Rolf Steinbuch • Simon Gekeler Editors

Bionic Optimization in Structural Design

Stochastically Based Methods to Improve the Performance of Parts and Assemblies



Contents

1	Motivation							
	Rolf Steinbuch							
	1.1	A Sho	rt Historical Look at Optimization	1				
		1.1.1	Optimization in Engineering History	2				
		1.1.2	Finding Relevant Numbers in Engineering	2				
		1.1.3	High Level Mechanical Methods	3				
		1.1.4	Drop of Hardware Costs and Better CAD Systems	3				
	1.2	Optim	ization and Simulation as Part of the Virtual Product					
		Devel	opment	5				
	1.3	Optim	ization in Nature	6				
	1.4	Terms	and Definitions in Optimization	7				
	1.5	Why H	Bionic Optimization?	9				
	Refe	rences		10				
2	Bionic Optimization Strategies							
-	Rolf Steinbuch, Julian Pandtle, Simon Gekeler, Tatiana Popoya,							
	Frank Schweickert, Christoph Widmann, and Stephan Brieger							
	2.1	Evolu	tionary Optimization	12				
		2.1.1	Terms and Definitions	12				
		2.1.2	Description of the Evolutionary Strategy	14				
		2.1.3	Evolutionary vs. Genetic Strategy	16				
		2.1.4	Discussion	18				
	2.2	Fern (Detimization	19				
		2.2.1	Description of the Approach	19				
		2.2.2	Discussion	20				
	23	Partic	le Swarm Ontimization	21				
	2.5	231	Terms and Definitions	21				
		2.3.1	Description of the Particle Swarm Optimization	22				
		2.2.2	Dynamic Particle Inertia	25				
		2.3.3	Dynamic Particle Inertia	25				

Contents

		2.3.4	Limitation of the Particles' Velocity	27					
		2.3.5	Discussion	27					
	2.4	Artific	ial Neural Net Optimization	28					
		2.4.1	ANN Architecture	29					
		2.4.2	Training ANNs	30					
		2.4.3	Conclusion	33					
	2.5	Ant C	olony Optimization	33					
		2.5.1	The Ant Colony Strategy in Bionic Optimization	34					
		2.5.2	Description of the Approach	34					
	2.6	Non-p	arametric Optimization	37					
		2.6.1	Topological Optimization	38					
		2.6.2	Local Growth	41					
	2.7	Meta 1	Models	42					
	2.8	Rando	om or Deterministic Methods	46					
	2.9	Violat	ion of Boundary Conditions	51					
	Refe	rences		54					
3	Prot	olems a	nd Limitations of Bionic Optimization	57					
	Tatia	ana Pop	ova, Iryna Kmitina, Rolf Steinbuch, and Simon Gekeler						
	3.1	Efficie	ency of Bionic Optimization Procedures	57					
		3.1.1	Comparing Bionic Optimization Strategies	58					
		3.1.2	Measuring the Efficiency of Procedures	59					
		3.1.3	Comparing the Efficiency of Bionic Optimization						
			Strategies	59					
		3.1.4	Conclusions	63					
	3.2	The C	urse of Dimensions	65					
	3.3	Accel	eration of Bionic Optimization Processes	67					
		3.3.1	Selecting Efficient Optimization Settings	69					
		3.3.2	Parallelization and Hardware Acceleration	72					
	Refe	rences		77					
Λ	Ann	lication	n to CAF Systems	79					
.	Rolf	Steinh	uch Andreas Fasold-Schmid Simon Gekeler	,,,					
	and	and Dmitrii Burovikhin							
	4 1	Inner	and Outer Loop Optimization	81					
		4 1.1	Inner Loop Process	82					
		4.1.2	Outer Loop Process	84					
	4.2	Imple	mentation in CAE-Systems	86					
		4.2.1	Mono-objective Parametric Shape Optimization	88					
		4.2.2	Formulation of Structural Optimization Problem	89					
		4.2.3	Bionic Parametric Shape Optimization with PTC	90					
		4.2.4	Bionic Parametric Shape Optimization with	,					
			Siemens NX 9.0	94					
	Refe	erences		99					

Contents

5	Application of Bionic Optimization							
	Oska	r Glück	c, and Ashish Srivastava	100				
	5.1	Earthq	uake Stability and Tuned Mass Dampers	102				
		5.1.1	Earthquake and Design for Earthquake Loading	102				
		5.1.2	Brief Introduction to Tuned Mass Dampers	103				
		5.1.3	A Simplified Approach to Study TMD in High					
			Buildings	107				
	5.2	Metal	Forming	109				
		5.2.1	Deep Drawing	110				
		5.2.2	Backward Extrusion	112				
	5.3	Brake	Squeal	115				
	0.0	531	Types of Brake Noise	115				
		532	Modeling of Brake Squeal	116				
		5 2 2	Minimizing the Risk of Brake Squeal Using Bionic					
		5.5.5	Ontimization	121				
	Refe	rences		121				
,								
0		rent ru	elds of Interest	125				
	KOII	Steind	ility and Debustment	126				
	0.1	Kellab		120				
		6.1.1	Reliability-Based Design	127				
		6.1.2	Robust Design	128				
		6.1.3	Reliability and Robustness Integration	129				
		6.1.4	A Sketch of a Formulation of a Unified Reliability					
			and Robustness Strategy	130				
		6.1.5	Robust Optimization	130				
		6.1.6	Conclusion	136				
	6.2	Multi-	Objective Optimization	138				
		6.2.1	Terms and Definitions	138				
		6.2.2	Strategies for MOO	141				
	6.3	Optim	ization and Process Management of the Virtual					
		Devel	opment Process	145				
	References 1							
7	Future Tasks in Optimization and Simulation 14							
	Sim	on Gek	eler and Rolf Steinbuch					
	7.1	Main	Trends in Optimization	147				
	7.2	Oualif	fications and Quality Assurance	149				
	73	Intern	retation of Simulation Results	150				
	74	Believ	ving in Standards and Defaults	150				
	75	Linki	ng Development and Manufacturing	151				
	7.5	Nau	ng Development and manufacturing	151				
	7.0 77	Dell's	alle Une Matchals	150				
	1.7	Reliat	ble Loading Systems	152				
	7.8	Prepro	ocessing and Mesning	152				
Index								