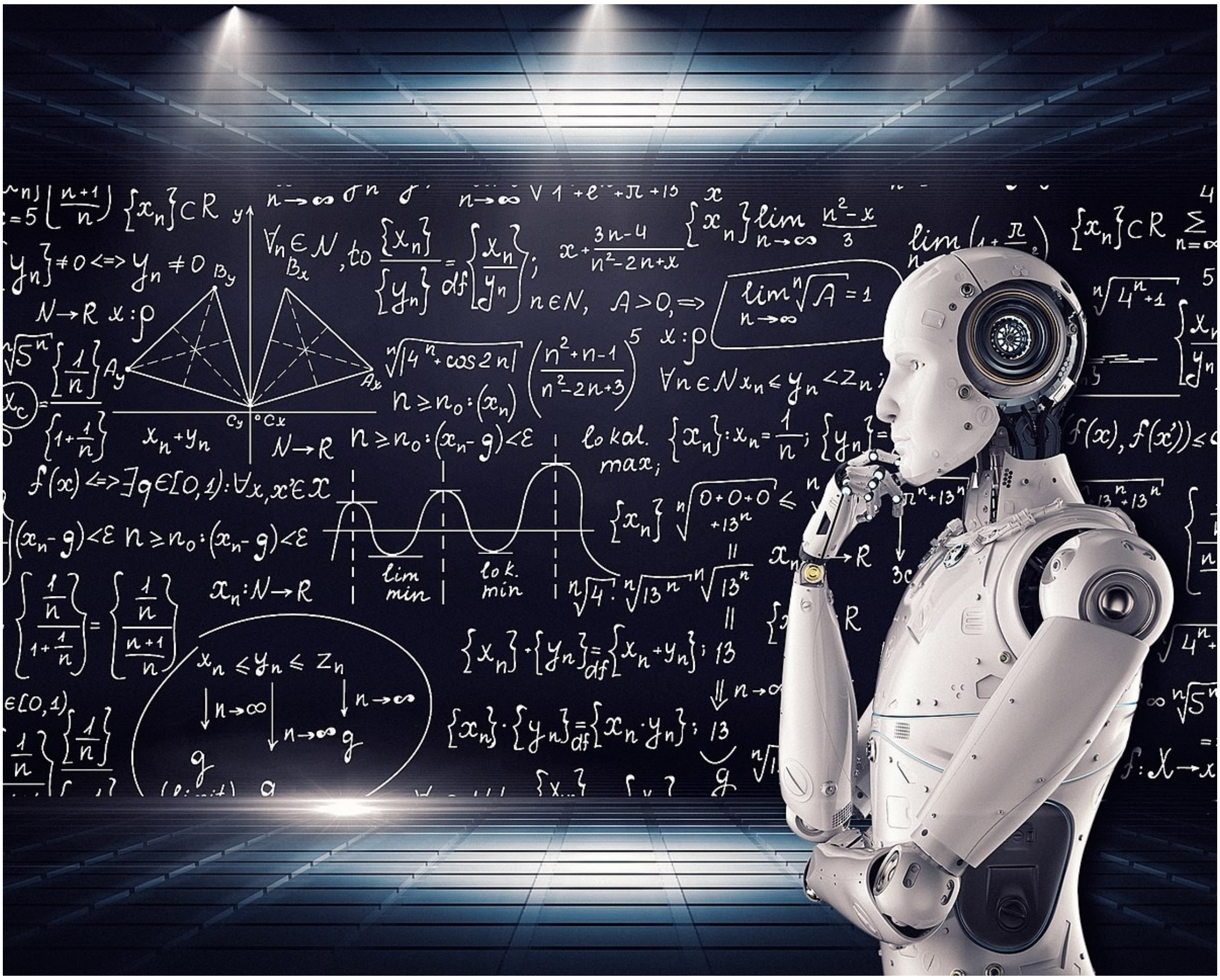
Introduction to AI; A structured Essay



By Joshua John-Baptiste

Contents

Introduction

Artificial intelligence (AI) is the replication or imitation of human intelligence by a computer to execute tasks that require human intelligence. There are multiple methods to achieving this intelligence such as:

- Machine Learning
- Vision e.g. image recognition
- Speech e.g. speech to text

For anything to be considered intelligent it must:

- Be able to learn
- Have reasoning
- Perform tasks

AI accomplishes this with clever technological solutions. With the proliferation of AI, the solutions, techniques and use case is forever growing and will play big part in our societies future. Artificial intelligence already plays many roles in our society today, simplifying processes, enhancing our capabilities, providing analysis and insight, improving efficiency, basic services and so much more!

