Università degli Studi di Padova

Quantum Information and Computing

2021 - 2022

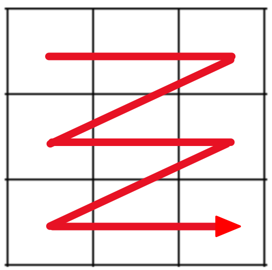
Saverio Monaco

21/11/2021

Exercise 3

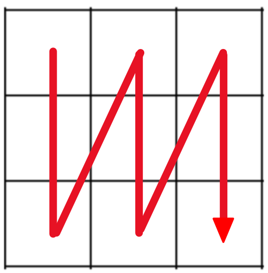
Physics of Data

Scaling of the matrix-matrix multiplication



Loop method

$O(N^3)$



Loop2 method (not chache optimized)

$O(N^3)$

`matmul(A,B)`

May use Strassen algorithm [1]

$O(N^{\log_2 7})$

$\log_2 7 \approx 2.807$

Scaling of the matrix-matrix multiplication

Pseudocode for Loop function:

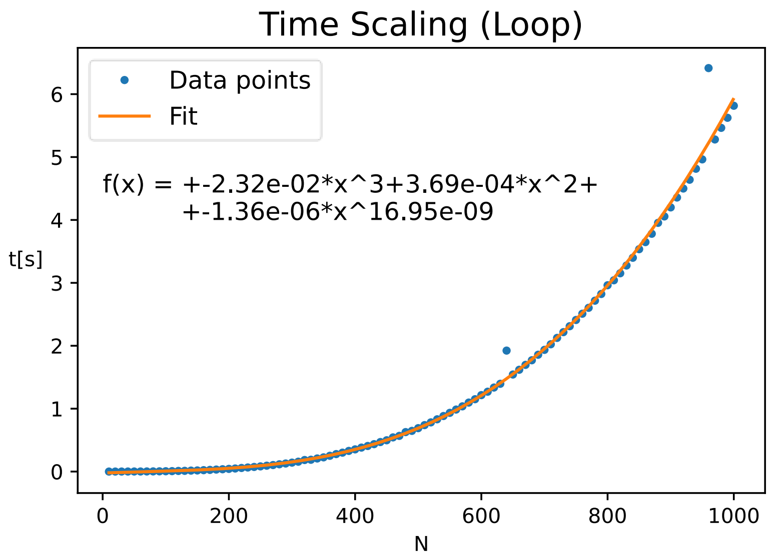
```
LOOP(A,B): # multiplies A and B
    C = matrix(A.ncols,B.nrows)
    for i from 1 to A.ncols:
        for j from 1 to B.nrows:
            sum = 0
            for k from 1 to A.nrows:
                sum = sum + A_ik × B_kj
            end for
        end for
    end for
```

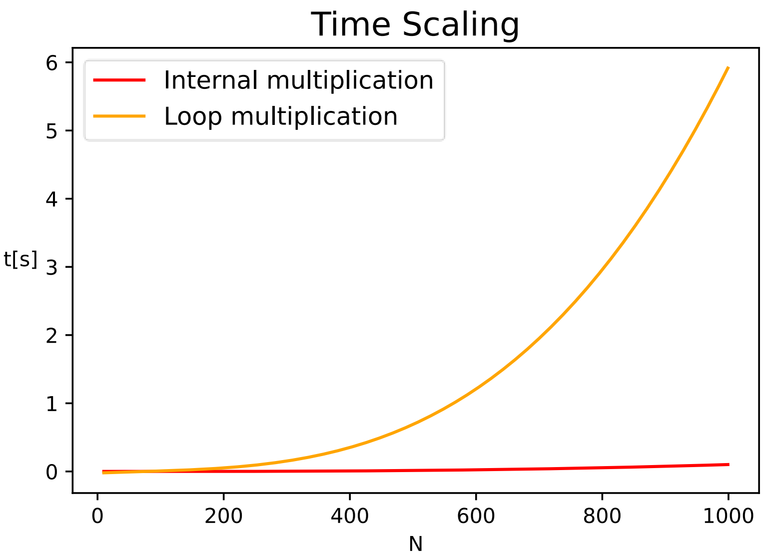
```
Loop multiplication - matmul:
|    0.00000000      -7.62939453E-06   0.00000000      |
|    0.00000000       0.00000000       0.00000000      |
|    3.81469727E-06   0.00000000       0.00000000      |
```

