Assignment 3

SCP8082721 - QUANTUM INFORMATION AND COMPUTING

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Exc 1

- From $\Delta t = m \cdot n^b$ we can get $\log \Delta t = b \cdot \log n + \log b$ and do a linear fit on this data to get the coefficients. Matrices of sizes 250 to 2600 were used.

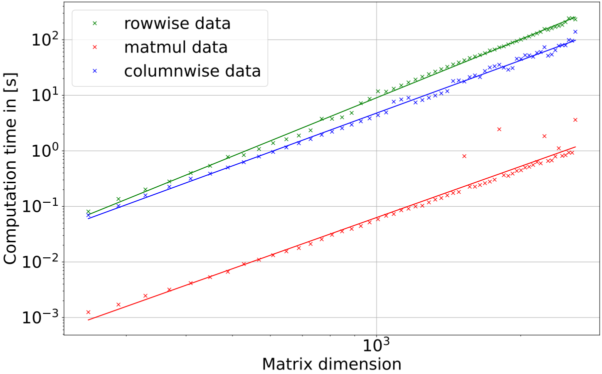

Figure: Doing a time complexity analysis on the unoptimized results (-O0 optimization flag): matmul gives $\mathcal{O}(n^{3.06})$ and the rowwise calculation scales as $\mathcal{O}(n^{3.5})$, columnwise as $\mathcal{O}(n^{3.16})$.

Exc 2 and 3: Intro and theory

- exercise was to generate a random hermitian (or diagonal) Matrix, diagonalize it and calculate the distribution of the normalized spacing between Eigenvalues.
- a Hermitian matrix is a matrix which has the property $A = A^\dagger$
- the normalized spacing between the eigenvalues is given by $s_i = \frac{\Lambda_i}{\overline{\Lambda}}$ with $\Lambda_i = \lambda(i+1) - \lambda(i)$ and $\overline{\Lambda}$ the average Λ_i, given that the eigenvalues are stored in ascending order.
- the following distribution is fit to the data $P(s) = as^\alpha \exp\left(bs^\beta\right)$

Exc 2 and 3: Code development

- Fortran program that has class "diagstuff", which includes type to save global variables and three subroutines. One for the math and two for writing on txt files.
- rand_eigen(val, N, LDA)
  1. calls ZLAGHE from LAPACK to create a random Hermitian matrix with customary number of non-zero subdiagonals
  2. calls ZHEEV from LAPACK to calculate eigenvalues
  3. returns array W with the eigenvalues stored inside

```
Program test
    use diagstuff
    Implicit none

    integer :: N, LDA, i
    type(store) :: val
    N = 1500
    LDA = 1500
    do i=1,50
        call rand_eigen(val, N, LDA)
        call store_eigenvalues(val)
        call store_normspacing(val)
    end do
end program test
```

Exc 2 and 3: Results

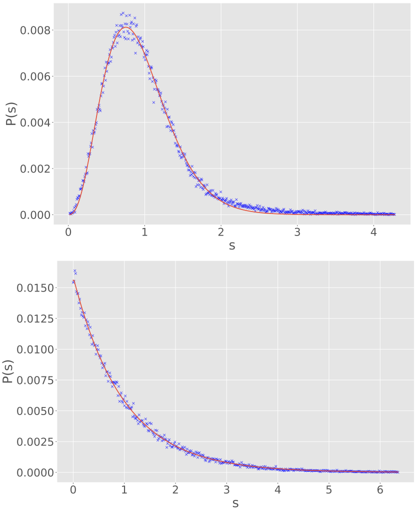

Figure: a.) P(s) for Hermitian matrix and b.) P(s) for diagonal matrices. Used in the calculation were 50 times 1500x1500 random matrices.

- the resulting functions are:
- $P_{diag}(s) = 0.016 \cdot s^{0.0028} \exp\left(-1.02 s^{0.979}\right)$
- $P_{herm}(s) = 0.123 \cdot s^{2.60} \exp\left(-2.87 s^{1.31}\right)$
- note, the resulting distribution of diagonal matrices resembles very closely a Poisson distribution $P(s) \propto \exp\left(-s\right)$