GENERAL PROBABILITY

Basic Probability Relationships

$\Pr(A \cup B) = \Pr(A) + \Pr(B) - \Pr(A \cap B)$

$\Pr(A \cup B \cup C) = \Pr(A) + \Pr(B) + \Pr(C) - \Pr(A \cap B)$
$\quad - \Pr(B \cap C) - \Pr(A \cap C) + \Pr(A \cap B \cap C)$

$\Pr(A') = 1 - \Pr(A)$

Law of Total Probability

$\Pr(B) = \sum_{i=1}^{n} \Pr(B \cap A_i)$

De Morgan's Law

$\Pr[(A \cup B)'] = \Pr(A' \cap B')$

$\Pr[(A \cap B)'] = \Pr(A' \cup B')$

Conditional Probability

$\Pr(A|B) = \dfrac{\Pr(A \cap B)}{\Pr(B)}$

Independence

$\Pr(A \cap B) = \Pr(A) \cdot \Pr(B)$

$\Pr(A|B) = \Pr(A)$

Bayes' Theorem

$\Pr(A_k|B) = \dfrac{\Pr(B|A_k) \cdot \Pr(A_k)}{\sum_{i=1}^{m} \Pr(B|A_i) \cdot \Pr(A_i)}$

Combinatorics

$n! = n \cdot (n-1) \cdot \ldots \cdot 2 \cdot 1$

$_nP_k = \dfrac{n!}{(n-k)!}$

$_nC_k = \binom{n}{k} = \binom{n}{n-k} = \dfrac{n!}{(n-k)! \cdot k!}$

$\text{Partition} = \dfrac{n!}{k_1! \cdot k_2! \cdot \ldots \cdot k_y!} \qquad k_1 + k_2 + \ldots + k_y = n$

$\text{Probability} = \dfrac{\text{number of outcomes that satisfy the event}}{\text{total number of outcomes}}$

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*Learn both discrete and continuous cases

***Probability Mass Function (PMF)**

$\sum_{\text{all } x} p_X(x) = 1$

$\Pr(X = a) = 0$ (continuous)

***Cumulative Distribution Function (CDF)**

$F_X(x) = \Pr(X \le x) = \sum_{i \le x} p_X(i)$

$\Pr(a < X \le b) = F_X(b) - F_X(a)$

$f_X(x) = \dfrac{d}{dx} F_X(x)$ (continuous)

$S_X(x) = 1 - F_X(x) = \Pr(X > x)$

***Expected Value**

$\mathrm{E}[g(X)] = \int_{-\infty}^{\infty} g(x) \cdot f_X(x)\, dx$

$\mathrm{E}[g(X)] = \int_{0}^{\infty} g'(x) \cdot S_X(x)\, dx$, for $x \ge 0$ and $g(0) = 0$

$\mathrm{E}[g(X)|j \le X \le k] = \dfrac{\int_{j}^{k} g(x) \cdot f_X(x)\, dx}{\Pr(j \le X \le k)}$

$\mathrm{E}[c] = c$

$\mathrm{E}[c \cdot g(X)] = c \cdot \mathrm{E}[g(X)]$

$\mathrm{E}[g_1(X) + \ldots + g_k(X)] = \mathrm{E}[g_1(X)] + \ldots + \mathrm{E}[g_k(X)]$

Variance, Standard Deviation, and Coefficient of Variation

$\mathrm{Var}[X] = \mathrm{E}[(X - \mu)^2] = \mathrm{E}[X^2] - (\mathrm{E}[X])^2$

$\mathrm{Var}[aX + b] = a^2 \cdot \mathrm{Var}[X]$

$\mathrm{Var}[c] = 0$

$\mathrm{SD}[X] = \sqrt{\mathrm{Var}[X]}$

$\mathrm{CV}[X] = \mathrm{SD}[X]/\mathrm{E}[X]$

Percentiles

The $100p^{\text{th}}$ percentile is the smallest value of π_p where $F_X(\pi_p) \ge p$.

Modes

The mode(s) of a random variable is/are the value(s) where the probability function is maximized.

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Jasper McCoy

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