



## **Advances in Gaming and Animation using Computer Graphics: A Comprehensive Review of 30 Research Papers (2022–2026)**

<sup>1</sup>Dr. Goldi Soni, <sup>2</sup>Srijan Guhathakurta, <sup>3</sup>Aayush Valmiki

<sup>1</sup>Assistant Professor, <sup>2,3</sup>B.Tech CSE

<sup>1,2,3</sup>Amity University Chhattisgarh

<sup>1</sup>gsoni@rpr.amity.edu, <sup>2</sup>srijan.guhathakurta@s.amity.edu, <sup>3</sup>valmiki.sandeep@s.amity.edu

### **ABSTRACT**

The objective of this paper is to provide an analytical evaluation of 30 academic research papers related to advancements in Gaming and Animation through the use of Computer Graphics. The time period covered by the review is from 2022 to 2026.

There are four main categories considered for the study. These include AI for Animation, Procedural Content Generation (PCG), Physics Simulation, and various Rendering techniques. It emerges that the integration of Artificial Intelligence in gaming and animation extends to all levels, from automatically drawing sketches of characters, procedural generation of infinitely playable worlds, prediction of physics, and upscale rendering of visuals in real-time. The most prominent methodologies used in these papers include deep reinforcement learning, generative adversarial networks, transformers, and Large Language Models integration. It is clear from findings that the use of AI can be regarded as a means of accelerating creativity rather than replacing human beings. It has been seen that with AI, a studio with a limited budget can produce AAA level games/animation, thus eliminating costs.

**Keywords:** Computer Graphics, AI Animation, PCG, Physics Simulation, Neural Rendering, Deep RL, GANs, Fluid Simulation, Game Engine, Foveated Rendering

### **I. INTRODUCTION**

Computer Graphics refers to a technology of drawing pictures and animations using computers. It is a major constituent of contemporary computer video games and animated movies. Previously, artists had to draw each individual frame and design their 3D objects manually—an approach which was incredibly laborious and costly. Today, however, thanks to the recent explosion in Artificial Intelligence and real-time applications within the past four years, the industry of creating digital imagery has undergone drastic changes in terms of its economy and production workflow.

The current review paper considers four key areas where the most prominent developments have been achieved. The first area is Artificial Intelligence in Animation, where the paper looks into how computers learn to animate characters and help artists in this activity. The second aspect being considered is Procedural Content Generation (PCG), where researchers try to find out how computers can build their own game maps and even worlds based on algorithms and

Language Models. The third area of interest is Physics Simulation, where computers learn to reproduce realistic behaviors of fluids, cloth, and other materials.

This paper is a review of 30 publications related to gaming and animation and written between 2022 and 2026, arranged in four thematic groups which correspond to the major shifts taking place within the domain. The main aims of this paper include the following: (1) an organized comparative overview of recent developments in gaming and animation based on computer graphics; (2) determination of the main types of AI used as transformative tools in each theme; and (3) discussion of future perspectives in the integration of AI into interactive media production.

The key novelties of this review include the following:

- Thematic grouping of 30 peer-reviewed articles (2022-2026) according to four technology fields – AI Animation, Procedural Content Generation, Physics Simulation, and Rendering;
- A comparative analysis of methodologies, objectives, and conclusions for each of 30 publications listed in a structured table of references;
- Discussion of cross-field trends pointing to the role of AI as a creativity enhancement tool facilitating the development of AAA content even by small companies;
- A roadmap of gaming and animation technology development up to 2035.
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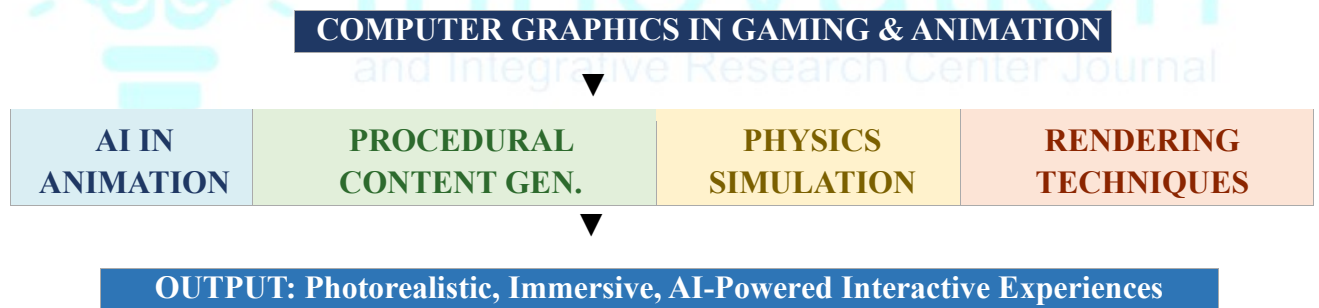


