

# Using Open-Source Software for Business, Urban, and Other Applications of Deep Neural Networks, Machine Learning, and Data Analytics Tools

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## ABSTRACT

This article provides an overview with examples of what neural networks (NN), machine learning (ML), and artificial intelligence (AI) and data analytics are and their applications in business, urban, and biomedical situations. The characteristics of 29 types of neural networks are provided including their distinctive graphical illustrations. A survey of current open-source software (OSS) for neural networks, neural network software available for free trial download for limited time use, open-source software (OSS) for machine learning (ML), and open-source software (OSS) for data analytics tools are provided. Characteristics of artificial intelligence (AI) technologies for machine learning available as open source are discussed. Illustrations of applications of neural networks, machine learning, and artificial intelligence are presented as used in the daily operations of a large international-based software company for optimal configuration of their helix data capacity system.

## KEYWORDS

Artificial Intelligence (AI), Data Analytics, Deep Neural Networks (DNN), Machine Learning (ML), Multi-Factor Prediction, Neural Networks (NN), Open-Source Software (OSS)

## INTRODUCTION

In a constantly evolving world, modern society also has to change, and through complex Artificial Intelligence (AI), and Artificial Neural Network (ANN) Algorithms are helping not only biochemistry to solve issues like modeling bio-processes, algorithms and methods to promote the design and synthesis of bio-compounds but also to assist with medical diagnosis, drug discovery, gene identification, and protein structure prediction such as those discussed in Sino et al. (2020).

Other applications as discussed in this article include those for business such as for prediction of credit card churn, prediction of spending of mall customers based on factors such as gender, customer identification, and annual income; and for urban applications such as prediction of the number of automobile accidents by hour of the day during different weather conditions; and prediction of Uber

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traffic and reasons for the delay. Other business applications discussed in the article include the applications of Neural Networks for cognitive routing of chatbot systems of a large software company and the use of machine learning for the optimal configuration of their Helix Data Capacity system.

The basic Neural Network layout involves the interconnection of nodes by arcs as discussed below, and also later with the diversification of the many types of possible variants as shown in Figure 2 such as Neural Turing Machine (NTM) that includes memory cells, Hopfield Network (HN) that includes back-fed input cells, and Echo State Network (ESN) that includes recurrent cells.

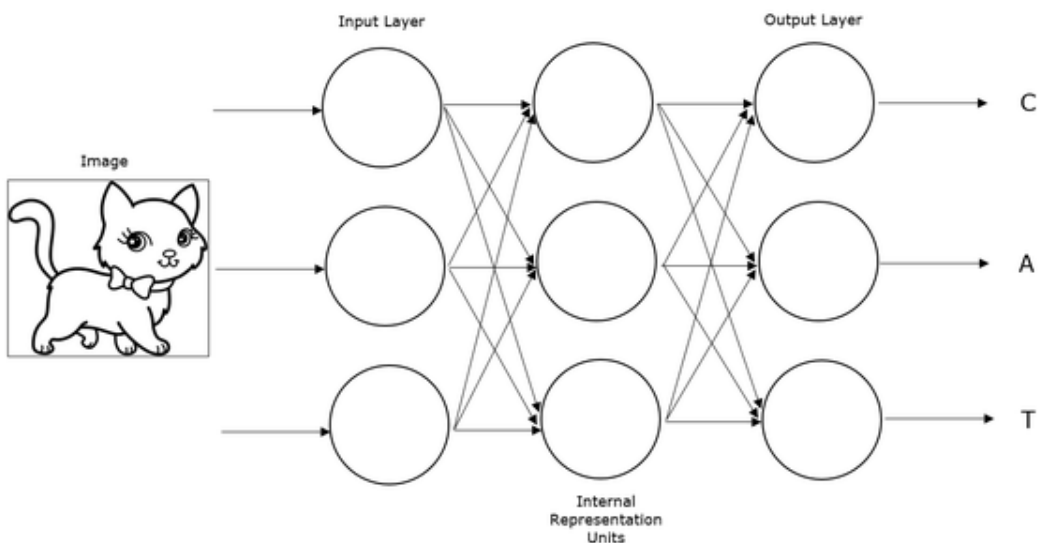
The research objectives of this paper include the provision of the availability of free and open-source software for (1.) Neural Networks that perform operations such as training, validating, and querying neural networks, and simulation of hierarchical, multilayered Artificial Neural Networks (ANN); (2.) Machine Learning includes features such as numerical computation using data flow graphs, and tensors that can develop dynamic graphs to accelerate the machine learning process; (3.) Artificial Intelligence (AI) that have features such as a diverse assemblage of cognitive algorithms, and (4.) Data Analytics has features such as rapid distributed large-scale data processing, and a platform that can create data visualizations and reports that can be embedded into web or client applications.

### Neural Networks (NN)

A Neural Network (NN) is a network consisting of arcs and nodes or circuits of neurons. An Artificial Neural Network (ANN) is composed of artificial neurons or nodes. (Hopfield, 1982). A Neural Network (NN) can be either a biological neural network, made up of real biological neurons, or an Artificial Neural Network, for solving Artificial Intelligence (AI) problems. (Purves et al., 2012)

Figure 1 shows a basic Neural Network with an input layer, processing layer, and output layer of nodes. The connections of the biological neuron are modeled as weights. A positive weight reflects an excitatory connection, while negative values mean inhibitory connections. All inputs are modified by weight and summed. This activity is referred to as a linear combination. An activation function controls the amplitude of the output. For example, an acceptable range of output is usually between 0 and 1, or it could be  $-1$  and  $1$ . (Sharma, 2021)

Figure 1. Feed-forward neural network used for image classification task with machine learning



The reader is referred to previous work on computer modeling of neural networks that includes comparing learning rules using computer graphics in Segall (2004, 2003, 2001, 1996, 1995), in Segall & Zhang (2006) for applications of neural networks and genetic algorithm data mining techniques in bioinformatics discovery, Fish & Segall (2002) for visual analysis of learning rule effects and variable importance for neural networks employed in data mining operations, and Biedenkemper et al. (2011) for text mining using rule-based and neural network-based approaches.

A basic overview of neural networks for beginners is presented by Russo (2019), SAS (2020b), Taylor (2017), and Haykin (2020). A novel application of the Hidden Markov Model (HMM) category of neural networks was presented by Jayasinghe et al. (2016) for hand gesture recognition that is captured by using a general-purpose web camera that was implemented using the MATHLAB HMM toolbox.

## **Machine Learning (ML)**

Machine learning (ML) is the study of computer algorithms that improve automatically through experience and is a subset of artificial intelligence. Machine learning algorithms build a model based on sample data, known as “training data”. (Xu et al., 2018)

Machine learning approaches are traditionally divided into three broad categories (1.) supervised learning (Mohri et al., 2018), (2.) unsupervised learning, (Hilton et al., 1999) and (3.) reinforcement learning (Francois-Lavet et al., 2018). Supervised learning is when the computer is presented with example inputs and desired outputs. Unsupervised learning is when learning is on its own to find structure in its input such as discovering hidden patterns in data, Reinforcement learning is when a computer program interacts with a dynamic environment in which it must perform a pre-specified goal.

A basic overview of machine learning is presented in Henderson (2019). Other related research on machine learning was presented by Chouldechova and Roth (2020), David (2020), Geron (2020), G2 (2020), Hasan (2020), Haykin (2020), Jensen (2018), Jones (2018), Kelleher et al. (2015), McFrockman (2020), Meng et al. (2015), Ramezani (2020), Rhys (2020), SAS (2020c), and TrustRadius (2020). One hundred and one (101) machine learning algorithms for data science with ‘cheat sheets’ was presented by Piccini (2019). Open-Source machine learning tools are discussed by Algorithmia (2019) and Springboard India (2019), Yegulalp (2020), and well as others as discussed in Table 3 of this article.

## **Artificial Intelligence (AI)**

Artificial intelligence (AI), is intelligence demonstrated by machines, unlike the natural intelligence displayed by humans and animals. (Poole et al., 1998)

Current work in Artificial Intelligence (AI) is presented by Campesato (2020) for a book on AI, ML, and deep learning, Hasan (2020) on best AI and machine learning software and framework, McFrockman (2020) with AI mastery with “4 Books in 1”, SAS (2020a) of what AI is and why it matters, and Stone (2019) on the mathematics of deep learning.

An article by Daley (2021) presented details of studies on “twenty-three examples of artificial intelligence shaking up business as usual” that included examples in manufacturing robots, self-driving cars, disease mapping, automated financial investing, virtual travel booking agents, social media monitoring, inter-team chat tool, conversational marketing bot, and natural language processing (NLP) tools.

Lin (2022) presented an article on large-scale artificial intelligence models that includes the discussion of both large-scale unimodal models and large-scale multimodal models. Lin (2022) states that as artificial intelligence models rapidly grow in size, their potential is stimulated.

## **Applications of Neural Networks to Biomedical and Business Applications**

There are many different applications in which Artificial Neural Networks (ANN) can be applied for example biomedical computer tomography images (Ruano and Ruano, 2013), real-world business

applications, and travel preference data (Lisboa et al., 2000) to deep learning within business applications for developers (Viera and Ribeiro, 2018) as discussed below.

Ruano and Ruano (2013) authored an article on the use of Artificial Neural Networks (ANN) as a classifier, dynamic model, and diagnosis tool for biomedical applications that included: blood flow emboli classification, tissue temperature modeling, and identification of ischemic cerebral vascular accident areas based on computer tomography images.

