University of Liverpool
Department of Computer Science
Autumn 2021

Maths and Stats for AI and Data Science
COMP533

Programming Assignment (The three distributions) 100/100

This assignment allows you to experiment with simple codes written in Python. This is to practice this programming language and better understanding of probabilistic distributions we studied in the class.

The tasks

We have recently studied a number of probabilistic distributions including their probability mass/density distribution. In this programming assignment you will be asked to compute recursively and visualize probability mass distributions for Binomial and Poisson distributions. Finally you will be asked to translate points (segments) in any Normal distribution to the relevant points in the standard Normal distribution. The three tasks are:

(T1) In the first task the focus is on Binomial distribution in which the probability mass distribution for n trials where the probability of success is given by function $f(n,k,p) = \binom{n}{k} p^k (1-p)^{n-k}$, for all integer $0 \le k \le n$.

We know that the recursive definition of $\binom{n}{k}$ is

A - $\binom{n}{0} = 1$
B - $\binom{n}{n} = 1$
C - $\binom{n}{k} = \binom{n-1}{k-1} + \binom{n-1}{k}$ in any other case.

(20 Pts) Establish (and provide justification) similar recursive relationship for $f(n,k,p)$ including

A - $f(n,0,p) = ?$
B - $f(n,n,p) = ?$
C - $f(n,k,p) = ? \bullet f(n-1,k-1,p) + ? \bullet f(n-1,k,p)$ in any other case.

(20 Pts) Amend the content of code *Binomial.py* to compute and plot the relevant probability mass distribution. Make sure you change this code only in lines with comment *# <- change here*.

Submit the amended code *Binomial.py* **and a note on the recursive definition of** $f(n,k,p)$ **in a separate (joint for all tasks) pdf document as the solution**.

(40 Points in total)

(T2) In the second task the focus is on Poisson distribution with the expected value λ in which the probability mass distribution is given by function $f(k,\lambda) = \frac{\lambda^k e^{-\lambda}}{k!}$, for all integer $k \geq 0$.

(20 Pts) Establish (and provide justification) similar recursive relationship for $f(n,k)$ including

A - $f(0,\lambda) = ?$
B - $f(k,\lambda) = f(k-1,\lambda)\ \bullet ?$, for all integer $k > 0$.

(20 Pts) Amend the content of code *Poisson.py* to compute and plot the relevant probability mass distribution. Make sure you change this code only in lines with comment *# <- change here*. Please note that in the code parameter λ is represented by the variable l.

Submit the amended code *Poisson.py* **and a note on the recursive definition of $f(k,\lambda)$ in a separate (joint for all tasks) pdf document as the solution**.

(40 Points in total)

(T3) In the third task the focus is on Normal (Gaussian) distribution with the expected value μ (in the code mu) and the standard deviation (in the code s) in which the probability density distribution is given by formula $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}(\frac{x-\mu}{\sigma})^2}$, for all integer $k \geq 0$.

(15 Pts) Amend the content of code *Normal.py* to plot the probability mass distribution in the adopted Normal distribution (AND) based on parameters mu and s determined by the code and to plot the probability mass distribution for standard Normal distribution (SND). In addition compute standardization of two points $X1 = 5$ and $X2 = 10$ in AND to $X1z$ and $X2z$ in SND. Make sure you change this code only in lines with comment *# <- change here*.

(5 Pts) Compute also the probability that a random variable drawn from AND belongs to segment $(X1, X2)$ using points $X1z$ and $X2z$ in SND and precomputed probabilities for SND.

Submit the amended code *Normal.py* **and a short answer (including reasoning) to the last question in a separate (joint for all tasks) pdf document as the solution**.

(20 Points in total)

Please make sure that the amended codes and an answer to (4) are submitted via CANVAS by

5:00 pm on Wednesday December 3rd 2021.