Contents

Preface **vii**

1 Quick Start **1**
1.1 Gradients or no gradients? . . . 3
1.2 Evaluating the dimension of the active subspace . . . 6
1.3 Sufficient summary plots . . . 7
1.4 An example with a parameterized PDE . . . 10

2 Parameterized Models in Physics and Engineering **13**
2.1 What is random? . . . 14
2.2 The parameter studies . . . 15
2.3 Too many parameters! . . . 15
2.4 Dimension reduction: Subsets and subspaces . . . 16

3 Discover the Active Subspace **21**
3.1 Parameterized simulations and $f(\mathbf{x})$ . . . 21
3.2 Defining the active subspace . . . 22
3.3 Computing the active subspace . . . 25
3.4 A practical recipe . . . 35

4 Exploit the Active Subspace **45**
4.1 Dimension reduction and mappings . . . 45
4.2 Response surfaces . . . 48
4.3 Integration . . . 59
4.4 Optimization . . . 62
4.5 Inversion . . . 65

5 Active Subspaces in Action **71**
5.1 HyShot II scramjet . . . 71
5.2 Photovoltaic solar cell . . . 78
5.3 Airfoil shape optimization . . . 81

6 Summary and Future Directions **87**
6.1 Multiple outputs . . . 87
6.2 Coupled systems . . . 88
6.3 Anticipating active subspaces . . . 88

Bibliography **89**

Index **99**