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Artificial Neural Networks and Data Science

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INTRODUCTION

Artificial neural networks (ANNs) provide an ability to identify known and obvious patterns in the data as well as Knowledge Discovery in Datasets (KDD). KDD, the process of finding non-obvious patterns or trends in complicated systems or datasets (Mannila, 1996), is critical to providing useful algorithmic processes. ANNs leverage biologically-inspired computational pattern recognition methods to predict, describe, classify, group, categorize and identify information from data sources (Jain, Duin, & Mao, 2000). One advantage of ANNs is that they are able to learn nonlinear patterns in data in an efficient manner. The non-linear patterns in data and the complex algorithms result in ANNs, and resultant ANN models, being complex and opaque to many users (Weckman, et al., 2009). While ANNs have been applied in many business applications, these applications have been tempered and approached with some hesitation due to a lack of understanding and misconceptions of what is occurring because of the 'black-box' nature of ANNs (Dewdney, 1997).

ANNs methods consist of interconnected networks of weights and nodes, in which the weights are trained on patterns in data through statistical learning methods (Jain, Duin, & Mao, 2000). Although ANNs are computationally complex, inherently ANNs are statistical in nature and epistemologically similar in function to Bayesian methods (Beck, King, & Zeng, 2004), using conditional probability and likelihood methods (Verikas & Bacauskiene, 2002). Various software packages are now available for practitioners, including NeuroDimensions (2005), Matlab (2010), JMP (Sall, Lehman, Stephens, & Creighton, 2012), Python (Vasilev, Slater, Spacagna, Roelants, & Zocca, 2019), and R (2008). Many of these software packages are open-source in nature, e.g., R and Python. The objective of this chapter is to provide readers with a general background of ANNs, ANN business applications, and developing quality ANN models. The target audience is intended to be readers who may not be familiar with this form of mathematical modeling and application but may want to pursue and investigate ANN techniques for their business needs.

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In Bihl, Young, and Weckman (2018), the authors provided a brief overview of ANNs and their applications in business with an example end-to-end analysis of business data using ANNs with the JMP13 Pro platform. Herein, the authors expand upon this discussion with a concise background of the ANNs, considerations for deep learning, proper methods to developing and deploying repeatable ANNs, and the processes needed to support the development through the deployment of ANNs to support business applications.

BACKGROUND

Computational ANNs are based on the biological neuron models consisting of multiple interconnected nodes termed "neurons." However, unlike biologic neurons, ANNs employ statistical methods to learn patterns between inputs and outputs (Jain, Duin, & Mao, 2000). A conceptualization showing the ANN interconnected neurons is presented in Figure 1. Through organizational and iterative principles, connection weights between neurons, inputs, and outputs are computed to learn a nonlinear input-output relationship (Jain, Duin, & Mao, 2000).

Inputs to ANNs, such as Figure 1, are in data form and are analogous to biological axons from other neurons feeding into a neuron's dendrites (Bihl, Young II, & Weckman, 2018). In biologic neurons, the cell processes the inputs, this is represented through hidden nodes in an artificial neuron whereby a transfer and activation function process the input data and an output signal is created. The outputs are then analogous as axons in biology and probabilities in ANNs (Bihl, Young II, & Weckman, 2018). However, biological neurons are currently understood to communicate in a complex manner through molecular, electrical, cellular, systems, and behavioral means (Sweatt, 2016) (Kandel, Siegelbaum, Mack, & Koester, 2021); thus, artificial neurons are a considerable simplification of the system using only the electrical aspect of transmission.

Figure 1. Basic conceptualization of an ANN