Hands-On Genetic Algorithms with Python

Applying genetic algorithms to solve real-world deep learning and artificial intelligence problems

Eyal Wirsansky

Packt
www.packt.com

Hands-On Genetic Algorithms with Python

Applying genetic algorithms to solve real-world deep learning and artificial intelligence problems

Eyal Wirsansky

BIRMINGHAM - MUMBAI

Hands-On Genetic Algorithms with Python

Commissioning Editor: Sunith Shetty
Acquisition Editor: Porous Godhaa
Content Development Editor: Pratik Andrade
Senior Editor: Ayaan Hoda
Technical Editor: Mohd Riyan Khan
Copy Editor: Safis Editing
Project Coordinator: Anish Daniel
Proofreader: Safis Editing
Indexer: Priyanka Dhadke
Production Designer: Deepika Naik

First published: January 2020

Production reference: 1300120

Published by Packt Publishing Ltd.
Livery Place
35 Livery Street
Birmingham
B3 2PB, UK.

ISBN 978-1-83855-774-4

www.packt.com

To my wife, Jackie, for her love, patience, and support. To my children, Danielle and Liam, whose creativity and artistic talents inspired me in writing this book.

– Eyal Wirsansky

Packt.com

Subscribe to our online digital library for full access to over 7,000 books and videos, as well as industry leading tools to help you plan your personal development and advance your career. For more information, please visit our website.

Why subscribe?

- Spend less time learning and more time coding with practical eBooks and Videos from over 4,000 industry professionals
- Improve your learning with Skill Plans built especially for you
- Get a free eBook or video every month
- Fully searchable for easy access to vital information
- Copy and paste, print, and bookmark content

Did you know that Packt offers eBook versions of every book published, with PDF and ePub files available? You can upgrade to the eBook version at www.packt.com and as a print book customer, you are entitled to a discount on the eBook copy. Get in touch with us at customercare@packtpub.com for more details.

At www.packt.com, you can also read a collection of free technical articles, sign up for a range of free newsletters, and receive exclusive discounts and offers on Packt books and eBooks.

Contributors

About the author

Eyal Wirsansky is a senior software engineer, a technology community leader, and an artificial intelligence enthusiast and researcher. Eyal started his software engineering career as a pioneer in the field of voice over IP, and he now has over 20 years' experience of creating a variety of high-performing enterprise solutions. While in graduate school, he focused his research on genetic algorithms and neural networks. One outcome of his research is a novel supervised machine learning algorithm that combines the two.

Eyal leads the Jacksonville (FL) Java user group, hosts the Artificial Intelligence for Enterprise virtual user group, and writes the developer-oriented artificial intelligence blog, ai4java.

I would like to thank my family and close friends for their patience, support, and encouragement throughout the lengthy process of writing this book. Special thanks go to the Jacksonville Python Users Group (PyJax) for their feedback and support.

About the reviewer

Lisa Bang did her BS in marine biology at UC Santa Cruz, and an MS in bioinformatics at Soongsil University in Seoul under the tutelage of Dr. Kwang-Hwi Cho. Her masters' thesis was on a method for making QSARs reproducible using Jupyter Notebook, and contained a genetic algorithm component to reduce search space. This is now being developed into DEAP-VS to be compatible with Python 3. She also worked at Geisinger Health System as part of the Biomedical and Translational Informatics Institute, using next-generation sequencing and electronic health record data to analyze outcomes in cancer and other diseases. She now works at Ultragenyx Pharmaceutical, focusing on preclinical research using bioinformatics and chemoinformatics on rare genetic diseases.

Thank you to my family, my teachers, and my mentors.

Packt is searching for authors like you

If you're interested in becoming an author for Packt, please visit `authors.packtpub.com` and apply today. We have worked with thousands of developers and tech professionals, just like you, to help them share their insight with the global tech community. You can make a general application, apply for a specific hot topic that we are recruiting an author for, or submit your own idea.