In the health sector

The Da Vinci System is device used to assist in surgery created by Intuitive. It was designed to be “a natural extension of the surgeons eyes and their hands”[1]. The device has HD 3D monitor and robotic arms, which can be used as an extension of human arms. The surgeon sees with the monitor and controls the robotic arms to perform the surgery. It has assisted surgeons for 20 years and is a leading robotic surgery solution. The device facilitates surgeries without human errors like such as shaking.It also has the capability to make recommendations based on the current situation of the surgery. Through the years, intuitive has continued to iterate on their designs, incorporating data and feedback from its continued use. Dr Matthew Sappington advocated the use of the Da Vinci system, describing it as “giving them [surgeons] more flexibility to operate”. He then goes on to mention that its addition gives the surgeons “much more functionality to our hands” [2]. A paper reviewing the Da Vinci system concludes that an iteration of the system “simplifies multi-quadrant surgery through its improved docking interface and extended reach” [3].

In the security sector

Artificial intelligence has reinforced and expedited checks for safety. Facial recognition has played a big role in that. With the help of deep learning or ANN (more on this later), a scan of an individual’s face can be used as a sort of password, to assist in security checks and more[4]:

Pros

- More robust for than passwords which can be forgotten or misplaced
- Expedites security process
- With a robust system, it can identify criminals more accurately than manual processes which are vulnerable to human error

Cons

- Privacy issues
- Racial disparities, more on this later [9]
- 3rd parties may need to verify faces, consuming the scan faces. This opens up a lot of concerns

With the proliferation of the technology a lot of people believe in its potential even with the drawbacks it introduces, with 68% of Americans believing it can make society safer and 83% of Americans believing governments should works with law enforcement on facial recognition technology rather than banning it [5].

In the farming industry

AI is transforming the farming industry making it more efficient, boosting productivity and removing simple manual processes in a variety of ways. Farmers can now use AI to maintain the safety of their livestock with AI. Virtual pastures can prevent cattle from getting hurt on wired fences, designed to keep out intruders, like predators. With the assistance of GPS collar trackers, they can keep cattle in a defined area with an app on their smartphones. The can omit noises or give the cattle a shock, if they go out of bounds.

This ironically introduces the potential ethical and moral problems and highlights the potential issues AI can impose, even if its intended for good. For now, its use will need to be monitored and policed, which is the case with the shock collar [6].

With image recognition technology, bots and drones can pick fruits and vegetables automatically. In addition, they can remove weeds[8]. Drones can also be used to eliminate pest like Moths, with the assistance of sensors.

In the employment industry

Like all human decisions, the recruitment process can be subject to bias, potentially discriminating against a group of people. For things like names, ethnicity and or sex, people can be blocked from job opportunities that they’re qualified for. This is where Knockri comes in. They came up with a AI solution that removes these biases. With the assistance of facial recognition and speech recognition, they can screen candidates and evaluate their skills and expertise, without the candidates exposing details, which can be used to discriminate against them [15].

AI Decisions Making

Minimax is a type of algorithm that facilitates decisions in game theory and artificial intelligence. It determines the best strategy in a two player or agent(more on agent later) zero-sum game (a game where one agent will win and the other will lose) with perfect information (historical data on the previous moves/ decisions and its result). Its designed to highlight the best move or situation that leads to a pre-defined goal for an agent, assuming that both agents are playing optimally in the game.

The algorithm works by simulating a game with both agents playing optimally. With both agents in the game playing optimally, the simulated game will adhere to the nash equilibrium. The nash equilibrium is a concept involving a two agents in a game, where both agents are playing with the best possible strategy given the opposing agent's strategy. Neither agent would change or adapt to the opposing agent’s strategy since they're already using the best strategy regardless of the circumstance. The simulated game will be based on the current state of the game and will help an agent decide the best outcome. Within the simulated game, the agents playing are each assigned one of the following labels:

- Maximiser- this agents purpose is to find the move with the highest possible utility or a goal, trying to setup the best outcome for itself. When its the maximiser’s turn to move, it will pick the move that increases the minimiser’s minimum utility, which they will eventually pick in an optimal game
- Minimiser- This agents purpose is to choose a move with the lowest possible utility, trying to find the best possible outcome for itself. When its the minimiser’s turn to move, it will pick the move that decreases the maximiser’s maximum utility, which they will eventually pick in an optimal game

In the simulated game each agent will take turns, one after the other, making moves and all moves and their outcomes will be evaluated to identify that moves utility. It’s up to the player or creator to decide how to gauge the utility of each move. Once all potential moves are evaluated, the algorithm will then backtrack from the goal state to identify the path with highest utility that puts the maximiser in the position to win unless its finds a path to the goal state. If a goal state is identified at the end of any path, that path will picked as the solution. Given that all optimal moves and their outcomes are evaluated, if the best optimal solution exist it will find it. Each move and the predicted outcome are commonly plotted using a tree diagram. Each move is represented as a node that can be evaluated.

Although this algorithm is effective, its has its limitation. For example, with complex games like Chess, where the potential moves and the branching of their potential outcomes is vast and computationally taxing, illustrated below in figure 2.1. and demonstrated here. The algorithm’s will be slow or impossible to execute in that scenario. In situations like Chess, alpha-beta pruning is apt.