Lisboa et al. (2000) authored an entire book on the real-world business applications of neural networks that include the use of neural networks for the analysis of travel preference data, developments in accurate consumer risk assessment technology, novel techniques for profiling and fraud detection in mobile communications, and detecting payment card fraud with neural networks.

Vieira and Ribeiro (2018) authored a book with technical examples as an introduction to deep learning (DL) business applications for developers' potential applications, challenges, and opportunities of deep learning from a business perspective. These applications include image recognition, segmentation and annotation, video processing and annotation, voice recognition, intelligent personal assistants, automated translation, and autonomous vehicles.

## **Applications of Machine Learning to Biomedical and Business Applications**

Castle (2017) presented six common machine learning applications for business that includes: (1.) customer lifetime value modeling, (2.) churn modeling, (3.) dynamic pricing, (4.) customer segmentation, (5.) image classification, and (6.) recommendation engines. In this list is customer churn modeling that can identify which customers are likely to stop engaging with your business and why. Also in this list is image classification that according to Castle (2017) has a wide range of business applications including 3D construction plans based on 2D designs, social media photo tagging, and informing medical diagnoses.

The biomedical applications of Faggella (2020) and Thomas (2022) extended the business applications of Castle (2017) to medical and patient data, diseases, medical imaging, and diagnosis. Similarly, the customer churn modeling and dynamic pricing tactics of Pratt (2020) build upon those of Castle (2017) as further discussed below.

Faggella (2020) presented seven applications of machine learning in pharma and medicine that includes: (1.) disease identification/diagnosis, (2.) personalized treatment/behavioral modification, and (3.) drug discovery/manufacturing. (4.) clinical trial research, (5.) radiology and radiotherapy, (6.) smart electronic health records, and (7.) epidemic outbreak prediction.

Thomas (2022) presented sixteen examples of machine learning in healthcare that are revolutionizing medicine in the categories of (1.) Smart records, (2.) medical imaging and diagnostics, (3.) drug discovery and development, (4.) medical data, and (5.) treatment and diagnosis of disease. An example of drug discovery and development is that Pfizer uses machine learning for immunology research about how the body's immune system can fight cancer.

Pratt (2020) presented ten common uses for machine learning applications in business that includes: (1.) real-time chatbot agents. (2.) decision support systems (DSS), (3.) customer recommendation engines, (4.) customer churn modeling, (5.) dynamic pricing tactics, (6.) market research and customer segmentation, (7.) fraud detection, (8.) image classification and image recognition, (9.) operational efficiencies, and (10.) information extraction.

A "chatbot" as listed above in Pratt (2020) as the first common use is as described by Brush (2019) is sometimes referred to as a chatterbot is programming that simulates the conversation or "chatter" of a human through text or voice interactions. There are several types of "chatbots" as described by Pratt (2020): (1.) scripted or quick reply chatbots, (2.) keyword recognition-based chatbots, (3.) hybrid chatbots, (4.) contextual chatbots, and (5.) voice-enabled chatbots.

The use of "chatbots" that is later presented in this paper by BMC Software (2020) for a real large international software company builds upon that as described by Pratt (2020).

The applications of machine learning techniques of smart pricing and customer segmentation as discussed by Castle (2017) were extended by Rodriquez-Pardo et al. (2020) for smart tourism and retail and Bogomolov et al. (2020) for identifying fresh produce purchases.

A collection of technical blogs, including code samples and notebooks, is available from Databricks (2022) “The Big Book of Machine Learning Cases” which includes those for business applications for detecting sales trends and financial fraud.

## Data Analytics

Data analytics is the science of analyzing raw data to make conclusions about that information. Many of the techniques and processes of data analytics have been automated into mechanical processes and algorithms that work over raw data for human consumption. (Frankenfield, 2022)

## RESEARCH FINDINGS FOR NEURAL NETWORK (NN) AND MODELING TECHNIQUES

### Twenty-Nine (29) Types of Neural Networks

There are many types of Neural Networks and Figure 2 of Asimov Institute by Van Veen and Leijnen (2019) shows twenty-nine different variants from which Table 1 was constructed that provides characteristics of each of these. The Key in Figure 2 defines the fourteen types of cells utilized that including Input cell, Backfed Input Cell, Noisy Input Cell, Hidden Cell, Probabilistic Hidden Cell, Spiking Hidden Cell, Capsule Cell, Output Cell, Match Input-Output Cell, Recurrent Cell, Memory Cell, Gated Memory Cell, Kernel, and Convolution or Pool.

This article also presents Table 2 of Open-Source Software (OSS) (Laurent, 2004) for Neural Networks (NN), and Table 3 of Neural Network Software available for free trial download.

This article then presents how Neural Network algorithms are used by a large software company BMC Software which is a privately held multinational firm operating in North America, South America, Australia, Europe, and Asia and has multiple offices located around the world with its international headquarters located in Houston, Texas, United States.

### Neural Networks as Used in Large International Software Company

A large international software company BMC Software uses neural network algorithms for what we call “cognitive routing.” Most chatbots only transfer to the next available agent. The company uses Natural Language Processing (NLP) algorithms to find the best agent to resolve the problem the employee/customer is having. Example: If requesting a visa application, the request will be routed to Human Resources (HR).

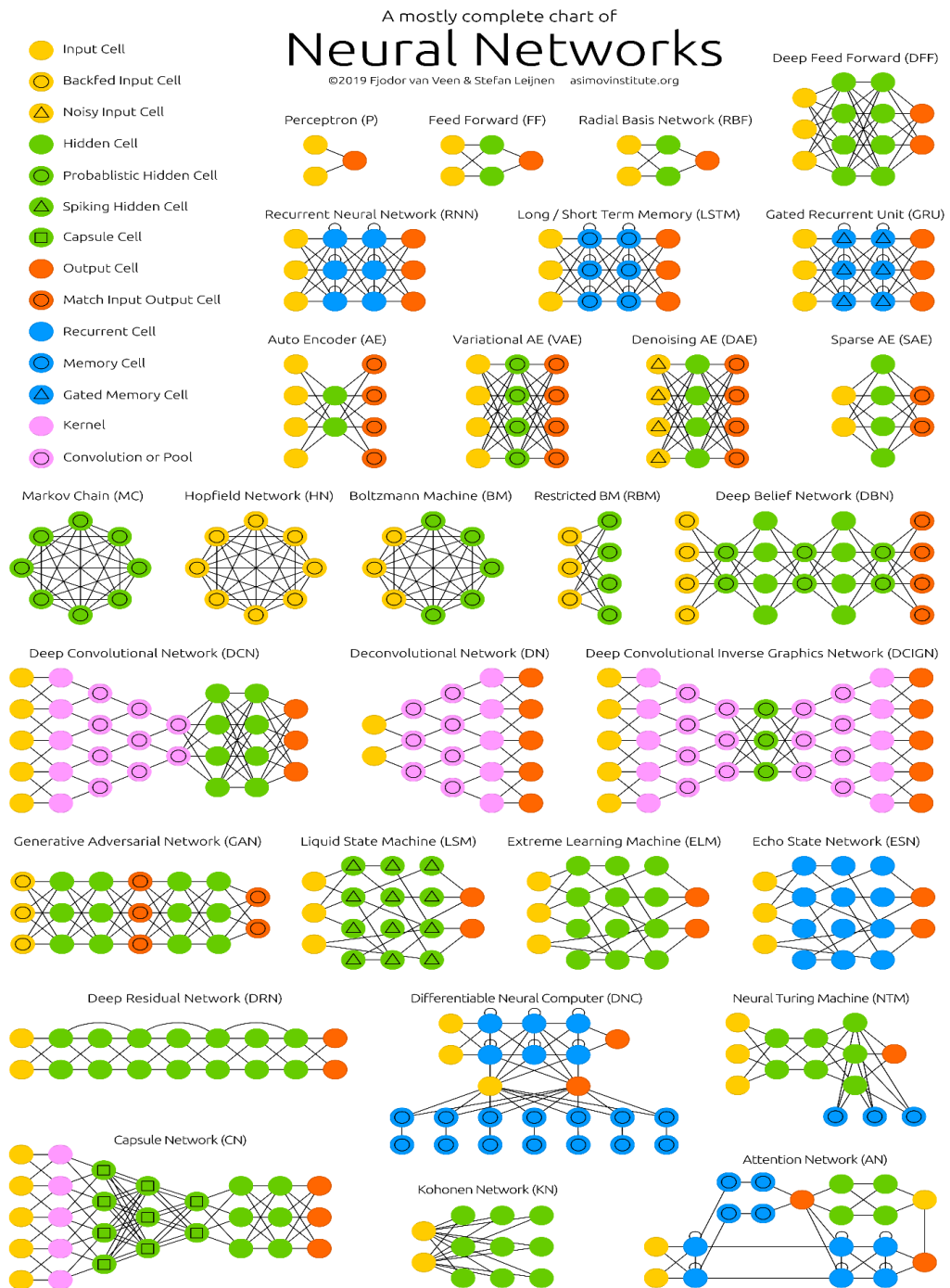
#### *Text Summarization – Understand the Content*

- **Chatbot:** An employee is talking to a chatbot. After conversation. The chatbot was not able to answer user questions. We ask if they want a live agent. Once transfer happens, the live agent is provided a conversation summary (that occurred with the chatbot) before engaging with an employee. This is shown in Figure 3.

