Classical Programming and Machine Learning

Sean Andrew Thawe

Abstract

Classical programming has been applied in many fields and is still being used today. Artificial Intelligence has taken the world by storm. Improvements in computing systems and also accumulation of data over the years have branched out a lot of computing solutions. Machine Learning as a branch of Artificial Intelligence is greatly used in many industries including entertainment and also automatic cars. There are a lot more fields still emerging including Deep Learning. While Deep Learning is inspired by the biological human brain, we'll find out that it is something else entirely. We are going to be introduced to the basics of Machine Learning and Classical programming paradigms throughout this paper and also talk a bit about Deep Learning.

Classical Programming and ML Differences

Classical programming depends entirely on the user input and the pre-defined set of instructions or logic.

Machine Learning utilizes algorithms that enable it to learn from its environment and experience after seeing patterns from big and dynamic complex datasets.

Classical programming would have users design specific instructions, and create boundaries, rules, and logic that tie each program process to a specific outcome such as sorting data.

Machine Learning models are more defined by the training data provided to them by written rules. Algorithms are prepared for different scenarios through classifications and predictions based on new data.

Data

Machine Learning can work through various big dynamic and unstructured datasets to identify patterns and perform predictive analysis. Classical programming is entirely dependent on structured and static data.

Flexibility

Machine Learning is much more flexible giving it an upper hand as it can learn from different data sources and adapt quickly.

Classical programming is much less flexible and generally rigid.

A Machine Learning model which has been designed to classify animals can easily be retrained to identify other items houses or vehicles through a process called transfer learning.

A classical program designed to solve sums, can not easily be changed to sort through graphic data.

Applications

Machine Learning is mainly used for dynamic and complex tasks that require in-depth analysis and continuous adaptation and learning.

Classical programming systems are best used for tasks that are repeated and well-defined in basic logic.

Expertise

The classical programming approach requires a developer to be well-versed in computer programming (coding languages) languages, software engineering frameworks, and principles.

Machine Learning requires its experts to be comfortable working with complex algorithms, neural networks, deep learning, statistical models, and data science.

Classical Programming

A computer is given a set of instructions in a language that the computer can understand. A set of instructions, or code, is known as a computer program or software, through the process called programming.

Classical programming is a manual process. A programmer creates a set of rules or logic for the program. The logic is manually made up and fed into the computer alongside input data. Then the computer processes the given data according to the rules that were manually coded and then comes up with answers as output.

Applications of Machine Learning

Recommendation systems

Machine Learning models are built for building recommendation systems that can study user profiles, preferences, and behavior patterns.

Natural Language Processing

Machine Learning algorithms are used to optimize Natural Language Processing systems that are part of software solutions intended to understand human language and input.

Image Recognition

With Machine Learning a model with image recognition capabilities can be built to identify different objects within an image.

Applications of classical programming

It can be used in rule-based systems. Classical programming can be used to create systems that run by specific rules and have set criteria for decision-making that are usually pre-defined. An example can be the case of spam filters built into email systems. The logic behind it can be to filter certain words that match fixed criteria as spam.

Real-time systems

Classical programming languages can be used for real-time systems where a computer is required to react quickly to predicted inputs that lead to pre-defined solutions.

Simple calculations

Classical programming is great for simple calculations or creating systems that run on deterministic behavior such as a banking app that can easily calculate interest based on the amount and duration based on deposited sum.

Machine Learning

- **Machine learning** - “The field of study that gives computers the ability to learn without being explicitly programmed” - Arthur Samuel (1959) while **Data Science** is the science of extracting knowledge and insights from data.
    - ML often results in a piece of software that runs taking in input and producing results.
- Machine learning is ideal for handling dynamic and complex data including big datasets.
- **The goal of machine learning models: highest accuracy possible.**
- “Machine learning is a subfield of AI and computer science that has its roots in statistics and mathematical optimization.” - M. Tim Jones
- Machine learning is the science where to predict a value, algorithms are applied for a system to learn patterns within data.
    - Given sufficient data the relationship between input variables and values is established.
    - This becomes easier as a system can predict a new value given other input variables.
    - So much momentum is being made with the state-of-the-art technology like processors and GPUs being developed as well as abundant data

Machine Learning Terminologies

- Labels: is what is being predicted which is the **y** variable in a simple linear regression.

- Features: This is an input variable - the **x** variable in simple linear regression. A simple ML might use a single feature or fewer features as compared to a more sophisticated ML which could use millions of features.
- Training: is when a model is created in simple terms it is when a model learns good values for all the weights and biases from the labeled in the case of supervised learning. In the case of supervised ML the model gradually learns the relationship between features and labels that are fed into it as input so it can make predictions when unseen data is fed into the model after its creation.
- Regression: a regression model predicts continuous values.
- Classification: a classification model predicts discrete values.