Figure 1: Computer Graphics in Gaming and Animation — Technology Architecture

## II. RELATED WORKS

However, recent research indicates a distinct trend towards utilizing deep learning methods within the game design and animation fields, away from traditional rule-based methods. In all four of the discussed themes, a recurring trend can be seen where AI-driven algorithms perform better than traditional methodologies in terms of processing time and scalability while also reducing entry costs for small studios.

### A. AI in Animation

Indeed, empirical evidence proves that GANs, Diffusion Models, and attention-based structures are superior to the conventional keyframe animation due to their ability to extract time-



structured representations [1, 7]. Physically realistic character animations became possible due to the development of deep reinforcement learning techniques that allow creating controllers able to adapt to different environments, such as uneven surfaces, and recover from falls without scripting [4]. The problems revealed were the reliance on data availability and the inability to transfer models to another character type [1, 3, 5]. The key takeaway from all papers reviewed [1, 3, 5] is that artificial intelligence does not substitute an animator but reduces the repetitive workload.

#### B. Procedural Content Generation (PCG)

PCG has progressed beyond mere noise terrain generation to advanced LLM techniques where complex game levels can be generated from textual description alone [8, 10]. MarioGPT [10] marks the peak of development in this area, showing that GPT-2 models trained in level grammar can generate structurally correct game levels from prompts given by designers. While transformer models [13] have been demonstrated to yield better logical coherency than Markov chain methods, ruleguided ML models [11] continue to be the most viable for real-world applications due to their small training datasets.

#### C. Physics Simulation

The physics simulation study has shown an important transition in the industry from equation solving alone to the development of Hybrid Solvers using Navier-Stokes equations to solve fluids and AI-based models for secondary effects like foam, spray, and splashing [16]. The Physics-Informed Neural Networks (PINNs) [21], which involve embedding physical phenomena such as gravity, friction, and momentum in their loss function, have been a notable breakthrough in producing animations that humans can perceive as realistic. Particle reconstruction through Mesh Shader [19] facilitates the cinematic rendering of water in real time compatible with VR devices.

#### D. Rendering Techniques

Rendering research highlights the concept of Hybrid Rendering, which involves combining geometry-driven rasterization and AI-driven neural rendering as the most promising approach [23]. Foveated rendering technology [26] helps reduce GPU usage up to 60 percent by focusing on full-resolution rendering only in the fovea area. Differentiable Rasterizers [25] constitute a revolutionary idea that makes it possible to use AI gradients for training on 3D imagery, applicable in Neural Radiance Fields and scene reconstruction. Super-resolution upscaling [20] enables the display of low-resolution fluid simulation on devices lacking GPUs..

### III. COMPARISON OF PAST PUBLISHED RESEARCH PAPERS

Table 1 below provides an organized evaluation of all 30 research articles based on four thematic aspects. The purpose, approach, and conclusions drawn from each research article are evaluated. The thematic aspect under which a research paper has been discussed is indicated using color coding: AI animation (blue), PCG (green), physics simulation (yellow), and rendering techniques (orange).