#### *Ticket Summarization*

Another example is “intelligent swarming.” BMC Software uses AI to route a ticket to a group of people. As the group works on the incident, the AI/neural network algorithm is used to then decide who is the best person to work on the incident:

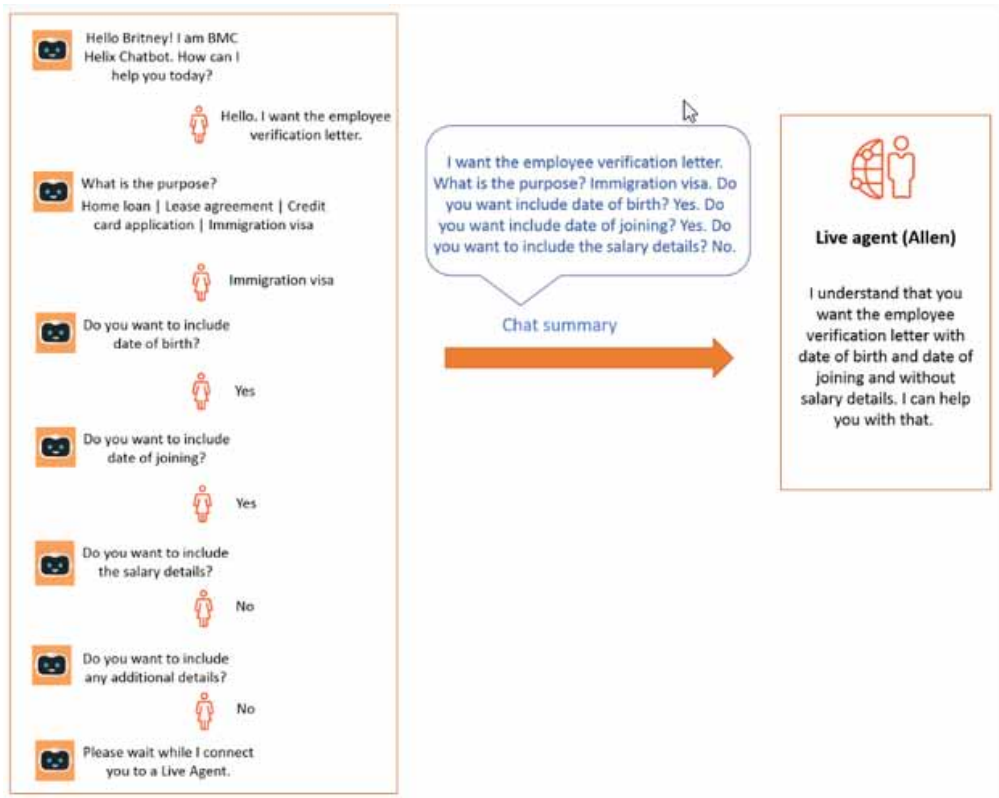
Figure 2. Chart of 29 types of neural networks (Source: <https://www.asimovinstitute.org/neural-network-zoo/> and available for open-source download in the public domain from <https://www.asimovinstitute.org/wp-content/uploads/2019/04/NeuralNetworkZo19High.png>)



**Table 1. Characteristics of 29 Types of Neural Networks (Derived from Van Veen, F. & Leijnen, S. (2019))**

Neural Network Category	Characteristics
Auto Encoder (AE)	Encode information automatically with a network that always resembles an hourglass shape.
Attention Network (AN)	Use an attention mechanism to combat information decay.
Boltzmann Machine (BM)	Starts with random weights and learns through back-propagation with neurons mostly having binary activation patterns.
Capsule Network (CapsNet)	Neurons are connected with multiple weights (vector) instead of just one weight (scalar).
Deconvolutional Network (DN)	Also called Inverse Graphical Networks (IGNs) are reversed convolutional neural networks.
Deep Belief Network (DBN)	Effectively trainable stack-by-stack.
Deep Convolutional Inverse Graphics Network (DCIGN)	Can learn to model complex transformations on images.
Deep Convolutional Network (DCN)	Primarily used for image processing but can be used for other types of input such as audio.
Deep Feed Forward (DFF)	Multi-layers of inner processing nodes.
Deep Residual Network (DRN)	Very deep Feed-Forward Neural Networks with extra connections passing inputs from one layer to a later layer as well as the next layer.
Denoising AE (DAE)	Feeds input data with noise (e.g., grainy images)
Differential Neural Computers (DNC)	Enhanced Neural Turing Machines with scalable memory.
Echo State Network (ESN)	Random connections between neurons cause unorganized sets of layers.
Extreme Learning Machine (ELM)	Start with random weights and train the weights in a single step according to the least-squares fit.
Feed Forward (FF)	Feed information from the input to output layers.
Gated Recurrent Unit (GRU)	Contain an update gate.
Generative Adversarial Network (GAN)	Consists of any 2 networks: one to generate content and the other to judge content.
Hopfield Network (HN)	Every neuron is connected to every other neuron.
Kohonen Network (KN)	Utilize competitive learning to classify data without supervision.
Liquid State Machine (LSM)	Uses threshold functions and each neuron is also an accumulating memory cell.
Long/Short Term Memory (LSTM)	Contain forget gate.
Markov Chain (MC)	Every state you end up in depends completely on the previous state.
Neural Turing Machine (NTM)	Instead of coding a memory cell directly into a neuron, the memory is separated.
Perceptron (P)	Consists of only one output node with its input nodes.
Radial Basis Network (RBF)	Feed-Forward Neural Networks (FFNNs) with radial basis functions as activation functions.
Recurrent Neural Network (RNN)	Feed-Forward Neural Networks (FFNNs) have connections between passes.
Restricted Boltzmann Machine (RBM)	Only connect every different group of neurons to every other group.
Sparse Autoencoders (SAE)	Encodes information in more space.
Variational Autoencoders (VAE)	Have the same architecture as AE but have an approximated probability distribution of the input samples.

Figure 3. Illustration of Cognitive Routing by Neural Network using Chatbot by Large Software Company (Figure provided upon written permissions from BMC Software (2020))



- Whenever an employee/customer raises a ticket, a machine answers back. If the machine is unable to resolve the issue, the ticket is then assigned to an agent. If an agent is unable to resolve it, the ticket may get transferred to a second agent. The ticket history is summarized and prepared for this new agent. This is done through the use of Natural Language Processing (NLP) and neural networks and is illustrated in Figure 4 (BMC Software, 2020).

## Open-Source and Free Trial Software for Neural Networks

See Tables 2 and 3.

## EXAMPLES OF MACHINE LEARNING (ML) IN ARTIFICIAL INTELLIGENCE (AI) SYSTEMS

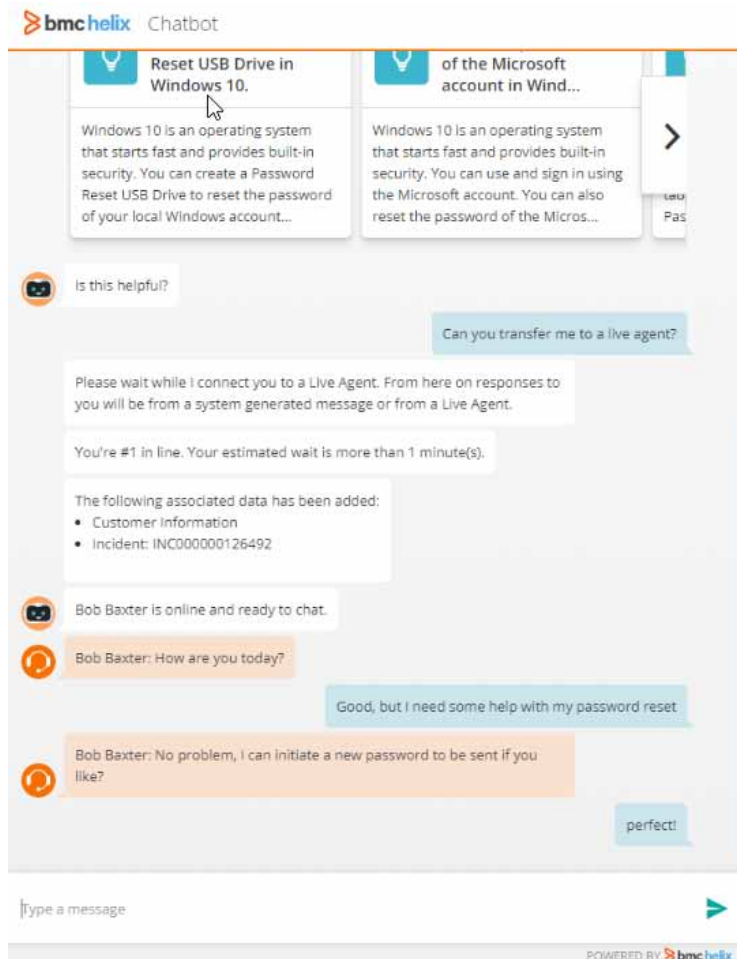
The following four examples were provided to the author by BMC Software Corporation as illustrations of their applications of machine learning for obtaining the optimal configuration of their Helix Data Capacity system.

### Example 1: Health of Information Technology (IT) Infrastructure Resource for Business Applications and Services

Use AI/machine learning to understand how IT infrastructure resources are used (compute, storage, and network). In the Figure 5 screenshot, a summary view of resource use is provided. Through



Figure 4. Example of neural network of “intelligent swarming” with ticket routing (Figure provided upon written permissions from BMC Software (2020))



regular analysis, the health of the infrastructure resources that support business applications and business services is reflected. The red means there that an IT resource is about to be saturated and will soon impact the performance of the application. Yellow means you are headed towards saturation that could affect performance and green means resources are in a good state. The grid provides this view by individual applications or business services (group of applications that deliver a service).

