RIS 2005
Geospatial Technology

Dynamics of GPS Readings

The Scientific Method Framework 1

1. Observe and formulate a Question(s)
   - Observation:
     - A GPS unit can be used to determine the geographic position of an object on the surface of the earth.
     - However, the readings of the geographic coordinates of a stationary object obtained with a GPS unit tend to differ with time.
   - Questions:
     - How accurate are the readings of the geographic coordinates of a stationary object from a GPS unit?
     - Does time of day affect the accuracy of GPS readings?
     - Does the accuracy of the readings vary with different GPS units?

The Scientific Method Framework 2

2. Develop a hypothesis
   - Assemble and organize the facts through a review of the literature.
   - Working Hypotheses:
     - The accuracy of readings of the geographic coordinates of a stationary object from a GPS unit is affected by the time of the day the readings are taken.
     - The accuracy of readings of the geographic coordinates of a stationary object from a GPS is affected by the type of GPS unit used to take the readings.

The Scientific Method Framework 3

3. Test the hypothesis (Experimental Design)
   - Propose likely solution or make a prediction. During this process you will need to develop the specific research hypotheses (i.e., Null and Alternate Hypotheses).
   - Conduct experiment to collect data
   - Analyze the data and draw conclusions relevant to the research hypotheses.
   - Report the results.

Steps in the Experimental Design of the GPS Study

1. State the objective(s) of the study and identify research components.
2. Decide what type of data (response variable) to collect.
3. Determine the proper sample size.
4. Choose the experimental units.
5. Collect the data.
6. Analyze the data.

Case 1a
STEP 1: Research Components and Objective

Experimental Unit (EU): An individual GPS reading of the geographic coordinates of a stationary object.

Factor 1: Time of Day
   - Level 1: Morning
   - Level 2: Afternoon

Response Variable (RV): accuracy of the GPS reading (as measured by the deviation from the true readings).

To determine whether time of day affects the accuracy of the GPS readings of the geographic coordinates of a stationary object.
### Case 1b

**STEP 1: Research Components and Objective**

**Experimental Unit (EU):** An individual GPS reading of the geographic coordinates of a stationary object.

**Factor 1:** Type of GPS Unit  
- Level 1: Unit 1  
- Level 2: Unit 2

**Response Variable (RV):** Accuracy of the GPS reading (as measured by the deviation from the true readings).

To determine whether the **[type of GPS unit]** affects the **[accuracy]** of the GPS readings of the geographic coordinates of a stationary object.

### Case 2

**STEP 1: Research Components and Objective**

**Experimental Unit (EU):** An individual GPS reading of the geographic coordinates of a stationary object.

**Factor 1:** Time of Day  
- Level 1: Morning  
- Level 2: Afternoon

**Factor 2:** Type of GPS Unit  
- Level 1: Unit 1  
- Level 2: Unit 2

**Response Variable (RV):** Accuracy of the GPS reading (as measured by the deviation from the true readings).

This is a 2 x 2 factorial experiment.

To determine whether **[time of day and GPS unit]** affect the **[accuracy]** of the GPS readings of the geographic coordinates of a stationary object.

### Observational or Experimental Study?

- **Case 1a:** To determine whether **[time of day]** affects the **[accuracy]** of the GPS readings of the geographic coordinates of a stationary object.
- **Case 1b:** To determine whether the **[type of GPS unit]** affects the **[accuracy]** of the GPS readings of the geographic coordinates of a stationary object.
- **Case 2:** To determine whether **[time of day and type of GPS unit]** affect the **[accuracy]** of the GPS readings of the geographic coordinates of a stationary object.

### Type of Factors and Study...

- Factors in the GPS study are **Time of Day** and **Type of GPS Unit**.
  - What type of factors are these? Qualitative, Quantitative or Extraneous?
  - What are some examples of extraneous factors in the GPS study?
  - Is the GPS study Prospective or Retrospective?

