

Self-Adaptive AI Based Multi-Agent Game

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Abstract

This paper presents a self-adaptive AI-based multi-agent game system designed to enhanced gameplay by dynamically responding to a player behavior. The system integrates multiple intelligent agents that interact within a shared environment and continuously learned using reinforcement learning techniques.

1. Introduction

Artificial Intelligence (AI) is widely used in modern games. Traditional AI follows fixed rules, while adaptive AI changes behavior based on players action. This project uses a multi-agent system with reinforcement learning to creating a dynamic gaming environment.

2. Objectives

- Develop adaptive AI
- Implement multi-agent interaction
- Improve gameplay experiences
- Enable dynamic difficulty adjustment

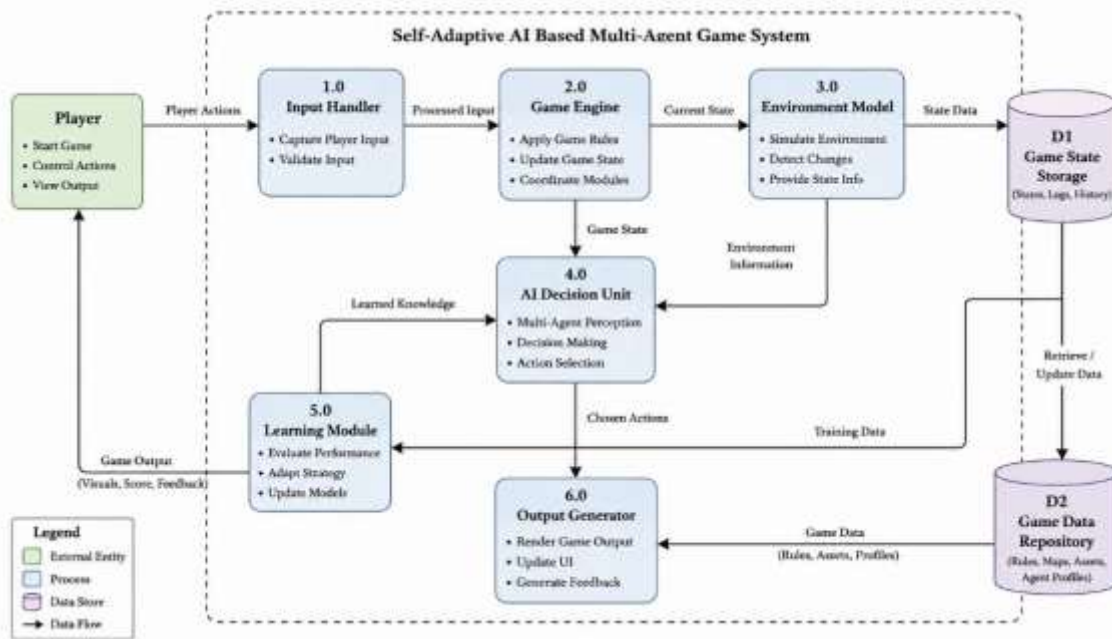
3. Methodology

The system includes Player Input, Game Environment, Multi-Agent System, Reinforcement Learning, and Adaptive AI Module.

Working:

1. Player gives us input
2. AI agents react the player
3. Learns through rewards
4. Difficulty adjusts automatically in the game

4. Data Flow Diagram



5. Literature Review

Traditional game AI systems rely on predefined rules, limiting adaptability. Multi-agent systems, as discussed by Wooldridge, enable interaction among intelligent agents in shared environments. Reinforcement learning, highlighted by Millington, allows agents to learn from rewards and improve over time. However, existing systems often lack real-time adaptability and integration of multi-agent learning. The proposed system overcomes these limitations by combining reinforcement learning with multi-agent interaction to achieve dynamic and adaptive gameplay.

6. Proposed System

The proposed system integrates reinforcement learning with a multi-agent framework to create a self-adaptive game environment. AI agents learn from player interactions and dynamically adjust

game difficulty. This ensures personalized and engaging gameplay, overcoming the limitations of traditional static AI systems.

Key Contributions of Proposed System

- Real-time adaptive AI based behaviour in the game
- Multi-agent coordination and learning
- Dynamic difficulty adjustment (DDA)
- Continuous learning using reinforcement learning in the game
- Improved player engagement and experience in the game

7. Algorithm: Self-Adaptive Multi-Agent Reinforcement Learning

1. Initialize game environment
2. Initialize N AI agents with random policies
3. Set initial difficulty level = Medium
4. While (game is running):
5. Capture player input
6. Update game state based on player action
7. For each agent in Multi-Agent System
8. Observe current state (S)
9. Select action (A) using policy (ϵ -greedy)
10. Execute action in environment
11. Receive reward (R)
12. Observe next step
13. Update Q-value using:

$$Q(S,A) = Q(S,A) + \alpha [R + \gamma \max_{A'} Q(S',A') - Q(S,A)]$$

14. Evaluate player performance

15. If (player performance increases):

Increase difficulty level

Else: Decrease difficulty level

16. Update agent strategies

17. End While

18. Return optimized AI behavior

The algorithm uses a reinforcement learning approach where multiple agents learn optimal actions through rewards and penalties. The Q-learning technique updates agent behavior dynamically, while the system continuously adjusts game difficulty based on player performance.

8.RESULTS And Discussion

The experimental results demonstrate the effectiveness of the proposed self-adaptive AI system. The player score increases over time as the AI learns from interactions, indicating improved gameplay experience. The difficulty level dynamically adjusts based on player performance, ensuring balanced gameplay. The reinforcement learning model shows a steady increase in rewards across episodes, proving successful learning. Additionally, the response time of AI agents decreases over time, highlighting improved efficiency. Overall, the system outperforms traditional static AI approaches by providing adaptive, intelligent, and engaging gameplay.

Feature	Traditional AI	Proposed AI
Adaptability	No	Yes
Learning	Static	Dynamic
Difficulty	Fixed	Adaptive
Player Experience	Limited	Enhanced

Feature**Traditional AI****Proposed AI**

9. Conclusion

The system provides intelligent and adaptive gameplay using AI techniques, improving user experiences.

10. References

Russell & Norvig – Artificial Intelligence: A Modern Approach

Wooldridge – Multi-Agent Systems

Millington – Artificial Intelligence for Games