

“QuantumKnight”:AI-Powered Chess on Blockchain

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Abstract - Traditional online chess platforms do not provide financial rewards, personalized training, or secure transactions. Blockchain-based games attempt to include decentralized finance, but they often overlook how artificial intelligence can help with skill development and strategy during matches. Players now want platforms that offer smart coaching, secure transactions, and the ability to use assets across different games. QuantumKnight is a new chess ecosystem that addresses these needs by combining artificial intelligence with blockchain technology. It creates a clear, decentralized, and rewarding space where players can improve their skills with AI-driven training, earn rewards through competitive play, and manage digital assets across the gaming world. By ensuring secure economic interactions and offering smart gameplay support, QuantumKnight transforms the online chess experience for today’s digital players.

Keywords-Online Chess,Artificial Intelligence,Blockchain Technology,Decentralized Gaming,AI Coaching

I.INTRODUCTION

The global chess community has started using digital platforms for training and competition. However, many traditional systems fail to provide financial rewards for players and to protect user data and transactions. These gaps reduce player engagement and hinder the long-term success of these platforms. Meanwhile, blockchain gaming has become more popular, offering decentralized ownership and economic incentives. Yet, most blockchain-based games either oversimplify gameplay or overlook how artificial intelligence can help with personalized coaching and gameplay improvement.

Gamers face issues such as poor management of assets across different platforms, a lack of transparency in financial transactions, and limited trust in the integrity of digital gaming economies. There is a growing need for a platform that combines engaging gameplay, secure economic models, and smart coaching systems.

QuantumKnight addresses these challenges. It blends the strategic aspects of chess with AI for dynamic coaching and game analysis, all within a blockchain framework that ensures secure, transparent, and

verifiable transactions. By creating a decentralized ecosystem, QuantumKnight allows players to own digital assets, promotes progress, and fosters personalized growth. This signals a new era for competitive and intelligent online chess.

II. LITERATURE SURVEY

Recent developments in artificial intelligence and blockchain have greatly changed digital gaming experiences. Technologies have improved strategic gameplay and created decentralized economies. Silver et al. (2018) presented AlphaZero, a groundbreaking AI system that learned chess, Go, and shogi using deep reinforcement learning without any human involvement. AlphaZero's skill in learning and innovating solely through self-play shows the significant potential of AI to offer strategic insights and personalized coaching in games like chess.

Khan et al. (2023) examine how real-time decision-making and secure data exchange with AI and blockchain can improve the security and effectiveness of smart grid systems. AI methods like machine learning and reinforcement learning help with spotting problems and ensuring maintenance. Meanwhile, blockchain employs smart contracts to provide automation, transparency, and reliability.

The study points out the promise of hybrid models despite challenges such as scalability and energy use. This research is similar to QuantumKnight's design, where blockchain ensures secure and clear transactions while artificial intelligence drives smart games, allowing for reward distribution, fair play, and verifiable outcomes..

By combining blockchain technology with Trusted Neural Networks (TNN), Alsemmeiri et al. (2023) introduce a hybrid security framework for the Internet of Medical Things (IoMT). TNN improves the reliability of AI for identifying anomalies in real time. At the same time, blockchain uses smart contracts to allow safe, unchangeable data exchange. Their method is suitable for real-time applications because it achieves high accuracy and low latency. For QuantumKnight, this integration is important because it mirrors the platform's use of blockchain for transparent game logging and prize distribution. It also uses AI for secure matchmaking and strategy suggestions, which ensures data integrity and player trust.

Gaber et al. (2023) proposed a hybrid AI method for detecting intrusions in IIoT networks that combines Particle Swarm Optimization (PSO) with machine learning. Their approach fits real-time, resource-limited applications because it improves accuracy and cuts down on false positives. While they do not discuss blockchain, QuantumKnight's use of AI for strategy analysis, matchmaking, and cheat detection relates to their emphasis on secure, optimized AI. This improves the platform's smart and safe gaming environment.

A cybersecurity architecture that uses GANs and CNNs to identify intrusions in IIoT systems is presented by Hassini and Lazaar (2024). CNN accurately identifies threat, while GANs generate realistic attack data. This AI-based method improves security and flexibility. The work supports QuantumKnight's AI features, such as move analysis and opponent profiling, by demonstrating how effective models can protect decentralized systems and improve real-time gameplay reliability, even though blockchain is not mentioned.

Nandini and Jahnavi (2021) showed how quantum cryptography and blockchain can work together to create secure and efficient digital systems. Their

framework combines quantum key distribution (QKD) for unbreakable encryption with blockchain's tamper-proof ledger. This approach tackles weaknesses in traditional systems and ensures fast transactions. Their research backs QuantumKnight's plan for secure reward distribution and match verification, while QKD protects player assets from quantum threats. Their work lays a solid foundation for reliable decentralized gaming platforms.

