

# Self-assessment exercises: Basic programming

March 1, 2022

1. Write functions that take a matrix  $M$  of size  $N \times N$  as an input and calculate the following quantities:

- The trace of the matrix.
- The sum, mean and maximum of the entries.
- The sum, mean and maximum of the absolute value of the entries.
- A vector of size  $N \times 1$  containing the mean of each row.
- A vector of size  $N \times 1$  containing the mean of each column.
- A matrix of size  $N \times N$  containing the result of multiplying  $M$  with its transpose.

**Note:** Write the corresponding code in any language of your choice *without* using built-in functions that can directly give the result wanted in each function. For example, when using MATLAB the function `trace(M)` calculates the trace of the matrix  $M$  and therefore should not be used for this calculation.

2. Write a function that takes a matrix  $M$  of size  $N \times N$  and a real number  $a$  as inputs and returns a matrix  $A$  of size  $N \times N$  where the entry  $A_{ij}$  is 1 if  $M_{ij} \geq a$  and  $-1$  otherwise.

3. Test all the functions using the matrix  $M$  of size  $20 \times 20$  with entries given as

$$M_{ij} = \frac{1}{2}(i - j), \quad i, j = 0, \dots, 19$$

4. Write a program which takes a vector of size  $N \times 1$  whose entries are real numbers and sorts it in ascending order. For example, the vector  $[3, 6, 4, 9]$  should become  $[3, 4, 6, 9]$ .

5. Write a program which computes prime numbers up to a given maximal number using the iterative algorithm called sieve of Eratosthenes. The iteration starts with the prime number 2 and marks the multiples of 2 as not prime. Then it proceeds to the next larger number, which is not marked and is therefore a prime number. The multiples of it are marked as not prime and so on.