

Machine Learning Applications in Operations Management and Digital Marketing
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Summary

With the rise of data collection also comes the need for methods to analyze the data, and for novel approaches of leveraging the data to improve decision-making. Machine learning is a set of algorithms with the primary purpose of identifying patterns in data to accomplish specific tasks. Since 2012, the number of Google searches containing the term machine learning has increased by 7 fold, and the data scientist, an occupation that often requires machine learning skills, has been rated by Glassdoor as the best job in America three years in a row. Academic publications in machine learning have also enjoyed a significant popularity boost. Although machine learning has been wildly popular, its scientific success has mostly been captured in the fields of computer science and artificial intelligence. The use of machine learning in business research, specifically in the areas of operations management and digital marketing, has been limited. In this dissertation, I study how machine learning can be used to solve prominent problems in operations management and digital marketing. The primary motivation is to show that the application of machine learning can solve problems in ways that existing approaches cannot. In its entirety, this dissertation is a study of four problems—two in operations management and two in digital marketing—and develops solutions to these problems via data-driven approaches by leveraging machine learning. These four problems are distinct, and are presented in the form of individual self-containing essays. Each essay is the result of collaborations with industry partners and is of academic and practical importance. In some cases, the solutions presented in this dissertation outperform existing state-of-the-art methods, and in other cases, it presents a solution when no reasonable alternatives are available.

Chapter 2 provides an introduction to the basics of machine learning. Chapter 3 studies the problem of consumer debt collection. For this problem, I develop a data-driven algorithm to optimize when and to whom phone calls should be made to maximize the collection of delinquent debt cases. This algorithm was tested in a controlled experiment at a Dutch collection agency and was found to have increased the amount of debt collected per call by 47.2%. Chapter 4 studies the problem of contact center staffing and scheduling. For this problem, I develop a machine learning approach to accurately approximate a complex simulation of contact centers, leading to a fast and reliable method for identifying high-quality staffing schedules at low costs. Using numerical simulations that represent real-life contact centers, it is found that my approach can improve upon the existing approaches by over 4%, and is able to analyze more complex contact centers than previously possible.

Chapter 5 studies the problem of attribution of online purchases to digital advertisements. For this problem, I develop a new attribution model that extends a well-known existing framework to incorporate customers' web-browsing behavior when evaluating the effectiveness of digital advertisements. Using data from a Dutch online travel agency, it is shown that customers' web-browsing behavior are highly predictive of purchasing decisions, and thus should be taken into account when attributing purchases. This solution is currently the only attribution model that is able to incorporate web-browsing behavior at the individual customer level. Finally, Chapters 6 and 7 studies the problem of probabilistically matching web-browsing devices (or browser cookies) to users based on browsing behavior. I consider two different instances of this problem, one of devices browsing a single news publishing website (Chapter 6) and another of devices captured by an ad exchange (Chapter 7), and develop solutions to them separately. In both cases, I show that matching can be performed with good reliability, and that display advertising firms can potentially use this technology to improve their advertising effectiveness.

All in all, I hope that this dissertation can help the reader better understand how machine learning can be used to solve operations management or digital marketing problems.