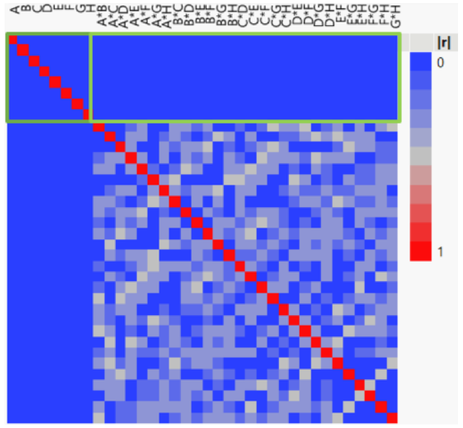
KU LEUVEN

Mohammed Saif Ismail Hameed[1], José Núñez Ares[1] and Peter Goos[1,2]
[1]KU Leuven, [2]University of Antwerp

A tailored analysis of data from OMARS designs

Orthogonal minimally aliased response surface (OMARS) designs

- Three levels per factor
- All main effects orthogonal to each other
- All main effects orthogonal to all second-order effects
- Broader family of designs than DSDs, BBDs and CCDs
- Available for many different run sizes
- Often fold-over designs



Correlation chart

1	−1	−1	−1	−1	−1	−1	−1	−1
2	1	1	1	1	1	1	1	1
3	−1	−1	−1	1	1	1	0	0
4	1	1	1	−1	−1	−1	0	0
5	−1	−1	1	−1	0	0	1	1
6	1	1	−1	1	0	0	−1	−1
7	−1	1	−1	0	0	1	1	0
8	1	−1	1	0	0	−1	−1	0
9	−1	1	0	−1	0	1	0	−1
10	1	−1	0	1	0	−1	0	1
11	−1	1	0	0	−1	0	−1	1
12	1	−1	0	0	1	0	1	−1
13	−1	0	1	1	1	0	−1	0
14	1	0	−1	−1	−1	0	1	0
15	−1	0	1	0	1	−1	0	−1
16	1	0	−1	0	−1	1	0	1
17	−1	0	0	1	−1	−1	1	1
18	1	0	0	−1	1	1	−1	−1
19	0	−1	−1	−1	1	0	0	1
20	0	1	1	1	−1	0	0	−1
21	0	−1	1	0	−1	1	1	−1
22	0	1	−1	0	1	−1	−1	1
23	0	−1	0	1	−1	1	−1	0
24	0	1	0	−1	1	−1	1	0
25	0	0	−1	1	0	−1	1	−1
26	0	0	1	−1	0	1	−1	1
27	0	0	0	0	0	0	0	0

8 factor 27 run foldover OMARS design

Overview of design tailored analysis methods

Method	Miller and Sitter, 2001	Miller and Sitter, 2005	Jones and Nachtsheim, 2017	New method
Assumption	3rd or higher order effects are negligible			
Application	Orthogonal fold-over designs	Fold-over designs	DSDs	OMARS designs
Step 1: Main effects selection	Lenth's method	Design based subset selection for main effects	t-tests for main effects using model independent estimate for error variance using dropped columns	t-tests for main effects using model independent estimate for error variance using residual degrees of freedom
Step 2: Second order effects selection	Traditional subset selection	Design based subset selection for second-order effects	Subset selection with F-test based stopping rule.	Subset selection with F-test based stopping rule.
Limitation	Use of R^2 increments in second order model selection (subjective).	Use of R^2 increments in second order model selection (subjective).	Application limited to DSDs and error degrees of freedom > 0	Error degrees of freedom > 0

Contact:

Mohammed Saif Ismail Hameed - mohammedsaif.ismailhameed@kuleuven.be
José Núñez Ares - jose.nunezares@kuleuven.be
Peter Goos - peter.goos@kuleuven.be

Simulation results

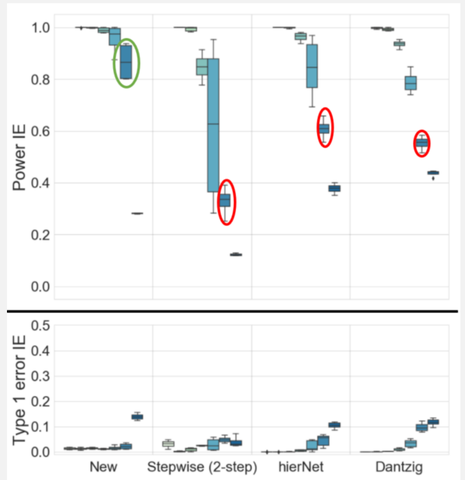
Main Effects

For main effects. the differences in power between the new method and the benchmarks (stepwise regression, hierNet (lasso with strong heredity constraints) and the Dantzig selector) can only be seen for a signal to noise ratio as low as 1:

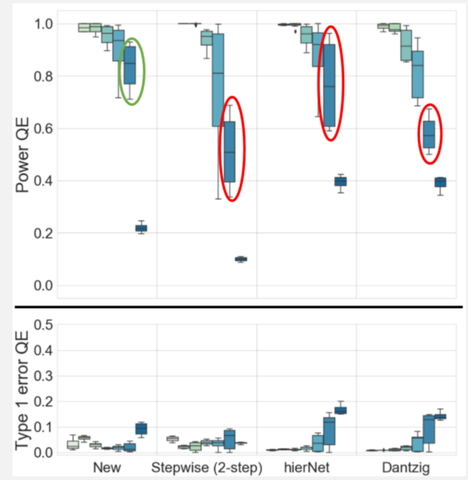
	Methods			
	New	Stepwise (2-step)	hierNet	Dantzig Selector (DS)
Power	**0.99**	0.95	0.92	0.92

The type 1 error rate for the new method is always around 0.05, whereas it is close to 0 for other methods.

Interaction effects (Signal to noise ratio ≥ 2)



Quadratic effects (Signal to noise ratio ≥ 2)



Contributions

- We introduce a model selection method tailored to OMARS designs which is a new and attractive class of response surface designs.
- We show significant improvements in powers to detect active effects especially for cases with a higher number of active second order effects.
- Our method can be used with any OMARS design (DSD, face-centered CCD and BBD) as well as with strength 3 Orthogonal Arrays.

References

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