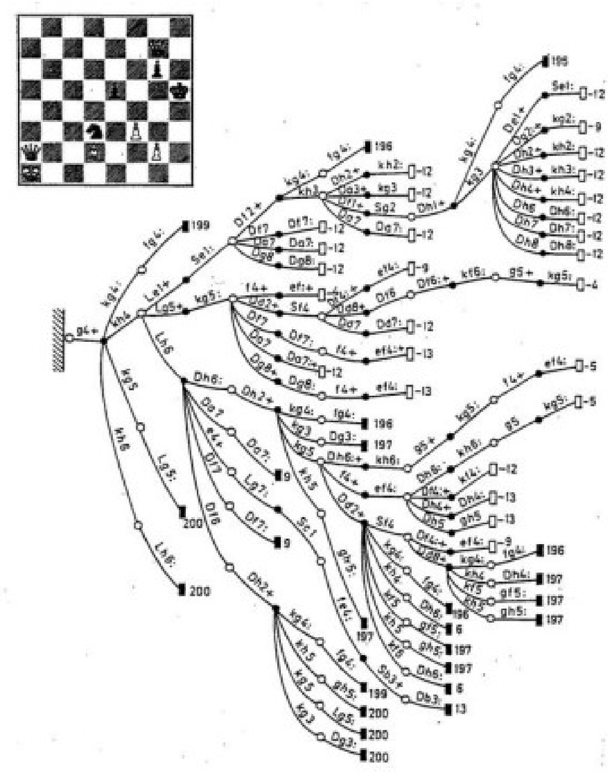


Fig. 1: Example of a game tree for chess

Figure 2.1 A game tree for chess using minimax [7]

Alpha-beta pruning is an extension of minimax that doesn't evaluate all branches for potential moves. It leverages the utility of other branches to decide whether it needs to further explore potential moves on a branch or sub branch. It will also prune evaluated branches with low utility because an optimal game is simulated and it will not impact the outcome.

This algorithm is only effective in games with complete perfect information. In an imperfect information game without complete information like Rock, paper, scissors, it hard for its to identify the optimal strategy.

The minimax algorithm is more apt in games like tic tac toes and connect four, which can provide complete perfect information about the state of the game. Unlike Chess, it will have the capacity to evaluate all branches and find best strategy because there are less potential moves to make than in connect four or tic tac toe.

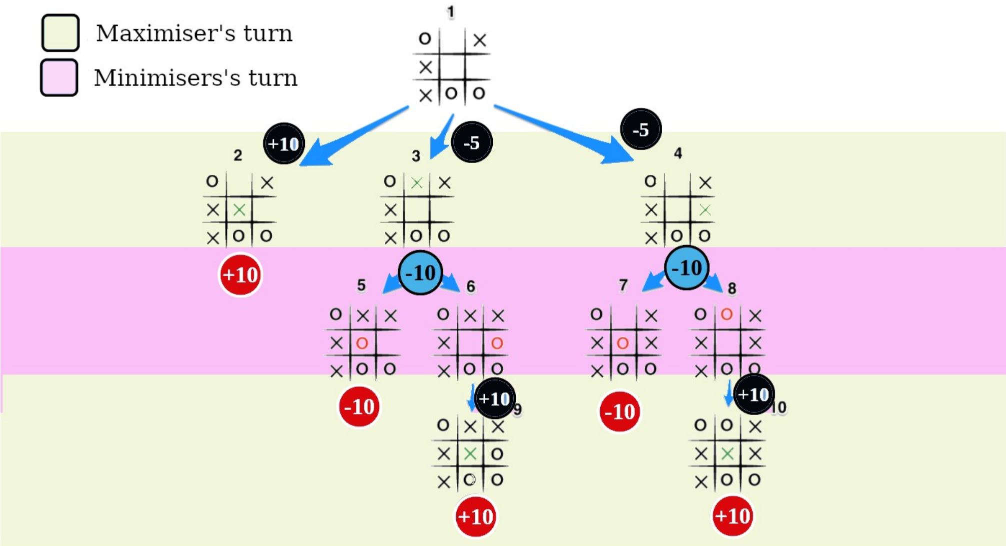


Figure 2.2 A tree search diagram illustration of minimax with tic tac toe

In figure 2.2, I have created a minimax tree search for tic tac toe. The tree highlights the decisions in the game and their utility, which is random. The red node represent the end of a tree of goal state. Based on the diagram, its clear that placing the "X" in the middle (diagram 2) is the best move to make if playing optimally as the maximiser, because that move has the highest utility. This is also demonstrated in this video. Alpha-beta pruning can still be applied to these games, optimising the decision making process.

Tree Searches

A search tree is a data structure used to find a solution to a predefined problem. The structure represents every potential state from the initial state using a tree structure, with the leaves known as nodes, representing a possible state.

The following terms are used to help explain the structure:

- Path- The actions leading from one state to another
- Successor function- The process that moves the current state onto a next state
- Initial state- The beginning or current state of the problem

- Goal state- The target state to be achieved
- Solution- The path or series of states that lead from the initial state to the goal state

Search Algorithms

Search algorithms are a means to finding a predefined goal state or a state space with the best utility for making decisions. It moves from the initial state and will move down each branch/ path until it finds a goal state. If the algorithm can't locate a goal state, then the state space with the highest utility will be recommended as the solution. The implementer can put a limit on how many moves the algorithm should evaluate, before a the search for the goal state is abandoned and the state space with the highest utility is chosen. The implementer can also decide how to measure the utility of each state space. Below I will be discussing two search algorithms where a search tree can be used to describe the algorithm and its process in finding the goals state.

