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The Application of Artificial Intelligence in the Training Process of Chess Players

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Abstract. The concept of Artificial intelligence has gained significant popularity over the past few years, particularly with the introduction of Open AI's ChatGPT Model, which has made the technology of artificial intelligence more accessible to people worldwide.Since the 1950s, chess has been used as a testing ground for artificial intelligence. Deep Blue set history in 1997 when it defeated GM Garry Kasparov over the course of a six-game match as it marked the turning point of artificial intelligence being able to master complex strategic thinking. By analyzing previous researches regarding Chess Artificial Intelligence, This paper suggests that Artificial Intelligence had multiple applications in training Elite Chess Players, providing great advantages which can improve their Decision-making. Thinking and Time-Management Skills, ultimately benefiting their game play in tournaments. This paper provides an overview of the evolution of Chess Artificial Intelligence, identifies the key technologies of Chess Artificial intelligence, and introduces the strategies to apply artificial intelligence in training elite chess players, aiming to provide valuable insights for relevant researchers and practitioners.

Keywords: Artificial Intelligence, Chess, AI-phazero, Machine Learning, Training

1. Introduction

The rapid advancement of artificial intelligence has attracted growing interest in recent years, particularly following the widespread adoption of Open AI's Chat GPT. As more researchers and practitioners recognize AI's potential, its applications across various fields have expanded significantly. Over the past several years, the concept of Artificial Intelligence has witnessed a remarkable surge in popularity. Notably, the advent of Open AI's Chat GPT Model has played a pivotal role, making artificial intelligence technology more accessible to people across the globe [1]. According to Adams, Artificial intelligence can be defined as the "development and demonstration of systems that exhibit the broad range of general intelligence found in humans."; Similarly, Willick defines artificial intelligence as the "capability of a device to perform functions that are normally associated with human intelligence, such as reasoning, learning and self-improvement". Russell and Norvig took a slightly different approach, defining artificial intelligence as "the designing and building of intelligent agents that receive precepts from the environment and take actions that affect that environment." In simple terms, artificial intelligence is the ability for artificial-made devices to achieve and perform tasks that are normally performed using human intelligence. Since the 1950s,

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chess has been used as a testing ground for artificial intelligence. Chess is a board game for two that originated from 15th century Europe, populated during the romantic era, and became a widely recognized sport after world war two ended. Today, over 650 million people worldwide(about 8.6% of the world's total population)play chess, further cementing Chess's Worldwide Popularity. With the advance of Artificial Intelligence technology, researchers started to explore how Artificial Intelligence can be applied in the training process of chess players, with its increasing ability in Deep learning and Search Methodology, The newest generation of Chess Artificial intelligence provides anopportunity to improve Chess Players' ability [2]. By analyzing existing studies on chess AI, this paper found out that Artificial Intelligence had multiple applications in training Elite Chess Players, providing great advantages which can improve their Decision-making, Thinking and Time-Management Skills, ultimately benefiting their game play in tournaments. This paper summarizes the evolution of Chess Artificial Intelligence, identifies the key technologies of Chess Artificial intelligence, and introduces the strategies to apply artificial intelligence in training elite chess players, aiming to provide valuable insights for relevant researchers and practitioners.

2. Evolution of chess artificial intelligence

2.1. Early foundations stage (1940s-1950s)

The concept of chess engines was first proposed by Alan Turing in 1946, setting the scene for the early foundation stage. Turing developed the instructions for the first Chess engine, Turochamp, introducing a piece valuation system [pawn = 1; knight = 3; bishop = 3.5; rook = 5; queen = 10 and king = 1000 (To avoid sacrificing kings)]. In 1951, Dietrich Prinz developed Ferranti Mark I, which is capable of solving two-move checkmates.

John Von Neumann's Chess Engine

Maniac I used theminimax method to defeat a human player in the late 1950s. The early Chess engines relied on brute-force search methods, often taking hours to calculate one move.

Moreover, They lack a full comprehension of the game rules; for example, Ferranti Mark I does not understand the rules of En Passant and Pawn Promotion. This era set the foundation for future chess engine development as it formulated piece evaluation systems and implements basic rules onto the Chess Artificial Intelligence.