For example, an online buying experience typically includes several applications. And the bottom right shows the state of all IT resources. Companies need to understand the health/usage status of the IT resources that run their applications to prevent application failures (like an online shopping service failing because it cannot support the number of transactions that are occurring. This is a common situation for special events like Black Friday, Superbowl Sunday, Insurance open enrollment, University enrollment, etc.) (BMC Software, 2020)

### Example 2: Detecting Idle Virtual Machines (VMs) in Public Cloud Services

AI/ML is used to identify virtual machines in the public cloud that you have purchased, but are not using. These are detected using ML (Machine Learning) as shown in Figure 6. Algorithms such as

Table 2. Open-source software for neural networks

Software	Overview	Important Features	URL
Darknet	Written in C and CUDA, fast and easy to install and supports CPU and GPU computation.	YOLO (You Look Only Once): Real-Time Object Detection, ImageNet Classification, RNN (Recurrent Neural Networks) to represent data that changes over time.	<a href="https://pjreddie.com/darknet/">https://pjreddie.com/darknet/</a>
DNNGraph	Deep Neural Network Model Generation.	Visualization of network structure.	<a href="https://github.com/ajtulloch/dnngraph">https://github.com/ajtulloch/dnngraph</a>
JustNN	Trains validate and query neural networks.	Can import data files of text, CSV, binary, and XLS.	<a href="http://www.justnn.com/">http://www.justnn.com/</a>
MemBrain	Widely used in industrial manufacturing and technical control applications.	Can set neuron properties such as normalization settings, activation function, output recovery time, etc.	<a href="https://membrain-nn.de/english/download_en.htm">https://membrain-nn.de/english/download_en.htm</a>
Neocognitron	Specially designed to simulate hierarchical, multilayered artificial neural networks.	Preloaded project samples, lets user set input panel size as per the number of layers, can view output routings as well as optimal winner value and pattern.	<a href="https://www.softpedia.com/get/Network-Tools/Misc-Networking-Tools/Neocognitron.shtml">https://www.softpedia.com/get/Network-Tools/Misc-Networking-Tools/Neocognitron.shtml</a>
Neural Designer	Cross-platform neural network software with pre-loaded examples of projects in multi-disciplines.	Intuitive interface with Task Manager, Neural Editor/Viewer; can export data as TXT, CSV, XLS files, export R scripts, and Python files.	<a href="https://www.neuraldesigner.com/download">https://www.neuraldesigner.com/download</a>
Sharky Neural Network	Displays points graph and real-time error graph.	Can select network architecture from pre-defined ones, and shape to display learning points on a graph.	<a href="https://download.cnet.com/Sharky-Neural-Network/3000-2054_4-10967073.html">https://download.cnet.com/Sharky-Neural-Network/3000-2054_4-10967073.html</a>
Simbrain	Inputs many network types (Back-prop, Competitive network, Echo State Network, Feed Forward, etc.)	Provides many simulation types (Actor-Critic, Agent Trails, and Cortical Circuit). Can visualize network simulation with bar charts, time series, projection plot, raster plot, etc.	<a href="http://simbrain.net/Downloads/downloads_main.html">http://simbrain.net/Downloads/downloads_main.html</a>
Spice-Neuro	Provides multi-layer neural network (MLP) application.	Can select training parameters of activation functions for hidden and output layer, splitting data, and stop conditions; can view learning rate in Training and Testing.	<a href="https://spiceneuro.wordpress.com/english/">https://spiceneuro.wordpress.com/english/</a>

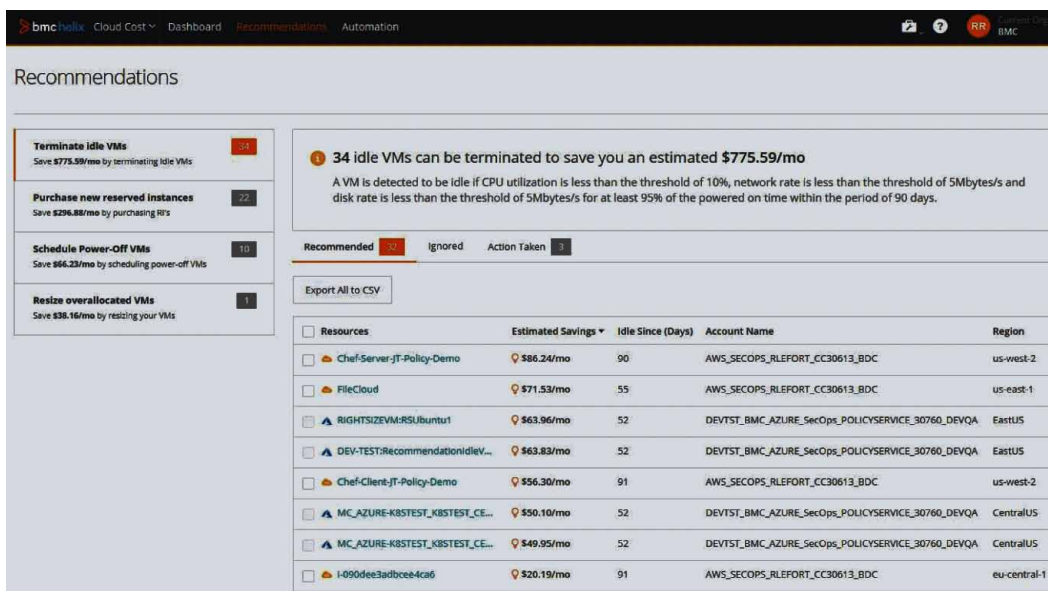
Table 3. Neural network software available for free trial download

Software	Overview	Important Features	URL
AForge.Neuro	Provides a Neural Network library containing sets of classes for creating different types of neural networks.	Calculating XOR functions, Multilayer Feed Forward, Kohonen Self Organizing Map.	<a href="http://www.aforgenet.com/framework/features/neural_networks.html">http://www.aforgenet.com/framework/features/neural_networks.html</a> <a href="http://www.aforgenet.com/framework/downloads.html">http://www.aforgenet.com/framework/downloads.html</a>
ConNetJS	JavaScript library for training Deep Neural Networks	Ability to specify and train Convolutional Networks that process images, and contains an experimental reinforcement learning module based on Deep Q Learning.	<a href="https://cs.stanford.edu/people/karpathy/convnetjs/">https://cs.stanford.edu/people/karpathy/convnetjs/</a>
Cuda-convnet2	New Python backend called cudanet for integration into Nervana's neon framework.	Support for non-texture kernels and multi-way costs, Python interface to GPU memory.	<a href="https://github.com/NervanaSystems/cuda-convnet2">https://github.com/NervanaSystems/cuda-convnet2</a>
DN2A	Set of highly decoupled JavaScript modules for Neural Network and AI development	Performs training Step-By-Step, Step-By-Goal, and Continuous.	<a href="https://github.com/antoniodeluca/dn2a">https://github.com/antoniodeluca/dn2a</a>
goBrain	Includes just basic functions such as Feed Forward and Recurrent Neural Network	Feed Forward, Elman Recurrent Neural Network.	<a href="https://github.com/goml/gobrain">https://github.com/goml/gobrain</a>
HNN (Haskell Neural Network)	Powerful library for Feed Forward Neural Networks written in Haskell.	Haskell is a general-purpose, statically typed, purely functional programming language.	<a href="https://github.com/alpmestan/hnn">https://github.com/alpmestan/hnn</a>
Keras	High-level neural networks library written in Python.	Capable of running on top of either TensorFlow or Theano.	<a href="https://github.com/keras-team/keras">https://github.com/keras-team/keras</a>
LambdaNet	The library is written in Haskell that abstracts network creation, training, and use as higher-order functions.	Quadratic error cost function.	<a href="https://github.com/MrVPlusOne/LambdaNet">https://github.com/MrVPlusOne/LambdaNet</a>
Neon	Python-based deep learning library.	Swappable hardware backends, provide support for convnets, RNNs, LSTMs, and autoencoders.	<a href="https://www.predictiveanalyticstoday.com/neon/">https://www.predictiveanalyticstoday.com/neon/</a>
NeuralN	C++ Neural Network Library for Node.js.	Works with large datasets and multi-threaded training available.	<a href="https://github.com/totemstech/neuraln">https://github.com/totemstech/neuraln</a>
Neuroph	Lightweight Java neural network framework.	Data normalization, image recognition support, and stock market prediction sample.	<a href="http://neuroph.sourceforge.net/">http://neuroph.sourceforge.net/</a>
NeuroSolutions	For both novice and advanced developers.	Cluster Analysis, Sales Forecasting, Sports Predictions, Medical Classification	<a href="http://www.neurosolutions.com">www.neurosolutions.com</a>
RustNN	Feedforward neural network library.	Networks trained via backpropagation using incremental training mode.	<a href="https://github.com/jackm321/RustNN">https://github.com/jackm321/RustNN</a>
Stuttgart Neural Network Simulator (SNNS)	Library containing many standard implementations of neural networks.	Accessibility of all of the SNNS algorithmic functionality from R.	<a href="https://cran.r-project.org/web/packages/RSNNS/">https://cran.r-project.org/web/packages/RSNNS/</a>
Tflearn	Deep learning library built on top of TensorFlow.	Easy graph visualization with details about weights, gradients, activations, and more.	<a href="http://Tflearn.org">Tflearn.org</a>

Figure 5. Capacity Optimization Dashboard (Figure provided upon written permissions from BMC Software (2020))



Figure 6. Cloud Cost Dashboard in BMC Helix (Figure provided upon written permissions from BMC Software (2020))



those described by Alhassan & Abdulghani (2019) for VM allocation in public clouds, Liu et al. (2016) for anomaly detection of cloud platforms based on self-organized maps, and Li (2014) for virtual machine scheduling in cloud infrastructures look for usage of these virtual machines (VMs) over a while, such as 3 or 6 months, depending on what the business wants to define. Any VMs identified

as idle can be automatically shut down so the company does not waste money on paying for cloud resources they are not using. (BMC Software, 2020)

### Example 3: Probably Cause Analysis

Using AI/ML algorithms, data is gathered and analyzed to determine where the most like cause of a problem is that is causing an application to fail or run poorly. This is done by analyzing the data to identify changes in events that are collected. By analyzing event data and understanding what is normal and not normal, the algorithm can determine the most likely cause of the problem as shown in Figure 7 (BMC Software, 2020).