Depth First search:

Depth first search (DFS) is a iteration of a search algorithm that adheres to the concept of last in first out (LIFO). The algorithm will explore a path until it reaches then end or the algorithms depth limit, adding each state space as its goes along to the top of the stack. The top of the stack is then evaluated for the goal state. If a goal state exist, that path to the goal state is recommended as the solution. Otherwise, the utility of the end state space at the top of the stack will evaluated and removed from the stack. This will initiate the process of backtracking, looking for sibling state spaces from the parent state space, now at the top of the stack. If any siblings exist, that state space will be added to the top of the stack, and the algorithm will continue to explore that branch until it reaches the end, its depth limit or a goal state. This cycle of branching down and backtracking will repeat itself until a goal state is identified or until it has evaluated all potentials paths, building the search tree.

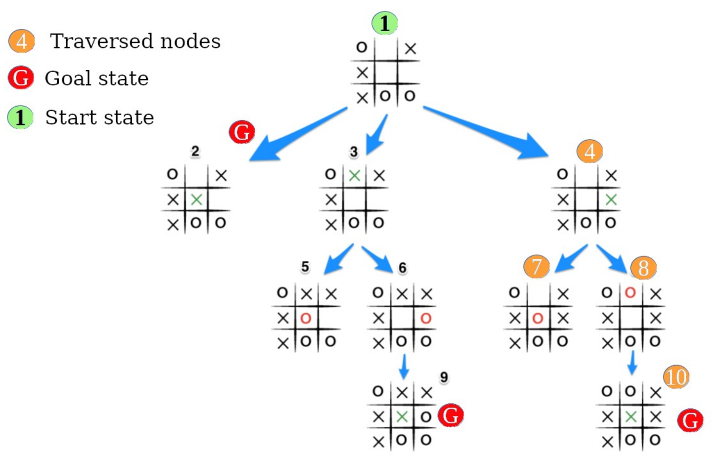


Figure 3.1 A search tree demonstrating depth first search

In figure 3.1, a search tree for the DFS algorithm highlights the path this algorithm will traverse to find the goal state, assuming it is moving from right to left. The algorithm will move from state 1, 4, then 7. Since it couldn't find a goal state on that path, it will backtrack and look for the goal state on state spaces 7's sibling space state 8. From space state 8, it will venture down to space state 10, where the goal state is identified. That path will now be recommended as a solution (1,4,8,10).

If the goal state did not exist on at state space 10, DFS will backtrack to state 1 and go down state 3 and repeat the cycle.

This algorithm is best implemented in games with limited branching, like tic tac toe. The minimax algorithm, mentioned in the previous section, implements DFS and is therefore applicable in Connect four, too.

This algorithm is effective in finding the goal state if it exist and the depth of the search stretches long enough in the current state. Its apt for deep searches middle level of potential state spaces.

Breadth First search:

Unlike DFS, Breadth First Search (BFS) adheres to the concept of first in first out (FIFO). BFS will add all state spaces to the back of the queue, matching the ordered in which they were discovered and evaluated. Once all state spaces on the same level are in that queue, it will then review each state space, targeting the goal state space. If no goal state exist on that level, the algorithm will sequentially look to add child state spaces to the end of the queue for the state spaces currently in the queue. The state spaces of the current level that were evaluated will then be removed from the queue. It will continue this pattern until a goal state is identified.

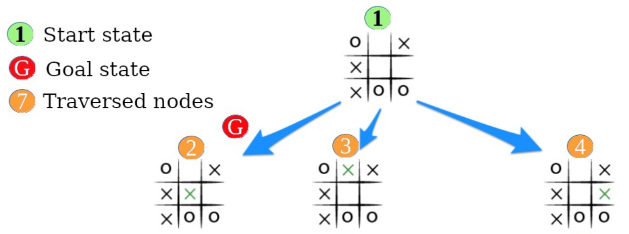


Figure 3.2 demonstrates a breadth first search tree

In figure 3.2, from the initial state (1), the algorithm will check state 4, 3 then 2 for the goal state, adding them to a queue to be evaluated assuming the structure is moving from right to left. Given that state 2 matches the goal state, that would be the recommended solution.