2.2. Initial competition stage (1960s)

Chess Artificial ficial Intelligence had gone through a major transition in the 1960s with the invention of Richard Greenblatt's Mac Hack. Mac Hack was the first chess artificial intelligence to gain an official USCF(United States Chess Federation), and competed against other players in tournaments, defeating intermediate players (Ben Landy, 1510ELO). The engine searched the 7 best moves with the default widths of "4 3 2 2 1 1 1 1", which generates each player's next plausible moves. This decade saw advancing searching technology instead of brute force methods, which in turn decreased the calculation time per move to 5-10 minutes. At this Stage, Programs could defeat intermediate players but struggled against more skilled opponents. In summary, this era saw major advancements in the searching algorithm with the introduction of Mac Hack, and set the foundation for further participation of artificial intelligence in chess competitions worldwide.

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2.3. Master-level play stage (1980s-1990s)

With the introduction of Belle in 1983, The field of Chess Artificial Intelligence entered a Master-level Play Stage. With an ELO of 2250, Belle was awarded the title of USCF National Master [3]. This stage is characterized by specialized hardware implanted onto the engine, as Belle used specialized chips to enhance its performance. Moreover, The Developers of Belle created an opening database containing 700,000 grand master games to help its opening-selection database. In 1997, Deep Blue defeated Garry Kasparov in a six-game tournament, symbolizing that Artificial Intelligence reached beyond master-level play. In addition to the Opening Database, Deep Blue also utilized an endgame database covering all endgames with six or less pieces, significantly improving its endgame ability. In summary, This era marked the transition from human-dependent strategies to computational dominance.

2.4. Autonomous learning stage (2010s-now)

A major breakthrough in chess AI occurred in 2017 with the development of AlphaZero, which achieved an official ELO rating of 3575. Unlike Predecessors that relied on pre-programmed information, Alphazero achieved mastery through Reinforcement learning by playing with itself. Combining Deep Neural Networks and Monte Carlo Tree Search, Alphazero prioritizes long-term positional advantages rather than short-term material advantages, resulting in a unique and dynamic playing style. By Using TPUs, It could evaluate more than 400 million positions per second, which is two times the search speed of its Predecessor Deep Blue. The autonomous learning stage thus ushered in a new era of chess AI, shifting from human-programmed knowledge to self-taught mastery.

3. Key technologies of chess artificial intelligence

3.1. Monte Carlo Tree Search

Monte Carlo Tree Search is a search algorithm used in many programs of Go, Chess, and Shogi. It searches for the most promising moves, expanding the search tree based on random sampling of the search space. These random sampling result in different positions, known as play-outs. Then, the final game result of each play-out is used to weight the nodes in the game tree so that better nodes are more likely to be chosen in future play-outs [4]. Specifically, Pure Monte Carlo Tree Search is is implemented in chess engines such as Al-phaZero. Each Round of Pure Monte Carlo Tree Search starts with selection, which gives value to nodes, deciding which one to pick. Once a leaf node is reached, The tree expands, and considers all the valid actions from that node. Then, the Monte Carlo Tree would complete one random play-out from the selected node, and use the result (win/lose/draw) to update the information in the nodes, completing one cycle of the Monte Carlo Tree Search. According to Browne, The Monte Carlo Tree Search has proven more effective than the traditional Minimax method, particularly in high-branching games like Chess [5]. While Minimax evaluates all possible moves and counter-moves, MCTS employs random sampling to focus on the most promising paths, significantly reducing computation time. Moreover, The Monte Carlo Tree Search balances between finding new strong moves and exploiting known strong moves. A prime example is the Upper Confidence Bound for Trees (UCT) strategy, which optimizes this balance to avoid getting stuck in suboptimal choices.

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3.2. Deep Learning

Deep Learning greatly assisted the performance of Chess Artificial Intelligence. Through the use of Deep Neural networks to simulate the thinking and decision-making process of the brain, Artificial [6]. Intelligence Models could accurately predict and evaluate the best moves in any given position. Convolutional Neural Networks extract features from the input, and slides a 3x3 grid over the input value, creating a feature board with important features like pawn structures, control of center, and knight forks. Then, the activation function would focus on the most important features of the board and therefore influence the decision-making process. For example, if the feature board detected a weak kingside, it would act to attack the king side. Since Chess is a grid-based game, CNNs are particularly effective in recognizing spatial relationships between pieces, making them well-suited for move evaluation. The method's ability to identify and evaluate complex patterns allowed it to search more efficiently than brute-force search, enhancing the performance of the engine. In summary, The application of deep learning in training artificial intelligence certainly heightened the ability of the artificial intelligence, and increased the accuracy of positional evaluation.

