

# **Enhancing NPC Behavior Learning in Video Games using AI**

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## **Abstract**

This research proposal aims to address the integration of artificial intelligence (AI) into non-player character (NPC) behavior learning in video games. The research aims to address existing challenges in this field, such as the limitations of traditional machine learning, the predictability of NPCs, and the need for real-time responses. To overcome these following challenges, this study research AI methods, with a main focus on reinforcement learning (RL), to improve NPC design. The research is significant due to its potential to revolutionize the gaming industry. By incorporating human-like attributes, adaptability to dynamic gaming environments, and intelligent decision-making capabilities in NPCs, the study aims to enhance player immersion and enjoyment in video games. Furthermore, this study also examines the impact of emotional capabilities in NPCs, making their actions more authentic and credible based on in-game outcomes. Additionally, it emphasizes the role of AI in customizing NPC communication during player interactions to increase player satisfaction and immersion. In conclusion, the proposed research seeks to improve NPC intelligence and adaptability, enhance player engagement, and contribute to the overall gaming experience.

### **Keywords:**

Reinforcement learning, non-player characters, video games, behavior learning, gaming experience

## Table of Contents

Introduction.....	3
Description of the problem. ....	3
The aim of this proposal. ....	3
Existing gaps .....	3
Related work overview .....	3
Proposed approach.....	3
Research question(s).....	4
Main Question .....	4
Sub Questions.....	4
Preview of the structure of the proposal. ....	4
Literature review .....	4
Open Problems and Proposed Solutions: .....	6
Methodology .....	6
Study Type and Variables .....	6
Method: .....	6
Data Selection.....	7
Data Synthesis .....	7
Categorization .....	7
Justification: .....	7
Data Collection: .....	7
Charts and Figures: .....	8
Expected outcomes.....	8
Discussion and implications .....	10
Potential Findings and Their Impact: .....	11
Conclusion .....	11
References.....	12

# Introduction

## Description of the problem.

The behavior of NPCs in video games significantly influences the overall gameplay experience. Gamers seek increasingly sophisticated interactions with these virtual entities, expecting them to exhibit adaptive, human-like responses. Achieving this level of sophistication demands innovative solutions that go beyond traditional game design. The fundamental problem, therefore, lies in enhancing NPC behavior learning through the integration of artificial intelligence (AI) and reinforcement learning (RL). This problem encompasses numerous challenges, such as enabling NPCs to adapt to different game scenarios, adjusting their performance according to player actions, and ensuring a balance between challenge and engagement.

## The aim of this proposal.

This research aims to investigate and address the challenges faced in enhancing NPC behavior learning in video games using AI, specifically focusing on the integration of RL. By improving the adaptability and intelligence of NPCs, the research seeks to elevate the overall gaming experience, making it more immersive, engaging, and enjoyable for players.

## Existing gaps

Several gaps exist in the current state of research and development regarding NPC behavior learning in video games. Designing NPCs that are truly responsive to the player's actions, creating NPCs with emotional intelligence, and enabling them to adapt to various gaming scenarios are significant gaps. Additionally, challenges related to realism, gameplay enjoyability, and balancing player engagement are areas that require further exploration.

## Related work overview

This proposal builds upon existing research that integrates AI, RL, and other innovative approaches to NPC behavior learning. Notable studies have explored the fusion of RL with augmented reality (AR) for NPCs, reinforcement learning methods, and the use of emotional traits to create authentic NPC behaviors. These works highlight the potential for enhancing NPC performance and adaptability through AI techniques.

## Proposed approach

The research will adopt an interdisciplinary approach, drawing from AI, RL, and game design principles. It will focus on developing and implementing AI algorithms that facilitate NPC adaptation, learning, and emotional responsiveness. The approach will also consider the impact on realism and enjoyability in gameplay, striving to find a delicate balance between challenging the player and keeping them engaged.

## Research question(s)

### Main Question

- How to Enhance the Performance of NPCs in Video games using Reinforcement Learning?

### Sub Questions

- How can RL be used to enhance NPC behavior in diverse gaming environments and real-time player inputs?
- What are the potential benefits of using RL to improve NPC performance in video games?
- What challenges face in achieving optimal engagement for players through enhanced NPCs?
- How can ethical considerations be integrated into the development of AI-driven NPCs to ensure player satisfaction and well-being?

