

Informatic Institute of Technolog

Trends in Computer Science 4COSC008C.3

2.Machine Learning

2.a. Overview of Machine Learning. How does it compare with conventional computing?

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ACKNOWLEDGMENTS

This acknowledgement is dedicated to those who helped and provided guidance in creating this report.

My deepest gratitude goes to Mr. Shivaraam Raghu, our lecturer, for providing knowledge on the subject matter and the report's process. Special thanks to our tutors, Ms. Sandunika Rasanjalee and Mr. Sahan Priyanayana, for their detailed guidance throughout the report creation process. Finally, I would like to express my thanks to my teammates and colleagues for their support and assistance.

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INTRODUCTION

As the field of information technology transitions from the era of information to the era of data[6], computing methods are evolving rapidly. One of the prominent technological advancements gaining momentum today is Artificial Intelligence (AI). With the advancement of AI, many computing systems are increasingly shifting from conventional computing methods to Machine Learning (ML) models[7].

This report aims to explain what machine learning and conventional computing are, compare their methods, and clarify why and how today's technology is shifting towards adoption of machine learning models.

1.OVERVIEW OF CONVENTIONAL COMPUTING

Conventional computing model has been the backbone of computer programs since its initiation.

In this model, the programmer codes the rules that needs to be applied to the given data, and then the machine gives the desired output after processing the data according to the coded rules. [4]



Figure 1;traditional programming

Source: Adapted from [8]

However, as the field of computer science has advanced and problems have become more complex, conventional computing methods have reached their limitations. [4]

The following discussion will illustrate how this has occurred, using the example provided below.

Example 1:

Writing a program that differentiate cats from dogs using conventional computing methods.

If programmers were to develop this code using conventional methods, they would need to explicitly define a set of rules to distinguish cats from dogs.

For arguments sake assume the rules were as given bellow.



Figure 2:cat
Source: Adapted from [8]



Figure 3:dog
Source: Adapted from [9]

Size=small.	Size=large.
Has whiskers.	Doesn't have whiskers.
Doesn't have a snout.	Has a snout.

Now, consider the introduction of small dog breeds like Chihuahuas and large cat breeds like Maine Coons. The existing rules would need to be updated to account for these exceptions. If new breeds of animals were introduced, the rules would once again need to be modified. This continuous updating results in a bulky and complicated code. Despite all updates, it would still be impractical to write all the necessary rules to accurately identify each animal. Furthermore, maintaining and improving the code as new breeds of cats and dogs are added becomes an increasingly daunting and humanly impossible task.

Instead of manually writing the code, consider a scenario where the computer is capable of generating the rules autonomously and updating the algorithm as new data is introduced. This is the fundamental principle behind the AI model known as machine learning.

2.OVERVIEW OF MACHINE LEARNING

2.1.Artificial Intelligence(AI)

According to Brian Christian, "Artificial intelligence (AI) is the capability of a machine to imitate intelligent human behavior." [1]

Computers use the following technologies to achieve the ability to mimic human like cognitive abilities.[2]

- natural language processing
- knowledge representation
- automated reasoning
- machine learning
- computer vision
- robotics

2.1.1.Machine Learning (ML)

As mentioned above Machine Learning (ML) is a discipline of AI.

ML utilizes algorithms to analyze data and identify patterns in given data to build models. These models are used to make predictions and decisions.[3]



*Figure 4 :machine learning
Source: Adapted from [4]*

Example 2

Referring to example 1, if the same program was to be written using ML, the computer would be provided with multiple labeled images of cats and dogs as data then the algorithm would find connections through patterns and write the rules by itself.

