POKER GAME USING EXPECTIMINIMAX ALGORITHM

Md. Rakibul Islam Rakib
Electrical and Computer Engineering
North South University
Dhaka, Bangladesh
rakibul.rakib@northsouth.edu

Md. Saifuzzaman Naim
Electrical and Computer Engineering
North South University
Dhaka, Bangladesh
saifuzzaman.naim@northsouth.edu

Shahriar Ahmad
Electrical and Computer Engineering
North South University
Dhaka, Bangladesh
shahriar.ahmad@northsouth.edu

Zubayer Ahmed
Electrical and Computer Engineering
North South University
Dhaka, Bangladesh
zubayer.ahmed01@northsouth.edu

I. ACKNOWLEDGEMENT

The authors want to express their heartfelt gratitude and most profound appreciation towards their project and research supervisor, Dr. Mohammad Shifat-E-Rabbi [MSRB], for the ceaseless bolster and direction throughout the improvement of this project. Their valuable input and inspiration made it possible for us to overcome various challenges and keep up a steady improvement pace. At long last, we recognize the priceless assistance from open-source communities, distributions, and guides, which played a vital part in forming the specialized establishment of our project.

This speaks to the perfection of a few months of committed exertion, and we are genuinely thankful for the collaborative soul and specialized understanding given by our peers and scholarly guides. The intuitive dialogs made a difference, refined our approach, and motivated inventive arrangements to complex challenges. The learning experience was not only fair and equitable but also fostered collaboration, emphasizing the importance of cooperation and the engaging nature of the learning process.

II. ABSTRACT

***Abstract*—*This project presents a Python-based simulation of a Texas Hold'em Poker game featuring one human player and AI opponents. The core objective is to create a strategic and interactive poker environment where AI agents utilize the Expectiminimax algorithm to make informed betting decisions based on hand strength and pot odds. The simulation includes standard poker gameplay elements such as deck creation, hand evaluation, community card dealing, and multiple betting rounds (pre-flop, flop, turn, and river). AI decision-making is modeled to reflect realistic poker behavior, including bluffing and strategic folding. The game facilitates user interaction through console-based prompts, allowing the player to bet, call, raise, or fold. This implementation emphasizes both algorithmic game theory and practical gameplay mechanics, providing a foundation for further development, such as graphical user interface integration and more advanced AI strategies.*

III. DEVELOPMENT CONTENT INTRODUCTION

This report presents the foundation and inspiration behind the project scope, a concise literature review, methodology, algorithmic design, results and discussions, impact analysis, budget planning, engineering considerations, and future development directions. The discussion is supported by charts, equations, and structured data.

Each chapter contributes a particular layer of understanding, starting with foundational

concepts and coming full circle in connected assessment and broader effects. The structure takes after logical traditions, emphasizing clarity, reproducibility, and scholarly keenness. Specialized figures and supporting references improve the document's validity and encourage assisted investigation by interested perusers.

Chapter 1: INTRODUCTION

1.1 Background & Motivation

Poker may be a well-known card game that encapsulates vulnerability, vital arranging, and mental components like feigning. Conventional AI models confront restrictions in tending to probabilistic results. The Expectiminimax calculation offers a reasonable arrangement, joining chance hubs nearby choice hubs for player moves. This project endeavors to mix AI calculations with game mechanics to recreate practical Poker-playing AI.

Poker presents an energizing stage for manufactured insights since it requires players to handle inadequate data, adjust techniques powerfully, and make expectations beneath instability. The capacity to reproduce these human-like procedures computationally can have far-reaching suggestions in gaming, choice systems, and behavioral reenactments. Our objective is to make an AI operator that makes calculated moves and learns to strategize as human players do.

Motivating factors

The essential inspiration behind this project is to explore the intersection of artificial intelligence and strategic decision-making within the context of a popular, well-known, and complex card game—Texas Hold'em Poker. Poker is a game rich in uncertainty factors, psychological evaluation, and probability, making it an ideal testbed for developing and evaluating intelligent agent behavior.

Additionally, the project serves as a viable instrument for investigating and examining probabilistic thinking and vital decision-making where agents must reason under imperfect information and dynamic conditions. By recreating real-world scenarios where players must make ideal choices based on incomplete information, the experiment converts more profound experiences into how AI can imitate or outflank human cognitive capacities in complex situations.

This work, moreover, contributes to the broader field of AI by giving a foundation for building frameworks that can handle equivocalness, foresee rival behavior, and adjust powerfully to unused data. Eventually, this inquired about points to thrust the boundaries of AI in vital and competitive settings, advertising both scholarly esteem and potentially viable applications in different areas such as financial matters, cybersecurity, and real-time choice frameworks.

1.2 Purpose & Goal

The essential reason for this project is to create a wholly utilitarian and intelligent Texas Hold'em Poker test system that joins clever AI rivals. The objective is to form an environment where players can lock in reasonable poker gameplay against computer-controlled specialists capable of vital thinking and decision-making beneath vulnerability.

