

Studies in Computational Intelligence

Volume 824

Series editor

Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland

The series “Studies in Computational Intelligence” (SCI) publishes new developments and advances in the various areas of computational intelligence—quickly and with a high quality. The intent is to cover the theory, applications, and design methods of computational intelligence, as embedded in the fields of engineering, computer science, physics and life sciences, as well as the methodologies behind them. The series contains monographs, lecture notes and edited volumes in computational intelligence spanning the areas of neural networks, connectionist systems, genetic algorithms, evolutionary computation, artificial intelligence, cellular automata, self-organizing systems, soft computing, fuzzy systems, and hybrid intelligent systems. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution, which enable both wide and rapid dissemination of research output.

The books of this series are submitted to indexing to Web of Science, EI-Compendex, DBLP, SCOPUS, Google Scholar and Springerlink.


More information about this series at <http://www.springer.com/series/7092>

Lorenzo Cevallos-Torres ·
Miguel Botto-Tobar

Problem-Based Learning: A Didactic Strategy in the Teaching of System Simulation

 Springer

Lorenzo Cevallos-Torres
Faculty of Mathematical and Physical
Sciences
University of Guayaquil
Guayaquil, Ecuador

Miguel Botto-Tobar 
Eindhoven University of Technology
Eindhoven, The Netherlands
University of Guayaquil
Guayaquil, Ecuador

ISSN 1860-949X ISSN 1860-9503 (electronic)
Studies in Computational Intelligence
ISBN 978-3-030-13392-4 ISBN 978-3-030-13393-1 (eBook)
<https://doi.org/10.1007/978-3-030-13393-1>

Library of Congress Control Number: 2019931854

© Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

We dedicate this book to our Family.

Preface

This book is designed to be a general, descriptive, and didactic introduction about the use of systems simulation with probability distributions, in this way might become a tool that helps to solve real-life problems, by evaluating alternative scenarios and finding answers to questions like “what would happen if?”.

This book aims the application of systems simulation as the main contribution in the teaching-learning model. We will analyze the different types of methodologies used in teaching to solve real-life problems, followed by process of building a simulation model by using a computer and probability distributions, allowing the correlation between a real model and a simulated model.

The conceptual part aims that the different methods are understood as a research instrument subjected to continuous review that allows a progressive refinement in the compression of system, which leads to a suitable position to make decisions in the problem solutions.

The systems’ simulation is based on the concept of experimentation itself of the scientific method, according to which, the experiments are carried out on a dynamic model instead of the real system so that the model results might be a valid representation of the system.

Consequently, one goal of this book is to help understand how the different simulation methods might be used to analyze phenomena and problems, and make decisions about them, i.e., to demonstrate the role of simulation in the processes of decision-making, especially in computer systems with a pedagogical teaching-learning approach.

The simulation allows getting better analysis and evaluation of the system’s performance before they are built. Thus it becomes a vital design tool, in any of its phases, and moreover, to estimate a priori the impact of proposed changes in the existent systems. It is expected to illustrate how the simulation can be applied in wide situations, through small projects such as: transport system analyze, logistics, queue’s theory, inventory’s theory, medicine.

Finally, to help the reader not only to the conceptual understanding of different methods of systems simulation, but also to understand how they work; when they should be used, and when not; what can expect from the simulation; what errors must be avoided in the development and use; and how the simulation might help to improve the performance of systems.

Guayaquil, Ecuador
December 2018

Lorenzo Cevallos-Torres
Miguel Botto-Tobar

Acknowledgements

We would like to thank God Almighty for giving us the strength, knowledge, ability, and opportunity to undertake this research study, and also to who are the invaluable protagonists who put their grain of sand in the elaboration of this book, our students at the University of Guayaquil.

Contents

1	The System Simulation and Their Learning Processes	1
1.1	Introduction	1
1.2	Fundamentals of Simulation	2
1.3	Simulation as a Teaching Method and Its Link with Engineering Careers	2
1.4	Teaching-Learning Process	4
1.5	Project Based Learning (PBL)	4
1.6	Role of the Teacher in the Teaching Process	6
1.6.1	Observe	6
1.6.2	Accompany	6
1.6.3	Stimulate	6
1.6.4	Evaluate	7
1.7	The Use of ICT in the Teaching Process	7
	References	8
2	Process Sampling	13
2.1	Population	13
2.1.1	Population Types	13
2.1.2	Population Elements	15
2.2	Sampling	15
2.2.1	Terminology	15
2.2.2	Sampling Types	16
	References	29
3	Pseudo-Random Numbers and Congruential Methods	33
3.1	Pseudo-Random Numbers	33
3.2	Pseudo Number Properties	34
3.3	Methods for Generating Pseudo Numbers	35

