

# *Immersive NPC Behavior Systems in Gaming*

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## **Disclaimer**

Before starting the literature review, we would like to remind you that our project is divided into two separate components, which will eventually be combined into one larger project, known as The Modular Adaptive Game.

In this literature review and competitive analysis, we will focus solely on our internal project, titled Immersive NPC Behavior System, with occasional explanations to highlight its connections to the broader project where relevant.

## **Introduction**

Non-player characters (NPCs) are essential in building immersive game worlds. Modern games utilize advanced AI systems to create lifelike behavior, contributing to the player's experience. This presentation focuses on the design and execution of NPC behavior systems in three renowned games—*Red Dead Redemption 2*, *Cyberpunk 2077*, and *The Witcher 3: Wild Hunt*. Below is an analysis of each game's philosophy, core logic, technical insights, and literature reviews.

## **Red Dead Redemption 2**

### **Philosophy**

Rockstar Games emphasized a world where NPCs appear independent and responsive. They created a framework where NPCs interact with their surroundings and player behavior to portray the Wild West convincingly.

## **Core Logic**

**Schedules:** NPCs follow unique routines based on their societal roles, influenced by time and context. Farmers work in the fields by day and socialize at night in saloons, shopkeepers tend to their businesses until dusk and drifters linger near towns, seeking food or opportunities to pickpocket.

**Context-Aware Behavior:** NPCs assess the player's appearance, actions, and surroundings. If Arthur Morgan enters town covered in mud, villagers might critique his hygiene or avoid him; brandishing a weapon spreads fear but may invite challenges, while stormy weather drives villagers to shelter and halts outdoor labor.

**Reputation Systems:** NPCs remember past player actions, integrating them into future interactions. Saving a villager from a robbery might earn heartfelt gratitude or future rewards, while repeatedly antagonizing townsfolk leads to distrust or hostility, limiting access to their services.

**Emergent Reactions:** Unscripted events spark dynamic responses. A horse spooked by gunfire can create chaos by scattering nearby NPCs, while witnesses to crimes may report them or retaliate depending on their courage.

## **Technical Insights**

**AI Framework:** Rockstar developed a proprietary AI engine capable of handling thousands of unique NPCs simultaneously.

- **Key Features:**
  - NPCs can dynamically switch between various behavioral states based on contextual stimuli (e.g., idle, working, fleeing, or interacting with the player).
  - Each NPC has its personality profile that dictates its responses to stimuli, such as bravery, fearfulness, or neutrality.
- **Underlying Tech:** This framework leverages multi-threaded processing to track the "awareness state" of all nearby NPCs without compromising performance, ensuring a seamless blend of scripted and emergent behavior.

**Hierarchical Behavior Trees:** NPCs in *RDR2* follow a hierarchical structure where high-priority behaviors override less urgent ones.

- **Details:**
  - Nodes in the behavior tree represent different actions, such as pathfinding, combat, or fleeing.
  - NPCs dynamically shift between nodes based on real-time data (e.g., the proximity of a threat or the appearance of rain).

- **Impact on Immersion:** This system ensures that NPCs act logically in chaotic situations, avoiding unrealistic "frozen" behavior or poor pathfinding.

**Emotive Speech and Animation Systems:** Rockstar employs advanced procedural animation blending and AI-driven dialogue systems for realistic NPC reactions.

- **Details:**
  - Facial expressions are procedurally adjusted to match emotional states, such as fear, anger, or happiness.
  - NPC dialogue dynamically updates to reference the player's recent actions or appearance.
- **Tech Highlights:** The integration of Rockstar's RAGE (Rockstar Advanced Game Engine) physics system ensures animations are fluid and adapt naturally to varied situations.

## Literature Review

**SegmentNext** details how NPCs in *RDR2* dynamically react to subtle player actions (e.g., weapon holstering influencing friendliness or fear). The NPCs' personalities (timid vs. brave) further deepen realism, making interactions unpredictable and engaging.

## Cyberpunk 2077

### Philosophy

The goal was to craft a chaotic and immersive cityscape where NPCs reflect the diversity and unpredictability of a cyberpunk dystopia.

### Core Logic

**Schedules:** NPCs exhibit daily activities reflective of their roles in Night City. Corporate workers commute during rush hour with briefcases, vendors open and close their stalls on schedule, and criminals linger in back alleys, engaging in shady dealings.

**Environmental Awareness:** NPCs adapt to their surroundings, such as weather, violence, or public disruptions. Pedestrians shield themselves with umbrellas during rain or react fearfully to car accidents, while the presence of a gang member intimidates bystanders, altering their routes and behaviors.

**Gang AI:** Each gang has distinct behaviors and territories, affecting how they interact with the player. The Maelstrom gang, infamous for their cybernetic

enhancements, aggressively patrols industrial zones, where venturing unprepared can result in ambushes or tense negotiations.

