Tasks labeled by the sign are optional and are worth extra credits.

General information

Contact: zsolt.lazar@ubbcluj.ro
Course website: MS Teams
Assignment: Submitted assignment should be archived folder with its name containing the assignment number and title of the assignment, e.g., `02_Random_walk_part_1`. The folder should be uploaded as a compressed archive containing the student's name, e.g., `Smith_John_02_Random_walk_part_1.zip`.

Requirements

Reports should include:

1. Students name
2. Title
3. Statement of the problem
4. Hypotheses
5. Strategy/method
6. Conclusions
7. Complete compilation/installation/execution instructions. Specifying dependencies are appreciated.
8. Results from demo runs including screen captures of charts, etc. - where it applies - should be included.
9. Detail the parameters used for the demonstrated runs (on the Figures)
10. Describe the environment(s) where the testing was successful (compilers, libraries, environments,...)
11. Have a list of source files attached.

Source code should be readable:

12. properly segmented, consistently indented
13. generously commented (including the description of the approach)
14. self-explanatory naming of variables

All programing tasks have to be implemented in C/C++. Some of the tasks are to be implemented ALSO in a language with vector/matrix operation capabilities like Python or Matlab. These are marked with a P/M sign.
In these cases emphasis is on employing builtin functions of the language and avoiding loops. The algorithms do not have to be fully equivalent to their C variant but rather focusing on simplicity as primary goal.
Difference between the two approaches (C vs. Python/Matlab), if any, together with benefits, drawbacks and limitations should be discussed.
Submission beyond deadline is possible but penalized.

Week 03 - Random number generation

Deadline: 28.03

1. histogram test of a built-in gaussian random number generator (R.N.G) (prove the $\exp(-x^2)$ decay) (only P/M)
   Hint: a.) $\sqrt{-\ln(\max(\text{histo})/\text{histo})}$ exhibits a linear V shaped dependence, b.) plot a correspondingly parametrized Gaussian (P/M)
2. return-map test of some built-in uniform R.N.G (P/M)
3. study the Pearson correlation of some built-in R.N.G (P/M)
4. write a linear congruential R.N.G
5. study the effect of the parameters in the linear congruential R.N.G on:
   (a) period
   (b) return-map (P/M)
   (c) pearson correlation (P/M)

   Suggestions: Check the method's Wikipedia page. In Python/Matlab use `subplot` to get multiple plots on the same figure.
6. prove that for some built-in uniform R.N.G in the return-map test the number of empty pixels decays exponentially (P/M)

   Hint: Work on a grid
7. Generate the following distributions (P/M):
   (a) $x^2,\ x \in [0, 1)$
   (b) $x^2,\ x \in [1, 2)$
   (c) $1 - x^2,\ x \in [-1, 1)$ **Hint:**
   The essence of the algorithm:
   - step 1: generate x uniformly between 0 and 1
   - step 2: solve the $y^3 - 3y - 2 + 4x = 0$ equation in y, e.g. by using bisection/Newton-Raphson/secant method, or interpolation.

   (d) (+10%) semicircular shape over the [-1, 1) interval

   Verify them using histograms. (P/M)
8. write a Gaussian R.N.G (Box-Muller algorithm) (P/M)
9. apply the histogram, return-map and Pearson correlation tests on it (P/M)