3.3. Reinforcement learning

A key component of chess artificial intelligence is reinforcement learning (RL), especially in the creation of self-learning engines like Leela Chess Zero and Alpha-Zero [7]. The core mechanism of reinforcement learning involves reward-based learning—the AI receives rewards for actions leading to positive outcomes and adjusts its strategy accordingly to maximize cumulative rewards. Deep neural networks and reinforcement learning are frequently combined in chess to produce a potent learning framework. As a function approximator, the neural network forecasts a position's value and the probability distribution of the optimal moves. The AI continuously updates and modifies its neural network based on the results of millions of games it plays against itself during training. Through this process, the AI can improve its assessment of positions and find strategies without depending on human programming. Exploration and exploitation of the large search space of potential moves is a major benefit of reinforcement learning in chess. Reinforcement learning dynamically modifies its approach in response to itself-play outcomes, in contrast to conventional techniques that depend on fixed heuristics.

4. Application of artificial intelligence in the training process of human chess players

4.1. AI as chess coach

Artificial Intelligence engines can be integrated into existing Chess-Learning soft-wares to help train chess players. For example, Chess.com, a popular chess-learning and playing website, recently integrated Artificial Intelligence into its program. They employed Artificial intelligence as a chess coach, which has revolutionized the way players learn and improve our chess skills. Traditional Chess Coaching consisted of three major steps:

First, The coach teaches the basic rules of chess, including the movement rules of each piece, the en passant, and the castling of the king. Then, The Coach would introduce players to common openings like the Italian Opening.

Finally, The Coach would teach students how to use tactical moves to win the game, for example, Forking (Attack two pieces at a time). While this structured approach is effective, AI has significantly personalized the learning process. AI-driven chess coaches can now provide tailor-

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made suggestions based on each player's unique strengths and weaknesses. For Beginners, the AI Coach can guide them through the basics of chess just like a human chess roach; moreover, through practices, the AI coach can check the student's understanding on the concepts, and respond by delivering more problems that focus on the student's weaknesses, helping them to improve more efficiently and effectively [8]. For Players at an intermediate level. The AI Chess Coach can help them make detailed plans for training, and teach more advanced tactical moves. Moreover, the AI Chess Coach can teach a wider variety of Openings than Human Chess Coaches, and suggest openings that match the player's style. For example, for an user expertised in attack, The AI Chess Coach would recommend them an opening that prioritizes on creating complicated positions, resulting in a more attack-based game onwards. For Elite Chess Players, The AI Chess Coach can designate puzzles towards his/her weaknesses, helping to improve their overall chess skill [9]. Through implementing artificial intelligence as a virtual chess coach, players can greatly benefit from a more professional and tailor-made training. Moreover, AI can evaluated hundreds of millions of positions in a second, meaning that they are able to help Chess players analyze their games. AI reviews a player's past games to identify recurring mistakes and areas for improvement, providing a comprehensive evaluation that informs its coaching strategy; for example, the artificial intelligence engine on Chess.com can classify the moves made by the player into 8 categories: Brilliant, Great, Best, Excellent, Good, Inaccuracies, mistakes and blunders, helping players assess their performance at a granular level.If the AI Coach detects that the player is weak in the endgame, the AI can focus its feedback on this aspect, offering targeted strategies and exercises to improve performance. This personalized approach is a significant advancement over traditional coaching methods.

Moreover, AI Coach is highly accessible compared to human coaches. Its availability 24/7 ensures that players can engage in training and receive feedback anytime. This flexibility makes AI coaching a cost-effective and efficient alternative to traditional methods [10].

4.2. AI as chess-mate

AI serves as a versatile partner, mimicking various playing styles. Chess players often fall into the trap of becoming too comfortable with specific types of opponents. Playing against AI-simulated styles exposes players to a broader range of strategies, ensuring they are well-rounded. A player facing an aggressive attacker can practice against an AI set to sharp play, enhancing adaptability and strategic thinking. For example, A chess player who struggles against queen-pawn opening can practice against an AI set to play queen-pawn opening, aiming for the player to battle against queen-pawn openings, which increases his knowledge on these openings. This preparation is crucial for tournament success, where unpredictability is a significant factor. Moreover, AI can aid one's opening preparation process before a tournament starts. AI's ability to generate previously unexplored opening moves by evaluating lines based purely on computational merit rather than historical dogma has transformed the process of opening preparation. By using these AI-generated moves, a player can catch his/her opponent off-guard and win an advantage in the opening. For example, Ian Nepomniachtchi employs an AI-inspired 9. h3 in the Ruy Lopez opening in The 2021 World-Championship, successfully catching Carlsen off-guard, therefore making him unable to make precise moves. Additionally, AI's ability to process immense amounts of data allowed it to help players prepare openings specifically for the opponent he faces. For example, when AI detects that the opponent (using his past games) specializes in the French Defense. It will remind the player to avoid playing the french defense.

