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Predictive Analytics in the Real World

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Table of Contents

List of Figures

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Executive Summary

After centuries of scientific progress in understanding the structural and periodic patterns of the natural world, as well as our success in developing so many useful technologies that leverage these patterns, most humans are reasonably confident that our future will continue to unfold in a similar fashion. The expectation that we will continue to find and utilize patterns, not only in the natural world but also in the realm of human and man-made system behavior, underlies the current enthusiasm for predictive analytics.

Amazon, Google, and Netflix have clearly demonstrated that predictions based on past user behavior can be profitable; fueling speculation that organizations of all types might benefit by uncovering the hidden patterns in their own data stores, and using these patterns to inform beneficial changes in their processes and systems.

Predictive applications can be used not only to find patterns that will increase sales and improve customer service, but also to improve the performance of complex systems. For example, even tiny changes to automated production processes, or catching anomalies before they turn into major malfunctions, can boost performance and profitability. In short, it just makes sense to think that hidden patterns in the data that are being collected about our behavior, and about the behavior of our devices and systems, will be useful in predicting, influencing, and even changing, future behavior.

The concept is so compelling, and the data so voluminous, that a burgeoning array of new database and analytical software tools are coming to market, joining the existing statistical and decision modeling solutions, to advance the process of prediction. Some of these new tools are based on well-worn statistical paradigms. Others feature algorithms developed in highly specialized realms of scientific research; while still others are being brought into commercial application, from research, into various types of machine learning.

Some of the newest predictive analytic solutions offer bundles of algorithms and automated mechanisms (more algorithms), to evaluate their performance, and to identify the ones that best fit the available data and the desired predictions. These algorithms owe their ability to work efficiently and rapidly to ongoing improvements in the software development frameworks that enable them, and in the ways that compute resources are scheduled and optimized.

The pace and intricacy of these developments make the field of predictive analytics one of the most complex and challenging subsets of the Big Data and advanced analytic market. There is also a very wide gap between the practitioners of predictive analytics—most of whom are statisticians, scientific

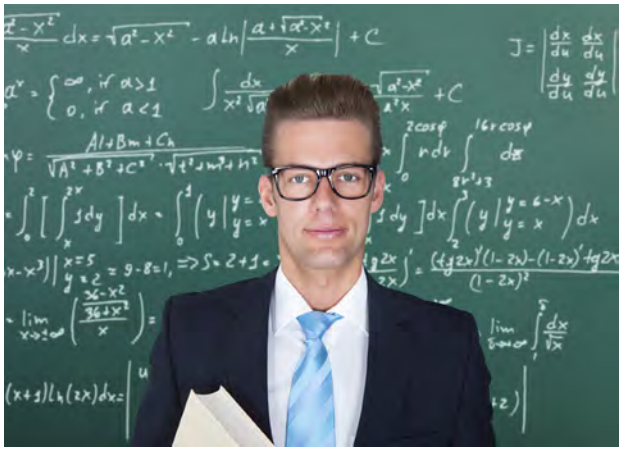
researchers and data scientists—and the people who most want to use predictive analytics for commercial and industrial applications.

Bridging this gap with accurate information and clear communication is imperative if predictive applications are to satisfy business users' expectations. The purpose of this report is to assist in building this bridge: first, by placing predictive analytics in a practical conceptual context for business people; then, by exploring several of the promising solutions that are coming to market.

Introduction[1]

Humans have an innate desire to predict the future; and we base our expectations for the future largely on what has happened in the past. Experience has been our teacher for thousands of years, as we have discovered reliable patterns in the natural world that inform our choices. We learned, for example, to depend upon seasonal weather changes, tidal flows and the apparent movement of stars and planets to decide when to plant crops or take sea voyages.

The more patterns we discovered, the more control we gained over our experiences. Today, humans in advanced societies can live comfortably indoors, regardless of the weather; confidently expecting to eat strawberries, communicate on smartphones, and take airplane trips, no matter what the season or the phase of the moon. These expectations depend upon the proper functioning of man-made inventions like thermostats, solar greenhouses, communication networks, and air traffic control systems—just a few examples of our ability to apply the intricate patterns of the electromagnetic spectrum.



