VINCENT GRANVILLE, PH.D.
CO-FOUNDER OF DATA SCIENCE CENTRAL

DEVELOPING ANALYTIC TALENT

BECOMING A DATA SCIENTIST

WILEY

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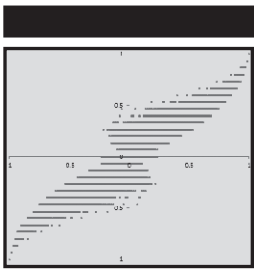

Developing Analytic Talent

Becoming a Data Scientist

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For my loving wife, Paris, my wonderful daughter, Capri, and son, Zinal, for their constant support. In loving memory of my father, Roger, who introduced me to mathematics when I was a kid.

About the Author

Vincent Granville, Ph.D., is a visionary data scientist with 15 years of big data, predictive modeling, digital, and business analytics experience. Vincent is widely recognized as the leading expert in scoring technology, fraud detection, and web traffic optimization and growth. Over the last 10 years, he has worked in real-time credit card fraud detection with Visa, advertising mix optimization with CNET, change point detection with Microsoft, online user experience with Wells Fargo, search intelligence with InfoSpace, automated bidding with eBay, and click fraud detection with major search engines, ad networks, and large advertising clients. Vincent also manages the largest big data and analytics data science group on LinkedIn, with more than 100,000 members.

Most recently, Vincent launched Data Science Central, the leading community for big data, business analytics, and data science practitioners. Vincent is a former post-doctorate of Cambridge University and the National Institute of Statistical Sciences. He was among the finalists at the Wharton Business Plan Competition and at the Belgian Mathematical Olympiad. Vincent has published 40 papers in statistical journals and is an invited speaker at international conferences. He also developed a new data mining technology known as hidden decision trees, owns multiple patents, published the first data science book, and raised $6M in start-up funding. Vincent is one of the top 20 big data influencers according to Forbes, and was featured on VentureBeat, MarketWatch, and CNN. Vincent can be reached on Twitter `@Analyticbridge`.

About the Technical Editor

Joni Ngai is a Digital Evangelist who works with senior executives at Fortune 500 companies to develop digital vision and leverage technology and data to intelligently engage customers in today's connected world. She has extensive experience leading agencies and customers to develop new practices across digital, CRM, online media, analytics, and technology development. Joni started her digital consulting career with Razorfish in New York in 2000. Since then, she has worked with a number of top digital agencies, such as MRM Worldwide and Havas Digital, across the Asia-Pacific region for many global brands like Intel, Microsoft, and P&G. Joni was appointed as Vice-Chair at I-COM China, an industry- backed global forum in digital measurement, to facilitate participation in standardizing online measurements to help industries grow.

Joni graduated from the University of Waterloo majoring in Electrical Engineering with an option in Management Science. She also received an Executive MBA degree from the Kellogg School of Management at Northwestern University and Hong Kong University of Science and Technology. Joni also teaches graduate courses for the Master of Science in New Media program at the Chinese University of Hong Kong.

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Contents at a Glance

Contents

Introduction

This book is a type of "handbook" on data science and data scientists, and contains information not found in traditional statistical, programming, or computer science textbooks. The author has compiled what he considers some of the most important information you will need for a career in data science, based on his 20+ years as a leader in the field. Much of the text was initially published over the last three years on the Data Science Central website, which is read by millions of website visitors. The book shows how data science is different from related fields and the value it brings to organizations using big data.

This book has three components: a multi-layer discussion of what data science is and how it relates to other disciplines; technical applications of and for data science including tutorials and case studies; and career resources for practicing and aspiring data scientists. Numerous career and training resources are included (such as data sets, web crawler source code, data videos, and how to build APIs) so you can start practicing data science today and quickly boost your career. If you're a decision maker, you will find information to help you make decisions on how to build a better analytic team, whether and when you need specialized solutions, and which ones will work best for your need.

Who This Book Is For

This book is intended for data scientists and related professionals (such as business analysts, computer scientists, software engineers, data engineers, and statisticians) who are interested in shifting to big data science careers. It is also for the college student studying a quantitative curriculum with the goal of becoming a data scientist. Finally, it is for managers of data scientists, and people interested in creating a startup business or consultancy around data science.

