

Emerging Techniques of Artificial Intelligence and Machine Learning

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Abstract

Artificial Intelligence (AI) and Machine Learning (ML) have revolutionized our world today. Some of the fields that AI and ML have contributed to include the medical field, the business sector, research, and more. However, what is the platforms that AI used on? What AI and ML to work efficiently? What are some related words in AI and some Marketing Implications of AI? This paper discussing the answers to these topics by examining “Emerging Techniques & Technologies of Artificial Intelligence & Machine Learning”. The parts of the essay will be segmented as follows:

- Tyra Buadoo:
 - Abstract
 - Introduction
 - Conclusion
 - Enabling Technologies
- Haley Granger
 - Architecture
 - Platforms
 - Optimization Techniques
- Leonard Hayes
 - Evaluation metrics
 - Related Works
 - Introduction
 - Education
 - Business
- Jaspinder Kaur
 - Marketing Implications
 - Challenges and Limitations

Introduction

Artificial Intelligence (AI) and Machine Learning (ML) have revolutionized our world today. It has been able to assist humans in research, the medical field, in our daily lives, and more through the act of Automation. As the field of AI and ML grows exponentially, different techniques have been developed for creating automated technologies. These techniques can range from basic algorithms such as “Rule-Based Learning” to more advanced techniques such as “Hybrid Learning”. As a result of these techniques, many new emerging technologies have come about in the world of Automation. When these techniques are implemented in the creating of AI, optimization is needed to ensure that these AI’s are working at their best. To determine what changes are needed in the AI and if the AI is working well, evaluation metrics are needed. Lastly, various marketing strategies are needed to adversities the benefits of AI and to spread the word regarding how it can be used to help improve society. Throughout this essay, we will be reviewing the following topics in AI: Enabling Technologies, Architectures, Platform, Optimization Techniques, Evaluation Metrics, Market Implications, Related Works, and the Challenges and Limitations of AI.

Related Works

Artificial Intelligence has been an ever-growing field, even more rapidly as of the early 2000s. With the field of study becoming steadily growing in breadth and depth, it has become difficult to define a true underlying understanding of what can be considered Artificial Intelligence and what cannot. The contribution our work provides amongst others is a foundation of artificial intelligence as it stands as a state-of-the-art science with a focus on its spread into both common lives as well as industrial life.

In one word “Artificial Intelligence Techniques in Software Engineering for Automated Software Reuse and Design” (Wangoo, 2018), they focus on the use of data mining regarding software engineering. Many of these techniques highlighted in this document align with our own, but unlike their work, we take a broad approach. We try to bring up the use cases of data mining both in and outside of software engineering, though they give a more focused point of view.

In another work “Survey of Grading Process for Agricultural Foods by Using Artificial Intelligence Technique.” (Elakkiya et al., 2018), the article references another way artificial intelligence in the agricultural field. Though not specifically mentioned in our work, many of the methods discussed in their work are mentioned in this work. They can be manipulated and utilized in different ways to uniquely solve problems.

These works and many others are like ours in that they focus on new and emerging technologies in their separate fields. We try to encompass all of these works in our general coverage of the emerging technologies and methodologies that are at the core of these newer technologies and how they work to create newer ones.

Enabling Technologies

As technology advances, we are beginning to see an increase in Expert System programs or ES Programs. ES are “computer programs which are derived from a branch of CSR called AI” (Latif, 2014). In other words, ES programs adapt to the thought process of human experts. One type of ES program that is very common today is Artificial Intelligence. Artificial Intelligence or “AI” is often is generally defined as a “machine [that] simulates functions that humans associate with other human minds, such as learning and problem solving” (Cioffi et al., 1999). To implement AI, various techniques such as Rule-Based Learning, Machine Learning, “Genetic Algorithms, ... Knowledge Representation...” (Cioffi et al., 1999). These techniques enable AI to work properly. We will be examining several techniques for implementing AI technology since these algorithms or techniques “represent an opportunity to handle high dimensional problems and data” (Cioffi et al., 1999).

Rule-based Learning

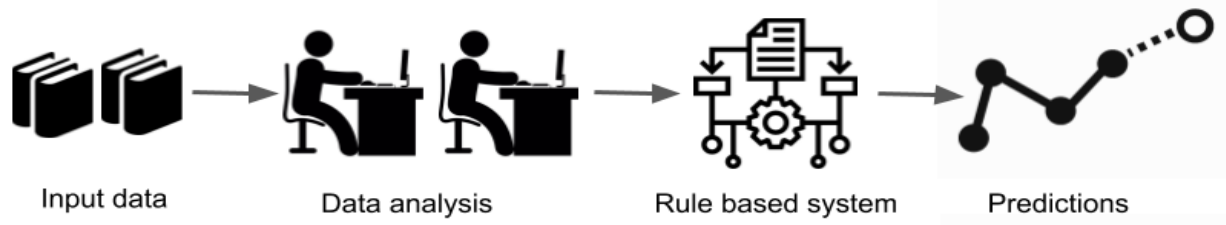


Figure 1: This diagram depicts the steps taken to implement Rule-Based Learning for AI (Labs, 2019).

Rule-based systems are a type of AI that “solve[s] problems by rules derived from expert knowledge” (Latif, 2014). These systems are implemented using a technique for building AI called “Rule-Based Learning”. Rule-based AI is conducted by giving a set of conditions in the form of an “if-else” statement, that will help the AI determine what outcome to portray. For example, a set of rules can be applied to an AI environmental system that can diagnose honeybee “pest”. This was done by Mahaman et al. and the rule rules goes as follows:

1. If the honeybee larva has been affected
2. And the larva's color is black or white,
3. And the larva seems as though it was mummified,
4. Or the cappings of the cell seem scattered,
5. then there is an 80 percent chance that the bees have the chalkbrood disease (Chen et al., 2008).

This form of learning is easy to maintain, implement, and easy to understand since the way that knowledge is provided to the system is straightforward. This is because the rules are derived from logical conditional statements as shown in the honeybee “pest” example above. The problem with rule-based learning is that there is no real learning in Rule-based learning. After all, the concept of learning is to acquire new knowledge that is added to pre-existing knowledge. Rule-base systems cannot acquire knowledge easily since they are run using a set of already established rules which cannot be automatically changed or added to. Therefore, Rule-Based Learning is only useful if a pre-existing knowledge-based is available for use. These limitations can be seen in the implementation of Intrusion Detection Systems or IDS.

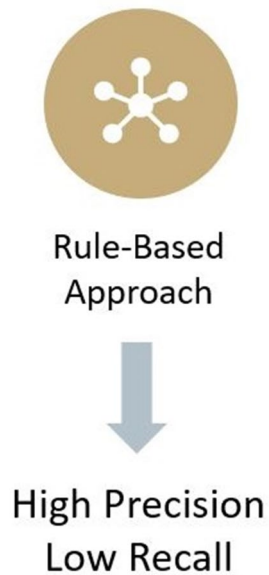


Figure 2: This diagram shows a brief description of the advantages and disadvantages of the Rule-Based technique (Bourlai, 2020).

Intrusion Detection Systems or IDS is “...the second line of defense against network anomalies and threats” are is very important when it comes to network security (Alrajeh and Lloret, 2013). IDS is used when building a Wireless Sensor Network (WSN). Many techniques are used when implementing IDS including techniques related to AI. Some of these techniques Rule-Based Learning. However, there are many limitations to Rule-Based Learning that poorly affect the abilities of an IDS. For this reason, other more advanced techniques such as ANN-based intrusion detection is deemed helpful to “eliminate the shortcomings of rule-based IDSs” (Alrajeh and Lloret, 2013).

