

AAD_Algorithms-Aided Design

Parametric Strategies using Grasshopper®

Arturo Tedeschi

with contributions by Stefano Andreani, Antonella Buono, Maurizio Degni, Lawrence Friesen, Andrea Galli, Francesco Lipari, Davide Lombardi, Ludovico Lombardi, Arthur Mamou-Mani, Alberto Pugnale, Antonio Turiello, Brian Vesely, Lorenzo Vianello, Fulvio Wirz.

Text revision by Brian Vesely

Each author bears responsibility exclusively for the contents he wrote and might dissent from contents of other authors featured in this book.

ISBN 978-88-95315-30-0

First edition 2014

Printed in Italy (february 2020)

© 2014 by Le Penseur

Via Montecalvario 40/3 - 85050 Brienza (Potenza) – ITALY

<http://www.lepenseur.it/books-and-training/en/>

All right reserved. No part of this book may be reprinted or reproduced or utilized in any form or by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying and recording, or in any information storage or retrieval system, without permission in writing from the publisher.

Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe. Grasshopper is a trademark of Robert McNeel & Associates. Autodesk and Ecotect are registered trademarks or trademarks of Autodesk, Inc., and/or its subsidiaries and/or affiliates in the USA and/or other countries.

Every effort has been made to contact and acknowledge copyright owners. If any material has been included without permission, the publisher offers its apologies. The publisher would be pleased to have any errors or omissions brought to its attention so that corrections may be published at later printing (please contact info@lepenseur.it).

The authors and publisher of this book have used their best efforts in preparing the material in this book. These efforts include the development, research and testing of the theories and computer methods to determine their effectiveness. The authors and publisher of this book make no warranty of any kind, expressed or implied, with regard to these methods explained, or the documentation contained in this book. The authors and publisher shall not be liable in any event for any damages, including incidental or consequential damages, lost profits, or otherwise in connection with any text and methods explained in this book.

This book mentions several projects and buildings not necessarily designed using the algorithm editor Grasshopper®, but whose complexity was suitable for illustrating the potentials of the algorithmic modeling.

CONTENTS

Acknowledgements	7
Foreword	9
Introduction AAD_ Algorithms-Aided Design from traditional drawings to the parametric diagram	15
1_algorithmic modeling with Grasshopper®	33
1.1 Prerequisites and installation	35
1.2 Grasshopper user interface	35
1.3 Components and data	40
1.4 Save and bake	53
1.5 Display and control	55
1.6 Grasshopper flow	59
1.7 Basic concepts and operations	61
2_data how to manage data in Grasshopper	69
2.1 Filters	69
2.2 Numerical sequences	87
2.3 Mathematical Functions	101
2.4 Conditions	107
2.5 Remapping numbers / Attractors	112

3_control curves and surfaces in Grasshopper	121	8_digital fabrication make ideas come true	309
3.1 NURBS curves	121	8.1 Fabrication Techniques	310
3.2 Parametric representation of a curve	124	8.2 Modeling Printable Objects	320
3.3 Analysis of curves in Grasshopper	126	8.3 Modeling objects for cutting based operations	330
3.4 Notion of Curvature for planar curves	136	8.4 NU:5 Installation	338
3.5 Parametric representation of a surface	138	8.5 Large-scale objects	341
3.6 Surface creation	141	<i>Over the material, Past the Digital: Back to Cities</i>	343
3.7 Analysis of surfaces using Grasshopper	144	<i>(Digital) Form-finding</i>	353
3.8 Notion of Curvature for surfaces	166		
4_transformations	183	9_digital simulation particle-spring systems	361
4.1 Vectors	185	9.1 Kangaroo plug-in	363
4.2 Euclidean transformations	187	9.2 Kangaroo workflow	364
4.3 Affine transformations	196	9.3 Cable simulation	365
4.4 Other transformations: <i>Box Morph</i>	210	9.4 Elastic behavior: Hooke's law	370
		9.5 Catenary simulation	375
5_skins advanced data management	217	9.6 Membrane simulation	382
5.1 Manipulating the <i>Data Tree</i>	220	9.7 Shell behavior	391
5.2 Skins	226	<i>Form as Unknown – Computational Methodology and Material Form Generation</i>	
5.3 Sorting strategies using Data Tree	248	<i>in the AA Rome Visiting School Workshops</i>	395
6_smoothness	255		
6.1 NURBS and Polygon Meshes	258	10_evolutionary structures topology optimization	405
6.2 Polygon meshes	260	10.1 Shape Optimization	406
6.3 Creating meshes in Grasshopper	263	10.2 Topology	411
6.4 SubD in Grasshopper: Weaverbird plug-in	273	10.3 Topology optimization	412
6.5 Subdivision of triangular meshes: Loop algorithm	274	10.4 Works	419
6.6 Subdivision of quadrangular meshes: Catmull-Clark algorithm	277	10.5 Examples	422
<i>Digital informing creativity</i>	293	10.6 Optimization: finding solutions with Grasshopper	432
7_loops	297		
7.1 Loops in Grasshopper: HoopSnake component	300	11_environmental analysis	441
7.2 Fractals	301	11.1 Tools	442
7.3 Loops in Grasshopper: Loop component	306	11.2 GEEO and Ecotect	442
		11.3 About GEEO's components	446
		11.4 Solar diagram and shadows	447
		11.5 Exporting geometries and importing data	453
		11.6 Insolation analysis	456
		11.7 Analysis Grids	459
		11.8 Light Control	461

Afterword_Post Digital Strategies	467
Pragmatic computation in Grasshopper	
Appendix	
I am City, we are City	473
Parametric Urbanism: a New Frontier for Smart Cities	475
Tools and methods for parametric urbanism	478
Playful computation – How Grasshopper3D & its Plugins increased my creativity with five project examples	482
The CloudBridge	491
Ilabo Shoes for United Nude	492
References	493
Decoded QR list	496