Project 1

Due Date: 2/9

1. Project Description

You will write a C++ program to create a double-type array, X^0, of size N. The elements in the array are initialized by random numbers that follows a normal distribution $N(\mu, \sigma)$, where μ is the mean of the random numbers and σ is their standard deviation.

You will create another array X^1 whose elements are the average of three numbers (left, ego, and right) from the previous array. That is,

$$X_k^{t+1} = \frac{X_{L(k)}^t + X_k^t + X_{R(k)}^t}{3} \quad \text{for } t \geq 0$$

where $L(k)$ and $R(k)$ are the indices of k's left and right elements, respectively. The array is considered as wrapped-around. The left of k is $k-1$ except 0 (zero) whose left side is $N-1$. Likewise, the right of k is $k+1$ except $N-1$ whose right side is 0 (zero).

Continue the iteration by incrementing t, then an array will eventually have all same value. It is called as the consensus. You are asked to answer the following questions:

a) How long (how many iteration) does it take to reach the consensus (consensus time)?
b) What are the major factors affecting the consensus time? The number of elements (N), the magnitude of values (μ), or the variance of values (σ)? What are the relationship between the major factor and the consensus time?
c) How can you determine that many values are all same when they are in floating-point variables?

2. Hints

a) A random function for the normal (Gaussian) distribution is available in the instructor's GitHub, https://github.iu.edu/dskim/lecture-os/tree/main/random
b) The left and right index functions are suggested as
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L(k) = (k - 1 + N) % N
R(k) = (k + 1) % N.
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c) The N above is described as if it is a constant. It is not necessarily a constant to make the project program flexible.
d) The value of t cannot be determined in advance. It depends on the convergence of N values.
e) As you see, the program code of the project is very simple for CS/CE seniors. The main focus is not the program itself. You have to concentrate on how to answer the questions reasonably and logically, and how to visualize the data to persuade the audience (the instructor and TA, in this case).
f) Start the evaluation with the basic normal distribution $N(0,1)$.

3. Notes

- The project is a team effort of 4 members. A team will submit a single copy of the report.
- The main part of the report must be no longer than 3 pages including a brief description of your approach (no source codes in the main part). Refer the format of the report at https://et.engr.iupui.edu/~dskim/tutorials/technical-writing/. The Google provides a guideline of technical writing at https://developers.google.com/tech-writing. Complete the writing course.
- The appendix of the report (without page limit) includes program sources, and compile/execute traces to verify that your program has been compiled and executed. Don't forget to add proper comments to the sources for helping to understand them. All source codes and trace outputs are submitted as pure text but not screen-captures.

- Each member must submit a Peer Rating Form individually and confidentially. Without the peer rating, you will be considered not to submit the project even though your team does. You should be fair in the peer evaluation.