Combinatorial Testing in Five Minutes

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Notices

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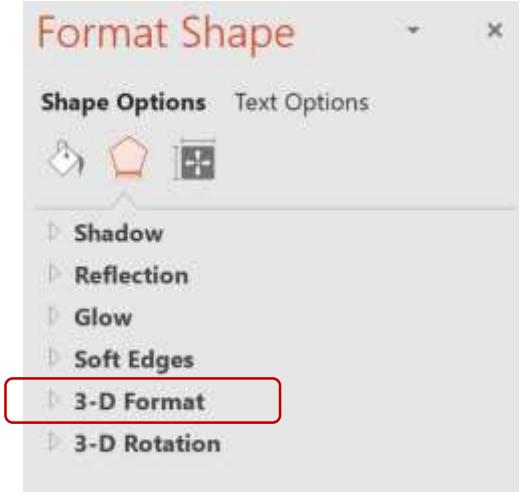
Example of a combinatorial testing challenge

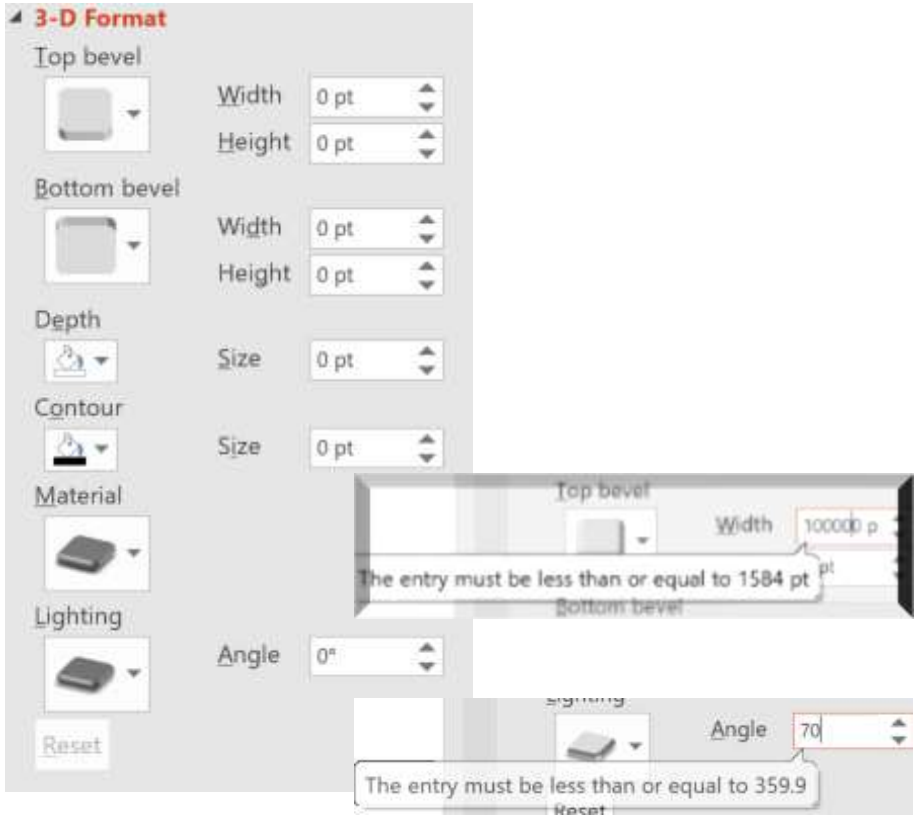


Consider the 3-D Format panel found in PowerPoint 2019

Suppose we want to test it

- How many tests are needed?
- Which ones?
- What settings/values to use?

Example of a combinatorial testing challenge



The controls accept the following

- Top Bevel: 13 types
- Bottom Bevel: 13 types
- Depth: 256 standard colors
- Contour: 256 standard colors
- Material: 11 settings
- Lighting: 15 settings
- Widths: 0..1584
- Angles: 0..359.9
- Sizes: 0..1584

How many combinations are there?

We need to choose specific inputs (“levels”) for each control (a “factor”). For this example, I use boundary values, all values of enumerated types, at least one randomly selected in-range value and one fuzzed value.