**Dynamic Reactions:** NPCs react collectively to large events. During firefights, crowds scatter in panic as law enforcement coordinates tactical responses, while the player's destruction prompts NPCs to assess the damage and choose between fleeing or retaliating.

### **Technical Insights**

**Crowd AI Framework:** Night City's dense crowds are powered by a complex system designed to balance individual NPC behaviors with collective dynamics.

- **Details:**
  - The framework tracks the location, actions, and environmental awareness of up to 1,000 NPCs simultaneously.
  - NPCs prioritize local stimuli (e.g., a nearby fight) while maintaining a broad environmental context.
- **Optimization:** The framework relies on "fading AI states" for distant NPCs to reduce processing load while retaining the illusion of activity.

**Environmental Integration:** NPC behaviors are intricately linked to the city's dynamic environment, enhancing immersion.

- **Details:**
  - NPCs react contextually to weather (e.g., using umbrellas in the rain) and to the player's disruptive actions.
  - Zones within the city are programmed with unique behavioral templates for NPCs, such as corporate professionals in the business district versus gang members in the slums.
- **Implementation:** Procedural scripts adjust NPC behavior based on the time of day, player presence, and other variables, ensuring varied responses.

**AI Layering:** NPCs combine individual logic with group behavior patterns to simulate realistic interactions.

- **Details:**
  - Group behaviors include coordinated gang attacks, crowd dispersal during emergencies, and synchronized environmental interactions (e.g., queuing at kiosks).
  - Layering allows NPCs to maintain unique routines while participating in broader group dynamics.

### **Literature Review**

**GeniusCrate** highlights how *Cyberpunk 2077* attempts to create a "living city," noting its mixed success. While crowd AI captures the feeling of chaos, criticisms focus on limited individual variability.

## The Witcher 3: Wild Hunt

### Philosophy

CD Projekt Red sought to create NPCs that reflected a believable medieval society, tying them closely to the environment and story.

### Core Logic

**Role-Based Routines:** NPC behaviors align with their societal roles. Farmers work fields by day and retreat at dusk, while tavern owners serve patrons and share gossip in the evening.

**Weather and Time:** Environmental conditions significantly impact NPC behavior. Villagers take shelter during rain, while soldiers adjust patrol routes based on day or night visibility.

**Monster Ecology Integration:** NPCs react to the presence of monsters or Geralt's efforts. Villagers flee from monsters, areas repopulate after Geralt clears dangers, and merchants hike prices in attack-prone regions.

**Environmental Awareness:** NPCs respond contextually to Geralt's presence. Drawing swords prompts nervous reactions or warnings, while a bloodied Geralt may inspire fear or admiration, depending on the NPC's worldview.

### Technical Insights

**Scripted Routines and Global AI:** NPCs operate on predefined schedules influenced by their roles and environment.

- **Details:**
  - The game's AI assigns unique tasks to each NPC, which shift based on the time of day or Geralt's actions.
  - Scripted events, like village attacks or festivals, affect the routines of large groups, creating the illusion of a lived-in world.
- **Efficiency:** To reduce processing demands, NPCs not in the player's immediate vicinity are managed using a "background simulation" that approximates their actions.

**Monster-Driven World Design:** NPC behaviors are influenced by the presence of monsters, integrating the world's danger into gameplay.

- **Details:**

- Monsters have their own AI routines, interacting with both the player and NPCs.
- Villages attacked by monsters will see reduced NPC activity until Geralt resolves the threat.
- **Implementation:** The system combines monster-specific AI with event-driven scripting to dynamically adjust NPC routines.

**Multi-Branch Decision Trees:** NPC decision-making processes rely on complex trees to handle varied scenarios.

- **Details:**
  - Decision branches are tailored to the NPC's role, allowing for diverse reactions in combat, trade, or environmental interactions.
  - NPCs weigh multiple factors, like proximity to danger, available escape routes, and Geralt's reputation in the area.
- **Tech Integration:** The decision trees are supported by an overarching global AI system that prioritizes realism over efficiency.

### Literature Review

**Gameranx** emphasizes the consistency of NPC behavior in *The Witcher 3*, particularly how schedules and interactions enhance immersion. Villages feel alive, and the integration of monsters into routines highlights the world's dangers.

### Summary

- **Red Dead Redemption 2** excels in NPC realism, blending emergent and systemic interactions into a cohesive world.
- **Cyberpunk 2077** captures the chaotic energy of a futuristic city, but its AI systems show uneven execution.
- **The Witcher 3** balances immersion with lore-driven NPC behaviors tied to environmental storytelling.

### Links and References

1. [How NPCs React to Your Actions in Red Dead Redemption 2 - SegmentNext](#)
2. [Analysis of Cyberpunk 2077 NPC Systems - GeniusCrate](#)
3. [NPC Behavior in The Witcher 3 - Gameranx](#)