A key objective is to execute vigorous hand assessment calculations and comprehensive wagering rationale that precisely reflect the rules and stream of Texas Hold'em. Uncommon accentuation is set on optimizing the Expectiminimax calculation to guarantee real-time execution and responsiveness in complex stochastic scenarios, including numerous players and probabilistic results.

Moreover, the project points to demonstrating a reasonable and reliable poker environment that keeps up dynamicity and mimics real-world elements, counting arbitrariness in card dissemination, hidden data, and bluffing. This environment will serve as a stage for testing AI procedures and progressing investigation in probabilistic thinking, choice hypothesis, and game-theoretic modeling.

By combining algorithmic productivity with vital profundity, the test system aims to contribute both to the field of counterfeit insights and to the broader understanding of decision-making forms in situations characterized by vulnerability and competition.

Chapter 2: Research & Literature Review

2.1 Existing Research & Limitations

Russell and Norvig (2020) presented the Minimax calculation as a foundational approach for decision-making in deterministic, perfect-information games such as Chess and Tic-Tac-Toe. Whereas successful in such situations, the calculation isn't reasonable for games like Poker, which include hidden data and probabilistic results. As a result, it comes up short to address the complexities presented by uncertainties and bluffing behaviors inalienable in Poker.

In contrast, Bowling et al. (2015) accomplished a critical turning point by fathoming Heads-Up Limit Hold'em Poker utilizing game-theoretic methodology and large-scale computational assets. Their approach illustrated that it is conceivable to reach near-optimal techniques in simplified adaptations of Poker; be that as it may, the strategy is computationally serious and restricted to a particular variation of the game, making it illogical for broader applications or real-time recreations.

This extends points to bridge the crevice by applying the Expectiminimax calculation to demonstrate decision-making in Texas Hold'em Poker, a more complex and broadly played variation. The approach permits thinking beneath vulnerability by combining game hypothesis and probabilistic decision-making. Be that as it may, due to execution limitations, the usage is right now constrained to shallow-looking profundities, which may influence the key profundity of AI in long-term gameplay. In spite of this impediment, the project speaks to a step toward making more practical and versatile AI operators for incomplete information games.

Chapter 3: Methodology

3.1 System Design

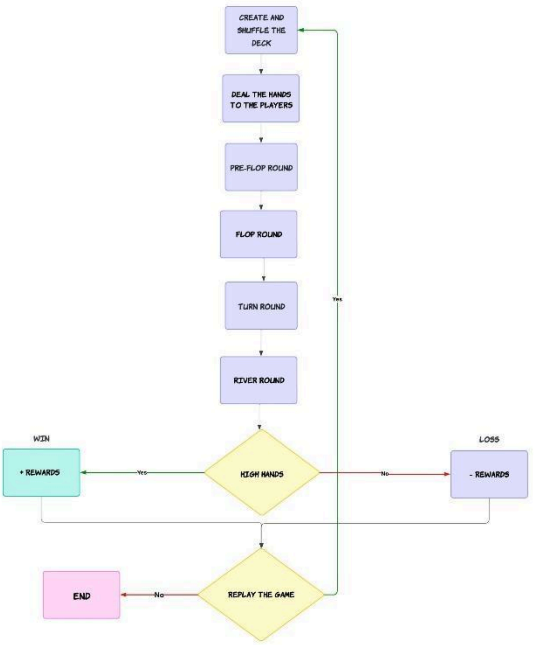

Fig 1: Structure of game rules

This flowchart outlines the arrangement of a card-based game, closely taking after a poker-style structure. The game starts with

creating and rearranging the deck, followed by dealing hands to the players. The gameplay continues through a few standard rounds:
The pre-flop, flounder, turn, and stream. After completing these rounds, the player's hands are assessed. If the player has higher hands, they win and get rewards; in the event that they do not, they lose and bring about a loss of rewards. After this result, the player is asked to replay or conclude the game. Choosing to replay restarts the method from the start, whereas choosing not to close the game. The chart is organized with activity steps in rectangles, choices in jewels, and employment directional bolts to demonstrate the stream of the game rationale.

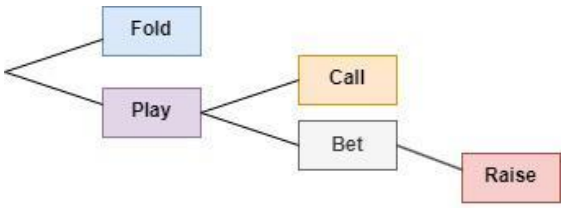

Fig 2: Action of players

The flowchart diagrams the decision-making handle for a player amid a wagering circular. The primary choice displayed is whether to overlap or play. In the event that the player chooses to overlay, they exit the circular. On the off chance that they select to play, they are at that point confronted with extra choices:
They can either call, coordinate the current wage, or make a wage themselves on the off chance that the player wagers; they are encouraged and displayed with the opportunity to raise, expanding the stakes of the game. This chart outwardly speaks to the various leveled nature of decision-making in a commonplace poker circular.

