Test Matrices

16.621

Prof. Earll Murman

Variables

- Independent Variable: A quantity that you will vary and control
  - E.G.; angle of attack, chamber pressure or temperature, coefficient in algorithm, luminosity, gain, ...
- Parameter: A quantity that is set or otherwise determined, which you will not vary but which needs to be recorded
  - E.G.; atmospheric pressure, constant in algorithm, battery voltage,...
- Dependent Variable: A measureable output quantity of your experiment which is a function of the input variables and parameters
  - E.G.; reaction time, force, energy consumed, temperature

Exercise

- With your partner, write down your expected variables and parameters.
- Independent Variables
- Parameters
- Dependent variables

Test Matrices

- A graphical display of your experimental independent variables to help:
  - Covey the scope of your experiment to your audience
  - Plan and execute your experiment
- Each cell represents a "data point" for your experiment for which you will collect values for the dependent variables.

Propeller RPM / IVs / Speed	0 RPM	1000 RPM	2000 RPM	3000 RPM	4000 RPM
0 mph					
5 mph		DVs			
10 mph					
15 mph					

Courtesy of Cyndi Vongvanith and Lester McCoy

Multi-Variable Experiments

- Factor = Number of independent variables
  - Four-Factor experiment has 4 independent variables
- Level = A given value of an independent variable
  - Numerical – 200, 300, 400 …
  - Qualitative – Brand x, Brand y, Brand z …
- Full-Factorial Experiment
  - All factors at all levels
  - May lead to a huge number of data points.
- Fractional-Factorial Experiment
  - Expert judgement: carefully selected subset
  - Adaptive: decide as you get some data
  - Design of Experiments: Taguchi, orthogonal arrays
    - Beyond scope of 16.62X

Presentation of Test Matrices: Full Factorial

- Test matrix used for graphical representation of test plan
  - Define: $A_n = n^{th}$ level of factor A

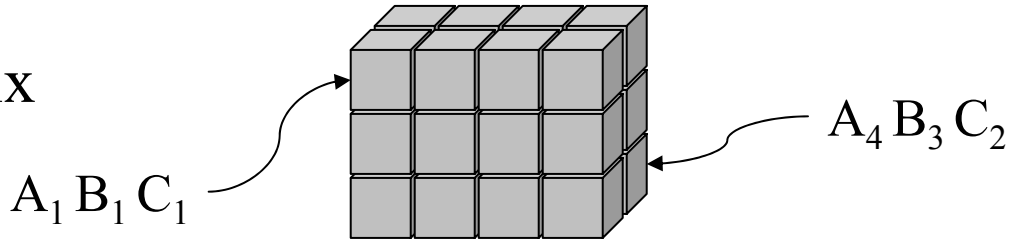
- One variable matrix

IV	DV1	DV2	DV3
A_1			
...			
A_n			

- Two variable matrix

A_1B_1	A_1B_2	Λ	A_1B_n
A_2B_1	A_2B_2	Λ	A_2B_n
M	M	O	M
A_mB_1	A_mB_2	Λ	A_mB_m

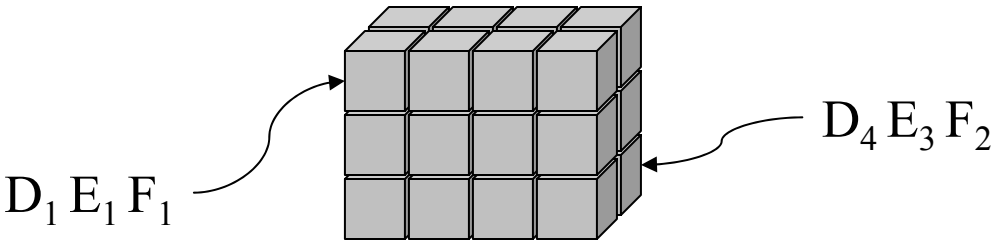
- Three variable matrix



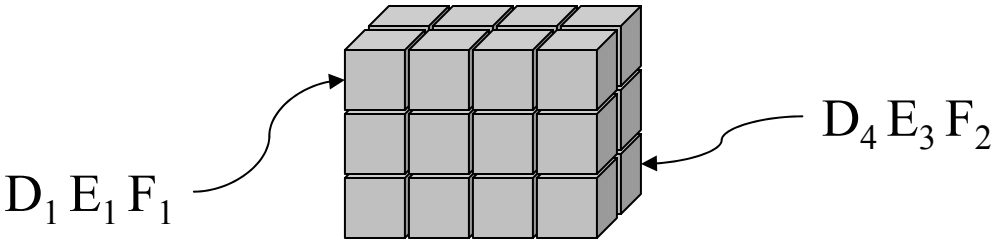
Presentation of Test Matrices: Full Factorial

- N- variable matrix
  - Creativity needed
  - Stamina will probably also be required!

For $A_1 B_1$:

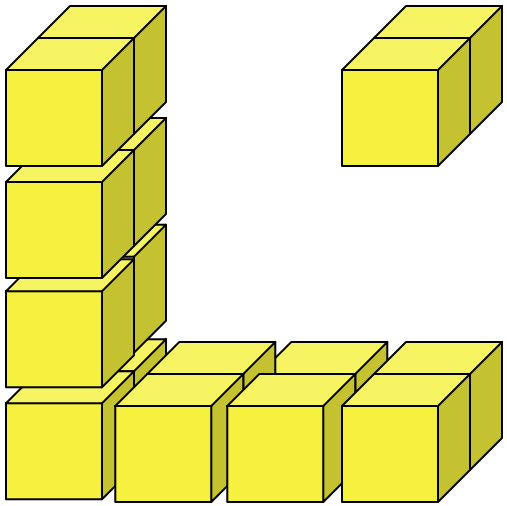


For $A_2 B_7$:



