Probability

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

If A and B are independent $P(A \cap B) = P(A)P(B)$

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Expected Value

$$E[x] = \int_{-\infty}^{\infty} xp(x)\,dx$$

$$E[g(x)] = \int_{-\infty}^{\infty} g(x)p(x)\,dx$$

Variance

$$Var[x] = E[(x - E[x])^2] = \sigma^2 = \int_{-\infty}^{\infty} (x - E[x])^2 p(x)\,dx$$

$$E((x - E[x])^2) = E[x^2] - (E[x])^2$$

Covariance

$$\begin{aligned} cov(X_1, X_2) &= E[(X_1 - m_1)(X_2 - m_2)] \\ &= E[(X_1)(X_2)] - m_1 m_2 \end{aligned}$$

Correlation

$$\rho = \frac{cov(X_1, X_2)}{\sqrt{V(X_1)V(X_2)}}$$

Probability Distribution

Normal

$$\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \qquad E[X] = \mu \qquad Var[X] = \sigma^2$$

Exponential

$$\lambda e^{-\lambda x} \qquad E[X] = \frac{1}{\lambda} \qquad Var[X] = \frac{1}{\lambda^2}$$

Uniform

$$\begin{cases} \dfrac{1}{b-a} & \text{for } x \in [a, b] \\ 0 & \text{otherwise} \end{cases}$$

$$E[X] = \frac{1}{2}(a + b) \qquad Var[X] = \frac{1}{12}(b - a)^2$$

Bernoulli

$$\begin{cases} q = 1 - p & \text{if } k = 0 \\ p & \text{if } k = 1 \end{cases} \quad E[X] = p \quad Var[X] = p(1 - p)$$

Binomial

$$\binom{n}{k} p^k (1 - p)^{n-k} \qquad E[X] = np \qquad Var[X] = np(1 - p)$$

Poisson

$$\frac{\lambda^k e^{-\lambda}}{k!} \qquad E[X] = \lambda \qquad Var[X] = \lambda$$

Pareto

$$\frac{\alpha x_m^a}{x^{\alpha+1}} \qquad E[x] = \begin{cases} \infty & \text{for } \alpha \leq 1 \\ \dfrac{\alpha x_m}{\alpha - 1} & \text{for } \alpha > 1 \end{cases}$$

$$Var[X] = \begin{cases} \infty & \text{for } \alpha \leq 1 \\ \dfrac{x_m^2 \alpha}{(\alpha - 1)^2(\alpha - 2)} & \text{for } \alpha > 1 \end{cases}$$

MLE

Hypothesis Testing

z-test

t-test