PLS 120: Applied Statistics in Agricultural Sciences

Tree Age Estimation Methods

Week 9 Tutorial Guide

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November 2024

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Important Links

Essential Course Resources

Course Website

All course materials available at:

Course Website Link

Interactive Binder Environment

Access Week 9 lab materials:

Week 9 Binder Link

Welcome to Week 9: Tree Age Estimation Methods

This week focuses on **method comparison techniques** using real tree age data. You'll master confidence intervals, understand the difference between independent and paired t-tests, and learn to make statistical decisions in agricultural research contexts.

Confidence Intervals

Understanding Confidence Intervals

Confidence intervals provide a range of plausible values for a population parameter based on sample data.

3.1.1 Confidence Interval Formula

95% Confidence Interval for Mean:

$$CI = \overline{x} \pm t_{\alpha/2,df} \times \frac{s}{\sqrt{n}}$$

Where:
$\overline{x}$ = sample mean
$t_{\alpha/2,df}$ = critical t-value
s = sample standard deviation
n = sample size
$df = n - 1$ = degrees of freedom

R Implementation:

```
t.test(data)$conf.int
mean(data) ± qt(0.975, df=n-1) * sd(data)/sqrt(n)
```

Method Comparison

Independent vs Paired Comparisons

Understanding when to use each approach is crucial for valid statistical inference.

4.1.1 Independent Samples

Independent Two-Sample t-test:
Use when comparing two separate groups
Example: Method A on trees 1-5, Method B on trees 6-10

Formula:

$$t = \frac{\overline{x_1} - \overline{x_2}}{SE_{diff}}$$

Where: $SE_{diff} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$

R Implementation:

```
t.test(method_A, method_B, paired = FALSE)
```

4.1.2 Paired Samples

Paired t-test:
Use when same subjects measured with both methods
Example: Both methods applied to same 10 trees

Formula:

$$t = \frac{\overline{d}}{s_d/\sqrt{n}}$$

Where: $\overline{d}$ = mean of differences, s_d = SD of differences

R Implementation:

```
t.test(method_A, method_B, paired = TRUE)
differences <- method_A - method_B
t.test(differences)
```

Assignment 9 Overview

Dataset: Tree Age Methods

Compare two techniques for estimating tree age on 10 trees:

- Method A: Traditional ring counting
- Method B: Modern imaging technique
- Same trees measured with both methods (paired design)

Assignment Structure (20 points total)

1. **Question A: Means and Confidence Intervals (4 points)**
   - Calculate means for both methods
   - Compute 95% confidence intervals
   - Include manual calculations
2. **Question B: CI Interpretation (2 points)**
   - Analyze confidence interval overlap
   - Draw conclusions about method differences
3. **Question C: Difference Analysis (4 points)**
   - Calculate mean difference between methods
   - Determine 95% CI for the difference
   - Use pooled variance approach
4. **Question D: Significance Assessment (2 points)**
   - Interpret CI for difference
   - Determine statistical significance
5. **Question E: Independent t-test (4 points)**

- Perform two-sample t-test
- Manual t-statistic calculation
- Hypothesis testing decision

6. **Question F: Paired t-test (4 points)**
   - Perform paired samples analysis
   - Calculate differences array
   - Compare with independent test results

Key Statistical Concepts

Confidence Interval Interpretation

Interpreting Confidence Intervals:

Individual CIs:
We are 95% confident the true mean lies within the interval

Overlapping CIs:
Suggests no significant difference between methods
However, overlap doesn't guarantee non-significance

CI for Difference:
If CI includes 0 → No significant difference
If CI excludes 0 → Significant difference

Example Interpretation:
Method A: 95% CI (22.3, 26.5)
Method B: 95% CI (19.9, 24.1)
Difference: 95% CI (-0.4, 5.2) includes 0 → Not significant

Test Selection Guide

When to Use Each Test:

- **Independent t-test:** Different subjects in each group
- **Paired t-test:** Same subjects measured twice
- **One-sample t-test:** Compare sample to known value

Tree Age Example:
Since both methods were used on the same trees, paired t-test is appropriate. However, we also demonstrate independent t-test for comparison.

Manual Calculations

Step-by-Step Calculations

7.1.1 Confidence Interval Calculation

Example: Method A Confidence Interval

Given: $n = 10$, $\overline{x} = 24.4$, $s = 2.95$

Step 1: Calculate standard error
$SE = \frac{s}{\sqrt{n}} = \frac{2.95}{\sqrt{10}} = 0.93$

Step 2: Find t-critical value
$t_{0.025,9} = 2.262$ (from t-table)

Step 3: Calculate margin of error
$ME = t \times SE = 2.262 \times 0.93 = 2.10$

Step 4: Construct interval
$CI = 24.4 \pm 2.10 = (22.30, 26.50)$

Special Features This Week

Complete Solutions Provided

Learning by Running Code:

- **All code cells** contain complete working solutions
- **Manual calculations** alongside R functions
- **Step-by-step explanations** in comments
- **Decision logic** with if/else statements
- **Formatted output** for easy interpretation

Educational Benefits:

- See immediate results by running cells
- Compare manual vs automated calculations
- Understand statistical decision-making process
- Learn proper result interpretation

Getting Started

1. Launch Week 9 Binder environment
2. Navigate to `assignment` folder
3. Open `Assignment9.ipynb`
4. Run each code cell to see complete solutions

5. Learn by observing calculations and interpretations

Learning Objectives

By the end of this week, you will be able to:

- Calculate and interpret confidence intervals for means
- Compare two measurement methods statistically
- Choose between independent and paired t-tests appropriately
- Perform manual statistical calculations
- Interpret confidence intervals for differences
- Make statistical decisions based on evidence
- Understand the relationship between CIs and hypothesis tests
- Apply method comparison techniques to agricultural research

Tips for Success

Best Practices:

- Run each code cell sequentially to see the complete analysis
- Pay attention to manual calculations vs R function results
- Understand when confidence intervals suggest significance
- Note the difference between independent and paired test results
- Focus on proper interpretation of statistical output
- Consider practical significance alongside statistical significance

Need Help?

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Zoom Link: Join Office Hours