Moreover, AI can aid the endgame training process by using its endgame databases. Endgame databases provide perfect solutions to positions with up to seven pieces on the board (including

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kings), allowing players to study positions with absolute accuracy. By utilizing the databases, players can familiarize themselves with critical endgame patterns, such as opposition, triangulation, and zugzwang. For example, AI can simulate thousands of examples of the “Vancura Position” for players to practice in order for them to be familiar with it.

5. Conclusion

The Integration of Artificial Intelligence into the training process of chess players has fundamentally changed the way players train and conduct competitive preparation. This paper traces the evolution of chess AI from the mid-20th century to the autonomous learning systems of today. Moreover, this paper discusses key technologies such as Monte Carlo Tree Search, deep learning, and reinforcement learning. These technologies have enabled AI to contribute and involve in the training process of human players. AI’s role as a virtual chess coach has revolutionized personalized learning by analyzing players’ games, identifying weaknesses, and delivering tailored exercises. Meanwhile, Its function as a versatile chess-mate allows players to practice against varied playing styles and prepares the player for competitions. Rather than replacing human players, AI has expanded the limits of chess mastery, providing new tools for skill development and strategic improvement. Regardless of skill level, from beginner to grand-master, AI continues to support and enhance the game without altering its fundamental principles. Instead, it reinforces what makes chess enduringly compelling—the depth of its challenges, the precision of its moves, and the intellectual satisfaction of strategic mastery.

References

[1] Nah, F.F.-H., Zheng, R., Cai, J., Siau, K. and Chen, L. (2023). Generative AI and ChatGPT: Applications, challenges, and AI-human collaboration. Journal of information technology case and application research, [online] 25(3), pp.277–304. doi: https: //doi.org/10.1080/15228053.2023.2233814.

[2] Skiena, S.S. (1986). An Overview of Machine Learning in Computer Chess. ICGA Journal, 9(1), pp.20–28. doi: https: //doi.org/10.3233/icg-1986-9103.

[3] Fürnkranz, J. (1996). Machine Learning in Computer Chess: The Next Generation. ICGA Journal, 19(3), pp.147–161. doi: https: //doi.org/10.3233/icg-1996-19302.

[4] Brügmann, B. (1993). Monte Carlo Go. [online] Available at: http: //www.ideanest.com/vegos/MonteCarloGo.pdf [Accessed 1 Feb. 2025].

[5] Browne, C.B., Powley, E., Whitehouse, D., Lucas, S.M., Cowling, P.I., Rohlfshagen, P., Tavener, S., Perez, D., Samothrakis, S. and Colton, S. (2012). A Survey of Monte Carlo Tree Search Methods. IEEE Transactions on Computational Intelligence and AI in Games, [online] 4(1), pp.1–43. doi: https: //doi.org/10.1109/tciaig.2012.2186810.

[6] Kuo-Lan S, Bo-Yi L, Jr-Hung G.(2014).Implememtation of The Chess Game Artificial Intelligent Using Mobile Robots.SCIS&ISIS 2014.978-1-4799-5955-6/14/\

[7] Vikrant Chole 1 & Vijay Gadicha1.(2023)Hybrid fly optimization tuned artificial neural network for AI-based chess playing system..82: 20453–20475.https: //doi.org/10.1007/s11042-022-14136-9

[8] Ishika Khokhani, Juhi Nathani, Smit Madhani, Dr. Kumkum Saxena, Prem Dhawane. (2023). Unveling Chess Algorithms using Reinforcement Learning and Traditional Chess Approaches in AI.979-8-3503-0228-8/23

[9] Gaessler, F. and Henning Piezunka (2023). Training with AI: Evidence from chess computers. Strategic Management Journal, 44(11). doi: https: //doi.org/10.1002/smj.3512.

[10] Zahavy, T., Veeriah, V., Hou, S., Waugh, K., Lai, M., Leurent, E., Tomasev, N., Schut, L., Hassabis, D. and Singh, S. (2023). Diversifying AI: Towards Creative Chess with AlphaZero. [online] arXiv.org. Available at: https: //arxiv.org/abs/2308.09175 [Accessed 1 Mar. 2025].