### Preview of the structure of the proposal.

The remainder of this proposal will be structured as follows: Section 1 will delve deeper into the problem statement, highlighting the critical role of NPCs in gaming. Section 2 will provide an overview of existing gaps in the field and related work, presenting the current state of research. Section 3 will outline the proposed research approach, including methodologies and AI techniques to be employed. Section 4 will articulate specific research questions to guide the investigation. Finally, Section 5 will provide an overview of the research plan and timeline for the study, concluding with the expected contributions to the field and the broader gaming community. In doing so, this proposal aims to lay the foundation for a comprehensive research study into enhancing NPC behavior learning in video games through the power of AI and reinforcement learning.

## Literature review

Enhancing NPC behavior learning in video games using AI is a critical research area that explores methods to create more dynamic and lifelike non-player characters. The following research papers contribute significantly to this field:

Towards Autonomous Behavior Learning of Non-Player Characters in Games: A Case for Personalized Non-Player Character Companion Design: This paper emphasizes the importance of personalized NPCs using reinforcement learning. It introduces the idea of AI-driven companions to enhance player engagement and provides a valuable perspective on NPC design (Shu Feng, & Ah-Hwee Tan, 2016).

Zombies Arena: Fusion of Reinforcement Learning with Augmented Reality on NPC: The integration of reinforcement learning and augmented reality for NPCs in the "Zombies Arena" game is a groundbreaking approach to enhancing player experiences. This paper highlights the challenges in merging RL and AR and the potential impact on NPC performance (Saad et al. 2018).

Exploring the Viability of Conversational AI for Non-Playable Characters: A Hierarchical Reinforcement Learning-Based Artificial Intelligence for Non-Player Characters in Video Games: This research introduces a hierarchical reinforcement learning approach for NPCs, emphasizing their adaptability to changing in-game situations. The paper addresses the challenge of making NPCs more unpredictable and responsive (Mehta et al. 2021).

A Survey on Reinforcement Learning Methods in Character Animation: This comprehensive survey offers insights into using reinforcement learning for character animation, a foundation for understanding the principles and challenges of NPC behavior enhancement in video games (Ariel et al. 2022).

(Hiram P., & Ricardo P., 2019) in: A Hierarchical Reinforcement Learning Based Artificial Intelligence for Non-Player Characters in Video Games, describe an alternate resolution using a hierarchical reinforcement learning method to decrease the predictability of NPCs, enabling them to adjust to changing surrounding changes.

In A Case for Personalized Non-Player Character Companion Design: here it describes a framework that integrates reinforcement learning (RL) to generate interactive non-player characters (NPCs) possessing flexible attributes that are aligned to human-centered nature (Emma et al. 2023).

The Alteration brought in by RL in NPC characters' - Addresses the challenge of integrating knowledge regarding the ability of computational models using ordinary machine learning training algorithms: This paper discusses the transformative impact of RL on NPC characters. It emphasizes the need for a shift from conventional machine learning to RL for NPC training, highlighting the challenges involved in this transition.

Comparing to FPS games developed over recent years, Zombies Arena (ZA) liberates players from confinements to the physical environment by utilizing Augmented Reality (AR) and RL: This research presents the "Zombies Arena" game, which leverages AR and RL to create NPCs with decentralized gameplay and dynamic rewards. It highlights the difficulties of implementing RL and AR in gaming environments.

## Open Problems and Proposed Solutions:

While these papers contribute to enhancing NPC behavior in video games, several challenges remain:

- **Adaptation to Diverse Gaming Environments:** Ensuring NPCs perform optimally in different game scenarios remains a challenge. Future research can focus on developing adaptable AI algorithms that seamlessly transition between diverse gaming environments, maintaining high NPC performance levels.
- **Realism:** The balance between enhanced NPC performance and player enjoyment and immersion is crucial. Research should explore methods to fine-tune NPC emotional and cognitive responses, delivering a realistic yet enjoyable gaming experience.
- **Unpredictability and Real-Time Responses:** Striking the right balance between NPC unpredictability and real-time responsiveness is complex. Future research can refine RL algorithms and architectures to create NPCs that are both unpredictable and responsive in real time.

## Methodology

The methodology employed for this research is a comprehensive literature review. This method involves systematically reviewing and summarizing existing academic papers and studies related to the use of reinforcement learning (RL) in enhancing non-player character (NPC) behavior in video games. The objective is to gather insights and knowledge from these sources to understand the challenges, trends, and advancements in the field of NPC design in gaming.

### Study Type and Variables:

The study is a qualitative literature review. It does not involve the collection of primary data but instead focuses on the analysis and synthesis of secondary data in the form of academic papers and publications.