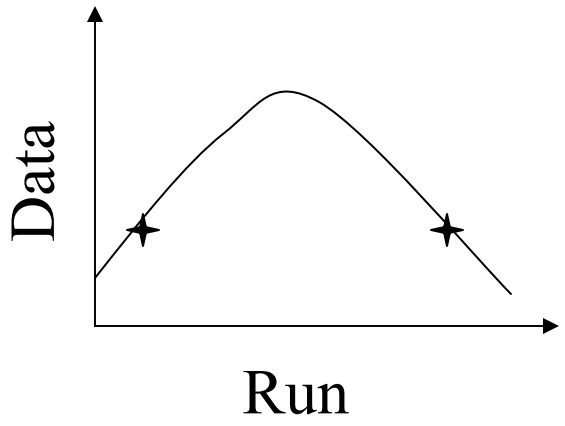
Expert Judgement Approach

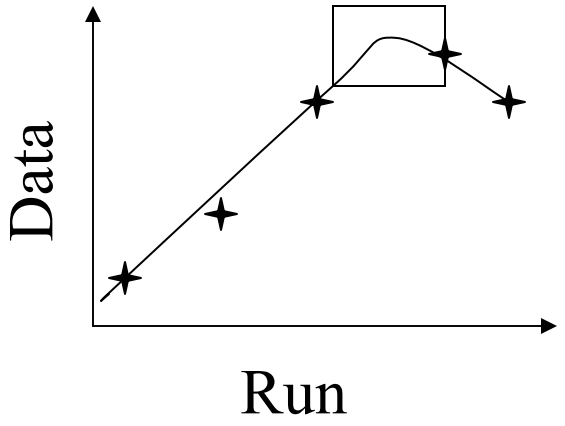
- Eliminate some combinations of independent variables to reduce the total number of data points
- Often required to make experiment feasible within time and budget constraints
- Strategies for elimination
  - Insight from previous theory or experiments
  - Wisdom from advisor or other subject matter expert
  - Logical thought about interrelationship of variables on the physics of the problem



Adaptive Approach

- Preliminary Runs
  - Use theory to bracket range
  - 2 or 3 test cases to check set-up
  - Compare with theory
- Production Runs
  - Data range and spacing
  - May not be uniform
    - Cluster samples in "interesting areas"





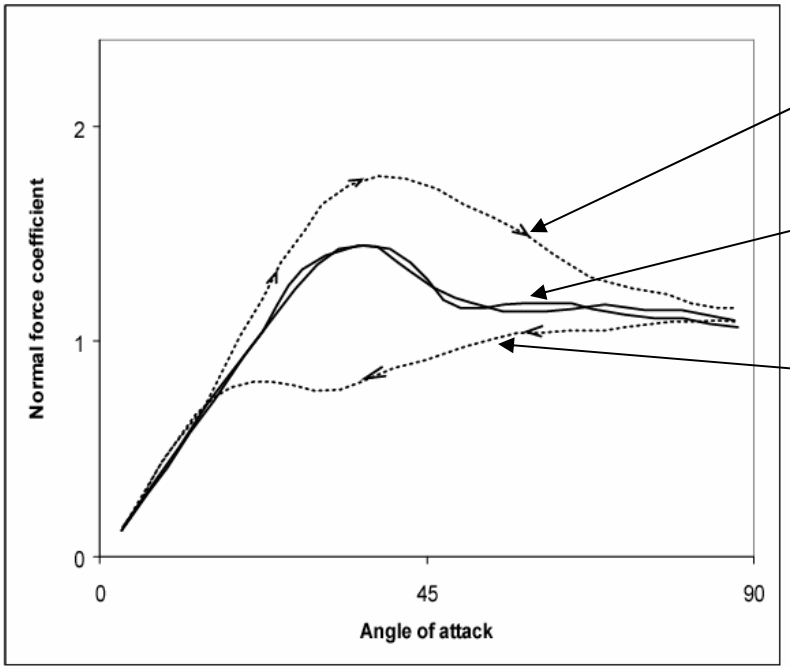
Additional Considerations

- Repeatability: Is there reason to believe that the measurement accuracy will be increased if multiple "runs" are made with the same independent variables and parameters?
- Hysteresis: Is there reason to believe the physical effect being studied may depend upon the sequence or rate in which you vary the independent variable?
- Learning: Is the reason to believe your human subjects or intelligent software will become more capable during the experiment through learning?
- Fatigue: Will your subjects become less capable during the test due to tiring?

Refer to backup slides for more information.

Hysteresis

- Hysteresis - "The lagging of an effect behind its cause, as when the change in magnetism of a body lags behind changes in the magnetic field." http://www.dictionary.com/
  - Feature of physical problem be studied
  - Feature of measurement device (undesirable)
- Example - pitching vs fixed delta wing



Hysteresis depends upon pitching rate

Learning

- "The act, process, or experience of gaining knowledge or skill" http://www.dictionary.com/
- The response of a human subject changes as an experiment proceeds because they gain skill or knowledge - the experiment changes the subject!
- E.G. measuring a response of a human to a video game experiment
  - Test 1 and Test 2 are different, but subject learns how to play the game in test 1 and can respond more quickly in test 2.
- Typical mitigation strategies
  - Train subjects to fix skill level
  - Test many subjects and vary the order of the test sequence to average out the learning effect.

Fatigue

- Fatigue: “Physical or mental weariness resulting from exertion.” http://www.dictionary.com/
- This is different than learning
  - Learning leads to a new skill level
  - Fatigue is a temporary loss of capability
- Fatigue can effect both the subject and the experimenter
  - Needs to be considered in the design of the execution of the experiment
- Fatigue can also apply to physical materials