UDC 004

CHESS USING COMBINED AI

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Introduction. In recent decades, chess has entered a new era thanks to the active introduction of artificial intelligence (AI) technologies. The development of computing systems has made it possible to model complex strategies, analyze a huge number of possible combinations, and develop optimal solutions. Now chess is seen not only as a competition of minds, but also as a platform for testing the capabilities of machine intelligence.

Thus, the introduction of AI has not only improved the quality of chess training, but also led to the emergence of new game formats, expanding the boundaries of human perception of chess [1].

The relevance of this study lies in the attempt to combine the two most powerful and well-known chess engines — Stockfish and AlphaZero — into a single intellectual complex. Such integration is of particular interest not only for chess practice, but also for the entire field of artificial intelligence. It allows us to explore the possibilities of synthesizing classical search algorithms with machine learning methods, which opens up prospects for the creation of a new generation of hybrid systems [2].

Recent studies show that combining the analytical rigor of engines such as Stockfish with the learnability of systems such as AlphaZero could lead to the emergence of intelligent programs capable of acting in a more flexible and adaptive manner. This is especially important in the context of the development of applied AI technologies, which require not just computation, but the ability to “learn from experience” and think strategically [3].

The current state of research in the field of chess AI covers a wide range of areas, from improving classic engines to creating hybrid and trainable systems, as well as studying the ethical and technical aspects of their application. All this underscores the importance of combining the Stockfish and AlphaZero approaches as a step towards a new stage in the development of artificial intelligence in chess and beyond [4].

Materials and methodology. At the initial stage of the study, a comprehensive review of existing solutions in the field of chess artificial intelligence is conducted, including the most well-known and influential engines—Stockfish and AlphaZero. This stage involves a detailed study of their architecture, operating principles, search algorithms, and position evaluation systems. Particular attention is paid to differences in approaches: while Stockfish is based on classic search through a tree of moves using heuristic evaluations, AlphaZero uses deep learning and reinforcement learning methods [5]. To ensure the reliability of the analysis, a systematic review of scientific and technical literature is used to identify the strengths and weaknesses of each engine, as well as to determine the areas where their combination can produce the greatest synergistic effect [6]. This stage also involves comparing the historical achievements of both systems, their evolution, and their contribution to the development of computer chess.

The second stage focuses on developing a hybrid architecture concept that combines the classical algorithmic search methods implemented in Stockfish with the self-learning neural network mechanisms characteristic of AlphaZero. The main goal is to create an integrated model capable of combining the strengths of both approaches: the analytical accuracy of a classical engine and the strategic intuition of a neural network. At this stage, a research hypothesis is formulated: the combination of traditional search and neural network learning can improve the quality of position evaluation and decision-making in complex chess situations. To test the hypothesis, an algorithmic scheme for the interaction of the two subsystems is developed, including data exchange between engines, weighting of results, and selection of the most reasonable move (Fig. 1). To empirically test the proposed model, a series of experiments is conducted using test chess games. The experimental part of the study involves the creation of several sets of games played between the classic Stockfish engine, the hybrid system, and AlphaZero (Fig. 2, 3).


```
self.stockfish = chess.engine.SimpleEngine.popen_uci(stockfish_path)
self.alphazero = alphazero_model
self.time_limit = time_limit
self.position_cache = {}
```

Figure 1 - Combining Stockfish and AlphaZero

```
final_move = self._select_best_move(
    board,
    stockfish_move,
    alphazero_move,
    stockfish_score,
    alphazero_score
```

Figure 2 – Execution of moves

```
weights = {
    'opening': {'stockfish': 0.4, 'alphazero': 0.6},
    'middlegame': {'stockfish': 0.5, 'alphazero': 0.5},
    'endgame': {'stockfish': 0.8, 'alphazero': 0.2}
}
```

Figure 3 – Who is more important at which stages

Particular attention is paid to modeling various game scenarios — from standard openings to complex endgames and unusual situations requiring a creative approach. This approach allows us to identify the advantages and weaknesses of the hybrid model in comparison with individual systems. All games are analyzed using standardized performance metrics, including the percentage of games won, the accuracy of positional evaluation, and the stability of calculations. The effectiveness of the developed hybrid system is assessed based on a set of quantitative and qualitative indicators. Key criteria include:

- Analysis accuracy: the system's ability to adequately evaluate positions and find optimal moves at various stages of the game.

- Computation speed: the time required to generate solutions under limited computational resources.
- Strategy quality: the ability to generate non-standard but logically sound moves that demonstrate strategic depth similar to the AlphaZero style.

A set of statistical metrics is used for evaluation, including the percentage of correct predictions, the average difference in position evaluation, the number of games won, and other parameters that allow for objective measurement of the hybrid engine's performance and intellectual efficiency.