### Example 4: Migrating Data Center Workloads to the Public Cloud

Companies are moving applications and workloads from their data center to the public cloud. They need to decide which virtual machine configuration they want to buy. Each configuration has a different price. There are over a million configurations to choose from.

Using AI/ML, BMC Helix Capacity Optimization makes a recommendation for what should be purchased. It does this by understanding the historical usage patterns of the virtual machine in the data center. Using this information, it then analyzes the cloud configurations and makes a recommendation based on the capacity needed (CPU, memory, storage), performance, and cost. In the Figure 8 screenshot, there is comparative data for the data center VM and the recommended Cloud VM (BMC Software, 2020).

### Example 5: Machine Learning and Neural Network Applications Using Business Model and Medical Datasets

Using business and medical model datasets from Kaggle, the following images/visualizations were created. Tensor Flow, Machine learning, and Deep learning Toolbox of MATLAB were used to construct Figures.

Using Kaggle datasets of customer ranges who spend more at the mall, the following clustered chart is predicted. This graph indicates that people with low salaries and those who are older spend less and save more. Despite their modest salaries, people in their younger years spend more. Some individuals have a high income and a high spending score, indicating that they are frequent consumers of the mall. People with high incomes have a low spending score in one category. According to the

Figure 7. Probability Cause Analysis in BMC Helix (Figure provided upon written permissions from BMC Software (2020))

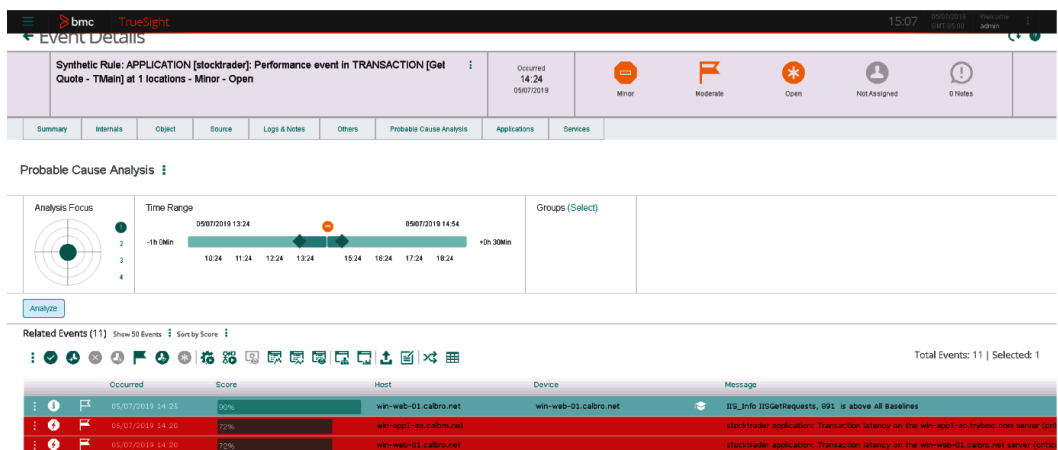
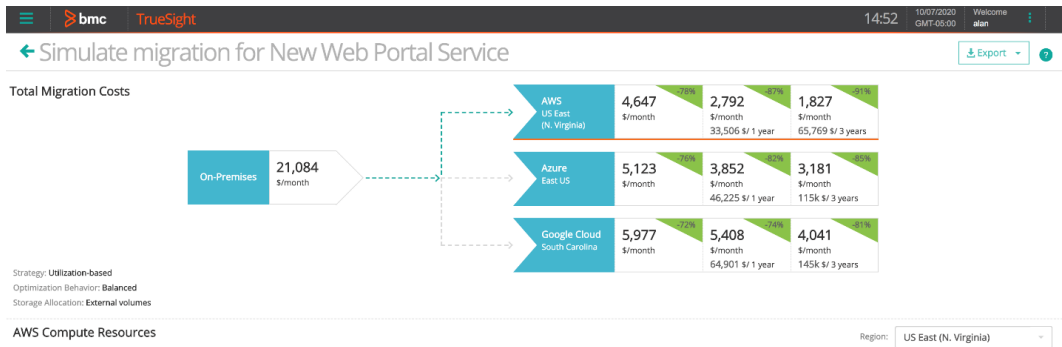


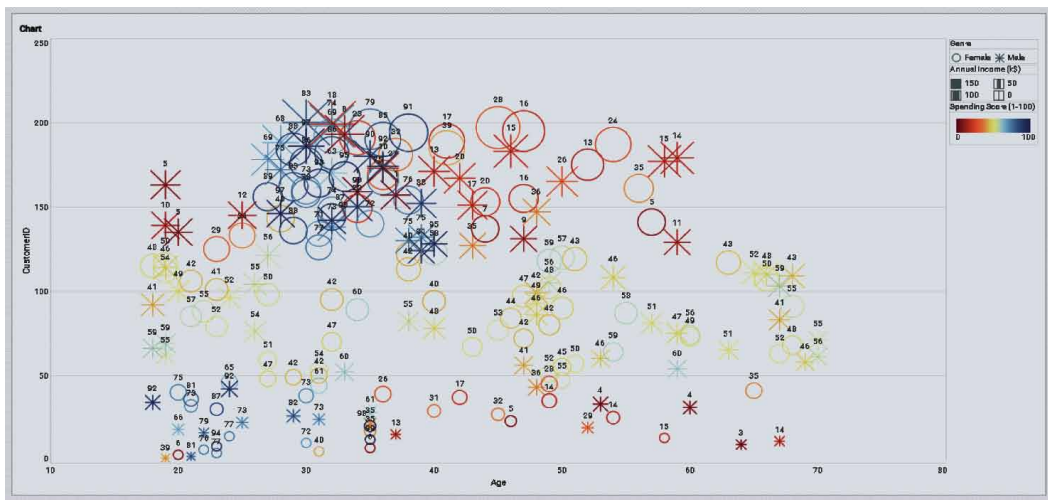
Figure 8. Migration Simulation using AI/ML for New Web Portal Service of BMC Helix (Figure provided upon written permissions from BMC Software (2020))



**AWS Compute Resources** Region: US East (N. Virginia)

Server	Before						After						
	Instance Type	Operating System	Cost (\$)	vCPU	Memory (GB)	Storage (GB)	Instance Type	Operating System	Cost (\$)	vCPU	Memory (GB)	Storage (GB)	Storage Type
apache_node_4	xlarge	Linux	683.52	4	16.00	4.00	m5a.xlarge	Linux	124.24	4	16.00	4.00	General Purpose
bea_backend	2xlarge	Linux	808.32	4	64.00	4.00	r5a.2xlarge	Linux	325.84	8	64.00	4.00	General Purpose
apache_node_2_2	xlarge	Linux	683.52	4	16.00	4.00	m5a.xlarge	Linux	124.24	4	16.00	4.00	General Purpose
apache_node_7	xlarge	Linux	683.52	4	16.00	4.00	m5a.xlarge	Linux	124.24	4	16.00	4.00	General Purpose
apache_node_8	xlarge	Linux	683.52	4	16.00	4.00	m5a.xlarge	Linux	124.24	4	16.00	4.00	General Purpose
core	2xlarge	Linux	1,323.52	8	16.00	4.00	c5.2xlarge	Linux	245.20	8	16.00	4.00	General Purpose

Figure 9. Clustered Chart to predict the spending of Mall Customers using age, customer id, gender, and Estimated salary using Machine Learning Toolbox (MATLAB)



predictions used to anticipate this data, mall authorities should target those with high income and low expenditure scores.

The Kaggle dataset of restaurants was utilized for a project in which the goal was to construct a top-n list of restaurants based on consumer preferences and significant attributes based on restaurant evaluations. This graph depicts the growth in sales of a restaurant based on whether or not it was a franchise.