Example 1

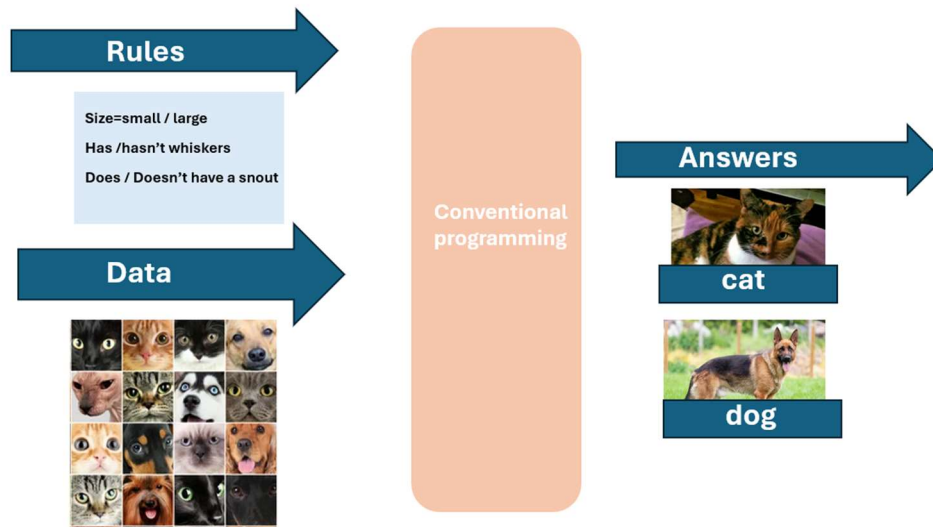


Figure 5:example 1 as a graph

Example 2

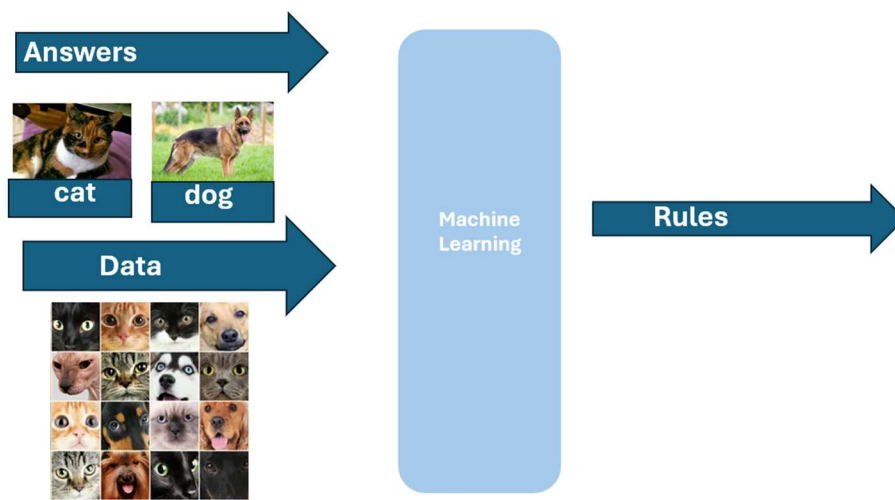


Figure 6:example 2 as a graph

As mentioned by Chip Huyen “In November 2016, Google announced that it had incorporated its multilingual neural machine translation system into Google Translate, marking one of the first success stories of deep artificial neural networks in production at scale. According to Google, with this update, the quality of translation improved more in a single leap than they had seen in the previous 10 years combined.” [7]

This rapid improvement in Google's translator demonstrates how ML is swiftly advancing new computing systems.

3. MACHINE LEARNING COMPARED WITH CONVENTIONAL COMPUTING

ML technology differs from conventional computing in its functionality.

Table 1:comparing technology

Conventional	ML
Functions on predefines rules made by programmers.[4]	Programmer inputs the data and the algorithm writes the rules by itself.[4]
Rule driven. [4]	Data driven.[4]

Over time, it has become evident that machine learning possesses characteristics that surpass conventional computing, leading to a shift towards machine learning models. Below are some advantages of ML compared to traditional computing.

Table 2:advantages of ML.

Conventional	ML
Bulky complicated code that is hard to maintain leaves room for human error[4]	Self-writing algorithm is accurate and efficient.[4]
Updates needs to be made manually.[4]	Updates automatically.[4]
Can only be used for well-defined problems..[5]	Can be used for complexed problems[4]

As we increasingly use ML models, we have noticed some drawbacks compared to previously used computing methods. These are mentioned below.

Table 3:disadvantages of ML

Conventional	ML
Hardcoded rules make output predictable and unchanging over time. [5]	Output depends on data, making it harder to predict and subject to change. [6]
Human bias in traditional systems is easier to detect and fix . [5]	Bias in ML can stem from data or algorithms, is hard to detect, and deep neural networks can become black boxes .[5]

4. CRITICAL EVALUATION

As noted, both machine learning and conventional computing have pros and cons. However, the future clearly leans towards adopting machine learning models. In this data-driven age, machine learning is becoming increasingly popular, as shown in the Google Trends graph below [6].

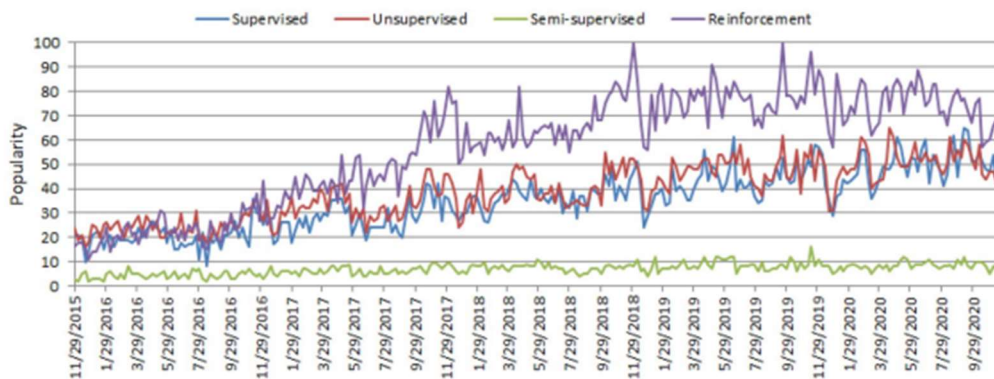


Figure 7

Source: Adapted from [6]

Machine learning has addressed many limitations of conventional computing, though it still has some drawbacks that need to be addressed. Despite these issues, ML has assist in developing many applications, such as image recognition, text generation, playing Go, and self-driving cars, and has been adopted in fields like law, medicine, finance, IoT systems, cybersecurity, business, recommendation systems, smart cities, healthcare and sustainable agriculture. [6].

5. CONCLUTION

As discussed in this report despite of both ML and conventional computing having their own pros and cons ,ML in comparison to conventional computing is a relatively recent field. Despite of having lesser time ML has been able to surpass conventional computing abilities .This suggest that ML technology will only continue to expand indicating that ML technology will increasingly shape the future of technology towards machine learning and similar AI models.

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