The final stage of the methodology is a comparative analysis of the hybrid model's effectiveness in comparison with the original Stockfish and AlphaZero systems. The analysis is carried out under various conditions of complexity, search depth, and time constraints per move. The results of the comparison allow us to determine in which game situations the hybrid system demonstrates the greatest advantages, as well as to identify areas for further improvement of the interaction algorithms. The comparison includes both quantitative data (percentage of wins, depth of analysis, accuracy of evaluation) and qualitative data — the nature of strategic decisions, the originality of the moves found, and adaptability to the dynamics of the game.

Result. When you open the program, you will see a menu (Figure 4). When you click “Play,” you will see the chessboard (Figure 5). If you want to start over, go to the menu and click “Play Again” (Figure 4).

Discussion. The results of the experiments confirm that the hybrid chess system, combining elements of the AlphaZero and Stockfish algorithms, has high potential for further development in the field of artificial intelligence. The data obtained shows that the integration of two different approaches—neural network training and classical algorithmic search—allows for a unique balance between analytical accuracy and strategic creativity.

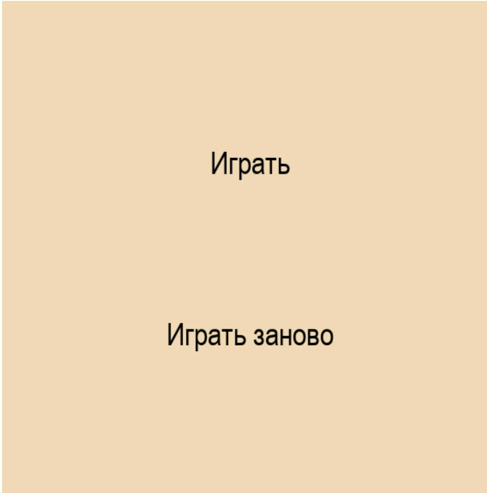

Figure 4 – start menu

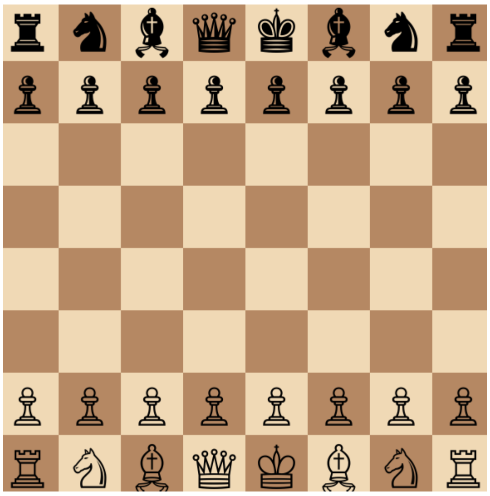

Figure 5 – playing field

This synthesis makes it possible not only to improve the efficiency of position evaluation, but also to expand the range of strategies, which is especially valuable in complex and non-standard game situations where traditional engines often demonstrate limited capabilities. In such positions, the hybrid system has demonstrated the ability to generate solutions that go beyond the usual logic of classical algorithms, while maintaining a high level of accuracy — a feature inherent in Stockfish. A particularly interesting observation was that in tactical positions with a limited number of options, the system tends to use the advantages of Stockfish algorithms, while in strategic and positional complications, it activates the neural network part based on the principles of AlphaZero**.** This confirms the hypothesis that combined architecture can dynamically adapt to the type of position, bringing it closer to the human style of thinking. However, the practical implementation of the hybrid model is fraught with a number of technical and conceptual difficulties. First of all, it is worth noting the high demands on computing resources associated with the use of AlphaZero neural network components. Their training and subsequent operation require significant graphics processing power and memory optimization, which limits the use of the hybrid engine in real time.

Table 1 – Comparison of algorithm elements

Core	Together	AlphaZero	Stockfish
Accuracy of analysis	Universal	Flexible	Straightforward
Speed of calculations	Medium	Small	Fast
Quality of strategies	Non-standard	Non-standard	Standard

Conclusion. The study demonstrated the promise of creating a hybrid chess system that combines the power of classical algorithms with the innovation of neural network strategies. This approach improves the accuracy and creativity of decisions, making the game not only more complex and interesting, but also closer to the human style of thinking.

However, for the widespread implementation of hybrid AI in chess practice, further research is needed in the areas of computation optimization, decision interpretation, and ensuring fair use of technology. It is also important to develop ethical standards governing the use of AI in competitions and training. The future of chess will likely involve the close integration of AI, and the proposed model could be one step toward creating more intelligent and adaptive systems capable of becoming reliable partners and opponents for players of all levels.

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