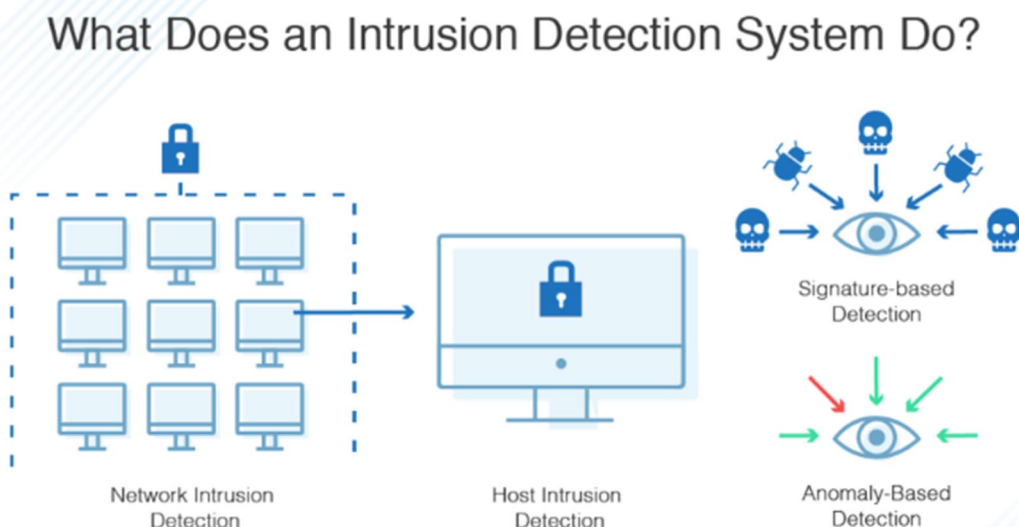
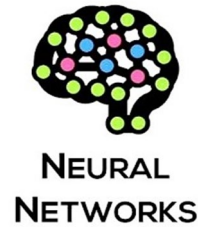


Figure 3: This diagram shows how IDS is used to protect a system (DNS stuff, 2020)

Artificial neural network (ANN)

An artificial neural network (ANN) is another technique used when building AI's. The concept of ANN comes from the “human nervous system, which is connected through neurons” (Alrajeh and Lloret, 2013). This technique allows the AI to learn and understand concepts through training just like a human brain can understand concepts through training. It has many processing units that act like neurons that work together (Chen et al., 2008).



- Classification†
- Pattern recognition

† Also for screenplay creation

Figure 4: This diagram shows a brief description of the uses of the ANN technique (Fisher, 2016).

These units are connected by links that mimic synapses. Information passed around in the ANNs may be feedforward-which is the most common version- or feedback. Information is passed along “unidirectional in feedforward ANNs, with no cycles”. However, information is passed along “in both directions in feedback ANNs so they have cycles [whose]...state evolves to equilibrium” (Chen et al., 2008). In other words, Feedforward ANN moves signals or information in one direction: starting from the input to output. Feedback ANN moves signals or information in both directions (Alrajeh and Lloret, 2013). There are other types of neural network architectures as shown in the image below, but this is beyond the scope of this report.

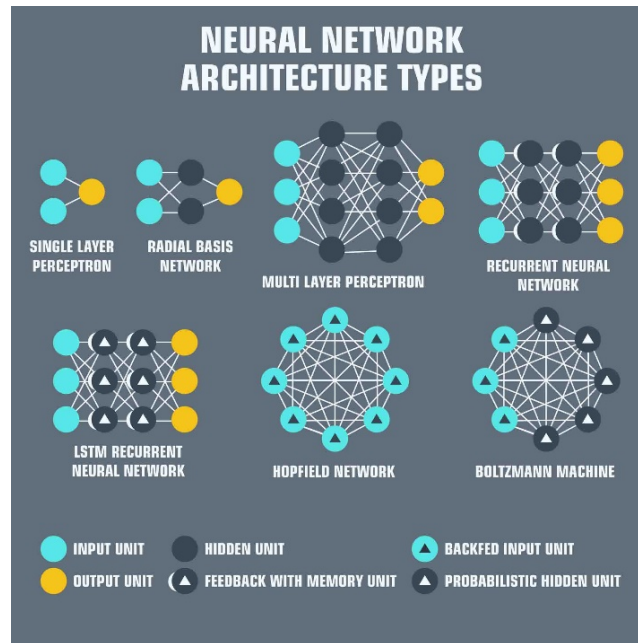


Figure 5: This diagram shows the type of neural network that can be used to set up a neural network (Joshinav, 2019)

The reason why ANN's are more useful than Rule-Based Learning because ANNs can solve problems where the "rules to solve the problem, are unknown or difficult to express" (Latif, 2014). ANNs are useful when solving problems that require a lot of data and can be used for function approximation, prediction, and, optimization to name a few. ANN's have many applications in technology that have been proposed when building Intrusion Detection Systems or IDS that are used in the creation of WSN (Wireless Sensor Networks). ANN's benefits can be seen in IDSs since the "detection rate for routing attacks is above 95%; however, the low detection rate is observed in case of channel access attack" (Latif, 2014).

Hybrid Learning System

The concept of ANN can be extended upon through Knowledge-Based Learning and Hybrid Learning (Latif, 2014). One method that is often used is the Hybrid system learning. Hybrid system learning is a method that is applied to ANN. It uses knowledge from a particular topic with additional examples to supplement the learning of an AI that is using the ANN technique. This is needed since the extra information can be given to the AI to learn in case it did not receive this knowledge during training. It is given the name "Hybrid Learning" because this technique of teaching the AI consists of a hybrid of learning with the ANN technique while adding additional information that the AI did not learn. Here is an example of how Hybrid Learning works:

One way that you can teach a student is to offer "lots of examples". When you show a student these examples, "you would tell your student only whether the example is or is not" correct. After showing a suitable number of examples, "your student could classify new examples by comparison to those already seen" (Latif, 2014).

Hybrid learning is useful because the system is expected to learn more efficiently by including extra learning materials for the system. The way that this system works alongside ANN is shown in the diagram below.

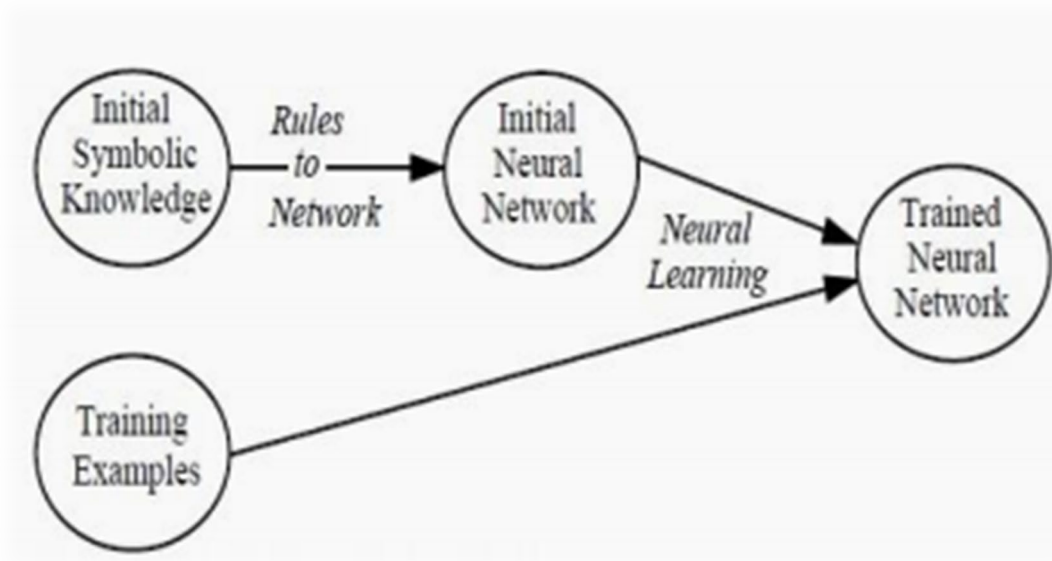


Figure 6: This image shows how Hybrid Learning techniques are used in conjunction with ANN to implement AI (Latif, 2014).

Genetic Algorithms

Genetic algorithms or GA “is a search technique mimicking natural selection” (Chen et al., 2008). Here is how this problem works: The Genetic algorithm holds a set of strings that stores a possible solution to the problem. Each possible solution that is written in a string is called “a chromosome” since these strings will change generation after generation similarly to a chromosome. These strings include a set of grammars or automata. Then, some operations (called Genetic Operators) are set that enables the population to evolve for the better in a function called the “fitness function”. This algorithm keeps evolving until the problem is fully solved. Then new populations of solutions or the newly generated strings “are known as generation” (Chen et al., 2008).