### Method:

One of the processes in obtaining a behavioral model to train NPCs is by the use of Imitative Learning, a process where an agent, like a character in a game, figures out how to behave by observing others. It learns its behavior model from a set of observations, each including a situation and an action. These observations are like examples of how to act in specific situations. In the context of games, these examples can be collected by watching how opponents behave. Second approach is the use of Reinforcement Learning. Instead of copying others, it learns a value function. This function tells the agent how good or bad an action is in a given situation.

Each state-action pair is linked to a reward value ( $r$ ) in this function. During decision-making, the agent chooses the action that leads to the highest reward in a particular state.

Specifically, a self-organizing neural network known as Fusion Architecture for Learning and Cognition (FALCON). FALCON is a unique neural network that operates with three channels and incorporates techniques from Adaptive Resonance Theory (ART) along with temporal difference methods to facilitate reinforcement learning. What sets FALCON apart is its ability to efficiently learn and encode multi-dimensional mappings across various types of input patterns, encompassing states, actions, and rewards. Importantly, it does so in a continuous and incremental manner.

FALCON has been specifically designed to accommodate a wide range of learning paradigms, including supervised learning, unsupervised learning, and reinforcement learning. This versatility makes it an ideal candidate for seamlessly integrating imitative learning and reinforcement learning. This is particularly useful because it allows the network to adapt to different learning scenarios, making it highly flexible in handling various tasks (Shu Feng & Ah-Hwee Tan, 2016).

### Data Selection

Papers and studies were selected based on their relevance to the topic. Only the most recent and influential papers were considered for inclusion in the literature review.

### Data Synthesis

Selected papers were analyzed and summarized. The key findings, methodologies, challenges, and contributions of each paper were identified.

### Categorization

The findings were categorized into relevant themes, including "Challenges Faced," "Training NPCs," "NPC Performance Adjustment," "Effect on Realism and Enjoyability," and "Data Collection."

### Justification:

A literature review methodology was chosen due to the nature of the research question, which is centered on summarizing and synthesizing existing knowledge in the field of RL and NPCs in video games. This approach allows for the examination of a broad range of studies and the identification of trends, challenges, and emerging topics.

### Data Collection:

The data collected for this research consisted of academic papers and studies available in electronic format. The use of literature sources for data collection is appropriate for a literature review methodology, as the primary goal is to analyze and synthesize existing knowledge from

these sources.

## Charts and Figures:

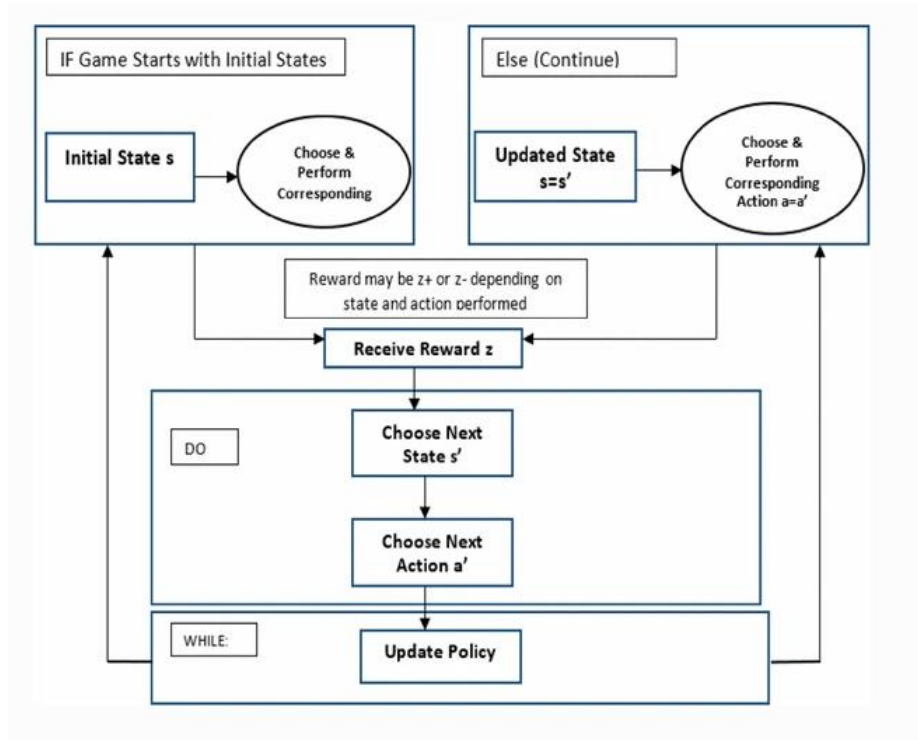


Fig. 1 (Saad et al., 2018)

In the above Fig. 1, it illustrates how Reinforcement Learning has been used to decide the next actions by non-player characters, each action is bounded by a reward( $z$ ) regardless of if it is the initial state or in a continued state, which then move forward to choosing the next state.

