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| *Student Full Name:* | Kevin Scully |
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# Task 1 – AI and Chess

Artificial Intelligence (AI) has been inspired by chess for decades, sparked by the IBM’s Deep Blue programs one point victory over then chess world champion Garry Kasparov in 1997. (Campbell, et al., 2002) This section will analyse AI strategies that have been applied to chess gameplay by two chess engines, Stockfish and AlphaZero.

The first AI strategy that will be analysed is the strategy deployed by the chess engine Stockfish. This is regarded as a traditional chess engine in that it considers factors such as control of the centre and king safety before making a move. (Degni, 2023) Stockfish uses the strategy of an alpha-beta pruning algorithm to search for the best move and then Efficiently Updatable Neural Network (NNUE) to evaluate the move following the tree search.

The alpha-beta pruning search algorithm improves upon the minimax search by reducing the computational power and time to make a move. It does this by applying forward pruning and reduction which avoids variations that will not occur due to the game be re-directed by either player. (Sadmine, et al., 2023) Forward pruning removes scenarios that are unlikely to be used in optimal play. Reduction is when the algorithm searches certain gameplay to a lower depth. The depth reaches increases when promising variations are found, but a short depth is used when less promising variations are discovered. Additionally, as the game proceeds and the number of possibilities increases, the depth is shortened due to computational and time restrictions. (Maharaj, et al., 2022)

When the alpha-beta pruning search algorithm reaches a node, an evaluation is applied to decide whether to choose a White or Black position. NNUE is used to make this decision. This is trained to predict the output of the move by evaluating the piece position, piece activity and the game phase. This evaluation slows the result but makes up for it in a better outcome. It uses the position of the white and black king in comparison to the other pieces. It then considers the board position before coming to a final decision. (Eisma, et al., 2024)

The second AI strategy that will be analysed is that of the chess engine AlphaZero. This is an AI based chess engine that uses the strategy of the Monte Carlo Tree Search and Convolutional Neural Networks (CNNs) to play chess. It uses CNN’s to appraise positions and predict the best moves. The Monte Carlo Tree Search is used to predict the best next move by using its repeated learnings from previous games. Both the neural network and the Monte Carlo Tree Search are trained together, which means both the ability to examine positions, and its search capabilities are improved continuously. By using this strategy, AlphaZero continuously becomes a better chess engine. (Degni, 2023)

AlphaZero uses the Monte Carlo Tree Search algorithm to search for the best moves by using repeated sampling. The algorithm performs random sampling in the form of simulations and then remembers the statistics of moves made to make more educated choices in future games. The search tree starts at the root and works through the branches of the tree according to the node values. The tree is expanded on each move with the node value of the highest probability. Then the algorithm goes back through the tree, updating the probability values of previous nodes passed. After many samples are gathered, the child node with the highest number of samples is selected. (Świechowski, et al., 2023)

Deep CNNs are used by AlphaZero for evaluation of moves and to assign a value to nodes in the tree search. Statistics from millions of self-play chess matches, where AlphaZero plays both sides, is generated. The self-play removes the reliance on human experts and tendencies, letting AlphaZero correct its mistakes and develop game strategies. Following the outcome of a self-play game, the CNN is trained to minimise the loss. During the game the CNN aims to predict the game result and look ahead at future moves to learn probabilities for the tree search. (Maharaj, et al., 2022)

These two different AI strategies for chess are both effective, although after only four hours of self-play, AlphaZero defeated Stockfish over 100 games, winning 28 and losing zero. (Degni, 2023)

# Task 2(b) – Computer Games and AI

AI is essential in modern gaming. The goal for any game is for the characters of the game to be human-like. To achieve this, characters need to go beyond the scripted interactions, and instead be responsive, adaptive and intelligent. They must learn about players during the game, then use their learnings to adapt their behaviours to interact with the player to provide a richer, more realistic experience. (Ram, et al., 2007) This section will focus on two AI strategies used within modern computer games and discuss the algorithm used to achieve this strategy.

The first AI strategy for computer games is pathfinding. At a high level, this refers to the shortest route between two points. This is important in role-playing and strategy computer games where characters must over-come obstacles and move from their current location to a determined destination. (Cui & Shi, 2011)

The A\* Algorithm is a popular algorithm for pathfinding within computer games. It is a best first search algorithm that uses a two-dimensional grid to find the shortest path between two points. Before using A\*, the problem must be abstracted to a two-dimensional grid. It maintains two queues, an open and closed queue. The open queue contains a list of nodes that have not yet been searched but will be searched next. When the node is searched, it is moved to the closed queue as it does not need to be searched again. A heuristic value is applied to all nodes, this is calculated as the cost of traveling from the start node to the current node plus the estimated cost of travel. The path chosen will be based on the lowest heuristic values. (Liu, 2023)

A\* Algorithm is used in the classic real-time strategy game ‘Age of Empires’. It is applied to move the military through a 256x256 grid with 65,536 possible locations. However, problems persist in the game play when obstacles such as forest become more complex, the military can become stuck in them. Cui & Shi (2011) found that more efficient pathfinding solutions are required for solving the increasing complexity of modern gameplay.