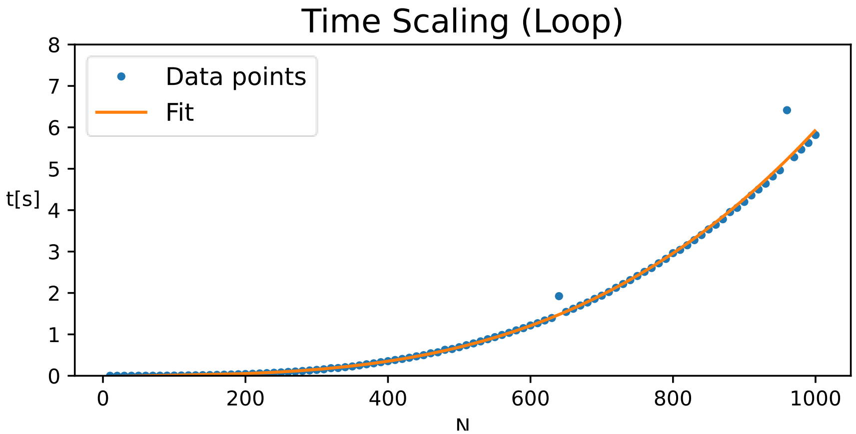
Fitted using `curve_fit` from `scipy.optimize` in Python with polynomial functions.

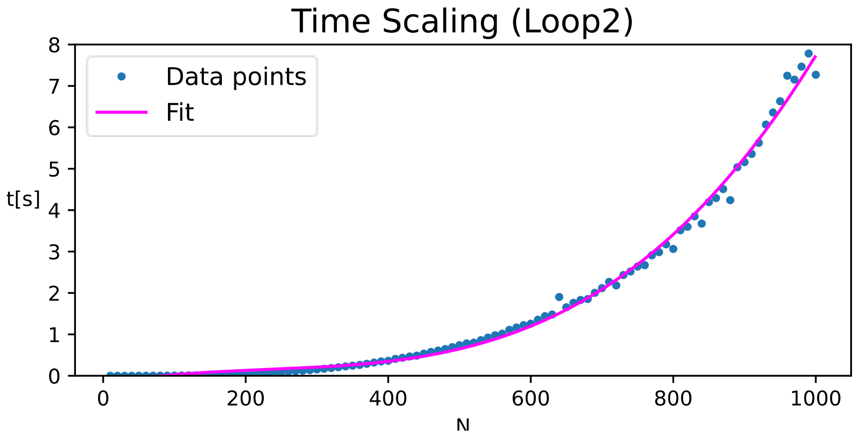
Università degli Studi di Padova

Scaling of the matrix-matrix multiplication









Random Matrix Theory

Study of the P(s) distribution, where s_i are the normalized spacings between eigenvalues:

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{13} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \longrightarrow \lambda_1, \lambda_2, \lambda_3 \quad \lambda_1 < \lambda_2 < \lambda_3 \longrightarrow s_i = \Delta\lambda_i / \overline{\Delta\lambda}$$

