Assignment-2

Adil Salfi - CS20BTECH11031

Download all python codes from

```
https://github.com/AdilSalfi/AI1103/tree/main/
    Assignment−2/Codes
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and latex-tikz code from

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https://github.com/AdilSalfi/AI1103/tree/main/
    Assignment−2
```

Problem

GATE-EC Question 59 :
Let X be a random variable having the distribution function :

$$F(x) = \begin{cases} 0 & x < 0 \\ \frac{1}{4} & 0 \le x < 1 \\ \frac{1}{3} & 1 \le x < 2 \\ \frac{1}{2} & 2 \le x < \frac{11}{3} \\ 1 & x \ge \frac{11}{3} \end{cases}$$

Solution

→Let us define the Heaviside step function $u(x)$

$$u(x) = \begin{cases} 0 & x < 0 \\ 1 & x \ge 0 \end{cases}$$

→The Heaviside step function can be used to obtain a function $F(t)$ whose output is $f(t)$ for the interval $[a, b)$ and 0 everywhere else using the the property

$$F(t) = f(t)[u(t-a) - u(t-b)] \tag{1}$$

→The derivative of the Heaviside step function $u(x)$ is the dirac delta function $\delta(x)$

$$\delta(x) = \frac{du(x)}{dx} \tag{2}$$

→An important property of the delta function is

$$\int_{-\infty}^{\infty} f(x)\delta(x - x_0)dx = f(x_0) \tag{3}$$

→To obtain the CDF $F(x)$ in terms of Heaviside step function $u(x)$, we use (1)

$$F(x) = \frac{1}{4}[u(x) - u(x-1)] + \frac{1}{3}[u(x-1) - u(x-2)] + \frac{1}{2}[u(x-2) - u(x - \frac{11}{3}] + u(x - \frac{11}{3})$$

$$\implies F(x) = \frac{u(x)}{4} + \frac{u(x-1)}{12} + \frac{u(x-2)}{6} + \frac{u(x-\frac{11}{3})}{2} \tag{4}$$

→To obtain PDF $f(x)$ we differentiate (4) and using (2), we get

$$f(x) = \frac{\delta(x)}{4} + \frac{\delta(x-1)}{12} + \frac{\delta(x-2)}{6} + \frac{\delta(x-\frac{11}{3})}{2} \tag{5}$$

→To obtain $E(x)$ we use the formula

$$E(x) = \int_{-\infty}^{\infty} x f(x) dx \tag{6}$$

→Substituting (5) in (6), we get

$$E(x) = \int_{-\infty}^{\infty} \frac{x}{4}\delta(x) + \int_{-\infty}^{\infty} \frac{x}{12}\delta(x-1) + \int_{-\infty}^{\infty} \frac{x}{6}\delta(x-2) + \int_{-\infty}^{\infty} \frac{x}{2}\delta(x - \frac{11}{3})$$

→Using (3), we get

$$E(x) = \frac{0}{4} + \frac{1}{12} + \frac{2}{6} + \frac{\frac{11}{3}}{2}$$
$$\therefore E(x) = 2.25$$

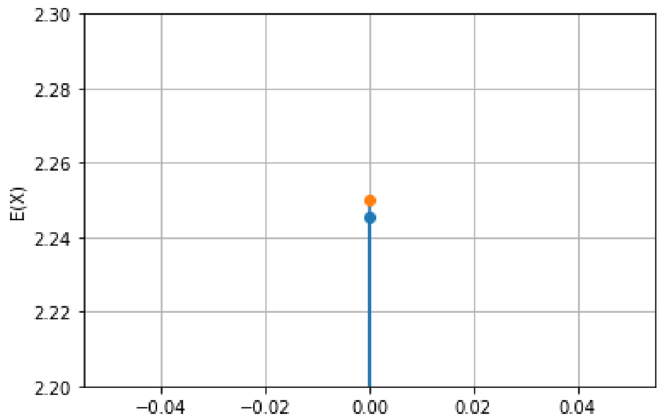

Fig. 1:Plot comparing Simulated and Theoretical value of $E(x)$