The second strategy used by video gaming companies to enhance the gaming experience is enhanced dialogue. This is done through a type of AI called Natural Language Processing (NLP). This significantly enhances responses, dialogues and personalities of non-playing characters within the game. This can allow for engaging dialogue, where responses can alter the outcome of the games story. (Picca, et al., 2015)

A common algorithm used for NLP is the Latent Semantic Analysis (LSA). This is an unsupervised AI model that is fully automatic. This model attributes words according to their contextual distributions across large volumes of text. It uses the context in which words appear and do not appear to determine meaning. After analysing the text, LSA creates a matrix of words and documents. In the matrix each row is a word, and each document is a column. It then reduces the number of dimensions in the matrix by applying Singular Value Decomposition (SVD) which determines the similarity between words using a scale of zero to one. (Miaskiewicz, et al., 2008)

A real example of NLP being used in a video-game is ‘Diablo III’ to form an interactive game that can result in different outcomes following dialogues with non-playing characters. (Varaksina & Dyshuk, 2024)

# Task 3 – AIBO (500words)

Aibo is a robotic puppy developed by Sony that is powered by AI. This puppy looks robotic, but it acts like a pet. It walks, runs, looks around, blinks and rolls over to name a few resemblances to a real dog. Sony claims Aibo can use its embedded cameras to recognise familiar faces and navigate around obstacles. After a lot of activity, Aibo becomes tired and goes to rest by its charging bay. Aibo’s personality will depend on how you treat it and interact with it, just like a real-life dog. (Sony, 2024)

## AI Characteristics that Aibo exhibits

The AI characteristics possessed by Aibo are:

* Learning

Aibo’s machine learning algorithm allows it to develop its own personality that is unique. Aibo will remember it’s owners’ favourite activities and request to perform these. (Sony, 2024) The algorithm allows Aibo to learn new behaviours through verbal and touch positive reinforcement, and through continuous interactions with the environment and human beings. (Guo, et al., 2023)

* Facial Recognition

Aibo can recognise and learn faces. As time progresses, Aibo can become more familiar with people and recognise those that interact with it and those that ignore it. (Sony, 2024) Facial recognition is a characteristic of AI. Algorithms such as Principal Component Analysis (PCA) and Local Binary Pattern (LBP) are deep learning algorithms that improve as more data is gathered. (Singhal, et al., 2021)

* Emotional Intelligence

Aibo can show emotions in the form of its body language and LED expressions. It shows happiness when praised and can act sad when ignored. It develops attachment to those it sees the most and can recognise strangers. (Sony, 2024) A key characteristic of AI is emotional intelligence. The goal is to get the object to act as human as possible. AI is designed and trained to capture and recognise human emotions and react accordingly (Weber-Guskar, 2021)

* Movement

Aibo has dynamic walking algorithms that make its stride like that of a real-life dog. It can recognise spaces as it enters a room, detect obstacles and find the shortest route to its destination. (Sony, 2024) Aibo can do this as it has 22 degrees of freedom and a range of cameras and sensors. It can then use the findings from these sensors to learn positions of objects. (Mingxuan & Kanada, 2024)

## AI characteristics that Aibo still lacks

Some potential AI characteristics that could be developed to further enhance Aibo are:

* Surveillance and Security

Robotic dogs can complete household surveillance. Aibo could monitor the house during the night or when its owners are away. It already possesses the tools to perform this task through its current algorithms. It uses the sensors and cameras to recognise people and can therefore recognise strangers. It also processes real time data so can alert and report threats quickly. Research by Marcu et al (2023) has shown that the presence of security robotic dogs can result in participants feeling more secure, however there was concerns of targeting of marginalised and oppressed groups.

* Fetching the mail

A further feature of Aibo could be to bring in deliveries. The algorithm would be required to be developed so that Aibo could understand the size and weight of objects to assess whether moving the parcel was feasible. Robotic dogs are being used for similar tasks in warehouses today, with their ability to avoid obstacles a key feature. (BSD, 2024)

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