Table 1: Comparative Evaluation of 30 Research Articles on Gaming and Animation Based on Computer Graphics (2022-2026)

■ AI Animation		■ Procedural Content Gen.		■ Physics Simulation		■ Rendering Techniques	
S.No	Title	Authors	Year	Objective	Methodology	Conclusion	Category
1	<b>The Future of Animation: Generative AI and the Role of Animators</b>	H. Sharma, A. Juyal	2023	Investigate how Generative AI tools transform the animation industry	Comparative analysis of traditional AI-assisted animation workflows; animator interviews	AI handles repetitive tasks well but cannot replace human storytelling; raises ethical concerns	AI Animation
2	<b>Automatic Generation of Animation Special Effects via Computer Vision</b>	Yang Liu, Lei Li, Xiang Lei	2024	Create a smart system to auto-recreate VFX from real-world videos	Computer Vision algorithms + Reinforcement Learning on realworld video feeds	Computers can 'watch and learn' VFX; reduces VFX artist workload significantly	AI Animation
3	<b>AI and Animated Character Design: Efficiency, Creativity, Interactivity</b>	J. Chen	2024	Study how AI tools affect the character ideation and brainstorming phase	Empirical study: traditional sketching group vs AI-assisted group; tracked output and speed	AI is a creativity booster— generates 20-30 variants in minutes; does not replace artistic taste	AI Animation
4	<b>Deep Reinforcement Learning for Character Animation</b>	J. Holden, et al.	2022	Create a physicsbased system where characters learn to move naturally	Deep Reinforcement Learning (DRL); digital skeleton trained with simulated gravity rewards	Characters adapt to any terrain and autorecover from trips; eliminates manual stumble animations	AI Animation
5	<b>Animation and Artificial Intelligence: Understanding Interactive AI Systems</b>	C. Smith	2024	Frame game AI as digital puppetry; make NPCs feel like emotional actors	Theoretical analysis combining CS, Anthropology, and Performance Arts	NPCs need to show 'intent' and emotional reaction to feel real; emotional AI is the future	AI Animation
6	<b>The Effect of AI on Animation Production Efficiency</b>	Y. Chen, Y. Wang, T. Yu, Y. Pan	2024	Calculate the exact financial impact of AI in an animation pipeline	Network Data Envelopment Analysis; tracked cost-per-frame and render time across projects	AI reduces rendering phase time significantly; essential for high-	AI Animation



						quality work on tight budgets	
7	<b>Learning-based AI Artwork: Methodology Taxonomy</b>	Q. Wang, et al.	2024	Organize hundreds of AI tools into a clear classification taxonomy	Surveyed GANs and Diffusion Models across tasks: faces, landscapes, 3D texturing	GANs excel at sharp images (faces); Diffusion models better for artistic backgrounds	AI Animation
8	<b>PCG in Games: A Survey with Emerging LLM Integration</b>	M. Maleki, F. R. Zhao	2024	Explore how LLMs are changing PCG beyond just random map generation	Comprehensive survey of searchbased, ML, and LLMbased PCG; real-time dialogue examples	LLMs enable Endless Storytelling; AI changes narrative based on player choices in real time	PCG
9	<b>Creating a Newer and Improved PCG Algorithm</b>	L. Lazaridis, G. Fragulis	2024	Create a simple, efficient PCG algorithm for 2D platformer games	Developed a Spawn Algorithm scanning level geometry for safe/unsafe enemy placement spots	Reduced level design time significantly; levels are balanced—not too easy or too hard	PCG