- 3.3.1 Manual Methods 35
- 3.3.2 Random Number Tables 35
- 3.3.3 Employing the Computer 36
- 3.4 Arithmetic Methods to Generate Pseudo Numbers 36
 - 3.4.1 Mean Square Method 36
 - 3.4.2 Medium Product Method 37
 - 3.4.3 Modified Medium Product Method 37
- 3.5 Congruence Methods 37
 - 3.5.1 Mixed or Linear Congruence Method 37
 - 3.5.2 Multiplicative Congruence Method 48
 - 3.5.3 Additive Congruence Method 53
- 3.6 Proposed Problems 57
- References 57
- 4 Random Variable Generation Methods 59**
 - 4.1 Introduction 59
 - 4.1.1 Types of Random Variables 60
 - 4.1.2 Methods for Generating Random Variables 60
 - 4.1.3 Inverse Transform Method 60
 - 4.2 Inverse Transform and Discrete Random Variables 61
 - 4.2.1 Bernoulli Probability Distribution 61
 - 4.2.2 Variables That Follow a Binomial Distribution 63
 - 4.2.3 Variables That Follow a Discrete Uniform Distribution 65
 - 4.2.4 Variables That Follow a Poisson Distribution 66
 - 4.2.5 Calculation of the Poisson Distribution 67
 - 4.2.6 Variables That Follow a Geometric Distribution 69
 - 4.3 Inverse Transform and Continuous Random Variables 70
 - 4.3.1 Variables That Follow a Uniform Distribution 70
 - 4.3.2 Variables That Follow a Triangular Distribution 72
 - 4.3.3 Variables That Follow an Exponential Distribution 75
 - 4.3.4 Variables That Follow a Weibull Distribution 77
 - 4.4 Inverse Transform and Empirical Distribution 78
 - 4.5 Accept-Reject Method 81
 - 4.6 Composition Method 82
 - 4.7 Convolution Method 82
 - 4.8 Proposed Exercises 83
 - References 83
- 5 Monte Carlo Simulation Method 87**
 - 5.1 Introduction 87
 - 5.2 Monte Carlo Method Justification 88
 - 5.2.1 Weak Law of Large Numbers 88
 - 5.2.2 The Central Boundary Theorem 89
 - References 95

- 6 Case Study: Logistical Behavior in the Use of Urban Transport Using the Monte Carlo Simulation Method** 97
 - 6.1 Introduction 97
 - 6.1.1 Related Work 98
 - 6.2 Case Study 98
 - 6.2.1 Queue Theory Model 98
 - 6.2.2 Using Computer Tools: Stat-Fit 99
 - 6.2.3 Log-Normal Distribution 100
 - 6.2.4 Binomial Probability Distribution 104
 - 6.3 Results 106
 - 6.4 Conclusion 109
 - References 109

- 7 Case Study: Project-Based Learning to Evaluate Probability Distributions in Medical Area** 111
 - 7.1 Introduction 111
 - 7.1.1 Related Work 112
 - 7.2 Case Study 112
 - 7.2.1 Evaluation 113
 - 7.2.2 Data Collection 113
 - 7.2.3 Activity Process 113
 - 7.3 Results and Discussion 115
 - 7.4 Conclusion 120
 - References 121

- 8 Case Study: Probabilistic Estimates in the Application of Inventory Models for Perishable Products in SMEs** 123
 - 8.1 Introduction 123
 - 8.1.1 Related Work 124
 - 8.2 Case Study 125
 - 8.2.1 Inventory Management 125
 - 8.2.2 EOQ Inventory Model 125
 - 8.2.3 Stat:Fit 127
 - 8.3 Results and Discussion 128
 - 8.4 Conclusion 131
 - 8.5 Future Work 131
 - References 131

About the Authors



Lorenzo Cevallos-Torres received his Bachelor in Computer Statistics Engineering, at Escuela Superior Politéctina del Litoral, Ecuador in 2005. He then received an M.Sc. degree in Productivity and Quality Management at the Escuela Superior Politéctina del Litoral, Ecuador in 2015, and an M.Sc. degree in Computational Modeling in Engineering at the Universidad de Cádiz, España in 2015. He joined the Department of Mathematics, and Physic Sciences at the University of Guayaquil, Ecuador as Assistant Professor in 2012–2015, as Professor from 2016. He is the Editor of the books “Análisis Estadístico Univariado” published by the Editorial University of Guayaquil and “El uso de las tecnologías de la información y la comunicación como estrategia de enseñanza-aprendizaje de la Estadística Univariada” published by Editorial Académica Universitaria, Universidad de las Tunas Cuba. His current research areas include Probability, Statistics, Quality management, and Soft computing. University of Guayaquil, Ecuador,
lorenzo.cevallost@ug.edu.ec



Miguel Botto-Tobar received his Bachelor in Computer System Engineering at Universidad Estatal de Milagro, Ecuador in 2010. He then received an M.Sc. degree in Software Engineering, Formal Methods and Information Systems at the Polytechnic University of Valencia, Spain in 2014. Currently, he is doing a Ph.D. in Computer Science at the Eindhoven University of Technology in the Netherlands. He joined the Department of Mathematics, and Physic Sciences at the University of Guayaquil, Ecuador as Assistant Professor in 2016. He is a recipient of the “Convocatoria Abierta” Scholarships (2011–2013) of the Ecuadorian government. He is the Editor of the books “Technology Trends” and Co-Editor “Information and Communication Technologies of Ecuador (TIC.EC)” all published by Springer, Switzerland. He is an Associate Editor of the Journal of Science and Research, and the Neutrosophic Computing and Machine Learning Journal. His current research areas include Software Engineering, Empirical Software Engineering, Model-Driven Development, and Human Aspects. Eindhoven University of Technology, the Netherlands m.a.botto.tobar@tue.nl, and University of Guayaquil, Ecuador, miguel.bottot@ug.edu.ec