Introduction to Design of Experiments

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Example

- We have a simulation of a radar system
- We want to test it
- How do we test it in every point in variable space
  - There could be a combination of variables where the system goes postal (unstable) or does not perform correctly
  - And how do we test it in a reasonable amount of time
    - Often an impossibility

Introduction & Overview

- Structured method for performing (repeated) tests or analyses on a given system
- Need (n + 1) tests to estimate n parameters
- Needed to estimate interaction parameters
- Need to test in the corners of the envelope
- DOE changes the factors independently of each other
- Allows discovery of interaction effects

Terms

- Factor – An Independent variable that can only take on a finite number of values (levels)
- Covariate – An independent variable that can take on a continuous range of values
- Parameter – A quantity that describes a statistical population (mean or variance)
- Level – a setting for a factor, represented at a -1 or +1 in the design/ test matrix
- Run – one trial at specific factor settings
- Repetition – Identical runs (combinations) done at the same time
- Replicate – Identical runs (combinations) at different times
- Response – the output or dependent variable
- Full Factorial Design – examines all possible combinations of factors and levels
- Fractional Factorial Design – Examines a fractional portion of the possible combinations of factors and levels

Validities

- External validity– the results generalize to the external world, that hold across different settings, procedures, & participants
- Internal validity - validity of causal inferences
- Construct validity– does the scale measure the unobservable construct that it is intended
- Statistical conclusion validity - refers to the degree to which one's analysis allows one to make the correct decision regarding the truth or approximate truth of the null hypothesis.

2^k Screening

- Full factorial 2 level design has 2^k experiments
- Tests at all possible points
- May take too much time
- If function is not monotonic (Continues in same direction)
  - Could miss activity in system
  - Should use at least a 3 level design

CCD

- Central Composite Design
  - Also called a “Box Wilson Central Composite design
- Contains imbedded [or fractional] factorial design
- Augmented with group of star points
  - Allow estimation of curvature
  - Twice as many star points as there are factors
- Three types:
  - Circumscribed
  - Inscribed
  - Face Centered

D-Optimal

- Produced by computer algorithm
- Usually not orthogonal
- Effect estimates usually correlated
- Straight optimizations
  - Based on the model and optimality criterion
  - Based on optimizing |X'X|
- Optimality is model dependent
- A set of treatment combinations created by using stepping and exchanging process

Response Surface Designs

- Latin Hypercube (volume filling)
  - Supported in GenSim
- Taguchi
- Smaller number of runs than full factorial
- Many others
  - Sequential bifurcation
  - Folded designs
  - Combined designs
  - Many more
- Each has its strengths & weaknesses

JMP

- Statistical Package
  - Works in Linux, Mac, Or PC
- Generates test matrix
- Easy to use
- Produces coded values
- Full or fractional factorial
- Taguchi

References

- *Modeling & Simulation* by Averil Law
- DASE – Design Analysis Simulation Experiments