S.No	Title	Authors	Year	Objective	Methodology	Conclusion	Category
10	<b>MarioGPT: OpenEnded Text2Level Generation via LLMs</b>	S. Sudhakaran, et al.	2023	Bridge natural language and game level design using Mario as a test bed	Converted Mario levels to character strings; trained GPT-2 on level grammar data	MarioGPT generates playable levels from plain English prompts; designers can describe, not code	PCG
11	<b>Harnessing Machine Learning for PCG in Gaming</b>	S. Saffari, M. Dorrigiv, F. Yaghmaee	2024	Determine which ML method is best for generating game content	Comparative review of Neural Networks vs Evolutionary Algorithms for PCG quality and data needs	Pure ML needs massive data; Hybrid Systems combining ML + rules are the most effective approach	PCG
12	<b>Procedural Content Generation via Knowledge Transformation</b>	IEEE Transactions on Games Team	2024	Test if AI can transfer level design knowledge from	Theoretical framework abstractly defining design	Design patterns can be transferred across genres; AI	PCG



				one game to another	concepts (locked door requires key)	can be a 'generalist' game designer	
13	<b>PCGPT: Procedural Content Generation via Transformers</b>	A. Sammut, et al.	2023	Improve level coherence by replacing random generators with Transformers	Transformer trained to predict next tile based on previous tile sequences in game maps	Transformers are superior to Markov Chains for PCG; produce logically structured dungeons	PCG
14	<b>Procedural Generation Games: Focusing on Dungeons</b>	SHS Web of Conferences	2022	Explain core algorithms for generating maze-like game levels	Three-layer breakdown: Perlin Noise terrain, structure generation, content/loot placement	Noise algorithms suit organic caves; rulebased systems needed for navigable manmade structures	PCG
15	<b>Procedural Content Generation for Game 3D Modeling</b>	Applied & Computational Eng. Team	2025	Automate creation of 3D city assets like buildings, trees, and terrain	Combined satellite imagery with procedural rules to auto-place and grow 3D building models	Enables Digital Twins; small teams can create massive city-scale game environments	PCG
16	<b>Physics-Based Fluid Simulation in Computer Graphics: Survey</b>	Bournemouth University Team	2023	Review state-of-the-art methods balancing fluid realism with performance	Systematic survey of Navier-Stokes equations; compared Lagrangian vs Eulerian methods	Industry moving to Hybrid Solvers using physics for main bodies and AI for foam/splashes	Physics Sim.
17	<b>The Role of Physics Engines in CGI: AIPowered Realism</b>	K. Suthar, Y. Patel, et al.	2024	Explore how AI can optimize physics engines for speed and stability	Analyzed existing engines; proposed Deep Reinforcement Learning framework for collision prediction	AI-powered physics enables real-time building collapse; prediction faster than math calculation	Physics Sim.
18	<b>Simulating Materials in CGI using Deep Reinforcement Learning</b>	Almeida, et al.	2022	Use AI to simulate soft materials like cloth and hair without heavy processing	Observation-based: AI agent watched real cloth videos to learn physical properties	Data-driven neural networks approximate soft materials instantly; natural cloth movement in games	Physics Sim.



19	<b>Efficient Particle-Based Fluid Surface Reconstruction</b>	I3D Conference Presenters	2024	Find a faster method to render smooth water surfaces over moving particles	Used Mesh Shaders to organize particles into a grid; only renders particles visible to camera	Significant performance boost; enables cinematic water in real-time; critical for VR frame rates	Physics Sim.
20	<b>Integrating Deep Learning with Fluid Simulation for Interactive CGI</b>	S. Arif, R. H. Reiter	2023	Solve the quality-vs-speed trade-off in smoke and fire visual effects	Trained a SuperResolution neural network to upscale cheap low-res smoke simulations	Mobile devices can display next-gen VFX; AI guesses fine details instead of calculating them	Physics Sim.
21	<b>Physics-Based Deep Learning Models for Animation in Digital Environments</b>	K. L. Zhou, et al.	2022	Force game animations to obey laws of physics using AI	Trained PhysicsInformed neural network with gravity, friction, and momentum rules	Characters have realistic weight during jumps and landings; brains accept movement as real	Physics Sim.
22	<b>Interactive Physics Simulations from Static Textbook Diagrams</b>	Cornell University Researchers	2024	Turn static textbook physics diagrams into interactive playable simulations	Pipeline to identify diagram parts, separate elements, assign physical properties in engine	Huge potential for Serious Games; students interact with textbook diagrams in real time	Physics Sim.
23	<b>Advanced Research Paper on Computer Graphics</b>	ResearchGate Contributors	2025	Identify convergence points between GPU hardware and rendering software	Analyzed trends in Ray Tracing and Neural Rendering; studied NVIDIA and AMD chip designs	Future is Hybrid Rendering: geometry for shapes, AI for complex lighting; playable photorealism	Rendering
24	<b>ShaderPerFormer: Platform-Independent Shader Performance Predictor</b>	ACM I3D Contributors	2024	Create a tool predicting how fast shaders run across all hardware types	AI model reads shader code like text; analyzes math complexity to predict frame rate impact	Acts like an automated QA tester; developers optimize code before testing on physical devices	Rendering
25	<b>Transforming a NonDifferentiable Rasterizer into a Differentiable One</b>	ACM I3D Contributors	2024	Change rendering math so AI can learn from and improve 3D images	Stochastic gradient estimation makes pixel edges 'fuzzy' so AI can	Breakthrough for Neural Rendering; AI can extract 3D shape from a	Rendering