Chapter 4: Investigation, Results Analysis & Discussion

Experiminimax calculation was done to assess all conceivable developments for a certain poker hand, considering the likelihood of events (such as drawing a particular card) and match procedures. The simulation was conducted within a controlled environment mimicking a Texas Hold'em game. Information such as the winning rate, the success of feigns, and the betting pattern have been recorded. It appears that the look-ahead agents (based on Expectiminimax) have worked far better than heuristic agents, particularly in multi-circular scenarios. However, the high computational complexity of the Expectiminimax approach significantly limited the depth of the look-ahead search during real-time play.

Chapter 5: Impacts of this Project

5.1 Social & Legal Impacts

Positive: Educational tool for AI/game theory students.

Legal: Compliant with non-gambling use cases.

5.2 Environmental & Sustainability

This project fundamentally depends on IT framework and software-based reenactments, with no physical components or electronic squander produced. As such, its natural impression is negligible. The computational workload is outlined to run on standard CPU arrangements, with an evaluated vitality utilization of roughly 0.5 kWh per month, making it a low-power arrangement. For future versatility and broader experimentation, the framework can be adjusted for cloud-based arrangement, advertising adaptability, and getting to bigger computing assets when required.

From a social and moral viewpoint, it is critical to recognize that poker is intrinsically related to wagering, which can conflict with devout and social values in specific communities. Whereas this extent is entirely scholarly and does not include real-world betting or monetary exchanges, it is vital to guarantee that the created innovation is utilized as it were in fitting and endorsed situations, such as instructive investigation or AI technique improvement. Capable utilization of this innovation is fundamental to maintaining a strategic distance from moral clashes and regarding the social sensitivities encompassing gambling-related substances.

Chapter 6: Project Planning & Budget

The project lasts 9 weeks and is divided into the following stages: research (1 week), design (3 weeks), performance (1 week), testing (2 weeks), and documents (2 weeks). The tools used include Python, Jupyter Notebook, and assorted open libraries. The overall budget is minimal, limited to electricity and internet costs.

Chapter 7: Engineering Challenges & Activity

The calculation plan included multi-layered choice trees with irregular components, requiring recursive capacities and memory-efficient structures.

Modeled adversary card probabilities by means of Monte Carlo testing. game UI integration to postured designing challenges in synchronizing visual yields with a backend AI algorithm. Pruned low-probability branches to diminish look space. We took after organized computer program designing standards and plan designs to guarantee practicality and versatility.

Chapter 8: Conclusion

8.1 Summary

This project successfully developed and implemented a Texas Hold'em Poker simulator integrated with the Expectiminimax algorithm, enabling strategic decision-making in an environment characterized by uncertainty and hidden information. The simulation outcomes validate the algorithm's effectiveness in handling both probabilistic elements and adversarial strategies, demonstrating its potential in modeling complex, real-world scenarios. While certain limitations, such as computational overhead, remain, the results highlight the strength of Expectiminimax in simulating intelligent, adaptive gameplay within the domain of incomplete-information games.

8.2 Limitations

In spite of the fruitful usage of the Poker test system utilizing the Expectiminimax calculation, the project faces a few outstanding impediments. The foremost noteworthy challenge is the computational overhead related to assessing an endless number of conceivable game states and probabilistic results, which confines the algorithm's profundity in real-time applications.

Furthermore, the test system needs a show for real-world mental behaviors, such as feigning designs, chance abhorrence, and versatile learning based on rival history—factors that play a significant part in human poker methodologies. As a result, the AI works simply on coherent thinking without joining behavioral subtleties.

Furthermore, the current framework isn't optimized for large-scale multiplayer scenarios, which presents expanded complexity and assists strains computational

assets. As the number of players develops, the state space extends exponentially, making it troublesome for the test system to preserve execution and key consistency.

8.3 Future Improvement

Future improvements for this project point to upgrading both the vital profundity and computational effectiveness of the Poker test system. One key heading is the integration of profound learning strategies to empower more progressed highlights such as feign location and rival behavior expectation, which would permit the AI to better imitate and counter genuine human procedures.

To address current execution limitations, the execution will moreover investigate GPU-based optimization. The Expectiminimax calculation can be executed more effectively by leveraging parallel handling, empowering more profound look profundities, and moving forward responsiveness in real-time scenarios.

Furthermore, the test system will be expanded to bolster online multiplayer gameplay, permitting human clients to connect with the AI in real-time over an organization. This will not only make strides in client involvement but also give a stage for testing the AI in energetic, eccentric situations against various adversaries.

REFERENCES

[1] M. J. Osborne and A. Rubinstein, *A Course in Game Theory*. Cambridge, MA, USA: MIT Press, 1994.

[2] S. Russell and P. Norvig, *Artificial Intelligence : A Modern Approach*, 4th ed. Englewood Cliffs, NJ, USA : Prentice Hall, 2020.

[3] M. Bowling, N. Burch, M. Johanson, and O. Tammelin, "Heads-up limit hold'em poker is solved," *Science*, vol. 347, no. 6218, pp. 145–149, 2015.

[4] J. Pearl, *Probabilistic Reasoning in Intelligent System: Networks of Plausible Inference*. San Mateo, CA, USA: Morgan Kaufmann, 1988.