These readers will find valuable information throughout the book, and specifically in the following chapters:

- **Data science practitioners** will find Chapters 2, 4, 5, and 6 particularly valuable because they contain material on big data techniques (clustering and taxonomy creation) and modern data science techniques such as combinatorial feature selection, hidden decision trees, analytic APIs, and when MapReduce is useful. A number of case studies (fraud detection, digital analytics, stock market strategies, and more) are detailed enough to allow the reader to replicate the analyses when facing similar data in the real world when doing their jobs. However, it is also explained in simple words, not spending too much time on technicalities, code, or formulas, to make it accessible to high level managers.
- **Students** attending computer science, data science, or MBA classes will find Chapters 2, 4, 5, and 6 valuable for their purposes. In particular, they will find more advanced material in Chapters 2, 4, and 5, such as practical data science methods and principles, most of it not found in textbooks or taught in typical college curricula. Chapter 6 also provides real life applications and case studies, including more in-depth technical details.
- **Job applicants** will find resources about data science training and programs in Chapter 3. Chapters 7 and 8 provide numerous resources for job seekers including interview questions, sample resumes, sample job ads, a list of companies that routinely hire data scientists, and salary surveys.
- **Entrepreneurs** who want to launch a data science startup or consultancy will find sample business proposals, startup ideas, and salary surveys for consultants in Chapter 3. Also, throughout the book, consultants will find discussions on improving communication in data science work, lifecycles of data science projects, book and conference references, and many other resources.
- **Executives** trying to assess the value of data science, where it most benefits enterprise projects, and when architectures such as MapReduce are useful will find valuable information in Chapters 1, 2, 6 (case studies), and 8 (sample job ads, resumes, salary surveys). The focus of these chapters is usually not technical, except, to a limited extent, in some parts of Chapters 2 and 6, where new analytic technologies are introduced.

What This Book Covers

The technical part of this book covers core data science topics, including:

- Big data and the challenges of applying traditional algorithms to big data (Solutions are provided, for instance in the context of big data clustering or taxonomy creation.)

- A new, simplified, data science–friendly approach to statistical science, focusing on robust model-free methods
- State-of-the-art machine learning (hidden decision trees and combinatorial feature selection)
- New metrics for modern data (synthetic metrics, predictive power, bumpiness coefficient)
- Elements of computer science that are needed to build fast algorithms
- MapReduce and Hadoop, including numerical stability of computations performed with Hadoop

The focus is on recent technology. You will not find material about old techniques such as linear regression (except for anecdotal references), since such are discussed at length in all standard books. There is some limited discussion on logistic-like regression in this book, but it's more about blending it with other classifiers and proposing a numerically stable, approximate algorithm (approximate solutions are often as good as the exact model, since no data fits perfectly with a theoretical model).

Besides technology, the book provides useful career resources, including job interview questions, sample resumes, and sample job ads. Another important component of this book is case studies. Some of the case studies included here have a statistical/machine learning flair, some have more of a business/decision science or operations research flair, and some have more of a data engineering flair. Most of the time, I have favored topics that were posted recently and very popular on Data Science Central (the leading community for data scientists), rather than topics that I am particularly attached to.

How This Book Is Structured

The book consists of three overall topics:

- What data science and big data is, and is not, and how it's different from other disciplines (Chapters 1, 2, and 3)
- Career and training resources (Chapters 3 and 8)
- Technical material presented as tutorials (Chapters 4 and 5, but also the section on Clustering and Taxonomy Creation for Massive Data Sets in Chapter 2, and the section on New Variance for Hadoop and Big Data in Chapter 8), and in case studies (Chapters 6 and 7)

The book provides valuable career resources for potential and existing data scientists and related professionals (and their managers and their bosses), and generally speaking, to all professionals dealing with increasingly bigger, more complex, and faster flowing data. The book also provides data science recipes,

craftsmanship, concepts (many of them, original and published for the first time), and cases studies illustrating implementation methods and techniques that have proven successful in various domains for analyzing modern data — either manually or automatically.

What You Need to Use This Book

The book contains a small amount of sample code, either in R or Perl. You can download Perl from `http://www.activestate.com/activeperl/downloads` and R from `http://cran.r-project.org/bin/windows/base/`. If you use a Windows machine, I would first install Cygwin, a Linux-like environment for Windows. You can get Cygwin at `http://cygwin.com/install.html`. Python is also available as open source and has a useful library called Pandas.