Table of Contents

Preface

Drawing inspiration from Charles Darwin's theory of natural evolution, *genetic algorithms* are among the most fascinating techniques for solving search, optimization, and learning problems. They can often prove successful where traditional algorithms fail to provide adequate results within a reasonable timeframe.

This book will take you on a journey to mastering this extremely powerful, yet simple, approach, and applying it to a wide variety of tasks, culminating in AI applications.

Using this book, you will gain an understanding of genetic algorithms, how they work, and when to use them. In addition, the book will provide you with hands-on experience of applying genetic algorithms to various domains using the popular Python programming language.

Who this book is for

This book was written to help software developers, data scientists, and AI enthusiasts interested in harnessing genetic algorithms to carry out tasks involving learning, searching, and optimization in their applications, as well as enhancing the performance and accuracy of their existing intelligent applications.

This book is also intended for anyone who is tasked with real-life, hard-to-solve problems where traditional algorithms are not useful, or fail to provide adequate results within a practical amount of time. The book demonstrates how genetic algorithms can be used as a powerful, yet simple, approach to solving a variety of complex problems.

What this book covers

`Chapter 1`, *An Introduction to Genetic Algorithms*, introduces genetic algorithms, their underlying theory, and their basic principles of operation. You will then explore the differences between genetic algorithms and traditional methods, and learn about the best use cases for genetic algorithms.

`Chapter 2`, *Understanding the Key Components of Genetic Algorithms*, dives deeper into the key components and the implementation details of genetic algorithms. After outlining the basic genetic flow, you will learn about their different components and the various implementations for each component.

`Chapter 3`, *Using the DEAP Framework*, introduces DEAP—a powerful and flexible evolutionary computation framework capable of solving real-life problems using genetic algorithms. You will discover how to use this framework by writing a Python program that solves the OneMax problem—the 'Hello World' of genetic algorithms.

`Chapter 4`, *Combinatorial Optimization*, covers combinatorial optimization problems, such as the knapsack problem, the traveling salesman problem, and the vehicle routing problem, and how to write Python programs that solve them using genetic algorithms and the DEAP framework.

`Chapter 5`, *Constraint Satisfaction*, introduces constraint satisfaction problems, such as the N-Queen problem, the nurse scheduling problem, and the graph coloring problem, and explains how to write Python programs that solve them using genetic algorithms and the DEAP framework.

`Chapter 6`, *Optimizing Continuous Functions*, covers continuous optimization problems, and how they can be solved by means of genetic algorithms. The examples you will use include the optimization of the Eggholder function, Himmelblau's function, and Simionescu's function. Along the way, you will explore the concepts of niching, sharing, and constraint handling.

`Chapter 7`, *Enhancing Machine Learning Models Using Feature Selection*, talks about supervised machine learning models, and explains how genetic algorithms can be used to improve the performance of these models by selecting the best subset of features from the input data provided.

`Chapter 8`, *Hyperparameter Tuning of Machine Learning Models*, explains how genetic algorithms can be used to improve the performance of supervised machine learning models by tuning the hyperparameters of the models, either by applying a genetic algorithm-driven grid search, or by using a direct genetic search.

`Chapter 9`, *Architecture Optimization of Deep Learning Networks*, focuses on artificial neural networks, and discovers how genetic algorithms can be used to improve the performance of neural-based models by optimizing their network architecture. You will then learn how to combine network architecture optimization with hyperparameter tuning.

`Chapter 10`, *Reinforcement Learning with Genetic Algorithms*, covers reinforcement learning, and explains how genetic algorithms can be applied to reinforcement learning tasks while solving two benchmark environments—MountainCar and CartPole— from the OpenAI Gym toolkit.

`Chapter 11`, *Genetic Image Reconstruction*, experiments with the reconstruction of a well-known image using a set of semi-transparent polygons, orchestrated by genetic algorithms. Along the way, you will gain useful experience in image processing and the relevant Python libraries.

