Statistical & Probability Models

1. Hypothesis Testing

Hypothesis testing is a statistical method to make decisions about population parameters based on sample data.

- Null hypothesis (H_0): statement of no effect or no difference.

- Alternative hypothesis (H_1): statement we want to test.

Common tests: z-test, t-test, chi-square test, ANOVA.

Steps:

1. State H_0 and H_1

2. Choose significance level (α)

3. Select test statistic

4. Compute p-value

5. Compare p-value with α to reject/accept H_0.

2. Estimation

Estimation involves inferring population parameters from sample statistics.

- Point estimation: single value as an estimate (e.g., sample mean for population mean).

- Interval estimation: range of values (confidence intervals) within which parameter likely falls.

3. Confidence Intervals

A confidence interval (CI) gives a range of plausible values for a parameter.

Formula for mean with known σ: $CI = \bar{x} \pm z^*(\sigma/\sqrt{n})$.

For unknown σ, use t-distribution.

Level of confidence (e.g., 95%) indicates probability interval contains true parameter over repeated samples.

4. Probability Distributions

- Normal: continuous, symmetric, bell-shaped. Parameters: μ, σ.

- Binomial: discrete, fixed n trials, p success probability.

- Poisson: discrete, events in fixed interval, λ average rate.

- Exponential: continuous, time between events in Poisson process.

Applications: risk analysis, quality control, queuing, reliability.

5. Simulation Goals

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- Implement hypothesis tests on synthetic datasets.

- Generate and visualize common probability distributions.

- Construct and interpret confidence intervals.

- Estimate parameters using MLE and method of moments.