CS 2104 Homework Assignment 2

Problem 1. Individual work. 40 points. A *random walk* is a stochastic process in which a particle moves one step at a time from state to state in a structured space. For us, the state space will be $\mathbb{Z}$, the set of integers. The particle starts in an initial state $S_0 \in \mathbb{Z}$. If, after $i \geq 0$ steps, the particle is in state S_i, then in step $i+1$, it moves to state $S_i + 1$ with probability p and to state $S_i - 1$ with probability q; it cannot stand still. Of course, $p + q = 1$. If $S_0 = 5$ and $0 < p < 1$, then the sequence $5, 4, 3, 4, 3, 2, 3, 2, 3, 4$ is a possible sequence of states for the particle if it moves 9 times.

The Assignment. This assignment is to be done by each student in class individually.

The assignment is to write a program that will simulate a random walk for a given number of steps and that will compute certain statistics for the random walk.

The parameters for a simulation come from standard input as a single line of parameters, consisting of (1) the initial state S_0; (2) the value of p; and (3) the number of steps to simulate. For example, the parameter line

```
5 0.40 9
```

specifies a simulation starting at $S_0 = 5$ and running for 9 steps, with $p = 0.40$ and $q = 0.60$.

The output of the simulation goes to standard output. First, S_0 is printed. As the simulation proceeds, each new state is printed, one state per line. After that, the maximum state attained, the minimum state attained, and the average of all states (including the initial state) are printed, as in the following sample output:

```
5
4
3
4
3
2
3
2
3
4
Maximum 5
Minimum 2
Average 3.3
```

Random Numbers. To complete the program, you will need a source of random numbers. Each of the programming languages has at least one pseudo-random number generator, which you are welcome to use for this purpose. The CBB group in the Department of Computer Science has a true hardware random number generator that you can also use. Browse to

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http://bioinformatics.cs.vt.edu:51234
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and you will get 256 random numbers (32-bit signed integers). Each time you read the URL, you get a new sequence of random numbers. If you know how to retrieve web pages from inside a program, then you will be able to use these true random numbers.

Submission of problem I. The submission for this assignment must be the source file for your program. Each person uploads a single source file. The source file should be clearly commented and must include your name. Strictly follow the "Programming assignment guidelines" on the course web-site.

Problem 2. Group work. 30 points. .

To begin, each group member installs the latest version of *Mathematica* available through VT software distribution. He will familiarize himself with the very basics of it by following *First Five Minutes with Mathematica* tutorial available at the front page of the GUI version.

The group will use an already available piece of Mathematica code to research the following issue: how large is the variation in individual image recognition ability? That is if a group of people are presented with the same sequence of images that represent the same object at increasing level of detail, will they all begin to recognize the object at the same or different levels of "fuzziness"?

Specifically, you will be using a smooth curve to "fit" a set of points on the plane that are supposed to represent a well-recognizable object if the fitting is done well. A single variable — number of free parameters (constants) that describe the curve's mathematical form — controls the quality of the fit and hence the degree of realism of the image.

The group leader (and only the group leader) downloads this Mathematica notebook. He/she will play with it first, to see how it works. A "dial" at the very top of the image controls the number of parameters (constants), which can be changed from 2 to 30.

Once the group leader has familiarized himself with the code, he will "test" his group members. She will start with the lowest number of details (number of constants = 2) and then "dial them up" all the way to 15 or 20. She will demonstrate each result to his group members, and they will write down the name object they perceive. At the end of the exercise, each group member will have a two-column table "apparent object" vs. "number of fit constants". For example, the first couple of entries may look like "a blob" "1", "US map" "2". Needless to say, the team members are not expected to see each other's responses until the end of the exercise. At the end, they compare the responses and compute the average value of the "number of fit constants" at which the object becomes recognizable. The standard deviation will provide the spread in perception.

Submission of problem II Strictly follow the "General Assignment Guidelines" (required group assignment) on the course web-site. Provide the average and standard deviation computed above, plus add a short conclusion summarizing your results and their possible significance. You might want to include pictures of some of the images (if you figure out how to make them) if you feel these help you weave the story better. No more than 1 page total.