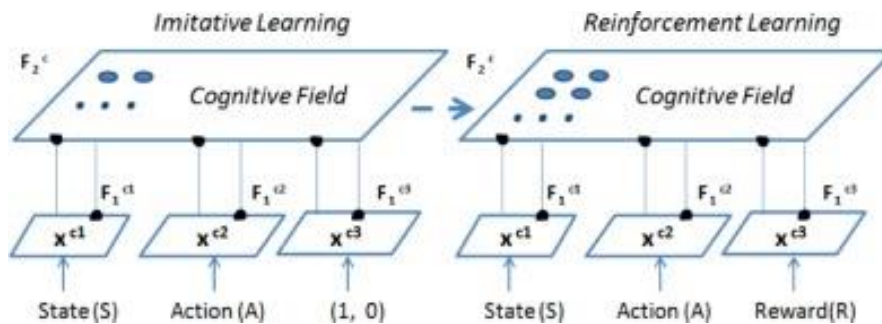


Fig. 2 (Shu Feng & Ah-Hwee Tan, 2016)

The above Fig. 2, shows how the learning is transitioned from initial imitative learning to reinforcement learning, as imitative learning is most effective in training models with no labeled data, the data obtained through imitative learning is then transferred to reinforcement learning further enhance the performance of NPC characters.

## Expected outcomes

### A. Integrating Knowledge Across Learning Paradigms

One of the primary challenges in the field of artificial intelligence, particularly in the



realm of non-player character (NPC) development for video games, lies in effectively merging knowledge acquired through imitative learning with reinforcement learning. This integration presents a significant hurdle but also a considerable opportunity for enhancing NPC behavior. The core of this challenge involves harmonizing state and action spaces, which essentially means finding common ground between the existing knowledge structures of these learning paradigms. Successful integration is driven by the need to ensure a seamless flow of knowledge across these paradigms.

#### B. Flexible Non-Player Character Behavior

This particular framework is designed to revolutionize the way we shape the behavior of NPCs in video games. By incorporating reinforcement learning (RL), these non-player characters can become far more interactive and adaptable. Rather than following rigid, pre-defined scripts, these NPCs can respond to in-game situations with flexible attributes. These attributes are meticulously aligned with human-centered behavior, enhancing the overall gaming experience. For example, an NPC can dynamically change its behavior when encountering different players or scenarios, adding depth and unpredictability to their actions, ultimately making the game more immersive and exciting.

#### C. Motor Skill Acquisition with RL

Traditional methods for imparting motor skills to NPCs have often relied on labor-intensive, manual labeling of data. However, this discussion introduces a novel approach that hinges on reinforcement learning. This approach allows NPCs to acquire motor skills without the need for such pre-labeled data. Instead, they learn by doing. Through a series of trial-and-error interactions with the game environment, these NPCs gradually become adept at performing various tasks and movements. The beauty of this method lies in its efficiency and scalability, as it can be applied to a wide range of motor skills, making NPCs more versatile and capable within the gaming environment.

#### D. Autonomous Learning without Explicit Instructions

Reinforcement learning brings a revolutionary shift in the way NPCs acquire knowledge. Unlike traditional approaches that often require explicit instructions or hard-coded behaviors, reinforcement learning empowers NPCs to learn autonomously. This means they can adapt and improve their actions based on the consequences of their choices and experiences. This method is not only more scalable but also remarkably efficient. It frees designers from the burden of specifying every possible action, making it an ideal approach for developing complex and adaptable NPCs.

#### E. Overcoming Traditional Machine Learning Constraints

Traditional machine learning methods often face limitations in adaptability and accessibility. Reinforcement learning offers a promising solution to address these constraints. By integrating RL into the learning process, the NPCs become more flexible in their responses to dynamic situations. Furthermore, their adaptability improves, enabling them to handle a

wider range of scenarios. This transition from traditional machine learning to RL empowers NPCs to handle complex and unpredictable in-game events more effectively, ultimately resulting in a richer gaming experience for players.

