

Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence

By John H. Holland

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Genetic algorithms are playing an increasingly important role in studies of complex adaptive systems, ranging from adaptive agents in economic theory to the use of machine learning techniques in the design of complex devices such as aircraft turbines and integrated circuits. *Adaptation in Natural and Artificial Systems* is the book that initiated this field of study, presenting the theoretical foundations and exploring applications.

In its most familiar form, adaptation is a biological process, whereby organisms evolve by rearranging genetic material to survive in environments confronting them. In this now classic work, Holland presents a mathematical model that allows for the nonlinearity of such complex interactions. He demonstrates the model's universality by applying it to economics, physiological psychology, game theory, and artificial intelligence and then outlines the way in which this approach modifies the traditional views of mathematical genetics.

Initially applying his concepts to simply defined artificial systems with limited numbers of parameters, Holland goes on to explore their use in the study of a wide range of complex, naturally occuring processes, concentrating on systems having multiple factors that interact in nonlinear ways. Along the way he accounts for major effects of coadaptation and coevolution: the emergence of building blocks, or schemata, that are recombined and passed on to succeeding generations to provide, innovations and improvements.

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Editorial Review

Amazon.com Review
John Holland's *Adaptation in Natural and Artificial Systems* is one of the classics in the field of complex adaptive systems. Holland is known as the father of genetic algorithms and classifier systems and in this tome he describes the theory behind these algorithms. Drawing on ideas from the fields of biology and economics, he shows how computer programs can evolve. The book contains mathematical proofs that are accessible only to those with strong backgrounds in engineering or science.

Review

Read this book, and even if you don't read it, buy it and display it proudly. Scientists, engineers, and coffee tables the world over should be interested in the revised edition of this seminal book that first gathered and developed the critical mass of ideas from mathematics, computational science, and systems theory necessary to launch and fuel the ongoing revolution in complex innovating systems. From mathematical optimization to the immune system, from machine learning to the central nervous system, from automatic control systems to even something as complex as human society itself, all innovating systems fall under the spell of Holland's mathematical-computational magic, and all individuals interested in understanding engineering such systems ignore Holland at their peril.

(David E. Goldberg, Unviersity of Illinois-Champaign)

Adaptation by natural selection has many analogies with adaptive learning to the environment in the higher animals and in human individuals and society. The possibility of exploiting this analogy to solve problems and to model individual and social behavior has become greatly enhanced with the resources of modern computing. John Holland has brilliantly drawn the analogies with precise algorithmic accuracy and has analyzed the different levels of adaptation and their interrelation. His methods have been employed in studying economic interactions and have permitted a replication of the economy in terms of artificial adaptive agents learning new strategies, an approach which permits us to see the effects of varying modes and capacities for adaptation on the workings of the economy.

(Kenneth J. Arrow, Stanford University)

This book is required reading for anyone who is interested in the evolution of complex adaptive behavior.

(W. Danny Hillis, Thinking Machines Corporation)

Adaptation in Natural and Artificial Systems is a classic. It launched the entire field of genetic algorithms and was one of the principal inspiration for the now-blossoming research area of Artificial Life.

(Douglas R. Hofstadter, Indiana University)

The last decade has seen a resurgence of interest in biological inspiration for parallel computing systems:

first, the artificial neural networks inspired by study of the brain, and the genetic algorithms inspired by the study of natural selection and evolution. Inevitably, newcomers to the field are beginning to suggest unifications. It will thus come as a delight to many to learn that John Holland's book...created the study of genetic algorithms within exactly such a interdisciplinary perspective.

(Michael Arbib, University of Southern California)

John Holland is a modern seer. Over fifteen years ago...he conceived a unified framework for adaptation and from that invented the genetic algorithms whose use in engineering, science, and especially, contemporary artificial intelligence and artificial life has -- after a long gestation in which the rest of us caught up -- entered a phase of explosive growth.

(Stewart Wilson, Rowland Institute)

This book will be enjoyed by all students of population genetics and evolution. The MIT Press has performed a real service by making it available again to a wide audience.

(Charles E. Taylor, University of California, Los Angeles)

About the Author

John H. Holland is Professor of Psychology and Professor of Electrical Engineering and Computer Science at the University of Michigan. He is also Maxwell Professor at the Santa Fe Institute and is Director of the University of Michigan/Santa Fe Institute Advanced Research Program.

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Jamie Ault:

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