Statistical Methods Reference

By Ouzidane Reda

1. Hypothesis Testing

(a) t-tests

- **One-sample t-test:**

$$t = \frac{\bar{X} - \mu_0}{s/\sqrt{n}} \quad (\text{df} = n - 1)$$

- **Independent two-sample t-test:**

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad \text{(Welch's df)}$$

- **Paired t-test:**

$$t = \frac{\bar{D}}{s_D/\sqrt{n}} \quad (\text{df} = n - 1)$$

(b) p-value

$$p = P(T \geq |t| \mid H_0) \quad (\text{Reject } H_0 \text{ if } p < \alpha)$$

2. Confidence Intervals

- **For mean μ:**

$$\text{CI} = \bar{X} \pm t_{\alpha/2} \cdot \frac{s}{\sqrt{n}}$$

- **For proportion p:**

$$\text{CI} = \hat{p} \pm z_{\alpha/2} \cdot \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

3. ANOVA (Analysis of Variance)

(a) One-Way ANOVA

$$F = \frac{MS_{\text{between}}}{MS_{\text{within}}} = \frac{SS_{\text{between}}/(k-1)}{SS_{\text{within}}/(N-k)}$$

- **Total Sum of Squares:**

$$SS_{\text{total}} = \sum (X_{ij} - \bar{X}_{\text{total}})^2$$

- **Post-Hoc (Tukey's HSD):**

$$\text{HSD} = q_{\alpha,k,df_{\text{within}}} \cdot \sqrt{\frac{MS_{\text{within}}}{n}}$$

4. Regression Analysis

(a) Linear Regression

$$Y = \beta_0 + \beta_1 X + \epsilon, \quad \beta_1 = \frac{\text{Cov}(X,Y)}{\text{Var}(X)}$$

$$R^2 = \frac{SS_{\text{regression}}}{SS_{\text{total}}}$$

(b) Logistic Regression

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X$$

5. Non-Parametric Tests

- **Mann-Whitney U:**

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

- **Kruskal-Wallis:**

$$H = \frac{12}{N(N+1)} \sum \frac{R_i^2}{n_i} - 3(N+1)$$

6. Effect Sizes

Metric	Formula	Interpretation
Cohen's d	$\frac{\bar{X}_1 - \bar{X}_2}{s_{\text{pooled}}}$	Small: 0.2, Medium: 0.5, Large: 0.8
η^2	$\frac{SS_{\text{effect}}}{SS_{\text{total}}}$	% variance explained

7. Decision Guide

Precision-crafted by Ouzidane Reda.

Scenario	**Test**
Compare 2 means	t-test
Compare $\geq$3 means	ANOVA + post-hoc
Continuous outcome prediction	Linear regression
Binary outcome prediction	Logistic regression
Non-normal data	Mann-Whitney/Kruskal-Wallis