Factor	Level Values	# of Levels
Height, Width, Size	-1,0,1, RandInRange(), 1584, 1585, Fuzz()	7
Angle	-1, -0.1, 0, 0.1, 1.0, RandInRange(), 359.9, 360, Fuzz()	9
Top Bevel, Bottom Bevel	B1..B13	13
Depth and Contour:	None, white, black, red, green, RandInRange()	6
Material	M1..M11	11
Lighting	L1..L15	15

All possible combinations of level values:

7 x 7 x 7 x 9 x 13 x 13 x 6 x 6 x 11 x 15 = 3,098,915,820

How to select a practical and comprehensive set of tests?

3 billion is too many.

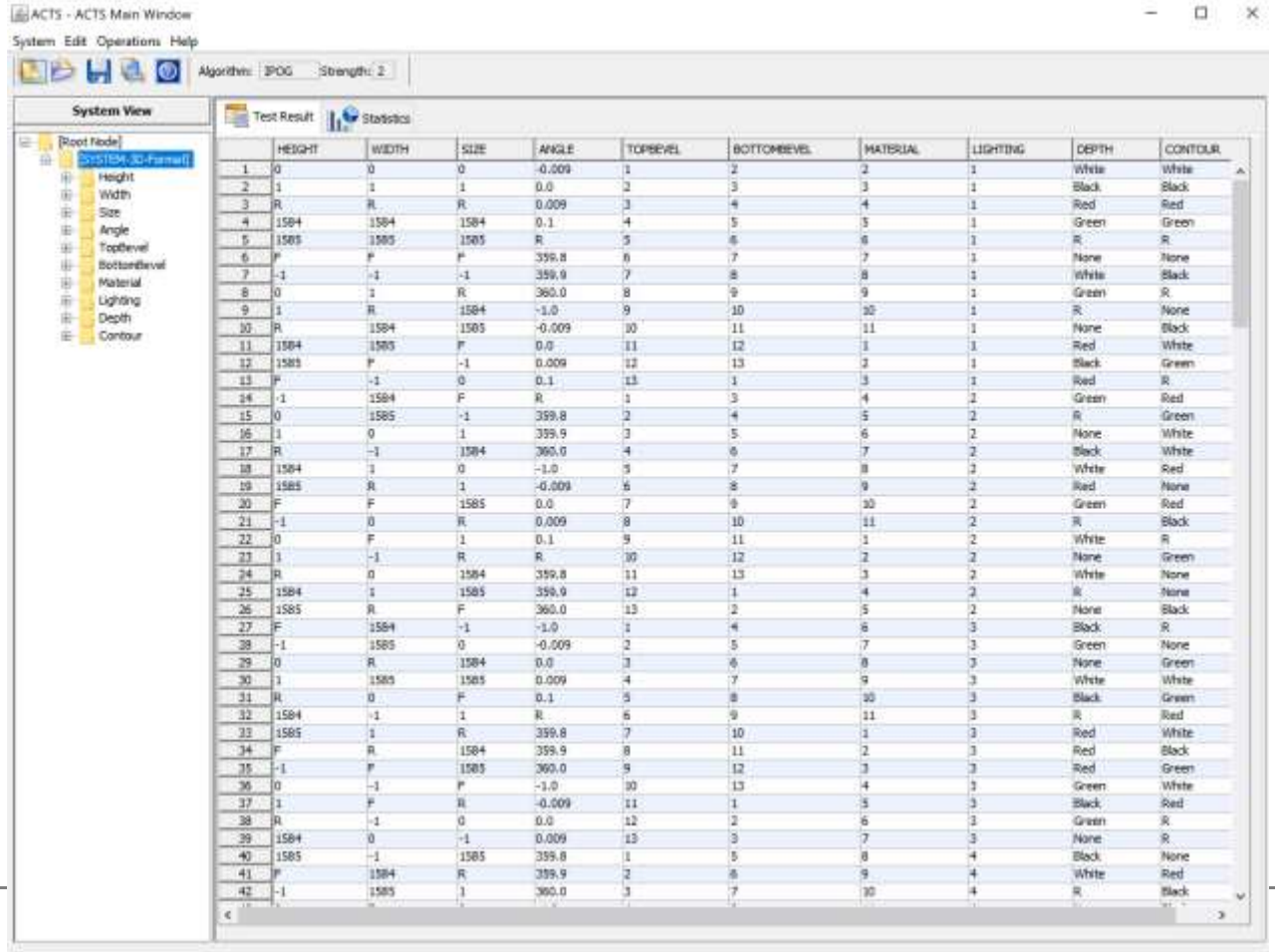
A few ad hoc and/or random selections is not enough.