McGrath et al. (2022) investigated how AlphaZero uses self-play to improve chess skills. They demonstrated its ability to come up with novel tactics that surpass human approaches. Their study in PNAS shows how reinforcement learning and Monte Carlo Tree Search help AI excel in positional evaluation and dynamic playstyles. These insights shape QuantumKnight's AI coaching system. They demonstrate how machine learning can adapt to players' skill levels and provide personalized strategy recommendations.

Taylor et al. (2020) study the effect of blockchain technology on cybersecurity. They point out how its decentralized and tamper-proof structure helps manage data safely in PII and IoT storage. Despite challenges like scalability, the research highlights the importance of trustless interactions and transactions that are clear and auditable. This allows QuantumKnight to use blockchain technology to keep safe, unchangeable records of gaming and awards. This approach makes its decentralized ecosystem more open and fair.

Artificial Intelligence (AI)

Artificial Intelligence (AI) refers to the simulation of human cognitive processes by computer systems. These processes include learning (gathering data and creating rules for using it), reasoning (drawing logical or approximate conclusions based on rules), and self-correction (improving performance based on feedback). In the context of QuantumKnight, AI plays a critical role in offering real-time strategy suggestions, personalized coaching, opponent profiling, and intelligent matchmaking—all tailored to enhance the player's chess experience.

Key Characteristics of AI in QuantumKnight:

- **Learning Capability:**

The AI system developed by QuantumKnight is built to absorb knowledge from enormous databases of past games, player patterns, and grandmaster tactics. It consistently enhances its strategic advice and prediction accuracy by utilizing machine learning techniques.

- **Autonomy:**

The AI functions independently. Without requiring human assistance, it analyzes user gameplay, makes strategy recommendations, and provides immediate feedback. It adapts to the style and development of each player.

- **Adaptability:**

The system adapts to varied game scenarios and player skill levels. By altering the intricacy and breadth of its recommendations, the AI tailors its assistance to the needs of both novice and expert players.

- **Reasoning and Problem Solving:**

QuantumKnight's AI uses algorithms to evaluate board positions, plan multiple moves, and suggest the best plays. It replicates the thinking style used by professional players. This makes decision-making feel more natural.

- **Perception:**

In addition to basic inputs, the AI looks at user interaction patterns like move timing and decision-making delays. This helps it provide more personalized guidance and understand player behavior better..

- **Natural Language Understanding:**

Players can ask for help or feedback in plain English because of integrated chatbots and assistants. The AI understands these questions and responds with thoughtful, human-like answers. This improves accessibility and user interaction.

Web 3.0

Web 3.0 marks a shift from centralized internet platforms to decentralized, user-focused ecosystems.

It creates a system where users can own their data and interact with decentralized applications

(dApps) without needing intermediaries. QuantumKnight combines blockchain technology with the main ideas of Web 3.0. It enables peer-to-peer communication, secure transactions, and clear game logic. QuantumKnight keeps player statistics, match results, and cash awards safe and transparent by using Ethereum smart contracts and decentralized storage options like IPFS. These contracts manage important functions like setting up matches, distributing rewards, and organizing tournaments, all without third-party control. This method improves user trust and system integrity while meeting the rising need for fairness, verifiability, and independence in gaming platforms.

Prerequisites

Web development tools, blockchain technology, and artificial intelligence are all necessary for QuantumKnight. AI models that mimic chess strategy are made with PyTorch or TensorFlow. Ethereum and Solidity allow for the creation of smart contracts. The user interface is designed on ReactJS, while the backend APIs rely on Node.js and Express.js. Web3 login is made easier with MetaMask, and blockchain node access and scalability are provided by cloud platforms such as AWS or Infura.

RESEARCH DESIGN

Finding significant holes in the existing chess platforms is the first step in the development process. In order to develop self-defeating reinforcement learning models, data is gathered. To automate cash rewards and game regulations, we develop smart contracts. Before going live, the system is tested for correctness, openness, and performance. We keep an eye on it and get user input to inform updates. This strategy guarantees the system's continued scalability, security, and user-friendliness.

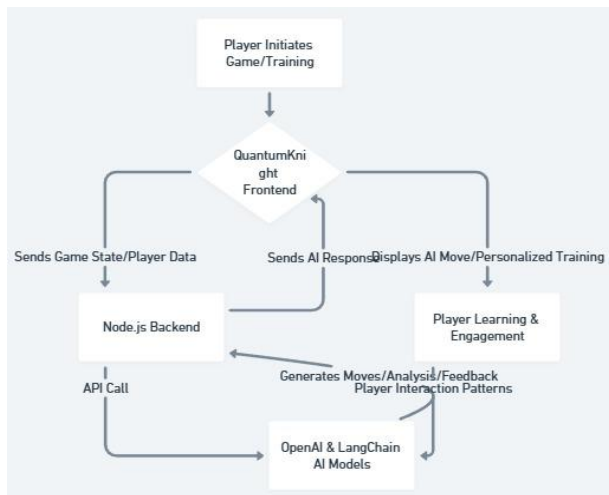
Literature Review

The literature review for QuantumKnight looks at key advancements in artificial intelligence, especially in machine learning, deep learning, and reinforcement learning. These areas are crucial for AI-driven gaming engines. Improvements in computer vision

tasks will improve AI's ability to recognize chess pieces and assess board conditions. Convolutional Neural Networks (CNNs) and object detection models are used. Furthermore, research shows that AI is increasingly used in fields such as healthcare, where it aids in diagnosis and monitoring. This demonstrates AI's adaptability and value across different areas. It is also important to tackle ethical issues like bias, transparency, and fairness to ensure responsible AI development. By addressing these concerns, we can help intelligent systems operate fairly and reliably.