Figure 10. Bar Graph showing the restaurant sales based on their franchises

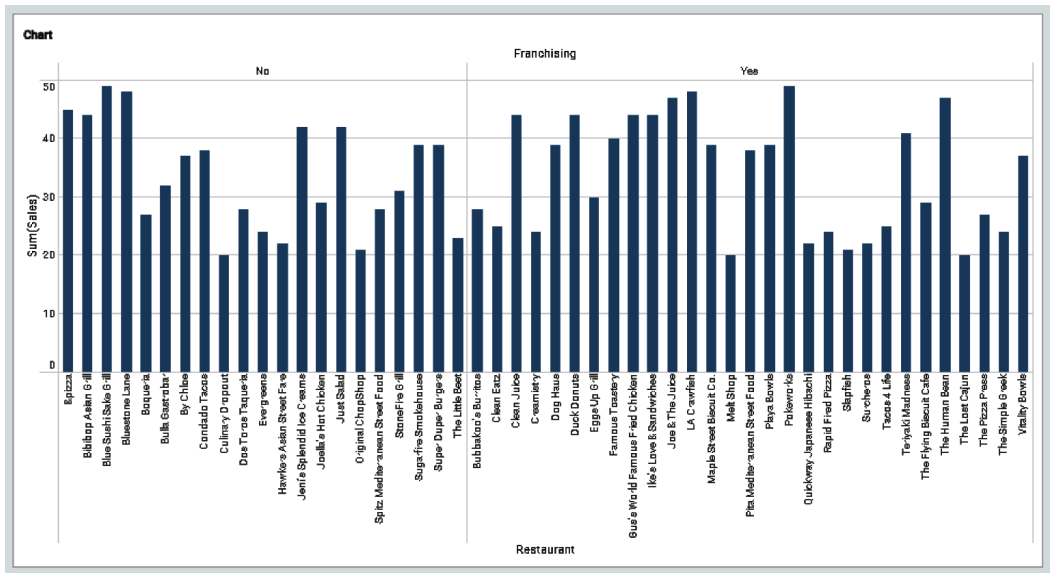
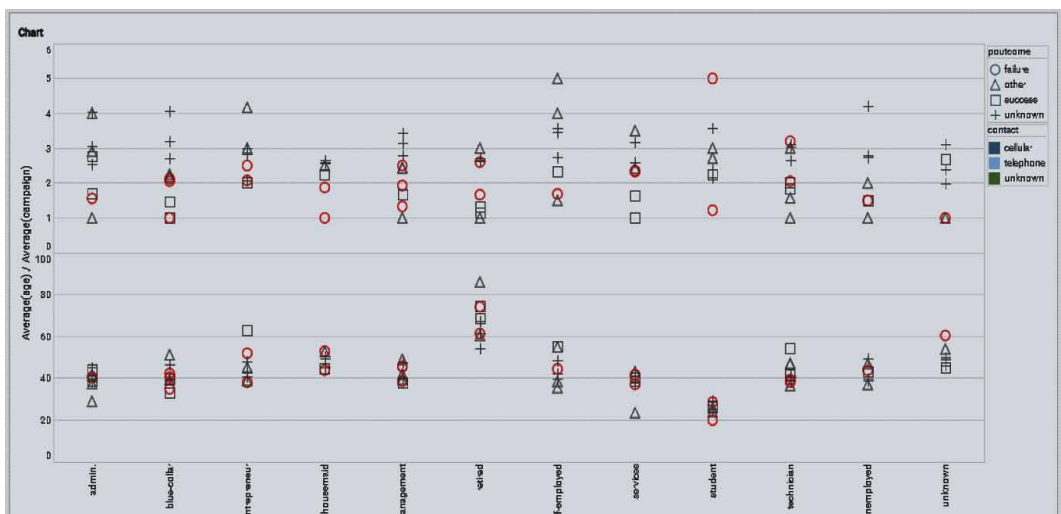


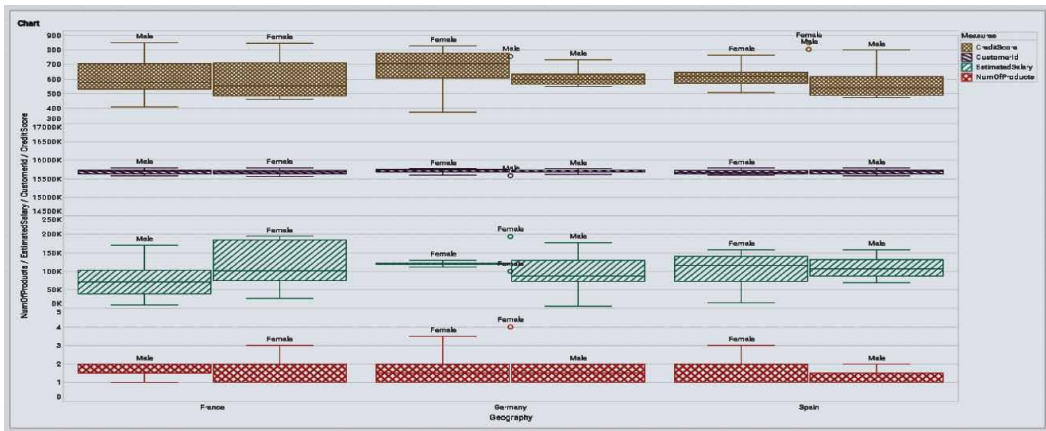
Figure 11. Prediction of Target Customers for the bank based on their age, job description, and the campaign method using TensorFlow



Based on their age, campaign mode (contacted by telephone/cellular and number of times contacted), and job roles the Kaggle dataset was utilized to estimate the intended customer reaction to campaigns. The retirees between the ages of 60 and 80 who had only been approached once were the most successful. Students who were approached several times had the highest failure rate.

Based on the geographic location, age, credit score, estimated salary, the unique ID given to each customer, and the number of products they are assigned such as loans, deposits, mortgages, and so on, the data was collected from Kaggle to predict the customers and the reason for leaving the

Figure 12. Facet Boxplot prediction of Churn Model – Customers leaving the Bank



bank using machine learning toolbox (MATLAB). Some consumers are portrayed to have left the bank based on the prediction, yet they have just left a product in the bank and continue to maintain an account. Some people are unpredictable, such as those who have money in their accounts but are no longer customers.

The data was collected from Kaggle and is based on Indian traffic and the reasons for Uber travel delays based on periods. The clusters are color and pattern coded to show the differences and the travel time in seconds based on what time a customer is traveling and the reviews given by the driver after each ride. The Uber is delayed more mostly in the early mornings and is more on time in the evenings.

This prediction shows the impact of cancer on the human body and the stages of cancer-based on the intensity of the concavity and fractal dimension and of the person is diagnosed with cancer before or if the symptom is new.

Figure 13. Cluster analysis prediction for Uber traffic and the reason for delays

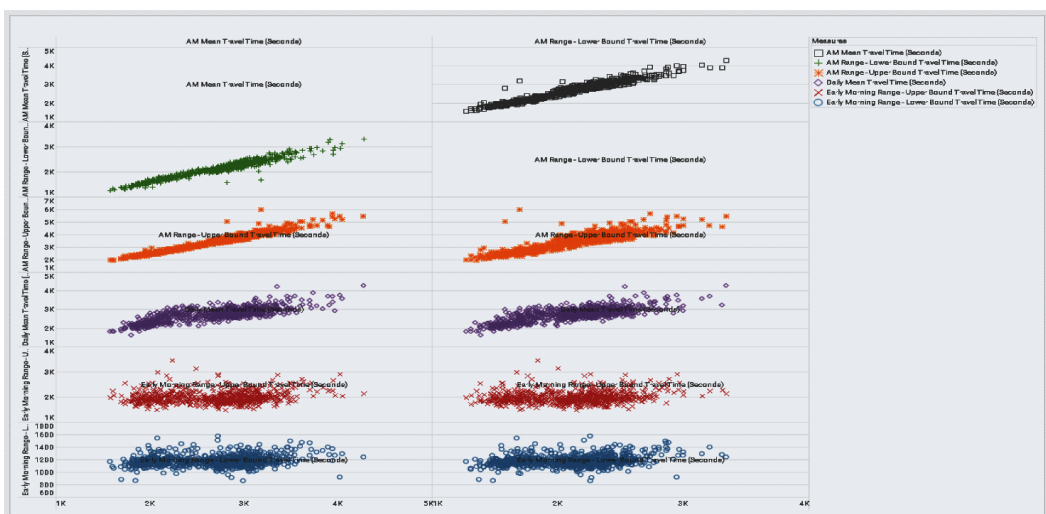
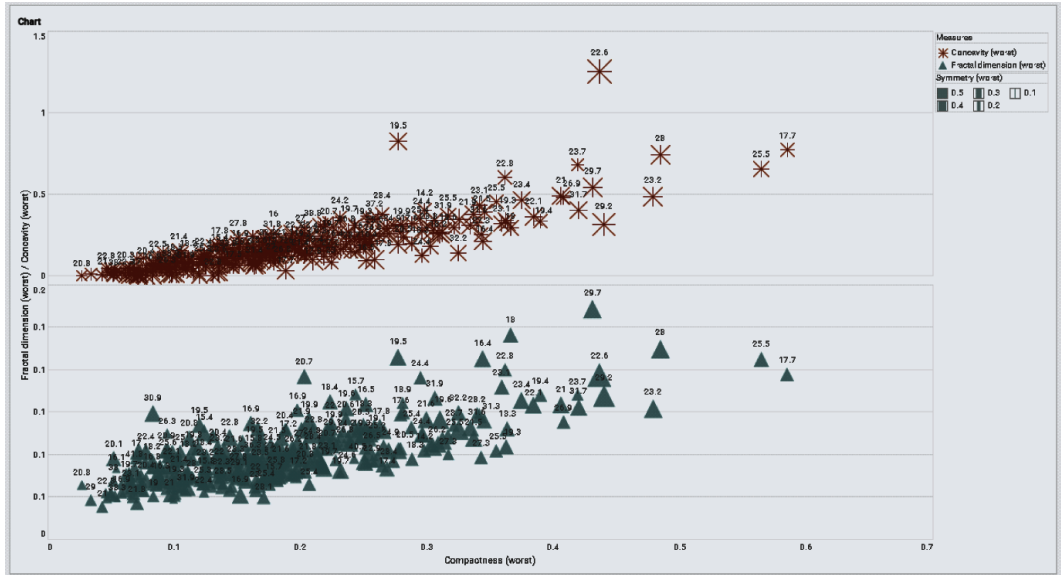




Figure 14. Cancer predictions using neural networks and machine learning algorithms based on the fractal dimension and concavity compared with the compactness



**Example 6: Use of Machine Learning and Data Analysis Approaches in Business Forecasting and Other Important Domains Such as Traffic and Accident Prediction, Credit Card Churn, Etc.**

Let’s define business forecasting first before moving on to the application of AI and machine learning. Business forecasting is the practice of estimating and predicting future changes in areas such as sales, revenue, and demand for resources and inventory using time series data. AI can provide as many company strategies as possible with a machine learning-based solution. Demand and growth forecasting are the two basic types of business forecasting (Anodot, 2021).