How about testing every possible pair of levels at least once?

How many unique tests would that take?

How to select a practical and comprehensive set of tests?

All pairs of levels can be covered with 202 test cases



	HEIGHT	WIDTH	SIZE	ANGLE	TOPBEVEL	BOTTOMBEVEL	MATERIAL	LIGHTING	DEPTH	CONTOUR
1	0	0	0	-0.009	1	2	2	1	White	White
2	1	1	1	0.0	2	3	3	1	Black	Black
3	R	R	R	0.009	3	4	4	1	Red	Red
4	1584	1584	1584	0.1	4	5	5	1	Green	Green
5	1585	1585	1585	R	5	6	6	1	R	R
6	F	F	F	359.8	6	7	7	1	None	None
7	-1	-1	-1	359.9	7	8	8	1	White	Black
8	0	1	R	360.0	8	9	9	1	Green	R
9	1	R	1584	-1.0	9	10	10	1	R	None
10	R	1584	1585	-0.009	10	11	11	1	None	Black
11	1584	1585	F	0.0	11	12	1	1	Red	White
12	1585	F	-1	0.009	12	13	2	1	Black	Green
13	F	-1	0	0.1	13	1	3	1	Red	R
14	-1	1584	F	R	1	3	4	2	Green	Red
15	0	1585	-1	359.8	2	4	5	2	R	Green
16	1	0	1	359.9	3	5	6	2	None	White
17	R	-1	1584	360.0	4	6	7	2	Black	White
18	1584	1	0	-1.0	5	7	8	2	White	Red
19	1585	R	1	-0.009	6	8	9	2	Red	None
20	F	F	1585	0.0	7	9	10	2	Green	Red
21	-1	0	R	0.009	8	10	11	2	R	Black
22	0	F	1	0.1	9	11	1	2	White	R
23	1	-1	R	R	10	12	2	2	None	Green
24	R	0	1584	359.8	11	13	3	2	White	None
25	1584	1	1585	359.9	12	1	4	3	R	None
26	1585	R	F	360.0	13	2	5	2	None	Black
27	F	1584	-1	-1.0	1	4	6	3	Black	R
28	-1	1585	0	-0.009	2	5	7	3	Green	None
29	0	R	1584	0.0	3	6	8	3	None	Green
30	1	1585	1585	0.009	4	7	9	3	White	White
31	R	0	F	0.1	5	8	10	3	Black	Green
32	1584	-1	1	R	6	9	11	3	R	Red
33	1585	1	R	359.8	7	10	1	3	Red	White
34	F	R	1584	359.9	8	11	2	3	Red	Black
35	-1	F	1585	360.0	9	12	3	3	Red	Green
36	0	-1	F	-1.0	10	13	4	3	Green	White
37	1	F	R	-0.009	11	1	5	3	Black	Red
38	R	-1	0	0.0	12	2	6	3	Green	R
39	1584	0	-1	0.009	13	3	7	3	None	R
40	1585	-1	1585	359.8	1	5	8	4	Black	None
41	F	1584	R	359.9	2	6	9	4	White	Red
42	-1	1585	1	360.0	3	7	10	4	R	Black

Impact of Adding Factors and Levels

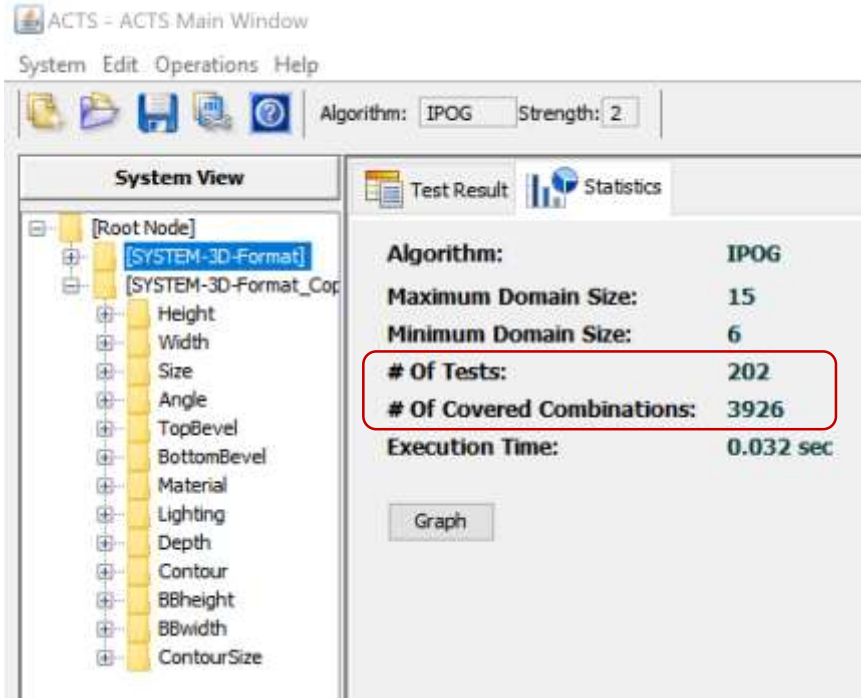
There are two flavors of width and height (top and bottom bevel).