Supervised Learning

A model learns from a data set containing input values that you would like to predict. Supervised ML models use the input to produce useful predictions on never-before-seen data.

When training supervised ML models, the model is fed with labels(y) and features. Labeled data has (features, label) which is (x, y), which is used to train the model, unlabeled example has (features, ?), that's (x, ?) which is used for making predictions.

Unsupervised Learning

Data has no labels instead the machine looks for *hidden* patterns in the dataset. In other words, a model learns from data without any guidance.

1. Clustering - groups unlabeled data based on similar characteristics
2. Association - used to identify relationships in the data
3. Dimensionality reduction - helps eliminate noisy redundant data from unmanageable datasets - fewer data

Reinforcement Learning

Reinforcement learning is one of the three basic learning paradigms. In Reinforcement Learning, a model learns to become more accurate in an environment based on feedback to maximize the notion of cumulative reward.

Deep Learning and Neural Network

Neural Network

A neural network is just a big mathematical equation

- A form of machine learning that uses a layered representation of data.
- Originally inspired by the brain, the details of how they work are almost completely unrelated to how biological brains work

Deep Learning

Deep learning or deep neural network is a machine learning subcategory, which can deal with nonlinear datasets.

Advanced Machine Learning is known as Deep Learning. A subset of Machine Learning comprising three or more layers. These neural networks try to simulate the human brain, allowing it to learn from large amounts of data. These additional layers give the neural network an upper hand for optimization and refined accuracy.

Deep learning algorithms attempt to learn high-level features from mass data, making it more powerful and beyond traditional machine learning.

It can automatically extract features through unsupervised or semi-supervised feature learning algorithms and hierarchical feature extraction compared to traditional Machine Learning where features are designed manually.

Data dependency: Deep Learning is often more complicated than Machine Learning. It requires a lot more input data for training the model and powerful hardware so it takes less time for the computer to analyze training data.

Deep Learning has been applied in many automated systems improving these automated systems and also performing analytical and physical tasks without human intervention. Deep Learning lies behind everyday products and services as well as emerging technologies such as self-driving cars.

How does Deep Learning work?

Deep Learning neural networks mimic the human brain through the use of data inputs, weights, and biases. These elements work together to accurately recognize, classify, and describe objects within the data.

A deep Learning network has got numerous interconnected nodes, each one building upon the previous layer to refine and optimize the prediction or categorization.

The input and output layers of deep neural networks are called *visible layers*. The Deep Learning model takes in data for processing through the input layer and then outputs it through the output layer where final prediction and classification is made.

Deep Learning algorithms are incredibly complex with different types of neural networks to address networks to address specific problems or datasets.

Examples of Deep Learning:

- Convolutional Neural Networks (CNNs) - computer vision and image classification applications
- Recurrent Neural Networks (RNNs) - Natural language and speech recognition

References

1. Machine Learning vs Traditional Programming: Choosing the Right Approach for Your Projects: https://www.institutedata.com/us/blog/machine-learning-vs-traditional-programming-choosing-the-right-approach-for-your-projects/
2. Transfer Learning: Leverage Insights from Big Data - Lars Hulstaert: https://www.datacamp.com/tutorial/transfer-learning
3. 15. What is Transfer Learning? | With code in Keras: https://youtu.be/DyPW-994t7w
4. A beginner's guide to artificial intelligence and machine learning, By M. Tim Jones: https://developer.ibm.com/learningpaths/get-started-artificial-intelligence/ai-basics/ai-beginners-guide/
5. What Is Artificial Intelligence? | Artificial Intelligence Explained: https://developer.ibm.com/learningpaths/get-started-artificial-intelligence/ai-basics/what-is-artificial-intelligence/
6. What is deep learning?: https://www.ibm.com/topics/deep-learning
7. Difference between Machine Learning and Classical Programming: https://architectyeung.medium.com/jdifference-between-machine-learning-and-classical-programming-7b2b534b71ff
8. Machine Learning vs. Normal Programming: What's the Difference?: https://datasciencenerd.com/machine-learning-vs-normal-programming-what-is-the-difference/
9. Introduction to Machine Learning: https://github.com/litaotao/machine-learning-crash-course
10. Your First Machine Learning Project in Python Step-By-Step: https://machinelearningmastery.com/machine-learning-in-python-step-by-step/
11. 23. Farhad Mortezapour Shiri, Thinagaran Perumal, Norwati Mustapha, Raihani Mohamed, *"A Comprehensive Overview and Comparative Analysis on Deep Learning Models: CNN, RNN, LSTM, GRU"*
12. Chuanqi Tan, Fuchun Sun, Tao Kong, Wenchang Zhang, Chao Yang, and Chunfang Liu, *"A Survey on Deep Transfer Learning"*, 6 Aug 2018, arXiv:1808.01974v1 [cs.LG]