For most of the book, one or two years of college with some basic quantitative courses is enough for you to understand the content. The book does not require calculus or advanced math — indeed, it barely contains any mathematical formulas or symbols.

Yet some quite advanced material is described at a high level. A few technical notes spread throughout the book are for those who are more mathematically inclined and interested in digging deeper. Two years of calculus, statistics, and matrix theory at the college level are needed to understand these technical notes. Some source code (R, Perl) and data sets are provided, but the emphasis is not on coding.

This mixture of technical levels offers the opportunity for you to explore the depths of data science without advanced math knowledge (a bit like the way Carl Sagan introduced astronomy to the mainstream public).

Conventions

To help you get the most from the text and keep track of what's happening, we've used a number of conventions throughout the book.

NOTE **Notes, tips, cross-references, and asides to the current discussion are offset and placed in features like this.**

As for styles in the text:

- We *highlight* new terms and important words when we introduce them.
- We show keyboard strokes like this: Ctrl+A.

- We show filenames, URLs, and code within the text like so: `persistence.properties`.
- We present code like this:

```
We use a monofont type with no highlighting for most code examples.
```

CHAPTER 1

What Is Data Science?

Sometimes, understanding what something ***is*** includes having a clear picture of what it ***is not***. Understanding data science is no exception. Thus, this chapter begins by investigating what data science is not, because the term has been much abused and a lot of hype surrounds big data and data science. You will first consider the difference between true data science and fake data science. Next, you will learn how new data science training has evolved from traditional university degree programs. Then you will review several examples of how modern data science can be used in real-world scenarios.

Finally, you will review the history of data science and its evolution from computer science, business optimization, and statistics into modern data science and its trends. At the end of the chapter, you will find a Q&A section from recent discussions I've had that illustrate the conflicts between data scientists, data architects, and business analysts.

This chapter asks more questions than it answers, but you will find the answers discussed in more detail in subsequent chapters. The purpose of this approach is for you to become familiar with how data scientists think, what is important in the big data industry today, what is becoming obsolete, and what people interested in a data science career don't need to learn. For instance, you need to know statistics, computer science, and machine learning, but not everything from these domains. You don't need to know the details about complexity of sorting algorithms (just the general results), and you don't need to know how

to compute a generalized inverse matrix, nor even know what a generalized inverse matrix is (a core topic of statistical theory), unless you specialize in the numerical aspects of data science.

TECHNICAL NOTE

This chapter can be read by anyone with minimal mathematical or technical knowledge. More advanced information is presented in "Technical Notes" like this one, which may be skipped by non-mathematicians.

CROSS-REFERENCE **You will find definitions of most terms used in this book in Chapter 8.**

Real Versus Fake Data Science

Books, certificates, and graduate degrees in data science are spreading like mushrooms after the rain. Unfortunately, many are just a mirage: people taking advantage of the new paradigm to quickly repackage old material (such as statistics and R programming) with the new label "data science."

Expanding on the R programming example of fake data science, note that R is an open source statistical programming language and environment that is at least 20 years old, and is the successor of the commercial product S+. R was and still is limited to in-memory data processing and has been very popular in the statistical community, sometimes appreciated for the great visualizations that it produces. Modern environments have extended R capabilities (the in-memory limitations) by creating libraries or integrating R in a distributed architecture, such as RHadoop (R + Hadoop). Of course other languages exist, such as SAS, but they haven't gained as much popularity as R. In the case of SAS, this is because of its high price and the fact that it was more popular in government organizations and brick-and-mortar companies than in the fields that experienced rapid growth over the last 10 years, such as digital data (search engine, social, mobile data, collaborative filtering). Finally, R is not unlike the C, Perl, or Python programming languages in terms of syntax (they all share the same syntax roots), and thus it is easy for a wide range of programmers to learn. It also comes with many libraries and a nice user interface. SAS, on the other hand, is more difficult to learn.

To add to the confusion, executives and decision makers building a new team of data scientists sometimes don't know exactly what they are looking for, and they end up hiring pure tech geeks, computer scientists, or people lacking proper big data experience. The problem is compounded by Human Resources