Some examples of how AI forecasting is proving to be extremely useful in several sectors. Is it an important aspect of corporate planning, whether for expansion or demand? As a result, regardless of the industry being forecasted, it appears that many businesses are beginning to recognize the value of AI-based accuracy.

This dataset was taken from Kaggle under Comprehensive H1-B visa analysis. An analysis of H1B Visa applications will help us understand the impact of recent changes in American visa laws on other countries, companies, and the global economy. This analysis classifies H1-B applicants as either direct or converting from F-1, shows the new jobs produced, and prevailing H1-B earnings, and differentiates them by US states.

Model execution should be considered throughout the entire process, from variable design through model interpretation, to make machine learning knowledge more executable. More than 10,000 users’ data were used to train the model in this study. Customers’ age, marital status, bank balance, credit card limit, credit card category, and 18 other characteristics are included in the data set.

The start time is given in hours and dimensions, and the number of accidents is calculated in a continuous form, with the weather condition color-coded and detailed. This graph is in a 12-hour format, and it shows that most road accidents occur around 4 a.m., with the least occurring at 4 p.m. When most of the accidents occurred, the weather was very overcast. When the fewest accidents happened, it was fair and windy. This is trained data using datasets from the year 2015-2021 to predict the number of accidents during the weather conditions.

Figure 15. Comprehensive H1-B visa Analysis using machine learning techniques

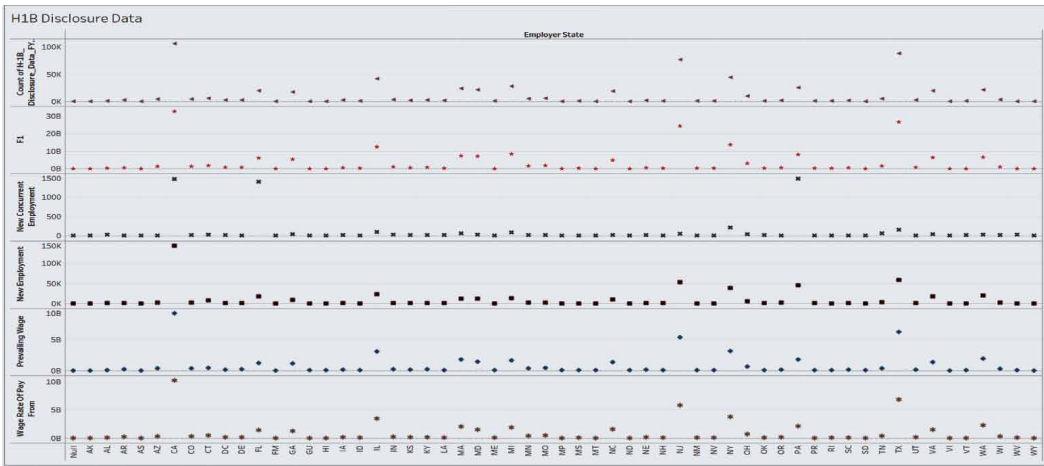
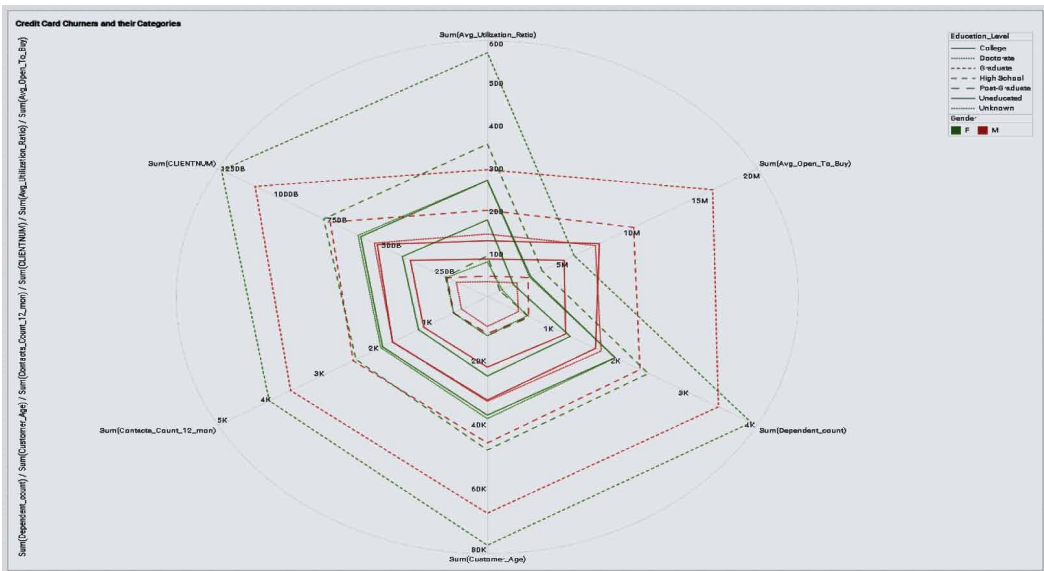


Figure 16. The credit card churn prediction method is depicted in this figure



The dataset used in this figure is the same as in Figure 17. This graph illustrates the number of accidents that occur throughout each hour of the day, as well as the hour with the most accidents. This graph shows the number of accidents that occurred in each hour of the day. According to the graph, most accidents occur between the time frame of 7:00 to 7:30 in the morning.

### Open-Source Software for Machine Learning

See Table 4.

Figure 17. Graph that displays the timeframe and number of most accidents according to weather conditions for the years 2015-2021

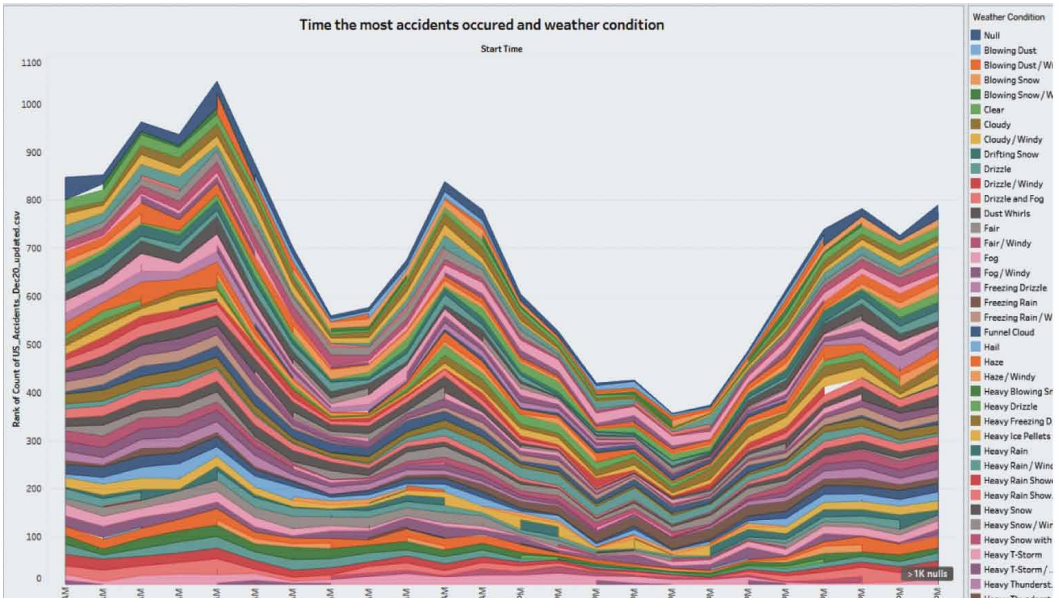
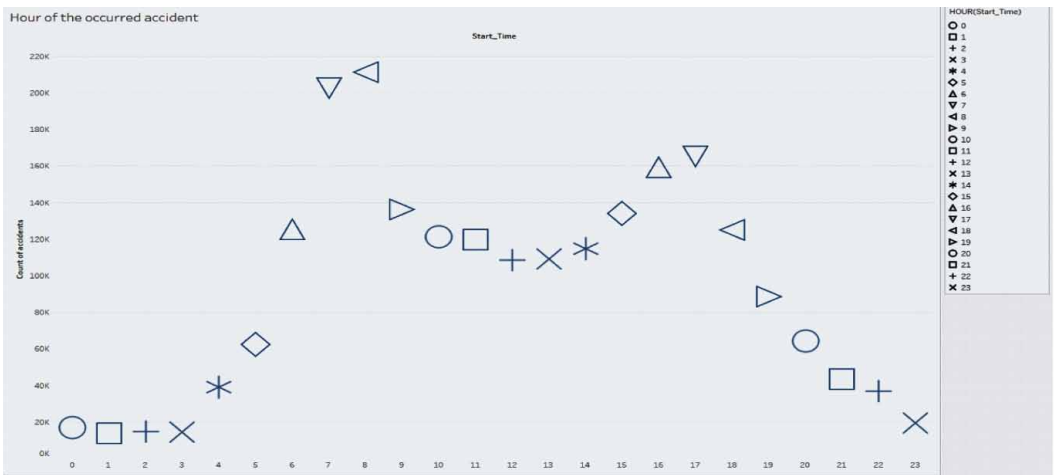


Figure 18. Analysis of the number of accidents happening every hour of a day



### Open-Source Artificial Intelligence Technologies for Machine Learning and Neural Networks

See Tables 5 and 6.

