Quantum-Inspired Decision-Making Strategies in Classical Craps: A Simulation-Based Comparative Study of Classical, Quantum Rational, and QBist Agents

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Abstract

This paper explores the application of quantum mechanics-inspired decision strategies in the classical gambling game of craps. We develop a simulation framework that models the standard rules of craps and introduces three types of betting agents: a classical rational agent, a quantum rational agent employing subjective probability structures derived from quantum measurement theory, and a QBist agent using personal probability updates. Extensive simulations are conducted to compare agent performance in terms of profitability, risk, and survival probability. The study examines whether quantum-influenced probability reasoning can lead to distinguishable outcomes in a classical stochastic environment.

Contents

1 Introduction

- Motivation for studying the influence of quantum mechanics concepts on decision-making strategies in classical gambling.

- Overview of quantum probability frameworks and their potential relevance to decision processes.

- Goals of comparing classical rational strategies with quantum-inspired approaches.

- Summary of the paper's structure and experimental methodology.

2 Classical Craps Overview

- Basic rules of craps.

- Description of key bets: Pass Line, Come bets, Odds bets.

- Probability and payout structures.

- Statistical properties of craps: house edge, expected values.

3 Quantum Mechanics and QBism: Foundations and Mathematical Structure

- Quantum Probability vs Classical Probability.

- Quantum Measurement Theory:

  - Projection-valued measures (PVMs).
  - Positive operator-valued measures (POVMs).

- Symmetric Informationally Complete POVMs (SIC-POVMs):

  - Definition and properties.
  - SIC representation of quantum states.

- Quantum Bayesianism (QBism):

- Subjective probability in quantum mechanics.
- Reinterpretation of the Born rule.
- Comparison to Copenhagen and Many-Worlds interpretations.

- Mathematical implications for decision-making:

  - Coherence, Dutch Book arguments.

4 Simulation Design: Modeling Classical and Quantum-Inspired Agents in Craps

- Overview of experimental goals.
- Classical craps engine:

  - Implementation notes (minimal restatement of game mechanics).
  - Validation methods.

- Agent models:

  - Classical Rational Agent.
  - Quantum Rational Agent.
  - QBist Agent.

- Parameters of simulation:

  - Bankroll limits, bet sizing, number of sessions.
  - Odds bets configuration.

- Output metrics:

  - Average ending bankroll.
  - Probability of bankroll depletion.
  - Variance and volatility measures.

- Summary of experimental hypotheses.

5   Results

- Presentation of results for each agent type.

- Comparative analysis:

  - Profitability.
  - Risk and volatility.
  - Survival rates.

- Statistical significance of differences.

6   Discussion

- Interpretation of results.

- Implications for quantum-inspired decision-making.

- Philosophical reflections on subjective probability in classical systems.

- Limitations and sources of error.

- Suggestions for future research.

7   Conclusion

- Summary of key findings.

- Broader significance for quantum foundations and decision theory.

- Closing remarks.

A   Appendix

- Sample Python code structure.

- Extended data tables and figures.

- Additional experimental runs.