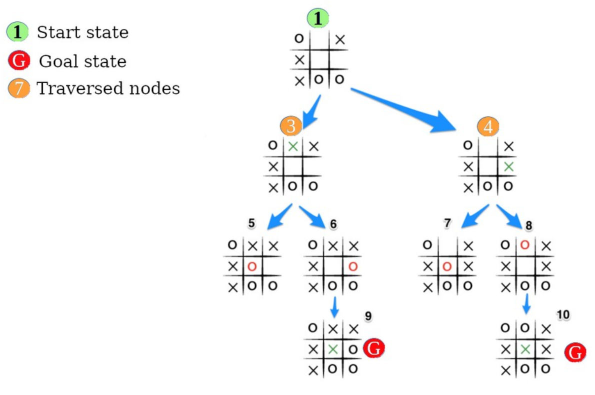


Figure 3.3 demonstrates a multilevel breadth first tree

In figure 3.3, it will add state space 4 and 3 to a queue to be evaluated. Given that states 4 and 3 aren’t goal states, it will add state space 7 and 8 to the queue because they’re child state spaces of state space 4. State space 4 will them be removed from the queue. The will be repeated for state space 3, adding its child state spaces 5 and 6 then removing it from the queue. At this point, all state space from the prior level were removed and it will repeat the process until a goal state is identified.

This algorithm is effective in finding the optimal path to the goal state. Its suited for shallow trees, where the goal state is close to the initial state. This algorithms can be used for graphs.

Similarities between breadth first and depth first search:
- Both find a solution to the goal state if it exists
- Can be represented using a search tree
- Both general purpose; capable of being applied for different problems

Differences between BFS and DFS:
- In BFS, sibling state spaces are reviewed before child state spaces on a branch. DFS opposes this approach
- BFS will require more memory to implement than DFS, especially if a goal state exists deep In the tree
- DFS is generally faster than BFS, depending on the situation where it applied, because it will potentially have less branches to evaluate
- BFS will give you the optimal solution, whereas DFS will give you the first solution that leads to the goal state
- BFS builds the search tree level by level where DFS builds the search tree sub tree by sub tree
- DFS adheres to LIFO but BFS follows FIFO
- DFS uses a stack data structure but BFS uses a queue data structure

Machine Learning

Machine learning (ML) is a method of artificial intelligence that enables computers to learn and make decisions without it being explicitly programmed. Unlike other forms of AI, it can detect an input and respond with an appropriate output, once trained with enough data. Data is used to train the computer's engine so it can analyse data, identifying the patterns of an input to produce an appropriate output. Once sufficiently trained on data, that training can be extrapolated to figure out what do on its own when it encounters new or real time data in a different setting. The more data that a training model consumes, the more accurate its predictions will be. Below I will be discussing 3 types of machine learning that differ in their approach to recognising patterns.

Supervised learning

With supervised learning, an algorithm helps the computer engine learn patterns through labelled input data that will be mapped to an output. That insight is extrapolated to make predictions on or categorise unseen data in new environments, leveraging that training as prior knowledge. The unseen data's analysed pattern is compared to existing patterns in model's prior knowledge. If the unseen data's pattern is similar to a pattern in the model's prior knowledge, then it will assume the unseen data should be categorised under the same label and produced or perform the associated output. This approach is task driven, because it relies on mapping between an input, associating it to label, then outputting something to achieve a task.

There are two types of supervised learning:

- Regression- Uses a set of input features to predict the continuous value of an output. When this model is trained to understand the mapping between input and output, its goal is to minimise the difference between predicted values and their actual values, creating a robust model. Some of its uses include forecasting, stock prices and housing prices
- Classification- consumes input data and classes or categorises it using discrete labels. When this model is trained to understand the mapping between input and output, its goal is to understand the pattern that links the consumed input to an existing label, categorising the data and performing appropriate task. An example of this is image recognition.

Limitations of Supervised learning:

- The technology is dedicated because its trained on handling a specific dataset. Therefore it does not have the capacity to handle additional datasets without the model being retrained or other task outside its scope. For example, if the German farmers who grow vegetables in the referenced video decide to introduce a new product, lets say Kiwis, their image recognition model will need to be retrained in order for the system to accommodate for the new item[8].

Unsupervised learning

A data driven approach to learning and making predictions. Unlike supervised learning it does not use labels to make predictions. Since its data driven, it analyses data to identify patterns and relationships, leveraging it to make predictions.

There are two types of unsupervised learning:

- Clustering- Analyses data and sorts the data into groups based on the data in the group being akin to one another. Internet adverts implement this approach when tailoring advertisements for you to see. Email marketing is another example.
- Association- Analyses large datasets to discover relations or patterns between variables that appear frequently. Leverages this insight to make future predictions. For example, if milk and cereal or milk and tea are frequently purchased together, this would be considered a pattern. If someone went to purchase milk and didn’t have tea or cereal in their basket, the model would recommended cereal or tea as something to add to your basket. Amazon use this to recommend products frequently bought together

Limitations

- The technology is at the mercy of the quality and quantity of data. If the data sample size is not large enough, the predictions can be prejudice and possible discriminate against a group [9].

Reinforcement Learning

With reinforcement learning, an agent is responsible for making decisions. It learns to make decisions through the environment it acts in by receiving feedback as rewards and penalities from the environment and adjusting its decision making policy accordingly. Its decision making policy maps the state of the environment to an action. Once sufficient rewards have been given overtime, it will produce the optimal action for each state in its environment. Reinforcement learning can be used to optimise large scale products and services [10].

