Sigma, para, err=0.001):
    """find tau stationary

    Args:
        Sigma (array): sigma as function of tau
        para (array): the parameter of line that find from scipy
        err (float, optional): Defaults to 0.001.

    Returns:
        float: tau stationary
    """
    I = []
    for i in range(len(Sigma)):
        if abs(Sigma[i] - para) < err:
            I.append(i)
        if len(I) > 100:
```

```
            break
    return I[99]
```

[ ]:
```
t5 = find_t(sigma5, parameter5)
t6 = find_t(sigma6, parameter6)
t7 = find_t(sigma7, parameter7)
t8 = find_t(sigma8, parameter8)
t9 = find_t(sigma9, parameter9)
```

[ ]:
```
plt.figure(figsize=(10,6))
plt.bar(x=["FGN_0.100", "FGN_0.300", "FGN_0.500", "FGN_0.700", "FGN_0.900"],␣
↪height=[t5, t6, t7, t8, t9], color="magenta")
plt.ylabel(r"$\tau_{stationary}$")
plt.title(r"The value of $\tau_{stationary}$ for all $Data_E$")
plt.show()
```