System Overview

In addition to AI bots powered by OpenAI and LangChain that provide opponents and training modules, QuantumKnight has a React interface and a Node.js backend. The platform uses move smart contracts, which offer verified match results, NFT minting, and secure escrow services, to connect to the Aptos blockchain. The AI system analyzes games to provide personalized strategies and feedback. Meanwhile, the blockchain connection makes achievement tracking and award distribution clear. This setup seamlessly connects verifiable in-game achievements, skill growth, and player interaction..



Information Collection

QuantumKnight uses both primary and secondary data sources for its information. Primary data is gathered directly from the source using techniques like user testing and surveys. This information sheds light on player preferences, training requirements, and behavior. Academic publications, blockchain

transaction logs, and publicly accessible chess game datasets are examples of secondary data. These resources aid in the development of economic mechanisms and AI model training. When combined, they promote a well-rounded and efficient development process.

Development Process

QuantumKnight uses an agile development approach. This method enables progress through ongoing development, testing, and feedback cycles. Features are created in sprints, and rapid prototyping helps check functionality and user experience early on. Input from test users is included in each iteration. This improves the platform's AI capabilities, gameplay mechanics, and blockchain features before full deployment.

IV.IMPLENTATION

Input Phase (User Data Collection)

Users register in during the input phase using safe techniques like blockchain authentication or Google. They can select game types, difficulty settings, and training choices on the main chess screen after logging in. Gamers exchange their level of experience, and all private information is protected and verified via blockchain technology. For transparency, every move performed while playing is documented on the blockchain.

Processing Phase (Data Analysis and Recommendation Generation)

QuantumKnight gathers information about player performance, game history, and blockchain transactions throughout the Processing Phase. By analyzing this data, the AI generates customized game plans, recommends the best tactics, and offers suggestions for enhancements. Additionally, it handles blockchain awards that are determined by player accomplishments. This guarantees an open and equitable system of rewards.

Player Experience

The AI engine in QuantumKnight facilitates real-time interaction, which raises player engagement. The

Node.js backend receives game data from the frontend when a player launches the game. The backend uses LangChain and OpenAI models to process requests. The player interface receives tailored feedback from these AI systems, which also generate adaptive moves and offer strategic analysis. A dynamic learning environment is created by the constant interaction between player input and AI response. Based on the player's interaction patterns and skill growth, the system progressively modifies its coaching.

Output Phase (Personalized Recommendations and Blockchain Rewards)

Players receive individualized recommendations, such as move suggestions and game strategy, during the Output Phase. For their accomplishments, players receive tokens or NFTs from QuantumKnight, which are safely stored on the blockchain. Players can stay informed and involved by receiving real-time alerts about tournaments, new challenges, and significant developments.

Asset Interoperability and Economy

Using Aptos smart contracts to convert player-earned things into blockchain-based NFTs, QuantumKnight establishes a unified asset economy. AI-powered market makers who enhance pricing and liquidity enable the trading of these digital assets in a decentralized marketplace. NFTs retain their worth across games and other platforms while maintaining transparent ownership records thanks to the system's cross-platform compatibility.

User Modification and Customization Phase

Players can adjust game settings, blockchain preferences, and AI difficulty during the User Modification Phase. By changing the time limits, token management, and difficulty settings, players may customize their gaming experience. This guarantees a distinctive and captivating gaming experience.

V. CONCLUSION

QuantumKnight is a noteworthy advancement in the integration of blockchain technology and artificial intelligence to enhance the chess-playing experience. Players of all skill levels can progress with QuantumKnight's AI-powered in-game tactics and individualized instruction. A secure and equitable gaming environment is produced through the integration of blockchain technology. In addition to offering incentives and proven accomplishments, it guarantees financial transactions are transparent.

The platform's flexible design merges blockchain technology with AI analysis to ensure secure payouts, making QuantumKnight a unique and engaging experience. The AI engine offers valuable performance feedback to players. Blockchain integration creates a decentralized and transparent economic system, benefiting participants with secure transactions, incentives, and staking options.

QuantumKnight focuses on user personalization, allowing players to change AI difficulty levels, game settings, and blockchain preferences for a unique experience. Its ability to combine these technologies shows how AI and blockchain can improve gaming and create new, rewarding experiences for players around the world.

This project demonstrates how technology, used in innovative ways, can change traditional industries and offer effective solutions to real-world challenges in gaming. The future of gaming will likely be influenced by QuantumKnight and similar new ideas.

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