Limitations

- Reinforcement learning is data hungry; it requires a lot of data before it can make optimal decisions. This can be time consuming, having a high computational cost

- Too much reinforcement can overload states, diminishing results. For example, car automation. Overloading states in that environment could produce the wrong action and be fatal for passengers

Deep Learning

Artificial neural network

Artificial neural network (ANN) is a subfield of machine learning designed to make predictions based on input data. Similar to supervised learning, the model is trained on labelled data before a production model can be used to make predictions. However, the architecture used to process data and learn differs from supervised learning. With ANN, its architecture mirrors a brain, using the concept of a network of interconnected artificial neurons to process data.

The architecture consists of 3 components:

- Input layer- This takes an input and passes it along to the hidden layer. If the consumed data is an image (which would be the case in a convolutional neural network), it will convert the image into pixels and feed it into a neuron in the input layer. Each neuron in the input layer will be interconnected to a neuron in the hidden layer and will pass the data there for it to be processed
- Hidden layer- ANN has at least one layer hidden layer, with the potential to have more. The data is received from the input layer by neurons and processed here. Each neuron in this layer will pass on the data to neurons interconnected in another hidden layer, if one exist, or the output layer. However, the data will only be moved if the neuron’s computed value, based on its received inputs, (more on this below) meets or is greater than a predefined threshold for this neuron to fire
- Output layer- This is where the prediction or yhat is provided. The yhat is based on the computed value received from the final interconnected hidden layer (more on this below). The greatest value received by a neuron in this layer will determine the prediction given. That prediction is compared to the actual output while training a model.

Data that is passed between interconnected neurons go through paths referred to as channels. Every channel has a value associated to, known as a weight, that is used to determine an inputs importance when the data is processed. The weight assigned to each channel is usually unique to ensure differences in how the data gets processed in each neuron. For each input in a neuron, its value is calculated with the associated weight from its channel and added together. A bias is then added to that sum to determine the yhat. If that yhat is equal to or exceeds a defined threshold, the neuron is fired and its value is passed to the next neuron.

When training some iterations of this model, comparisons between the expected output and the prediction are done to find the error. The function responsible for this is called the cost function. The insight found in the error is used to adjust the weights of channels, which will change the outcome and produce more accurate results, reducing loss. When automated, this process is known as backpropagation [11]. This is conceptually similar to punishments in reinforcement learning.

There are 3 branches of neural networks:

- **Convolutional neural network**- An approach that works on grid-structure inputs, like images. This approach would be used for image classification and facial recognition, where facials features are converted to values to be used as inputs [4].
- **Recurrent neural network**- designed to process sequential data, like time series and natural language. Uses hidden state, where information on previous states and the current input can

be used to make predictions on the current time series. Used to make prediction on future events, like sales forecasting
- **Feed forward neural network-** This iteration was covered above. Data moves in one direction from input to output without backtracking

Deep learning

Deep learning is an extension of ANN but differs in the following ways:
- Deep learning will always have more than one hidden layer
- Can ingest unstructured and structured datasets (labelled and non-labelled data)
- Can cluster or group data by observing patterns without human intervention (unsupervised learning)

Limitations:

- Training a neural network can take hours or months depending on the models complexity, the amount of epoch cycles, batches and batch size
- Training this model is computationally expensive and cannot be performed by conventional computers. A graphical processing unit (GPU), which has thousands of cores, is a necessity because it has the computational power that a CPU lacks
- If the training data is not diverse, the model will not accommodate and perform the task for all expected inputs. This can be problematic for systems like facial recognition, where in security, identifying someone is a matter of public safety. On the other hand, misidentifying people can lead to an unpleasant experiences with potentially disastrous consequences. [9]

AI Agents

An agent is anything with the capacity to detect its environment and comprehend the habitat through some form of sensor, then act with reason impacting the environment, autonomously. Therefore, for something to be considered an agent, it must have agency; the ability to act or exert power independently, without human intervention. With this definition in mind, the following can be considered as agents:

- Animals/ humans- can comprehend the world, make decisions based on their current perception of the world and act based on that decision. For example, if an Owl sees prey and its currently hungry, its will decide to kill and eat the prey, acting on that decision.
- Robots- Depending on the implementation, robots can have the ability to perceive its environment, make decisions and use actuators to impact its environment.
- Program/ virutal agents- Some segments of software or software in general have the capacity to perceive its environment, make rational decisions and then manipulate the environments its envelops

Agents can integrate with AI, feeding it input data, using it for reasoning and producing output based on a decisions coming from a form of AI. Automating AI can help solve a lot of problems in our society that would be difficult with our innate abilities. In the case of farming, the combination of scanners, drones (agent) and image recognition automates the process of eliminating Moths, driving the decision making process based on the detection of the sensors [8]. It can also be used to detect ripe fruits or plants and pick them with actuators [8]. Using any of the approaches mentioned previously (supervised, unsupervised and reinforcement learning) will give virtual and robotic agents reasoning, enabling it to automatically make decisions, independently.

There are multiple types of agents, which I will be discussing below:

Simple Reflex agent

Operates based on the current state of its habitat. It has predefined rules which dictate how it reacts to the environment's current state.

