Problem Set 1

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1 Implementation

Let's examine some mathematical data structures used in the implemented algorithms.

- **Scalar** - A scalar is a single number.

$$\begin{bmatrix} 4 \end{bmatrix}$$

- **Vector** - A vector is an array of numbers.

$$\begin{bmatrix} 4 & 5 & 6 & 9 & 8 \end{bmatrix}$$

- **Matrix** - A matrix is a 2-D array.

$$\begin{bmatrix} 3 & 4 & 5 & 4 & 4 \\ 5 & 5 & 3 & 3 & 9 \\ 8 & 3 & 3 & 2 & 1 \end{bmatrix}$$

Arrays are data structures that represent these mathematical concepts. In order to implement the various mathematical notation in code, scalars, vectors, and matrices are stored in some form of an array and passed through as parameters in the function (or method). For $\bar{x}$, the summation notation is:

$$\bar{x} = \frac{\sum_{i=0}^{n} x_i}{n}$$

In code, this algorithm iterates over a vector in the form of a 1D array by calculating the sum of all its elements and dividing it by the number of elements.

For `run1(x)`:

$$\sum_{i=0}^{n} \left[x_j^{(i)} - \bar{x}_j \right]^2$$

in which the algorithm loops over a vector in the form of an array. For each iteration, it calculates the number at that iteration and subtracts it with the mean of the entire array. It squares difference and takes the result to be added into a summation.

For `run2(x)`:

$$\text{RUN2(X)} = \sum_{j=1}^{p} \sqrt{\alpha(x_j)}$$

in which the algorithm loops through a matrix in the form of a 2-D array. The 2-D array is looped through by column. Each column is taken as a vector and passed into the previous function: iterate through column vector to calculate the sum of each element minus the mean of the vector squared. Then take the square root of that return value and add it to the summation for `run2(x)`.

2 Notation

Without function calls, `run2(x)` can be written as:

$$\text{RUN2(X)} = \sum_{j=1}^{p} \sqrt{\sum_{i=0}^{n} \left[x_j^{(i)} - \left(\frac{\sum_{i=0}^{n} x_i}{n} \right) \right]^2}$$