Genetic Algorithms

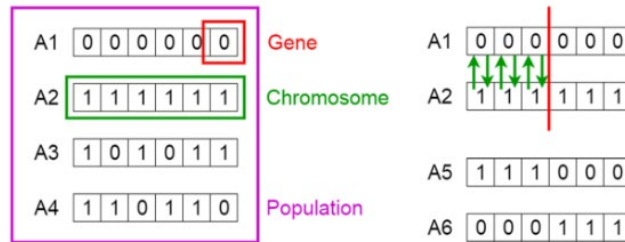


Figure 7: This diagram describes how strings are used to implement Genetic Algorithms (Seattle, 2020)

Some issues that must be considered to implement Genetic Algorithms are as follows (Yurtoğlu, 2018):

1. What information is offered in the list of strings (also known as the search space)? Does the list of strings only include *any* general grammars or only *correct* grammars?
2. How are the first generation of solutions constructed?
3. What are operations (called Genetic Operators) that will be used to generate new solutions? These operations can range from mutations (mutate a symbol in a given string into another symbol) or crossing-over (takes two strings and intertwines them to create new strings for the next generation).
4. What happens if new solutions are not generated after an evolution?
5. What type of fitness function should be used in the implementation?

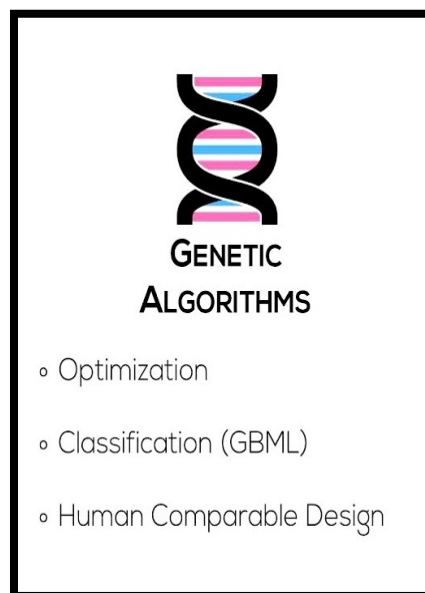


Figure 8: This diagram shows a brief description of the uses of the Genetic Algorithm technique (Fisher, 2016).

Genetic Algorithms seem to be the most successful when creating IDS (Intrusion Detection Systems). There are many parameters that this system takes into consideration such as protocol type and network services to create rules for the algorithm. IDS that are built using this technique are trained using specific sets of data to ensure that it can identify attacks on the security. Some authors claim that this type of algorithm has been deemed to produce a detection rate of DoS attacks that is at 100% (Alrajeh and Lloret, 2013).

Artificial Intelligence Architecture and Platforms

ANN's, Hybrid Systems, and Genetic Algorithms were introduced in the previous section so this section will explain other AI architectures and platforms. To understand these concepts, it is important to introduce the basic building blocks of artificial intelligence architecture. The reason and AI is such a vast field with limitless potential is because of the numerous attempts to mimic the human brain. AI focuses on being able to identify, perceive, adapt, and categorize objects in everyday life. These objects can be physical like facial detection or animal recognition or they can be pattern based like with genomic sequencing and prediction-based studies. The better that AI can imitate how humans perceive and classify the world around us, the more versatile AI becomes.

Benchmarks

To determine how well artificial intelligence techniques can interact and distinguish the world around us, there are many different benchmarks and classifiers that researchers use. As an introduction, it is important to talk about the Turing Test as an AI benchmark. The Turing Test was created by Alan Turing in the 1950s and it was designed as a psychological experiment. Psychology and AI are closely related since a lot of research with AI tends to attempt to mimic the human brain. The experiment was designed like this: A researcher is in a room and asks questions to two other people, each in separate rooms. One is a human and one is a robot. It is the robot's job to successfully answer the questions of the researcher so that the researcher cannot distinguish which individual is the human and which is the robot. This simple test can be expanded in other ways and benchmarks but the idea of creating a functioning robot to emulate a human is the same.

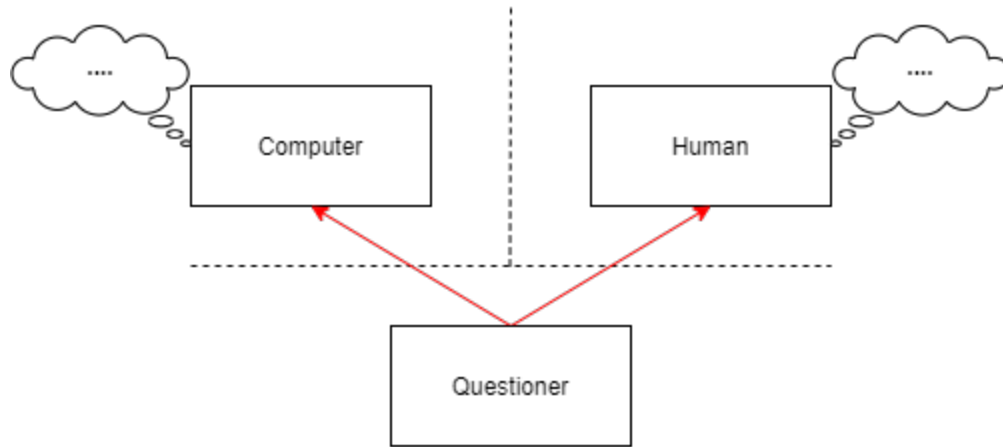


Figure 9: Turing Test (figure by Haley in Draw.io)

Artificial Neural Networks (ANNs)

“At a very high level, neurons interact and communicate with one another through an interface consisting of axon terminals that are connected to dendrites across a gap (synapse)”(Castrounis, 2016) These biological neural networks inspire artificial neural networks(ANNs) which are the most commonly used AI architecture. ANNs are composed of artificial layers of neurons that receive an input and apply a function and its cost to create an output. Artificial neural networks consist of input layers, hidden layers, and an output layer. ANNs can be extremely complex and reflect their complexity based on the given input and data set. Deep learning is worth mentioning and is an important part of AI as well.

Artificial neural networks encompass many different architectures and can be broken down into several categories: single layer, multi-layer, and recurrent networks. For this paper, we will focus on the general architecture of ANNs which will give an understanding of how a lot of neural networks work and can be implemented. ANNs consist of input layers, hidden layers, and output layers. Perceptron’s are single-layer neural networks that have a feed-forward approach. They have been around since the 1940s but became relevant once the idea of backpropagation was introduced into artificial intelligence (Stewart, 2020). Backpropagation is an important concept that allows neural networks to use hidden layers to adjust different weights, biases, and metrics to teach the network what the desired outcome should be. The hidden layer houses an activation function, of which there are many with different purposes to choose from.

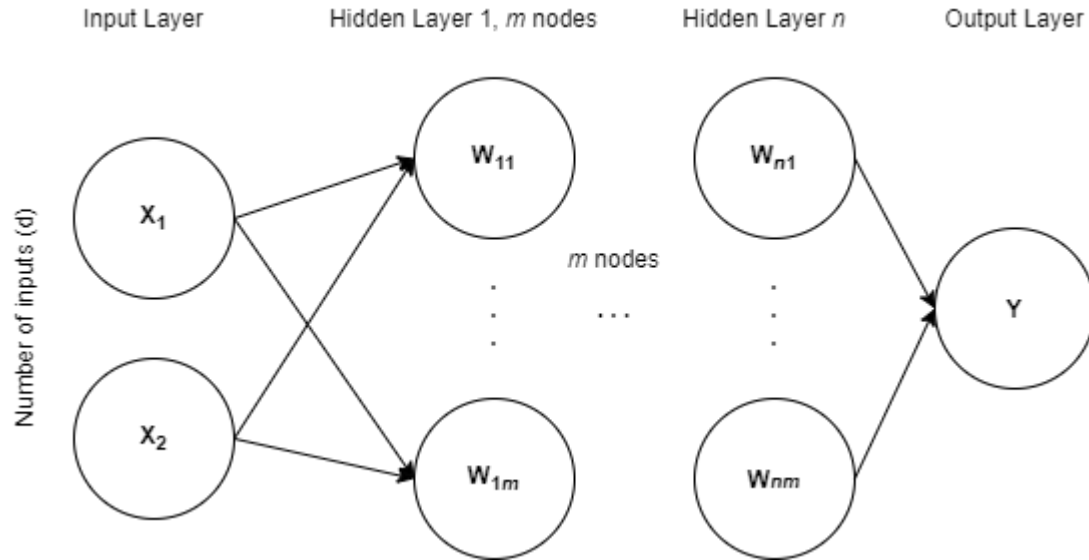


Figure 10: Multi-layer ANN architecture (figure by Haley in Draw.io)