Limitations:

- It does not consider the wider context and prior states, which can further impact or drive the decision-making process.

Model based agent

Follows the same logic as the simple reflect agent, but also considers the environment's previous state in the decision-making process. The model needs knowledge on the evolution of the environment and the consequences of actions on the environment.

Limitations:

- This model relies on accurate information on the habitat, which may not be possible in some instances and or is susceptible to human error
- Susceptible to overfitting, preventing it from adapting to a production environment
- It's not suited for dynamic, unpredictable habitats because it will not always have accurate information on the environment

Goal based agent

Builds on model based agent but adds goals to guide the decision making-process. Information on the environment and how it evolves still assists in making decisions, but goals and objectives are the main force driving the process.

Limitations:

- Does not make the optimal decision to achieve its goal
- Scalability- When the number and complexity of goals increase, so does the ability to make effective decisions

Utility Based agent

Further builds on the goal based agent, using goals to assist the decision-making process. However, this agent is focused on making the best value decision. Instead of picking the outcome that leads to a goal, all options are evaluated and the option with the highest utility is picked. In this way, the optimal option is picked.

Limitations:

- In dynamic environments, the utility of each decision may need to change which is not accommodated for
- In complex environments with lots of options, it will be computationally and temporally expensive to compute and evaluate the highest utility for all options
- Depending on the environment, it can be time consuming to implement because of all the factors that will dictate an options utility

Learning agent
A learning agent uses insight from past experiences to improve its decision-making process and make informed decisions. With each iteration, this agent collates each experience, its actions and the consequence of that action to adjust its decision making process. With enough repetitions, this agent would be able to gather enough knowledge on its habitat, its actions and their consequences on its habitat to make optimal decisions to achieve its goals. This agent can be used in a reinforcement learning model.

Limitation:

- Overfitting- If it is too well adjust to training data, it may not be able to adjust when introduced to new datasets
- Rational visibility- The rational behind decisions can be troublesome to interpret or view

Conclusion

After learning about AI its clear that it has a lot in common with human intelligence (HI). Both have the capacity to solve problems with rationality and have a memory, where they can recall and map patterns with solutions. The way babies learn basic skills or how humans learn is very similar to reinforcement learning. We refine certain actions until it produces the right results, which is at the heart of reinforcement learning.

Both can also perform incorrectly or Immorally if not taught and or implemented correctly. With AI, if an algorithm is not trained on deep diverse data, it will not perform as expected in different environments. For examples, if facial recognition is not trained on faces from a variety of ethnicities and facial features (e.g. tattoos and piercings), it will not always produced the appropriate output [9]. This can also be the case with human intelligence. Similarly with human intelligence, unless taught properly, humans have the capacity to do immoral or incorrect things. For example, if your not taught or have researched enough on a subject that you need to write a paper or report on, It's unlikely that your naturally going to make a good report. Another example is swimming or cycling, which you won't be able to do unless you learn the necessary mechanics, techniques, forms and the consequences of your actions in that situation. Both sets of intelligence are only as good as their training and or knowledge!

However, they also differ In many ways. AI, at this moment in time, is dedicated, only suited to performing specific task. HI is general purpose and we can extrapolate intelligence, using it many different areas or fields and applying or adjusting knowledge from a specific environment into other environments. Furthermore, humans have the capacity to think originally and abstractly without example, creating unique concepts and materials. AI is dependent on data, example in some form to achieve the same feat.

AI has come a long way with the prudent contributions of people like, Frank Rosenblatt, who produced the concept of neural networks, that was picked up and proven by Geoffry Hinton. Hinton iterated on Rosenblatt's work and undestood that to achieve something like image recognition, more hidden layers were required for that capability. This realisation birthed a convolutional neural network used to identify images- image recognition, created by AlexNet on 30 September 2012, which started the proliferations image recognition that has transformed our society in so many fields like security [4] [12]. At a time when his claims were heavily criticised and could not be proven or realised, Rosenblatt had the vision of the possible applications of AI with language recognition, which we have vindicated today [13].

In the immediate future, I believe we will continue to create new technology with the assistance of AI, that will enhance the human experience and help society. Especially as the new generations with fresh minds come forward. An example of that is a group of students, who recently won the Dyson award. Their invention, the Dolpot, allows women to self-check at home, detecting breast cancer or any changes [14]. Just like with Rosenblatt, the more innovations and breakthroughs we produce, the more source of inspirations someone else has to iterate or innovate something else from that. We have a lot discriminatory or bias procedures that needs to be address, where a little innovation and AI can make a difference, as Knockri has shown too [15]. With other problems like climate change and global warming becoming increasingly visible, AI can provide a solution that we all need to safeguard our future for everyone. Simon Redfern believes in its realistic applications and I too believe such solutions, or even better ones, are not far away and we continue to refinement AI's intelligence [16].

Bibliography

[1] Intuitive (31/07/2020) . Available at: https://www.youtube.com/watch?v=H4WzUSq9OeY (Accessed 30 January 2023).

[2] Veteran Health Administration (06/01/2021) . Available at: https://www.youtube.com/watch?v=_qwArCsWylQ (Accessed 30 January 2023).