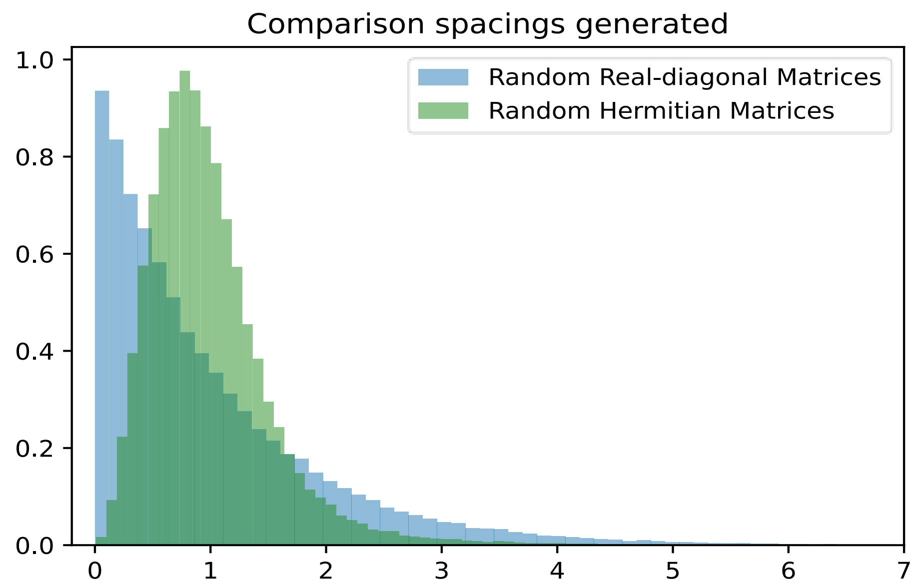
`ZHEEV()` (Lapack)

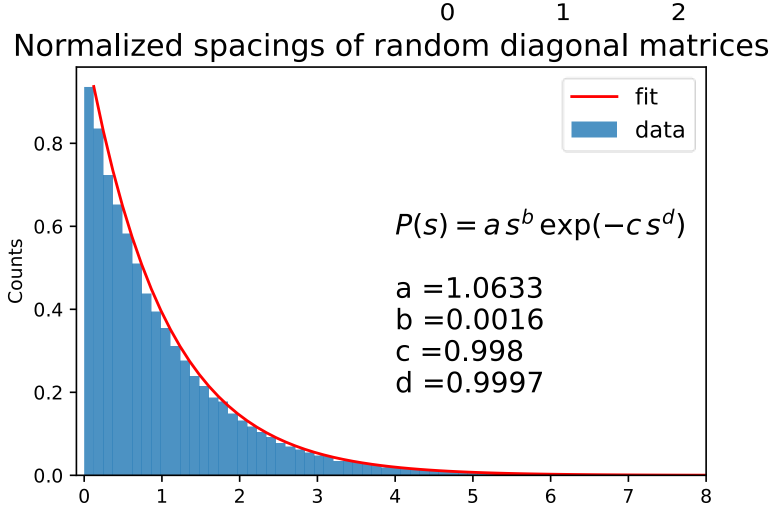
Fit P(s) using `curve_fit` from `scipy.optimize` in Python with the function:

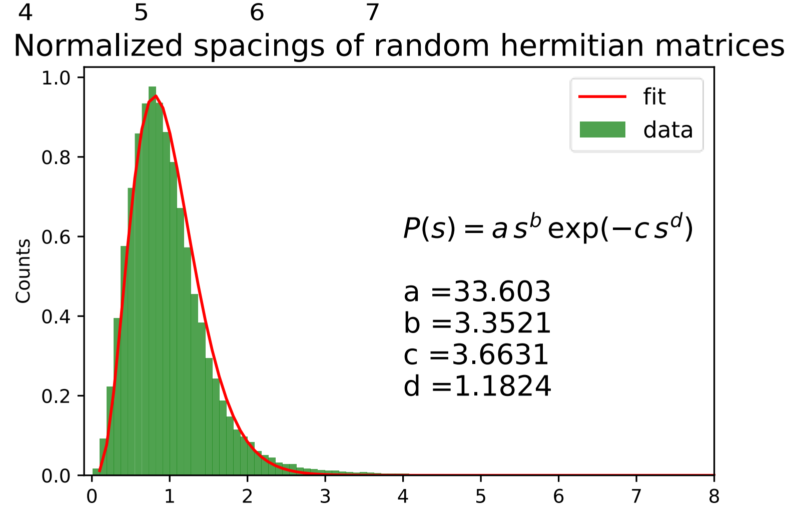
$$P(s) = a\, s^b \exp(-c\, s^d)$$

For random Hermitian matrices and random (real) diagonal matrices

Random Matrix Theory







800 ANNI 1222 • 2022

UNIVERSITÀ DEGLI STUDI DI PADOVA

Thanks for the attention