The activation function is similar to when neurons in the brain are fired off when certain criteria are met (Stewart, 2020). The function makes sure that neural networks are nonlinear and that gradients remain big throughout the hidden layers. The general formula for the activation function is:

$$h = f(W^T X + b)$$

where the function includes weights and biases which produce h , the output of the network. Once input is fed into a network, the data then goes into the hidden layers and is modified using the activation function and loss functions to feed something into the output layer. If the network is not sufficiently trained to deliver accurate output, the data is then backpropagated to be adjusted by the weights and biases and fed through the network again.

ANN architectures come in wide varieties and there are many different types of activation functions, network structures, and more variables to choose from. Generally, it is important to choose a network that is large enough to approximate with enough degree of accuracy but not too large so that the time it takes to train the network is too great (Stewart, 2020). Having a large dataset helps networks become more accurate and more hidden layers and cells within those layers will produce higher accuracy than networks with less hidden layers.

AI Architecture in User Interface Design

User Interfaces that implement an AI aspect can be broken down into two categories: artificial intelligence that contributes to optimizing user interfaces by reading user input and guidelines to update and change with the user. The second category is the artificial intelligence that contributes to the creation of optimal user interfaces at an application creation level. These two categories can go hand in hand but the first mainly considers users in real-time and changes based on how they interact. The second takes data about users, their tendencies, how they like certain features, and creates an interface that is optimal according to the neural network's output.

(Crider, 2013) Real-time use of AI in user interfaces architectures provide constantly improving feedback for users and changes. This has its limitations and sometimes it's not necessary to create an interface architecture that needs to be updated frequently. This is where using AI to create architectures optimally can be valuable. These architectures can be created with optimality in mind and AI is used as a tool to aid that creation. Before explaining UI implementations with AI it is important to have an overview of how artificial intelligence is categorized and its architectures.

Another important aspect of human-computer interaction in artificial intelligence is how easy it is to implement AI. User interfaces can create easy to understand graphical representations so that ANNs and other networks are easier to structure. When creating a neural network or an artificial intelligence algorithm, a programmer must hard code it. Recent technologies allow for easier access to resources that make it easier to develop and implement complicated networks. Keras and Tensorflow are libraries integrated into Python which allow for programmers to implement different layers and activation functions of neural networks. Other user interfaces can be used outside of python that teaches artificial intelligence implementation. These libraries are just one of many functionalities that have become popular over the past decade. The gap between user interfaces and artificial intelligence is closing and allowing research and programming to be done with neural networks with more functionalities.

Optimization Techniques

Optimization techniques are constantly being recalibrated and modified in the field of artificial intelligence. Facial recognition algorithms have developed from Gaussian to Laplacian algorithms to form a mix between the two in the past couple of decades. Genetic algorithms are constantly being modified and optimized and object Artificial intelligence can be defined as the study to optimize how computers classify and react to the world as we see it. While it is important to study optimization techniques in artificial intelligence, this section looks at optimization techniques in terms of user interface engineering. These techniques can be used for better human-computer interaction and efficient AI algorithms based on these concepts.

Optimization Techniques in User Interface Design

Optimization techniques for computing and artificial intelligence are important areas of study regarding user interfaces. Users must be able to interact with computers efficiently and with minimal or little learning curves. It is important to focus on users and how they interact with touch screens, typing, scrolling, and other basic interactions of interfaces. There are several techniques used to determine the efficiency of a user interface and predict how well users can interact with it. Major techniques include: "KLM (keystroke-level model), GOMS (goals, operators, methods, and selection rules), ACT-R (adaptive control of thought-rational), and EPIC (executive process-interactive control)."(Sarcar, 2018).

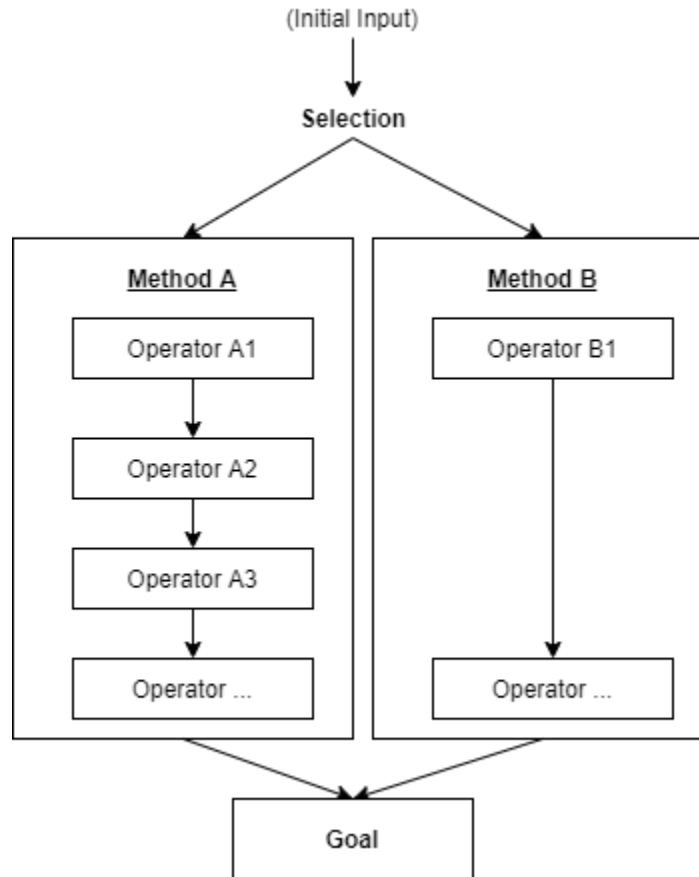


Figure 11: GOMS flow diagram (by Haley in Draw.io)

The KLM and other methods act as prediction techniques and can be examined and determined by using artificial intelligence techniques. KLM is used to assess how easy it would be for a professional to interact with a computer in a certain number of keystrokes without error (Card, 1980). This technique was developed in 1980 by Newell and the team to pinpoint efficient methods of human-computer interaction prediction. Newell, Card, and Moran broke human interaction down based on things they referred to as “unit tasks”. They derived that when given a large task, “users will break it into a series of small, cognitively manageable, quasi-independent tasks, which we call unit tasks” (Card, 1980) They go further to explain that human memory and cognition must use these unit tasks and complete them one at a time to complete the overall larger task. This leads to the areas in which they broke down the keystroke-level model into different operators. The keystroke level model can be broken down into six different areas: K, P, H, D, M. K stands for the keystroke or button presses. This measures the users' error percentage and includes each key or character press as a separate K operator. K depends on the level of users' motor skills and is calculated based on error percentage. P(pointing) represents the time that it takes for a user to point to a given target. This does not include a mouse click which would be considered a K operation. H(homing) includes how quickly a user can interact with other devices and return to the device being used. This is used to determine switching tasks back and forth. The “D operator represents manually drawing a set of straight-line segments using the mouse. D takes two parameters, the number of segments (nv) and the total length of all segments” (Card, 1980) Finally, M represents the amount of time it takes a user to make a mental decision about a task. M is a

simple operator and used to break down this mental decision as well as the time it among different users.

All these different operators depend on the type of user and reveal important insights into predictions of human-computer interactions. Other methods are discussed and used as prediction techniques as well, but KLM does a great job of simplifying user interaction and creating operators for different types of interactions. Methods such as these are a base for future artificial intelligence designs as they relate to user interfaces.