[3] Ngu, J.C.-Y., Tsang, C.B.-S. and Koh, D.C.-S. (2017) *The da vinci XI: A review of its capabilities, versatility, and potential role in robotic colorectal surgery*, *Robotic surgery (Auckland)*. U.S. National Library of Medicine. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6193435/ (Accessed: January 31, 2023).

[4] Reservation.com (2020) *Facial Recognition Statistics in airports: Survey shows 43% approve, 33% disapprove*, *Runaway Suitcase*. Available at: https://www.reservations.com/blog/resources/facial-recognition-airports-survey/ (Accessed: January 30, 2023).

[5] Woolf, M. (2023) *54+ facial recognition statistics, facts, and trends [2023]*, *Passport Photo Online*. Available at: https://passport-photo.online/blog/facial-recognition-statistics/ (Accessed: January 31, 2023).

[6] Department for Environment Food & Rural Affairs (2022) *Opinion on the welfare implications of using virtual fencing systems to contain, move and monitor livestock*. Gov.co.uk. Available at: https://www.gov.uk/government/publications/awc-opinion-on-the-welfare-implications-of-using-virtual-fencing-for-livestock/opinion-on-the-welfare-implications-of-using-virtual-fencing-systems-to-contain-move-and-monitor-livestock (Accessed: February 1, 2023).

[7] Shah, J.V. (2020) *Min-Max Algorithm, https://www.globalvoxinc.com/wp-content/uploads/2021/06/AI_term_paper.pdf*. Nirma University.

Available at: https://www.globalvoxinc.com/wp-content/uploads/2021/06/AI_term_paper.pdf (Accessed: February 1, 2023).

[8] DW Shift (2021) *Smart farming: How robots and AI can help us with farming | farming technology*, *YouTube*. YouTube. Available at: https://www.youtube.com/watch?v=gfCEQgx4d-4 (Accessed: February 2, 2023).

[9] CNN (2017) *Can tech be biased?*, *YouTube*. Available at: https://youtu.be/gTtbseMYm_s (Accessed: February 5, 2023).

[10] Conti, E. and Gauci , J. (2020) *Horizon: The first open source reinforcement learning platform for large-scale products and services*, *Engineering at Meta*. Available at: https://engineering.fb.com/2018/11/01/ml-applications/horizon/ (Accessed: February 8, 2023).

[11] Simplilearn (2019) *Neural network in 5 minutes | what is a neural network? | how neural networks work | Simplilearn*, *YouTube*. YouTube. Available at: https://www.youtube.com/watch?v=bfmFfD2RIcg (Accessed: February 5, 2023).

[12] coldfusion (2019) *Who invented A.I.? - The Pioneers of Our Future*, *YouTube*. YouTube. Available at: https://www.youtube.com/watch?v=IBe2o-cZncU (Accessed: February 6, 2023).

[13] Lefkowitz, M. (2019) *Professor's Perceptron paved the way for AI – 60 years too soon*, *Cornell Chronicle*. Cornell Chronicle. Available at: https://news.cornell.edu/stories/2019/09/professors-perceptron-paved-way-ai-60-years-too-soon (Accessed: February 15, 2023).

[14] McCallum, S. (2022) *Tool to spot breast cancer at home wins UK Dyson Award*, *BBC News*. BBC. Available at: https://www.bbc.co.uk/news/technology-62807367 (Accessed: February 7, 2023).

[15] CBCTheNational (2018) *Canadian startup uses AI to reduce job interview bias*, *YouTube*. YouTube. Available at: https://www.youtube.com/watch?v=vL9SEcIi6PI (Accessed: February 1, 2023).

[16] Redfern, S. (2019) *How ai can help tackle climate change*, *BBC Ideas*. BBC. Available at: https://www.bbc.co.uk/ideas/videos/four-ways-ai-can-help-tackle-climate-change/p07q435x (Accessed: February 5, 2023).

Sources

https://www.youtube.com/watch?v=gfCEQgx4d-4

https://www.youtube.com/watch?v=8vIT2da6N_o

https://www.youtube.com/watch?v=0i7p9DNvtjk

https://www.youtube.com/watch?v=trKjYdBASyQ https://www.javatpoint.com/ai-alpha-beta-pruning

https://www.javatpoint.com/mini-max-algorithm-in-ai#:~:text=The%20main%20drawback%20of%20the,lots%20of%20choices%20to%20decide

https://www.youtube.com/watch?v=l-hh51ncgDI

https://www.neverstopbuilding.com/blog/minimax

https://www.geeksforgeeks.org/difference-between-bfs-and-dfs/

https://www.youtube.com/watch?v=TJveOYsK6MY

https://www.youtube.com/watch?v=jmmW0F0biz0

https://www.youtube.com/watch?v=bfmFfD2RIcg

https://www.youtube.com/watch?v=6M5VXKLf4D4

https://www.youtube.com/watch?v=IBe2o-cZncU

https://www.bbc.co.uk/ideas/videos/four-ways-ai-can-help-tackle-climate-change/p07q435x