`Chapter 12`, *Other Evolutionary and Bio-Inspired Computation Techniques*, broadens your horizons and gets you acquainted with several other biologically inspired problem-solving techniques. Two of these methods—genetic programming and particle swarm optimization—will be demonstrated using DEAP-based Python programs.

To get the most out of this book

To get the most out of this book, you should have a working knowledge of the Python programming language, and basic knowledge of mathematics and computer science. An understanding of fundamental machine learning concepts will be beneficial, but not mandatory, as the book covers the necessary concepts in a nutshell.

To run the programming examples accompanying this book, you will need Python release 3.7 or newer, as well as several Python packages described throughout the book. A Python IDE (Integrated Development Environment), such as PyCharm or Visual Studio Code, is recommended but not required.

Download the example code files

You can download the example code files for this book from your account at `www.packt.com`. If you purchased this book elsewhere, you can visit `www.packtpub.com/support` and register to have the files emailed directly to you.

You can download the code files by following these steps:

1. Log in or register at `www.packt.com`.
2. Select the **Support** tab.
3. Click on **Code Downloads**.
4. Enter the name of the book in the **Search** box and follow the onscreen instructions.

Once the file is downloaded, please make sure that you unzip or extract the folder using the latest version of:

- WinRAR/7-Zip for Windows
- Zipeg/iZip/UnRarX for Mac
- 7-Zip/PeaZip for Linux

The code bundle for the book is also hosted on GitHub at `https://github.com/PacktPublishing/Hands-On-Genetic-Algorithms-with-Python`. In case there's an update to the code, it will be updated on the existing GitHub repository.

We also have other code bundles from our rich catalog of books and videos available at `https://github.com/PacktPublishing/`. Check them out!

Download the color images

We also provide a PDF file that has color images of the screenshots/diagrams used in this book. You can download it here: `https://static.packt-cdn.com/downloads/9781838557744_ColorImages.pdf`.

Code in Action

Visit the following link to check out videos of the code being run:
`http://bit.ly/3azd7Sp`

Conventions used

There are a number of text conventions used throughout this book.

`CodeInText`: Indicates code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles. Here is an example: "The `__init__()` method of the class creates the dataset."

A block of code is set as follows:

```
self.X, self.y = datasets.make_friedman1(n_samples=self.numSamples,
                                          n_features=self.numFeatures,
                                          noise=self.NOISE,
                                          random_state=self.randomSeed)
```

When we wish to draw your attention to a particular part of a code block, the relevant lines or items are set in bold:

```
self.regressor = GradientBoostingRegressor(random_state=self.randomSeed)
```

Any command-line input or output is written as follows:

```
pip install deap
```

Bold: Indicates a new term, an important word, or words that you see on screen. For example, words in menus or dialog boxes appear in the text like this. Here is an example: "Select **System info** from the **Administration** panel."

Warnings or important notes appear like this.

Tips and tricks appear like this.

Get in touch

Feedback from our readers is always welcome.

General feedback: If you have questions about any aspect of this book, mention the book title in the subject of your message and email us at `customercare@packtpub.com`.

Errata: Although we have taken every care to ensure the accuracy of our content, mistakes do happen. If you have found a mistake in this book, we would be grateful if you would report this to us. Please visit `www.packtpub.com/support/errata`, selecting your book, clicking on the Errata Submission Form link, and entering the details.

Piracy: If you come across any illegal copies of our works in any form on the internet, we would be grateful if you would provide us with the location address or website name. Please contact us at `copyright@packt.com` with a link to the material.

If you are interested in becoming an author: If there is a topic that you have expertise in, and you are interested in either writing or contributing to a book, please visit `authors.packtpub.com`.

Reviews

Please leave a review. Once you have read and used this book, why not leave a review on the site that you purchased it from? Potential readers can then see and use your unbiased opinion to make purchase decisions, we at Packt can understand what you think about our products, and our authors can see your feedback on their book. Thank you!

For more information about Packt, please visit `packt.com`.