Market Implementations

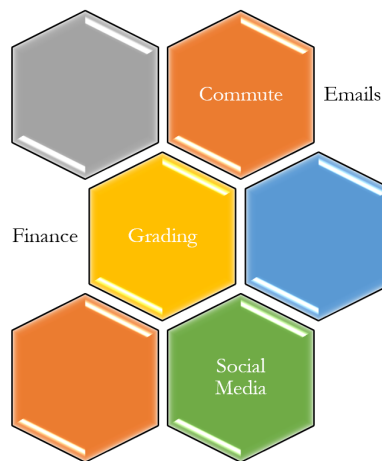


Figure 12: This figure (made by Jas) above displays the topics that will be discussed.

The range of artificial intelligence is disputed: As machines grow increasingly competent, jobs regarded as involving “power” are frequently removed from this explanation, the phenomenon called that artificial intelligence effect, leading to the quip, “AI is whatever hasn’t been done yet.” For example, visual character identification is often omitted from artificial intelligence, having become a regular application. Modern machine capabilities broadly classified as AI include successfully interpreting human language, competing in the highest degree in important play organization (e.g. chess and try), autonomously running cars, and intelligent routing in content delivery networks and military simulations (Desai, 2017).

Artificial intelligence has become intertwined with all that we do. From our architecture to our way of communication, to gathering data, Artificial Intelligence has progressed beyond what we thought possible only a few decades ago. It may be easier, now, to create a list of what artificial intelligence has not changed. Considered the keystone of the Fourth Industrial Revolution, AI has increased communication, increased automation, and enabled the production of smart technology with capabilities of analyzing and solving or assisting with problems without the need of humans.

Use of Artificial Intelligence

General Uses

The usage of artificial intelligence is growing into more widespread with possible benefits in countries as diverse as economics, philosophy, and care. Some different issues have been solved by artificial intelligence programs. Some examples are determining the winning movement (or series of motions) in the card game, formulating exact proofs, and controlling “virtual objects” in the computer-generated world (Copeland, 2020). Some examples of Artificial Intelligence are self-driving cars, instant machine translation, etc. It is hard to recognize how Artificial Intelligence affects the lives of regular people. At Emerj, the artificial intelligence research and advisory company, they are working with ambitious enterprise leaders who develop powerful Artificial intelligence strategies and find high-RIO artificial intelligence projects. New artificial intelligence use-cases and application ideas can come from consumer technologies also. Artificial intelligence is everywhere from when a person is going to work when a person is making an online purchase. Artificial intelligence is a broader goal of autonomous machine intelligence and machine learning is the specific scientific method currently in vogue for building artificial intelligence. All machine learning is artificial learning but not all artificial intelligence is machine learning. Artificial intelligence has improved in many areas. Below are some examples of how artificial intelligence is affecting the world today (Faggela, 2020).

Commuting

The first territory that artificial intelligence has improved is commuting. The vast majority drive to work or school, so it is important to attempt to chop down the drive time. Google's artificial intelligence-powered predictions utilize anonymized area information from cell phones. Google (maps) can investigate the speed of development of traffic at some random time. Maps can more effectively consolidate client revealed traffic episodes like developments and mishaps. Access to vast amounts of data being fed to its proprietary algorithms (such as Dijkstra's) implies Maps can decrease drive times by recommending the quickest courses to and from work. Ridesharing apps like Uber and Lyft, the way these applications can decide the cost of one's ride and limit the holdup time once one hails a vehicle and these administrations ideally coordinate an individual with different travelers to limit diversions. Artificial intelligence designing lead for Uber ATC Jeff Schneider utilizes Machine Learning to anticipate rider requests to guarantee that "surge pricing" (brief times of sharp cost increments to diminish rider requests and increment driver supply) will not be important soon. Uber's head of Machine Learning Danny Lange affirmed Uber's utilization of artificial intelligence for ETAs for rides, assessed dinner conveyance times on UberEATS, registering ideal pickup areas, just as for misrepresentation recognition. Moreover, business Flights utilize an artificial intelligence autopilot. Artificial intelligence autopilots are an early utilization of artificial intelligence innovation. The New York Times reports that the normal trip of a Boeing plane includes just seven minutes of human-directed flight, which is commonly held distinctly for departure and landing. An article written on artificial intelligence claims, “In the future, artificial intelligence will shorten your commute even further via self-driving cars that result in up to 90% fewer accidents, more efficient ride-sharing to reduce the number of cars on

the road by up to 75%, and smart traffic lights that reduce wait times by 40% and overall travel time by 26% in a pilot study.” (Faggela, 2020).

Emails

Artificial intelligence is additionally utilized in emails. For instance, spam channels, simple rules-based filters aren't viable because spammers can battle those. Spam channels must "learn" from an assortment of signs, for example, the words in the message, message metadata (where it is sent from, who sent it, and so forth). It needs to customize its outcome depending on what "spam" is for the individual. Messages like Gmail effectively channels 99.9% of spam. Gmail utilizes a methodology that classifies your messages into primary, social, and promotion inboxes. It additionally names messages as significant. Google acquainted smart replies to Inbox in 2015. Smart Reply utilizes machine learning to recommend three distinctive modified reactions to answer the email. Possibly later, the smart reply will have the option to give progressively complex reactions (Faggela, 2020).

Grading

Artificial intelligence is influencing evaluating and assessing territories such as plagiarism checkers, for example, Turnitin, which is a well-known tool utilized by teachers to dissect understudies' composition for copyright infringement. Turnitin doesn't uncover how it identifies copyright infringement. Research exhibits how machine learning can be utilized to develop a plagiarism detector. In the past, plagiarism detection for regular text (articles, books, essays, and so on) depended on having a colossal information base of reference materials to contrast with the understudy text; however artificial intelligence can identify the plagiarizing of sources that aren't situated inside the database, for example, sources in foreign languages or older sources that have not been digitized. Some Robo-readers help grade essays. For instance, the Graduate Record Exam (GRE), the essential test utilized for graduate school, grade articles utilizing one human reader, and one Robo-reader called e-Rater. If the scores contrast substantially, a second human reader is acquired to settle the error. In the future, we can have numerous enhancements in the education field. Classes might be replaced by customized, versatile learning that is custom-made to every students' individual quality and shortcomings (Faggela, 2020).



Figure 13: The picture above displays a Robo-reader as a teacher.

Finance

Banking and personal finance are profited by artificial intelligence. Most tremendous banks offer the ability to store checks through a wireless application, forgoing the necessity for customers to pass on a check to the bank. According to a 2014 SEC archiving, by a wide margin most critical banks rely upon development made by Mitek, which uses artificial intelligence and ML to decipher and change over handwriting on investigates text through OCR. Because of artificial intelligence, financial institutions can likewise decide whether an exchange is fraudulent. Generally, day by day exchange volume is excessively high for people to physically audit each exchange; accordingly, artificial intelligence is utilized to make frameworks that realize what sort of exchanges are false. Whenever you are applying for a loan or credit card, banks need to rapidly decide if to acknowledge or decay the applications. Artificial intelligence systems are utilized which see the interest rate, credit line amount, etc (Faggela, 2020).

Social Media

Artificial intelligence is used in social networking. For example, if you upload a picture on Facebook, the service automatically highlights faces and gives you an option to tag because Facebook uses artificial intelligence to recognize faces. Other companies such as Pinterest, Instagram, Snapchat. Pinterest uses computer vision, an application of artificial intelligence where

computers are taught to “see” to automatically identify objects in images and then recommend visually similar pins. Instagram can replace the text with emoticons according to the context, for example, “lol” can be supplanted by a giggling face emoticon. Instagram can also create and auto-suggest emojis and emoji hashtags. Snapchat has facial filters, which are called Lenses. They track facial movements that allow users to add animated effects or digital masks that adjust when their faces move. Online shopping has also benefited greatly from artificial intelligence. For example, if you look something up, websites such as Amazon bring up a list of most relevant products/items that are related to your search. Amazon has not revealed how it can do this, but they have said that they do make use of the past search patterns. There are recommendations for customers such as “customers who viewed this item also viewed” etc. Furthermore, there are personalized recommendations on the home page, through email, etc. Fraud protection is also one of the main uses of artificial intelligence in the online shopping area. It is to prevent fraud in online credit card transactions etc. We use artificial intelligence every day without even realizing it such as when we are sending a voice-to-text message or when we are using smart personal assistants such as Siri (Faggela, 2020). These are all examples of how artificial intelligence is being used today.