**Table 4. Open-Source Software for Machine Learning**

Software	Important Features	Language	Algorithms
Accord.Net	Cross-platform that provides machine learning libraries for image and audio-processing.	C#	Classification Regression Clustering
Apache Mahout	Extension of Apache Hadoop Platform and use of the MapReduce paradigms.	Java, Scala	Regression Clustering
Apache Spark MLlib	Apache Spark's scalable machine learning library allows users to implement machine learning in real-time.	APIs in Java, Scala, Python, and R.	Classification Regression Gradient Boosting Decision Trees
Keras	Cross-platform, high-level Deep Learning API that makes it very simple to train and run neural networks	Python	Neural Networks (Convolutional and recurrent)
KNIME (Konstanz Information Miner)	Can work with large data volume.	Java	Supports text mining and image mining through plug-ins
PyTorch	Uses Tensors and can develop dynamic graphs to accelerate your machine learning processes.	Python, C++, CUDA	Deep Neural Networks
Scikit Learn	Built on NumPy, SciPy, and matplotlib, and provides a library for Python programming language.	Python, Cython, C, C++	Classification Regression Clustering Dimensionality reduction Preprocessing Model Selection
Shogun	You can use it with all sorts of languages including Java, Python, C#, R, and Matlab.	C++	Regression Classification Distribution
TensorFlow	For numerical computation using data flow graphs. It was originally developed by Google.	Python, C++, CUDA	The most basic type of TensorFlow is a tensor that is a multi-dimensional array.
Weka	These machine learning algorithms help in data mining.	Java	Data preparation Classification Regression Clustering Visualization Association rules mining

## Open-Source Tools for Data Analytics

Table 7 provides a list of current Data Analytics Tools that are free and open-source tools for performing data analytics that include large-scale data processing, data visualization, creation of visual workflows, creating interactive reports, and platforms for machine learning, deep learning, and text mining, and predictive analytics.

## CONCLUSION AND RECOMMENDATIONS FOR FUTURE DIRECTIONS

Researchers and others need to be aware of the abundance of open-source software available with neural networks, machine learning-based algorithms, and data analytics tools that are applicable for multi-discipline applications and present many tabular listings of those currently available.

This article focused on applications of these software tools to business, urban, and biomedicine. The business examples for these applications ranged from real-time chatbot systems to predictions of customer spending patterns, customers leaving the bank, Uber traffic and delays, and automobile accidents. The biomedical examples include that cancer prediction using medical imaging based on machine learning algorithms.

Open-source software is also available for data analytics of large systems that can also be performed using multi-factor prediction for evaluation or estimates of the factors of such complex

Table 5. AI Technologies for Machine Learning available as Open Source (Derived using David (2020))

AI Technology	Features	Language	URL
AdaNet	TensorFlow-based framework.	Python	<a href="https://github.com/tensorflow/adanet">https://github.com/tensorflow/adanet</a>
Analytics Zoo	Able to scale data from laptop-size files to large clusters to big data.	Python	<a href="https://github.com/intel-analytics/analytics-zoo">https://github.com/intel-analytics/analytics-zoo</a>
Blocks	Constructs parametrized Theano operations called “bricks” to optimize neural network models.	Python	<a href="https://github.com/mila-iqua/blocks">https://github.com/mila-iqua/blocks</a>
ConvNetJS	Trains Convolutional Networks for images.	JavaScript	<a href="https://github.com/karpathy/convnetjs">https://github.com/karpathy/convnetjs</a>
Datum Box	Provides pre-trained models for different tasks.	Java	<a href="https://github.com/datumbox/datumbox-framework">https://github.com/datumbox/datumbox-framework</a>
DeepDetect	Machine Learning API	C++	<a href="https://github.com/jolibrain/deepdetect">https://github.com/jolibrain/deepdetect</a>
Dopamine	Allows fast prototyping of reinforcement learning algorithms.	Python	<a href="https://github.com/google/dopamine">https://github.com/google/dopamine</a>
Flair	Applies state-of-art Natural Language Processing (NLP) to Named Entity Recognition (NER) and part-of-speech tagging (PoS).	Python	<a href="https://github.com/flairNLP/flair">https://github.com/flairNLP/flair</a>
Mljar	Can train ML models for binary classification, multi-class classification, and regression.	Python	<a href="https://github.com/mljar/mljar-supervised">https://github.com/mljar/mljar-supervised</a>
NNI (Neural Network Intelligence)	Manages Automated Machine Learning (AutoML) experiments.	Python	<a href="https://github.com/Microsoft/nni">https://github.com/Microsoft/nni</a>
Plato	Supports interactions through text, speech, and dialogue acts.	Python	<a href="https://github.com/uber-research/plato-research-dialogue-system">https://github.com/uber-research/plato-research-dialogue-system</a>
Streamlit	Tool to build interactive web applications.	JavaScript & Python	<a href="https://github.com/streamlit/streamlit">https://github.com/streamlit/streamlit</a>
TuriCreate	ML tasks of image, sound, activity, and text classification.	Python	<a href="https://github.com/apple/turicreate">https://github.com/apple/turicreate</a>

**Table 6. Open-source tools for artificial intelligence**

Software Name	Features	URL
CNTK (Computational Network Toolkit)	The Computational Network Toolkit of Microsoft is primarily used for research in speech recognition.	<a href="https://www.cntk.ai">https://www.cntk.ai</a>
NUPIC	Based on Hierarchical Temporal Memory (HTM)	<a href="https://numenta.com">https://numenta.com</a>
OpenCog	A diverse assemblage of cognitive algorithms	<a href="https://opencog.org">https://opencog.org</a>
Opencyc	Useful for rich domain modeling and game AIs	<a href="https://www.cyc.com/opencyc">https://www.cyc.com/opencyc</a>

**Table 7. Data analytics tools**

Software Name	Features	URL
Grafana	Compose and scale observability with one or all pieces of the stack	<a href="https://grafana.com/">https://grafana.com/</a>
Redash	Connect to any data source, visualize and share your data, and democratize data access with your company.	<a href="https://redash.io/">https://redash.io/</a>
Knime	Create visual workflows using the drag and drop graphical user interface, model your analytical steps while controlling data flow, and ensure your work is current.	<a href="https://www.knime.com/knime-analytics-platform">https://www.knime.com/knime-analytics-platform</a>
Rapid Miner	RapidMiner is a cloud-based suite of products that helps you create an integrated end-to-end analytics platform.	<a href="https://rapidminer.com/">https://rapidminer.com/</a>
RStudio	An integrated development environment suite for the R coding language. The tool can create interactive reports, documents, web applications, and other types of reporting.	<a href="https://www.rstudio.com/">https://www.rstudio.com/</a>
Apache Spark	Apache Spark is a unified, open-source analytics engine that introduced a new system for rapid and distributed large-scale data processing.	<a href="https://spark.apache.org/">https://spark.apache.org/</a>
Pentaho	Pentaho is a data analytics platform that offers a suite of open source and proprietary tools.	<a href="https://www.hitachivantara.com/en-us/products/data-management-analytics.html">https://www.hitachivantara.com/en-us/products/data-management-analytics.html</a>
BIRT	BIRT is an open-source technology platform that you can use to create data visualizations and reports and then embed them into rich web or client applications.	<a href="https://eclipse.github.io/birt-website/">https://eclipse.github.io/birt-website/</a>
Metabase	Metabase is a simple and quick way to get business analytics and intelligence to everyone on your team.	<a href="https://www.metabase.com/">https://www.metabase.com/</a>
Kibana	Kibana is a free and open-source data visualization and exploration software that can run on-premises or other deployments like Amazon EC2 or Elasticsearch Service.	<a href="https://www.elastic.co/kibana/">https://www.elastic.co/kibana/</a>

systems. Data analytics includes the technique of Multifactor Dimensionality Reduction (MDR) which is a statistical approach that also can be used with Machine Learning (ML) as an automated approach for detecting and characterizing multi-combinations of attributes or independent variables that interact to influence a dependent or class variable. (McKinney et al., 2006)

This article presents 29 types of neural networks and their characteristics and images of each of these. A summary of available Open-Source Software (OSS) for neural networks is presented including Deep Neural Networks (DNN) for solving multi-layer networks for complex systems that are the foundation of many modern artificial intelligence applications. Deep learning is a subset of neural networks that in turn is a subset of machine learning and artificial intelligence that in turn can be used with Big Data Analytics.

This article also presented examples that were provided to the authors by BMC Software Corporation as illustrations of their applications of machine learning for obtaining the optimal configuration of their Helix Data Capacity system, and neural networks for the cognitive routing of their chatbot system.

There are limitless applications of Big Data Analytics that utilize multi-factor predictions with machine learning and the many types of neural networks. This article also presents insights into the availability of open-source software that utilizes artificial intelligence and machine learning with applications to business, urban, and biomedical situations, as illustrations of potential for applications to other fields. The practical and theoretical implications of this research are limitless.

The future directions of the research are to update the existing Tables with listings of new Artificial Intelligence Technology, Open-Source Software (OSS), and Data Analytics Tools, and to search for new data sets to perform new data visualizations and analyses. The recommendations for future research to others that would be extremely useful worldwide are to use the specific applications of these tools and open-source software and algorithms to available COVID-19 data and its variants as made public.

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## **CONFLICT OF INTEREST**

The authors of this publication declare there is no conflict of interest.

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