Introduction to Experimental Design

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- What is experimental design?
- Terminology
- Common mistakes
- Sample designs

Experimental Design and Analysis

How to:

- Design a proper set of experiments for measurement or simulation.
- Develop a model that best describes the data obtained.
- Estimate the contribution of each alternative to the performance.

Example

Personal workstation design

1. Processor: 68000, Z80, or 8086.
2. Memory size: 512K, 2M, or 8M bytes
3. Number of Disks: One, two, three, or four
4. Workload: Secretarial, managerial, or scientific.
5. User education: High school, college, or post-graduate level.

Five **Factors** at 3x3x4x3x3 **levels**

Terminology

- **Response Variable**: Outcome.
  E.g., throughput, response time
- **Factors**: Variables that affect the response variable.
  E.g., CPU type, memory size, workload used.
  Also called predictor variables or predictors.
- **Levels**: The values that a factor can assume, E.g., the CPU type has three levels: 68000, 8080, or Z80.
  Also called **treatment**.
- **Primary Factors**: The factors whose effects need to be quantified.
  E.g., CPU type and memory size only.

Terminology (Cont)

- **Secondary Factors**: Factors whose impact need not be quantified.

  E.g., the workloads.
- **Replication**: Repetition of all or some experiments.
- **Design**: The number of experiments, the factor level and number of replications for each experiment.

  E.g., Full Factorial Design with 5 replications: $3\times 3 \times 4 \times 3 \times 3$ or 324 experiments, each repeated five times.

Terminology (Cont)

- **Interaction** $\Rightarrow$ Effect of one factor depends upon the level of the other.

Table 1: Noninteracting Factors

	A_1	A_2
B_1	3	5
B_2	6	8

Table 2: Interacting Factors

	A_1	A_2
B_1	3	5
B_2	6	9

Types of Experimental Designs

- **Simple Designs**: Vary one factor at a time

$$\# \text{ of Experiments} = 1 + \sum_{i=1}^{k} (n_i - 1)$$

  - Not statistically efficient.
  - Wrong conclusions if the factors have interaction.
  - Not recommended.
- **Full Factorial Design**: All combinations.

$$\# \text{ of Experiments} = \prod_{i=1}^{k} n_i$$

  - Can find the effect of all factors.
  - Too much time and money.
  - May try 2^k design first.

Types of Experimental Designs (Cont)

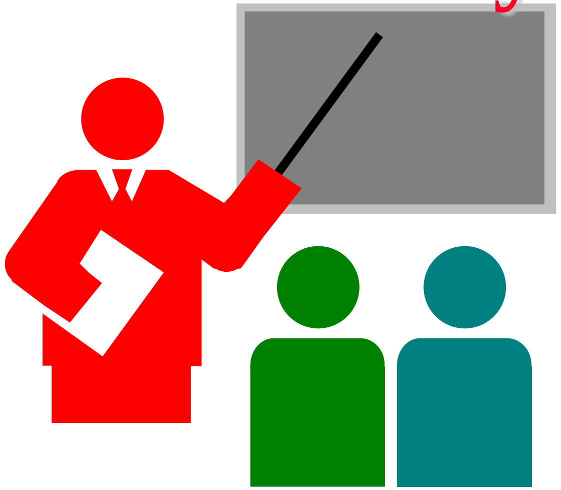
- Fractional Factorial Designs: Less than Full Factorial
  - Save time and expense.
  - Less information.
  - May not get all interactions.
  - Not a problem if negligible interactions

A Sample Fractional Factorial Design

- Workstation Design:
  (3 CPUs)(3 Memory levels)(3 workloads)(3 levels) = 81 experiments

Experiment Number	CPU	Memory Level	Workload Type	Educational Level
1	68000	512K	Managerial	High School
2	68000	2M	Scientific	Post-graduate
3	68000	8M	Secretarial	College
4	Z80	512K	Scientific	College
5	Z80	2M	Secretarial	High School
6	Z80	8M	Managerial	Post-graduate
7	8086	512K	Secretarial	Post-graduate
8	8086	2M	Managerial	College
9	8086	8M	Scientific	High School

Summary



- Goal of proper experimental design is to get the maximum information with minimum number of experiments
- Factors, levels, full-factorial designs