Education

Though the field of artificial intelligence is originally focused on the computer science and engineering aspects of education, it has a huge impact on other fields such as cognitive science, philosophy, neural sciences, and economics. Due to its interchangeability, there is no solid definition nor ground understanding of AI (Tegmark, 2018). It can be broadly described as “Computers which perform cognitive tasks, usually associated with human minds, particularly learning and problem-solving (Baker, 2019).” Here, AI can be defined to give computers the ability to problem solve and learn, compared to the way human minds work. When we look at applications in education, we can see this in several categories of software applications: tutoring, support and collaborative learning, and smart virtual reality.

Smart tutoring systems are commonly used across the country to simulate one-on-one personal tutoring. Utilizing different AI systems such as models, algorithms, and neural networks, they are capable of teaching students in many different learning paths and styles to help the student learn in any way they choose. This often helps the barrier between teachers and students when it comes to students’ many different learning styles. These tutoring systems have large potential, teaching millions of students a day and learning which way best suits different students’ cognitive abilities. Many styles of research support collaboration and malleability as the core of the learning process (Jonassen, 1995). However, like many AI models and processes, it must be monitored (Salmon, 2000). Smart AI can help with a collaborative learning environment by supporting and creating adaptive group formations, facilitating group interactions, or by simplifying discussions for professors to guide the students to the overall objectives of the course. Finally, smart virtual reality can help assist with learning in game-based learning environments. Virtual agents in this virtual reality can act as anyone from teachers to peers (Perez, 2017).

Business

In recent years, the evolution of technology and the rapidly changing needs and wants of consumers have put a heavyweight on world economics, countries, and their trades, on financial

services as well as businesses to balance their profitability with consumer needs. To compensate, Artificial Intelligence has been widely integrated into business applications such as data analytics, automation, and natural language processing. Industries utilize these three fields of AI to improve operations within the workforce and promote efficiency when providing customer services.

Automation, a core function of AI, allows for repetitive work to be alleviated. Many applications within the workforce that we use are examples of automation that go unnoticed by workers or consumers. Tasks such as taking orders at restaurants, toll booth collection, and even small things like retrieving money from an ATM, these are all examples of automation that allows the customer to make menial tasks much faster with less human to human interaction. It works for businesses as well because it saves on labor costs that can be used to make improvements within the business or the product itself. Automation is not limited to business-customer interactions either. Within different firms, automation makes work much more streamlined and efficient than relying on human interaction. For instance, compilation and organization of documents have become much easier with different development environments and advancements in cloud storage. These innovations make it possible for Automation to make it so tasks can be delegated to improve both efficiency and speed in the workplace and the field.

Challenges and Limitations

Artificial Intelligence has many challenges such as computing power, limited knowledge, privacy, data scarcity, etc. There are three main challenges today's Artificial Intelligence is facing right now. The first is distributing enough data in which it is hard to find ways to distribute data. The second is learning multiple tasks at once. And the third is the lack of insight we have into how these systems work in the first place. At the deep learning conference, the recurring theme was humility. Companies like Google say that we live in an artificial intelligence first age, but do we? There are a lot of areas that need to be worked on. Artificial intelligence is not simple, people at the front line of artificial intelligence research say there is a lot of work to be done (Vincent, 2016).

The process of artificial intelligence consists of learning about the world with the help of collected data. The amount of data involved is overlooked, there is an excessive amount of data needed. Neil Lawrence, a professor of machine learning at the University of Sheffield and part of Amazon's artificial intelligence team says that artificial intelligence requires hundreds of thousands of times more information than humans required to understand concepts and recognize. This means that if a person needs to skim through instructions to do something correctly, an artificial intelligence machine will need detailed instructions and complete practice before doing it correctly on its own. Lawrence also mentioned that big companies like Google, Facebook, and Microsoft can afford to run inefficient machine learning systems and make changes to improve them but smaller businesses might have ideas to fix the systems but they won't be able to follow through without data (Vincent, 2016).

The first main problem is to get enough data for artificial intelligence. Data and the right amount of necessary data are hard to get. To create an efficient artificial intelligence machine, a lot of resources and data are necessary. An example was given in the article which said the following: "Take health care, for example, where artificial intelligence is being used for machine vision tasks like recognizing tumors in X-ray scans, but where digitized data can be sparse." This

means that digital data can be scattered and it can alter the performance of machine learning algorithms and their ability to calculate accurate predictions. Also, Lawrence said that its “generally considered unethical to force people to become sick to acquire data.” Well, it is unethical, so we need to find a different way. He says we need to learn how we can make our deep learning systems efficient and able to work with fewer data. So, a solution to this problem will be to look for ways to use the data we already have (Vincent, 2016).

Another main problem is that artificial intelligence needs to be able to multitask but how will it? With deep learning, once current systems are trained to be more efficient, they will be able to identify all types of objects. Raia Hadsell, a Google DeepMind research scientist says that there is not any method that can be trained to identify objects or do tasks. Google’s DeepMind built a system that could beat 49 Atari games which were very impressive but each time it beat a game the system needed to be taught repeatedly to beat the next game. Hadsell said that you cannot try to learn multiple games at once because the rules of each game will interfere with the others. You can learn one at a time, but you will not always remember the previous game rules and how to play it. We want a machine to be able to learn multiple tasks and respond all together but we as humans cannot do that a lot of the time. A solution was provided which states that this is called progressive neural networks. It means that combining separate deep learning systems for them to pass on certain bits of information. A paper was published in which Hadsell and her team mentioned how their progressive neural nets were able to adapt to games of Pong that vary in small ways. In one version the colors were inverted and in the other version, the controls were flipped. It was faster than a normal neural net in which it had to learn each game from scratch. Although it is a great method it does have limitations such as not keeping on adding new tasks to their memory (Vincent, 2016).

The third main problem is the lack of insight into how these systems work. The challenge of understanding how artificial intelligence reaches its conclusions. We know how they are put together and what information is going in them but the reason we get certain decisions and outputs usually is undetermined. So, an experiment took place to see what the artificial intelligence machine looks at to determine the result it gives at the end. This experiment took place at Virginia Tech. Researchers created an eye-tracking system for a neural network in which it would record which pixels the computer looks at first. Researchers asked the artificial intelligence “What is covering the windows?” by showing neural net pictures of a bedroom. The artificial intelligence looked at the floor instead of looking at the windows and then searched for a bed and if the room had a bed then it answered as “curtains are covering the windows” It was correct but it was just because of the limited data the network was trained on. Based on the pictures shown, the neural net automatically concluded that if it were a bedroom then there would be curtains on the windows. So, it stopped looking right when it saw the bed. This would not work because some bedrooms do not have curtains (Vincent, 2016).

There is a solution to this problem which consists of building more coherence into deep learning systems. GOF AI stands for Good Old-Fashioned Artificial Intelligence. Murray Shanahan, a professor of cognitive robotics at Imperial College London and the scientific advisor on Ex Machina says that we can revisit the old, unfashionable strand of Artificial Intelligence which is known as GOF AI. This is based on the assumption that what goes in the mind can be reduced to basic logic, where the world is defined by a complex dictionary of symbols. By combining symbols, you can combine thinking. Shanahan says that we take the symbolic

descriptions of GOF AI and combine them with deep learning. So, it would provide the system some understanding of the world rather than wanting them to notice patterns through the data itself. He says it might solve the transparency problem of artificial intelligence and solve the problem of transfer learning. There is a new method created by Shanahan and his team called the deep symbolic reinforcement learning. They publish some small experiments to test it out. It is being tested to see whether it will scale up to larger systems and different types of data (Vincent, 2016).