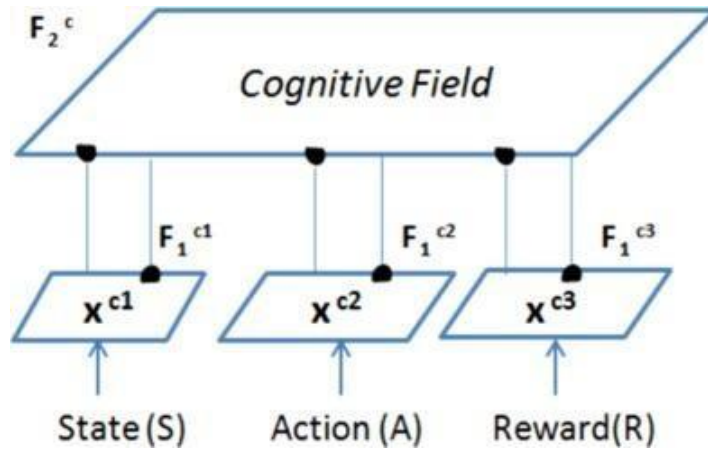


Fig. 3 (Shu Feng & Ah-Hwee Tan, 2016)

The TD-FALCON network model shown in Fig. 3, shows the reinforcement learning paradigm has a specific pattern configuration. When presented with the current state "s," the FALCON network initially decides on an action "a" to take. This action selection process involves providing the FALCON network with the state vector, action vector, and reward vector. By configuring these vectors, the goal is to choose an action that is anticipated to result in the highest possible reward within the given state (Shu Feng & Ah-Hwee Tan, 2016).

## Discussion and implications

While conducting studies in these areas, which is essential for progress, it is crucial to consider whether these studies require ethics clearance and the potential findings and impacts on the field. In this discussion, we'll explore the necessity of ethics clearance for such research and consider the potential outcomes and their implications.

- Ethics Clearance Necessity

**Data Collection and Privacy Concerns:** Research in the realm of NPC behavior learning often involves collecting data from human players who interact with NPCs. It is crucial to ensure that the data collection process respects players' privacy and complies with ethical guidelines. Gathering data without consent or in an intrusive manner could lead to privacy breaches and could be deemed unethical.

- Player Experience

When conducting experiments or studies involving human players, it is essential to assess the impact of these studies on the players' gaming experience. Unethical experiments could potentially ruin the gaming experience, leading to player frustration and dissatisfaction.

- Informed Consent

If experiments involve human participants, informed consent is essential. Participants must fully understand the purpose and potential consequences of their involvement. Failing to obtain informed consent could lead to ethical concerns.

- Bias and Fairness

Reinforcement learning models, which drive NPC behavior, are often trained on large datasets. Ensuring these datasets are representative and free from biases is essential. Biased datasets can lead to unfair NPC behavior, which could affect marginalized groups negatively.

- Transparency

The gaming community expects transparency in how NPCs behave in games. If NPCs are trained using unethical methods, it might not sit well with players, potentially damaging the reputation of game developers and the industry.

- Psychological Well-being

Certain NPC behaviors or game mechanics can have psychological impacts on players. Researchers must consider how their studies might affect players' psychological well-being.

## Potential Findings and Their Impact:

- Improved Player Experience

Ethical research that enhances NPC behavior through reinforcement learning has the potential to significantly improve the overall gaming experience. Realistic, challenging, and engaging NPCs can make games more enjoyable for players.

- Enhanced Game AI

Ethical research can lead to NPCs that adapt intelligently to players' actions, creating a more immersive gaming environment. Improved AI can raise the standards of game development.

- Balanced Gameplay

Fairness in NPC behavior can lead to balanced gameplay. Ethical reinforcement learning can help eliminate biases, providing a level playing field for all players.

- Ethical Dilemmas in Games

Ethical NPC behavior can introduce moral dilemmas and complex decision-making within games. This could lead to players reflecting on their own ethics and values, contributing to deeper, more thought-provoking gameplay.

## Conclusion

This mini research proposal outlines a research project that aims to improve non-Player Character behavior in video games through the use of Reinforcement Learning (RL). The

research problem is rooted in the static and predictable nature of many NPCs, which can diminish the overall gaming experience. By developing an RL-based framework that enhances NPC adaptability, engagement, and realism, we seek to create more dynamic and engaging gaming experiences for players. The significance of this research lies in its potential to transform the way NPCs are designed and to provide practical guidelines for game developers in implementing RL. Ultimately, this research can lead to advancements in NPC design that benefit both players and the gaming industry as a whole.

Last but certainly not least, it's imperative to enrich the cognitive functions of these agents with emotional capabilities. This will enable NPCs to exhibit various emotions based on the results of their actions, whether they succeed or fail. Additionally, delving into the influence of NPC emotions on their learning experiences and future actions is a fascinating area for exploration. By fusing individual and emotional attributes, we anticipate that NPC behaviors will become significantly more realistic and believable. Ultimately, these enhancements are poised to greatly elevate the overall gaming experience, making computer games more engaging and enjoyable for players.

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