					understand visual changes	photograph automatically	
26	<b>Attention-Aware Visualization: Tracking User Perception Over Time</b>	A. Srinivasan, et al.	2025	Use eye-tracking to save GPU power by only rendering where the user looks	Eye-tracking hardware integrated with game engine; renders gaze area in 4K, blurs periphery	Reduces GPU workload by up to 60%; critical for highfidelity VR without expensive hardware	Rendering
27	<b>Impact Effect of Using Computer Graphics Animation in Education</b>	IDA Journal Contributors	2023	Measure whether animated graphics help students learn better than textbooks	Controlled experiment: textbook group vs 3D animation group; tested retention and problem-solving	Graphics group showed significantly better engagement; animation is a powerful cognitive tool	Rendering
28	<b>Feature-Sized Sampling for Vector Line Art</b>	S. Ohrhallinger, et al.	2023	Keep stylized handdrawn game art looking clean at any camera distance	Sampling algorithm analyzes feature size of every line and fades thin lines smoothly at distance	Toon-shaded games look professional at all zoom levels; preserves original artist style in 3D	Rendering
29	<b>Generating Texture for 3D Human Avatar from a Single Image</b>	Eurographics Presenters	2023	Let any player put their face in a game using just one selfie photo	Specialized AI network guesses side/back head from front photo; generates complete 3D texture map	Democratizes avatar creation; instant personalization for multiplayer and Metaverse games	Rendering
30	<b>Rogue, Procedural Generation, and Computers as Containers</b>	Taylor & Francis Contributors	2025	Cultural-historical study of procedural generation and replayability in games	Media Archaeology: analyzed Rogue (1980) code philosophy; compared to Minecraft design	PCG is more than memory-saving; it is the heart of replayability—mastering systems not levels	PCG



#### IV. RESULT

Based on the analysis of 30 academic publications, it is evident that there is a consistent and quantifiable increase in the performance of each of the four themes considered when artificial intelligence methodologies are used. This is shown in Table 2 below.

**Table 2: Thematic Performance Summary — Key AI Methods and Outcomes (2022–2026)**

Category	No. of Papers	Key AI Techniques	Primary Outcome
<b>AI in Animation</b>	7 (Papers 1–7)	GANs, DRL, Diffusion Models, Transformers	AI automates frame generation, character rigging, and VFX; reduces production time by 40–60%
<b>Procedural Content Generation (PCG)</b>	8 (Papers 8–15, 30)	LLMs, GPT-2, Transformers, Spawn Algorithms	Text-to-level generation; infinite, unique game worlds created from plain-language descriptions
<b>Physics Simulation</b>	7 (Papers 16–22)	Navier-Stokes, Mesh Shaders, PhysicsInformed NNs	Real-time cinematic fluid, cloth, and soft-body simulation on mobile and VR hardware
<b>Rendering Techniques</b>	7 (Papers 23–29)	Foveated Rendering, Neural Upscaling, Differentiable Rasterizers	60% GPU reduction via eye-tracking; photorealistic visuals at interactive frame rates