There are two flavors of size (depth and contour).

The first model used only one of each.

What is the effect of adding 3 more factors?

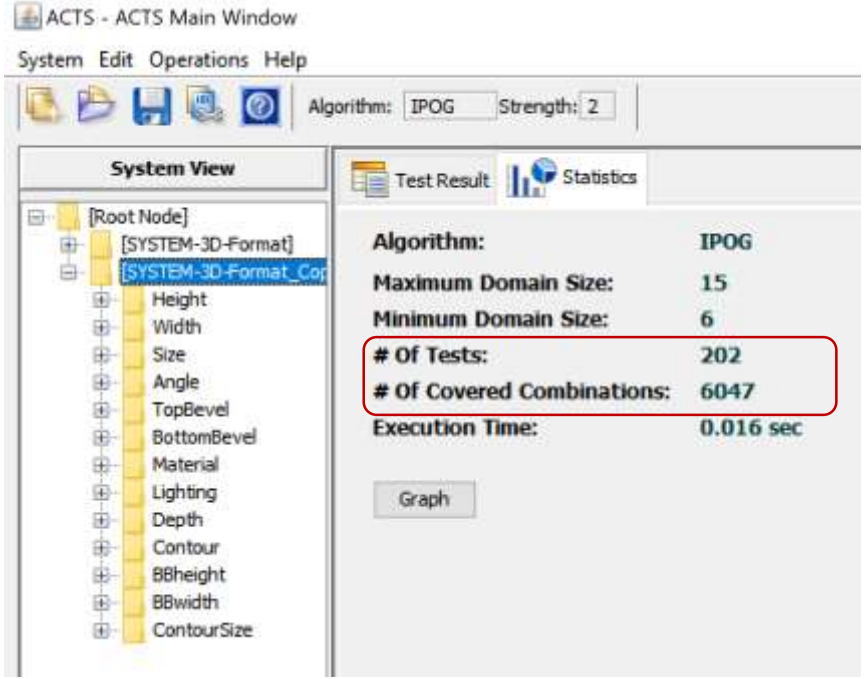
- Bottom Bevel Height
- Bottom Bevel Width
- Contour Size



Baseline Model

Impact of Adding Factors and Levels

No increase in the number of tests!



Model with 3 more Factors

Considerations

There are many ways to select level values besides those shown here.

The generated test cases typically do not include the expected result of the test - the tester must develop expected results or judge the response.

ACTS and other tools support constraints to automatically exclude infeasible combinations.

ACTS and other tools provide generic data export (csv, xls, etc.) that can be used for automated data-driven testing.

Besides selecting inputs for test cases, combinatorial design can generate:

- Configuration combos to be tested (OS versions, RAM, CPU, etc.)
- Test environment combos (temperature, operational mode, traffic volume, time of day, etc.)

Can be used at any scope (unit, integration, system) for any kind of interface (API, GUI, etc.), manual or automated execution, and for functional, regression, or performance testing.

Resources

ACTS tool from NIST

https://www.nist.gov/programs-projects/automated-combinatorial-testing-software-acts

Experience Reports about using combinatorial Testing

http://www.pairwise.org/results.asp

https://csrc.nist.gov/CSRC/media/Presentations/Introducing-Combinatorial-Testing-in-a-Large-Organ/images-media/poster-iwct14-lm2.pdf

https://app.hexawise.com/Combinatorial-Software-Testing-Case-Studies-IEEE-Computer-Kuhn-Kacker-Lei-Hunter.pdf

https://docs.hexawise.com/en/articles/2016946-does-pairwise-testing-really-work-evidence-data-and-case-studies

Collection of many resources

http://www.pairwise.org/index.asp

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