### STEP 2: Decide What Type of Data (Response Variable) to Collect

- What is the response variable in the GPS study?
- Is the response variable (data that are collected) Nominal, Ordinal, Discrete, or Continuous?

### STEP 3: Determine the Proper Sample Size

- One of the factors that affect sample size is variability in the response variable.  
  - As variability in the response variable increases, sample size also should increase.
- Do you expect there to be a lot of variability in the GPS readings with time of day or type GPS unit?
- How are the issues of variability and sample size handled in the GPS study?
STEP 4: Choose the Experimental Units for the Study

- Experimental units should be selected that are:
  - Representative of the entire universe of experimental units.
  - This ensures that biases (levels of the extraneous factor) do not occur disproportionately across the experimental units.
  - What did you do in the GPS Study to ensure that a representative sample of the experimental unit was obtained?

STEP 5: Collect the Data (Response Variable)

- Collection of the data begins with a consideration of the data analysis techniques.
- Use an efficient, easy to use, and well-established protocol.
- Collect as much information as possibly with the time and resources that are available.
- Quantity and quality of the data can be improved by following the two basic requirements of any good statistical experiment:
  - Randomization and Replication.

STEP 6: Analyze the Data (Response Variables)

Three general classes of analysis:

A. Description of the response variable measurements
B. Hypothesis testing
C. Making a prediction or estimating a response

A. Describing the Response Variable...

- Response variables can be described (summarized) either pictorially (graphs, charts, etc.) or numerically.
- Numerical descriptions of RVs:
  - Measures of Central Tendency
  - Measures of Dispersion

B. Hypothesis Testing ...

- Hypothesis testing is used to compare the response variable between factor levels to determine whether there is any meaningful difference in the variable between the levels.
- Steps in hypothesis testing
  1. Determine the null hypothesis ($H_0$) and alternative hypothesis ($H_A$)
  2. Determine a suitable significance level ($\alpha$ or alpha level) and power for the statistical test
  3. Choose and compute the test statistic (e.g., chi-square, $t$, $F$)
  4. Make a conclusion.

Case 1a: GPS Study Null and Alternate Hypotheses

To determine whether the [time of day] affects the [accuracy] of the GPS readings of the geographic coordinates of a stationary object.

$H_0$: The accuracy of GPS readings is the same in the morning and evening.
$H_A$: The accuracy of GPS readings is not the same in the morning and evening.

$H_0$: The accuracy of GPS readings is not affected by time of day.
$H_A$: The accuracy of GPS readings is affected by time of day.
**Case 1b: GPS Study**

**Null and Alternate Hypotheses**

To determine whether the [type of GPS unit] affects the [accuracy] of the GPS readings of the geographic coordinates of a stationary object.

- **Hₐ:** The accuracy of GPS readings is the same for each type of GPS unit.
- **H₀:** The accuracy of GPS readings is not the same for each type of GPS unit.

- **Hₐ:** The accuracy of GPS readings is not affected by the type of GPS unit.
- **H₀:** The accuracy of GPS readings is affected by the type of GPS unit.

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**Case 2: GPS Study**

**Null and Alternate Hypotheses**

To determine whether [time of day and type of GPS unit] affect the [accuracy] of the GPS readings of the geographic coordinates of a stationary object.

- **Hₐ:** The accuracy of GPS readings is the same in the morning and evening.
- **H₀:** The accuracy of GPS readings is not the same in the morning and evening.

- **Hₐ:** The accuracy of GPS readings is the same for each GPS unit.
- **H₀:** The accuracy of GPS readings is not the same for each GPS unit.

- **Hₐ:** There is no interaction of time of day and GPS unit on the accuracy of GPS readings.
- **H₀:** There is an interaction of time of day and GPS unit on the accuracy of GPS readings.

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**What happens next?**

- Decide on a (predetermined) significance level (α or alpha).
- Analyze data (see Handout).
- Compute appropriate test statistic.
- Determine whether to accept (fail to reject) H₀ as true or reject H₀ as false based on the attained significance level (P).

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**STEP 7: Report the Results**

 Publish or Perish