Artificial Intelligence is the development of computing systems and software to be able to perform tasks that require human intelligence. Artificial Intelligence is a lot more complicated than people think it is. The amount of data and resources needed to create a machine is undefinable. It is very hard to find good data and a good amount of data. Along with that, it is extremely complicated to get artificial intelligence machines to do multiple tasks at once. As humans, we have trouble multitasking so trying to create a machine that can multitask requires a lot of data. And not knowing how an artificial intelligence machine works internally and why it is doing what it is doing can lead to wrong conclusions and lead to making wrong changes. Overall, Artificial Intelligence machines are not easily built and perfectly efficient (Vincent, 2016).

Evaluation metrics

Evaluating the algorithm behind the AI is very important. Your algorithm may provide good results at one point and fail the next. To give a bit more context, the algorithm may give satisfying results when testing the accuracy, but poor results when testing its logarithmic loss when dealing with higher and more complex amounts of data. There are many ways to check our models, and at times we would like to use more than one method to ensure our models work in a real-world setting to ensure that they can withstand real-world applications.

Classification Accuracy

Classification accuracy is the most commonly used way of testing an Artificial Intelligence algorithm. This can be described as the ratio of correct predictions over the number of given samples. The downside to this method is that it only works if there is an equal number of samples per class, otherwise, the percent accuracy will be incorrect. For example, if there were two classes to train the model, A, and B, and 90% of samples went to A and only 10% went to B, the training accuracy would be 90% because the model would predict everything in class A. But if we take the model and test it on a batch where class A had 60% of the samples, the test accuracy would fall to 60%.

$$\text{Accuracy} = \frac{\text{Number of Correct Predictions}}{\text{Total number of Predictions made}}$$

Logarithmic Loss

Logarithmic Loss penalizes false classification, which works very well with multi-class classification. To use this method, the classifier assigns a probability for each of the samples. The output has no upper bound and starts at 0. When the output is closer to 0, it is more accurate whereas further away from 0 it is, it is less accurate.

$$\text{LogarithmicLoss} = \frac{-1}{N} \sum_{i=1}^N \sum_{j=1}^M y_{ij} * \log(p_{ij})$$

Confusion Matrix

Confusion Matrix uses a matrix as its output and describes the accuracy of the model. The matrix focuses on four main outputs: true positives, true negatives, false positives, and false negatives. All four rely on what we predicted and what was observed. To find the accuracy, you must calculate the main diagonal, True Positive plus True Negative divided by the total sample. This is typically seen as the basis for other metrics.

$$\text{Accuracy} = \frac{\text{TruePositive} + \text{TrueNegative}}{\text{TotalSample}}$$

This is typically seen as the basis for other metrics.

Area Under Curve

Area Under Curve is a commonly used metric for evaluation and can be used on binary classification problem sets. When calculating the AUC of a classifier, we look for the probability that the classifier will output a positive sample higher than a negative sample. Like a confusion matrix, the AUC looks for True and false positives and negatives but unlike confusion matrices, we create equations to find their rates. The true positive rate, defined as sensitivity, is calculated as TP / (FN + TP). Sensitivity corresponds to the amount of positive data considered as positive. True Negative, defined as Specificity, is calculated as TN / (FP + TN). This corresponds to the amount of negative data considered as negative. False Positive rate is defined as FP / (FP + TN). This shows us how much data was incorrectly given as positive.

$$\text{TruePositiveRate} = \frac{\text{TruePositive}}{\text{TruePositives} + \text{FalseNegative}}$$

Sensitivity corresponds to the amount of positive data considered as positive. True Negative, defined as Specificity, is calculated as:

$$\text{TrueNegativeRate} = \frac{\text{TrueNegative}}{\text{TrueNegative} + \text{FalsePositive}}$$

F1 Score

F1 Score is another evaluation metric used to measure accuracy. F1 Score is calculated using the Harmonic Mean, the reciprocal of the average of all reciprocals, between precision and recall. It tells you how precise the classifier is and how many instances it does not miss from a measure between 0 and 1. High precision but low recall shows that the instance is very accurate but misses a large number of instances it found difficult to classify, and vice versa. Higher scores equate to better performance. This can be expressed in the equation:

$$F1 = 2 * \frac{1}{\frac{1}{Precision} + \frac{1}{Recall}}$$

The goal of this evaluation metric is to find the balance between precision and recall. To calculate the precision, we take the correct positive results and divide it by all positive results provided by the results.

$$Precision = \frac{TruePositives}{TruePositives + FalsePositives}$$

A recall is calculated by the number of correct positive results divided by all relevant samples.

$$Recall = \frac{TruePositives}{TruePositives + FalseNegatives}$$

Mean Absolute Error

Mean Absolute Error calculates the average of the difference between the original values and the predicted values and the original values. The goal of this is to measure how far off the predictions are from actual output, though it does not give any real direction of the error, just that there is one. This one is common amongst supervised learning. It can be expressed as:

$$MeanAbsoluteError = \frac{1}{N} \sum_{j=1}^N |y_j - \hat{y}_j|$$

Mean Squared Error

Mean Squared Error and Mean Absolute Error are commonly used interchangeably, the difference being that Mean Squared Error takes the square of the difference between the original and predicted values. You would typically use Mean Squared Error because it's much easier to compute gradients, as opposed to Mean Absolute Error which requires a lot of complicated programming. This model is good for focusing on larger errors.

$$MeanSquaredError = \frac{1}{N} \sum_{j=1}^N (y_j - \hat{y}_j)^2$$

Project Summary

AI and ML have evolved itself in different Architectures and Platforms across the Medical Field, the Business field, and more. The Market Implementations for these technologies tend to vary depending on the expected end-users of the product. To ensure that AI and ML are implemented in the best way possible, there are many Enabling Technologies, Optimization Techniques, and Evaluation metrics that are used. For this reason, AI and ML have been able to grow exponentially in their abilities to solve many problems in society. However, with the advent of this technology comes challenges and limitations that also need to be discussed when creating and introducing this technology to the public. Therefore, when examining AI and ML, we need to weigh the pros and cons of these technologies when studying the Emerging Techniques & Technologies of Artificial Intelligence & Machine Learning.

Work Cited (Images)

Figure 1- Labs, L. (2019, November 4). [Illustration]. Accurate insurance claims prediction with Deep Learning. Lotus Labs Custom software development with machine learning. <https://lotuslabs.ai/accurate-insurance-claims-prediction-with-deep-learning/>.

Figure 2- Bourlai, E. (2020, February 14). [Illustration]. Combining the Best of Both Worlds: Machine Learning & Rule-Based Approach. <https://www.megaputer.com/best-of-b> Card, S. K., Moran, T. P., & Newell, A. (1980). The keystroke-level model for user performance time with interactive systems. Communications of the ACM, 23(7), 396-410.

Figure 3- dnsstuff. (2020, July 21). [Illustration]. IDS vs. IPS in 2020: What is the Difference? DNSstuff. <https://www.dnsstuff.com/ids-vs-ips>.

Figure 4- “Genetic Algorithms - Jeremy Fisher.” [Illustration]. Performance by Jeremy Fisher, Youtube, Cerner's Tech Talk Series, 2016, www.youtube.com/watch?v=7J-DfS52bnI. Accessed 3 Oct. 2020.

Figure 5- Joshinav, N. (2019, April 1). [Illustration]. 3 types of neural networks that AI uses: Artificial Intelligence. Application development. <https://www.allerin.com/blog/3-types-of-neural-networks-that-ai-uses>.

Figure 6- Kamran Latif. [Illustration]. “Hybrid Systems Knowledge Representation Using Modelling Environment System Techniques Artificial Intelligence”. In: Cornell University (Sept. 2014), pp. 1–3. DOI: 10.3897/bdj.4.e7720.figure2f. URL: <https://arxiv.org/abs/1409.11170>

Figure 7- Seattle, Eliot. [Illustration]. “Deadlock Detection - Windows Drivers.” Windows Drivers | Microsoft Docs, Microsoft 2020, 4 June 2020, docs.microsoft.com/en-us/windows-hardware/drivers/devtest/deadlock-detection.

Figure 8- “Genetic Algorithms - Jeremy Fisher.” [Illustration]. Performance by Jeremy Fisher, Youtube, Cerner's Tech Talk Series, 2016, www.youtube.com/watch?v=7J-DfS52bnI. Accessed 3 Oct. 2020.