When one of these devices or systems malfunctions, we repair or replace it; we do not question whether the electromagnetic spectrum is still intact or if it has been fundamentally misunderstood. In other words, we have enough experience to trust the models we have developed to describe the patterns of behavior of electricity and microwaves, as well as the models that describe how we modulate portions of the spectrum to produce, store and transmit light, heat and information.

Compared to the patterns of the electromagnetic spectrum, our understanding of many other patterns is still incomplete, as is our ability to model them accurately. In the natural world, for example, accurate predictions regarding the fluctuation of the earth's magnetic poles fascinate and elude scientists, but have little impact on human lives. On the other hand, many people will benefit

if predictive analytics can be used to uncover patterns and models that will help cure diseases or better educate our children.

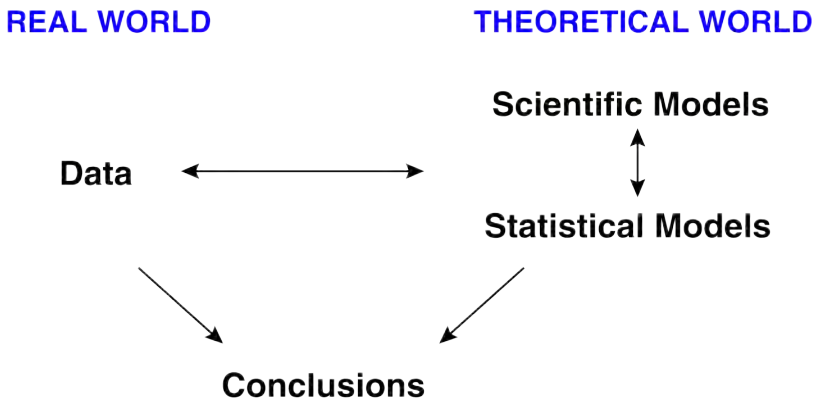
From a business standpoint, the hope of predictive analytics lies in the possibility of finding "actionable insights"; that is, patterns and models that can be used to inform decisions and actions that will improve the bottom line. For example, people who work in finance want to make predictions about changes that will drive up revenues, drive down costs, or reduce fraud and churn. Those who manage operations want to know how to optimize processes and how to predict when devices or systems will need adjustments, repairs, or replacement. Marketing, customer service, and product development managers want to predict which changes in their products and processes will best satisfy customers. In short, there is tremendous value to be gained by the skillful application of predictive modeling and analytics to every aspect of the business.

To put these potential applications of predictive analytics in perspective, business people need to first step back a bit in order to fully appreciate the abstract, theoretical nature of the statistical models they utilize.

Mapping the Theoretical World to the Real World

The combination of vast amounts of data, inexpensive computing resources, and increasingly sophisticated algorithms cannot guarantee predictive accuracy, for several reasons. In addition to the well-known challenges of data quality, and the shortage of data scientists to help business people apply predictive analytic solutions, it is easy to overlook the basic fact that all predictive models, from the simple to the exotic, are theoretical abstractions, as shown in Exhibit 1.

Exhibit 1: The Theoretical World of Models and the Real World of Data



Source: Robert E. Kass,[2] used with permission

Why is it so important to keep in mind the abstract, theoretical nature of predictive analytic solutions? The reason is simple: **The utility of predictive models depends on their accuracy,**

[2] Robert E. Kass, Ph.D. "Statistical Inference: The Big Picture," originally published in *Statistical Science*, 2011, Vol. 26, No. 1, pages 1–9, available online. Dr. Kass is a Professor in the Department of Statistics, Machine Learning Department, and Center for the Neural Basis of Cognition, Carnegie Mellon University. The journal *Statistical Science* is published by the Institute of Mathematical Statistics.

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