Figure 9- Figure made by Haley in Draw.io

Figure 10- Figure made by Haley in Draw.io

Figure 11 - Figure made by Haley in Draw.io

Figure 12- Figure made by Jaspinder Kaur in Microsoft Word.

Figure 13 - Robots. (2012, March 29). [Illustration]. Robo-Readers: The New Teachers’ Helper in the U.S. <https://www.reuters.com/article/us-usa-schools-grading-idUSBRE82S0ZN20120329>

Extended Resources

Reference URL	Reference Description
https://youtu.be/sXx-PpEBR7k	This video is a short introduction to the Turing Test, an AI benchmark used to determine if a computer can fool a human into thinking it is human as well.
https://www.youtube.com/watch?v=XB4MIexjvY0&t=857s	This video explains Dijkstra's algorithm, which is used in map services to figure out the shortest path.
https://www.youtube.com/watch?v=masnR4-vt3M	This video discusses all the benefits that AI provides such as solving complex problems etc.
https://www.youtube.com/watch?v=zs26A5qVFA4	This video discusses the challenges AI has and what we can do to prepare for them and advance further.
https://www.youtube.com/watch?v=7J-DfS52bnI	This video is a part of a whole series called Cerner's Tech Talk series published in 2016. This portion of the program is called The Genetic Algorithms. The speaker's name is Jeremy Fisher. He gives viewers an explanation of what Genetic Algorithms are and how to implement this type of Algorithm.
https://www.youtube.com/watch?v=Uk9YA1kwZLw	This video is a video from the 1980s called "Edward Feigenbaum & Penny Nii: Expert Systems (excerpt): Thinking Allowed w/ Jeffrey Mishlove". It is a clip from a TV show called ThinkingAllowedTV. In the video, a discussion about Expert Systems- which we know was one of the topics that lead to AI's today- is conducted.
https://www.youtube.com/watch?v=oLHc7rlac2s	This video called "Expert Systems"- provided by an education YouTube channel called "Gregg Learning" gives a brief explanation of what an expert system is.
https://www.youtube.com/watch?v=leXa7EKUPFk	This video called "3. Reasoning: Goal Trees and Rule-Based Expert Systems" is part three of a lecture from MIT in which the speaker describes the logic behind rule-based technology. The full lecture was about building Artificial Intelligence. The speaker is Patrick Winston.
https://www.youtube.com/watch?v=Ozipf13jRr4	This video called "John McCarthy (1927-2011): Artificial Intelligence (complete) - Thinking Allowed -Jeffrey Mishlove" is a clip from a TV show called "ThinkingAllowedTV". It is an interview with John McCarthy who discusses AI.
https://www.analyticsinsight.net/top-10-must-know-artificial-neural-network-software/	This article is a list of different libraries and user interfaces that make artificial neural network creation more user friendly.

References

- Alrajeh, N. A., & Lloret, J. (2013). Intrusion Detection Systems Based on Artificial Intelligence Techniques in Wireless Sensor Networks. *International Journal of Distributed Sensor Networks*, 9(10), 351047. <https://doi.org/10.1155/2013/351047>
- Baker, T., & Smith, L. (2019). Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges.
- Castrounis, A. (2016, September 01). AI, Deep Learning, and Neural Networks Explained. Retrieved September 10, 2020, from <https://www.innoarchitech.com/blog/artificial-intelligence-deep-learning-neural-networks-explained>
- Copeland, B. J. (2020, August 11). Artificial Intelligence. Britannica. Retrieved September 10, 2020, from www.britannica.com/technology/artificial-intelligence
- Crider, A. L., & Schwink, S. (2013). U.S. Patent No. 8,490,050. Washington, DC: U.S. Patent and Trademark Office. oth-worlds-rule-based-ml/.
- Desai, R. (2017, March 23). Artificial Intelligence. Retrieved September 10, 2020, from <http://drarajivdesaimd.com/2017/03/23/artificial-intelligence-ai>
- Faggella, D. (2020, April 11). Everyday Examples of Artificial Intelligence and Machine Learning. Retrieved September 10, 2020, from <https://emerj.com/ai-sector-ov>
- Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B. B. (1995). Constructivism and computer-mediated communication in distance education. *American Journal of Distance Education*, 9(2), 7–25. <https://www.tandfonline.com/doi/abs/10.1080/10590469508842000>
- Kamran Latif. “Hybrid Systems Knowledge Representation Using Modelling Environment System Techniques Artificial Intelligence”. In: Cornell University (Sept. 2014), pp. 1–3. DOI: 10.3897/bdj.4.e7720.figure2f. URL: <https://arxiv.org/abs/1409.1170>
- Mallawaarachchi, V. (2020, March 1). *Introduction to Genetic Algorithms - Including Example Code*. Medium. <https://towardsdatascience.com/introduction-to-genetic-algorithms-including-example-code-e396e98d8bf3>.
- N. Elakkiya, S. Karthikeyan and T. Ravi, "Survey of Grading Process for Agricultural Foods by Using Artificial Intelligence Technique," 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, 2018, pp. 1834-1838, doi: 10.1109/ICECA.2018.8474663.
- Nadir Yurtoğlu. “Artificial Intelligence Techniques”. In: History Studies International Journal of History 10.7 (2018), pp. 241–264. DOI: 10.9737/hist.2018.658. URL: <http://pagesperso.lina.univ-nantes.fr/~cdlh/book/ArtificialIntelligenceTechniques.pdf>
- Perez, S., Massey-Allard, J., Butler, D., Ives, J., Bonn, D., Yee, N., & Roll, I. (2017). Identifying productive inquiry in virtual labs using sequence mining. In E. André, R. Baker, X. Hu, M. M. T. Rodrigo, & B. du Boulay (Eds.), *Artificial intelligence in education*, (vol. 10,331, pp. 287–298)

- Raffaele Cioffi et al. "Artificial Intelligence and Machine Learning Applications in Smart Production: Progress, Trends, and Directions". In: Open Access Journal (Jan. 2020), pp. 1–26. URL: <https://ideas.repec.org/a/gam/jsusta/v12y2020i2p492-d306600.html>.
- Salmon, G. (2000). *E-moderating - the key to teaching and learning online*, (1st ed.,). London: Routledge.
- Sarcar, S., Jokinen, J. P., Oulasvirta, A., Wang, Z., Silpasuwanchai, C., & Ren, X. (2018). Ability-based optimization of touchscreen interactions. *IEEE Pervasive Computing*, 17(1), 15-26.
- Serena H. Chen, Anthony J. Jakeman, and John P. Norton. "Artificial Intelligence techniques: An introduction to their use for modelling environmental systems". In: *Mathematics and Computers in Simulation* 78.2-3 (2008), pp. 379–400. DOI: 10.1016/j.matcom.2008.01.028. URL: <https://www.researchgate.net/publication/257219838ArtificialIntelligenceTechniquesAnIntroductiontoTheirUseforModellingEnvironmentalSystems>
- Stewart, M. (2020, July 29). *Comprehensive Introduction to Neural Network Architecture*. Retrieved October 1, 2020, from <https://towardsdatascience.com/comprehensive-introduction-to-neural-network-architecture-c08c6d8e5d98>
- Tegmark, M. (2018). *Life 3.0: Being human in the age of artificial intelligence*. London: Penguin Books.
- Vincent, J. (2016, October 10). These are three of the biggest problems facing today's AI. Retrieved October 02, 2020, from <https://www.theverge.com/2016/10/10/13224930/ai-deep-learning-limitations-drawbacks>
- Wagoo, Divanshi Priyadarshni. (2018) *Artificial Intelligence Techniques in Software Engineering for Automated Software Reuse and Design*. Retrieved October 08, 2020. <https://ieeexplore.ieee.org/document/8777584/authors>
- Zawacki-Richter, O., Marín, V.I., Bond, M. et al. Systematic review of research on artificial intelligence applications in higher education – where are the educators?. *Int J Educ Technol High Educ* 16, 39 (2019). <https://doi.org/10.1186/s41239-019-0171-0>