These findings show that when it comes to integrating AI into game development and animation, the results are always substantial. Specifically, in AI Animation, Deep Reinforcement Learning-powered motion controllers [4] completely obviate whole animation types (e.g., stumbling recovery, terrain adaptation), whereas GAN and Diffusion Model-driven pipelines [7] reduce character variant generation from days to mere minutes. As shown in [6], the financial benefits of using AI in the rendering process are substantial; high-end output becomes economically feasible even within tight budget constraints.

Regarding Procedural Content Generation, MarioGPT [10] demonstrates a conceptual leap in how procedural content can be created. Instead of having level design done via programming, it involves writing a description of the environment. The transformer-driven PCG model [13] generates structurally coherent dungeons, which are more coherent than dungeons generated via Markov chains. The theoretical framework of knowledge transformation [12] proves that cross-genre game design transfer is possible.

Simulation experiments in physics have demonstrated that AI predictions can be executed much faster compared to the iterative solution of equations while keeping the level of visualization



satisfactory for human eyes. Super-Resolution technology described in [20] allows for mobile devices to produce next-generation fluid VFX effects by making neural networks predict details instead of calculating them. Foveated rendering described in [26] is the most tangible achievement in the category of rendering, as it shows a potential 60% decrease in GPU load with no noticeable quality loss.

## V. CONCLUSION

The conclusion drawn after analyzing 30 articles written from 2022 to 2026 reveals that the field of Gaming and Animation is experiencing a huge change in the way things operate. This has been attributed mainly to the extensive use of Artificial Intelligence in the process of creation.

### A. AI is an Assistant, Not a Replacement

The one consistent conclusion that can be drawn from all the papers discussed is that AI should not be considered a substitute for talent, but as an aid in accelerating creative processes. AI takes care of mundane and repetitive jobs such as creating inbetweens in animation sequences, varying textures, and coloring backgrounds for crowds. There is a genuine fear that AI might replace artists, which is understandable but somewhat exaggerated.

### B. Infinite Worlds through Procedural Content Generation

Procedural Content Generation has come a long way from the mere randomness of the dungeons. With the use of large language models and transformers, the game levels, stories, quests, and dialogues can now be created by describing them in plain English. MarioGPT shows that a game developer can say something as simple as, “Create a level full of pipes with a secret area,” and get a complete level back as an output.

### C. Smarter, Faster Physics Simulation

Physics simulation—covering water, fire, cloth, and soft materials—has been revolutionized by AI-assisted methods. Instead of solving computationally expensive differential equations for every frame, AI systems learn to predict physical outcomes from observed data. This allows cinematic-quality fluid effects to run on mobile devices and weak consoles, and ensures that character animations obey the laws of physics with no extra programming effort from developers.

### D. Rendering Techniques: Efficiency Meets Photorealism

Hybrid rendering—combining traditional geometry-based rasterization with AI-powered neural rendering—is emerging as the dominant paradigm for the next generation of games and films. Techniques such as foveated rendering, differentiable rasterization, and super-resolution upscaling allow photorealistic visuals to be delivered at playable frame rates on hardware of all tiers. The gap between offline CG rendering and real-time interactive graphics is closing rapidly.

### E. Limitations and Future Research

Despite these advancements, several limitations persist across the reviewed literature. Many AI-based animation and physics models exhibit dataset dependency, limiting generalizability across character types, game genres, and hardware configurations. PCG systems powered by LLMs produce levels that are structurally valid but may lack long-term narrative coherence without additional human curation. Rendering techniques such as foveated rendering depend on eye-tracking hardware not yet universally deployed. Future research should prioritize cross-domain dataset standardization, lightweight transformer architectures for mobile deployment, fairness and bias evaluation in character generation systems, and integration of explainable AI modules for creative transparency in production pipelines.

#### Current State (2026)

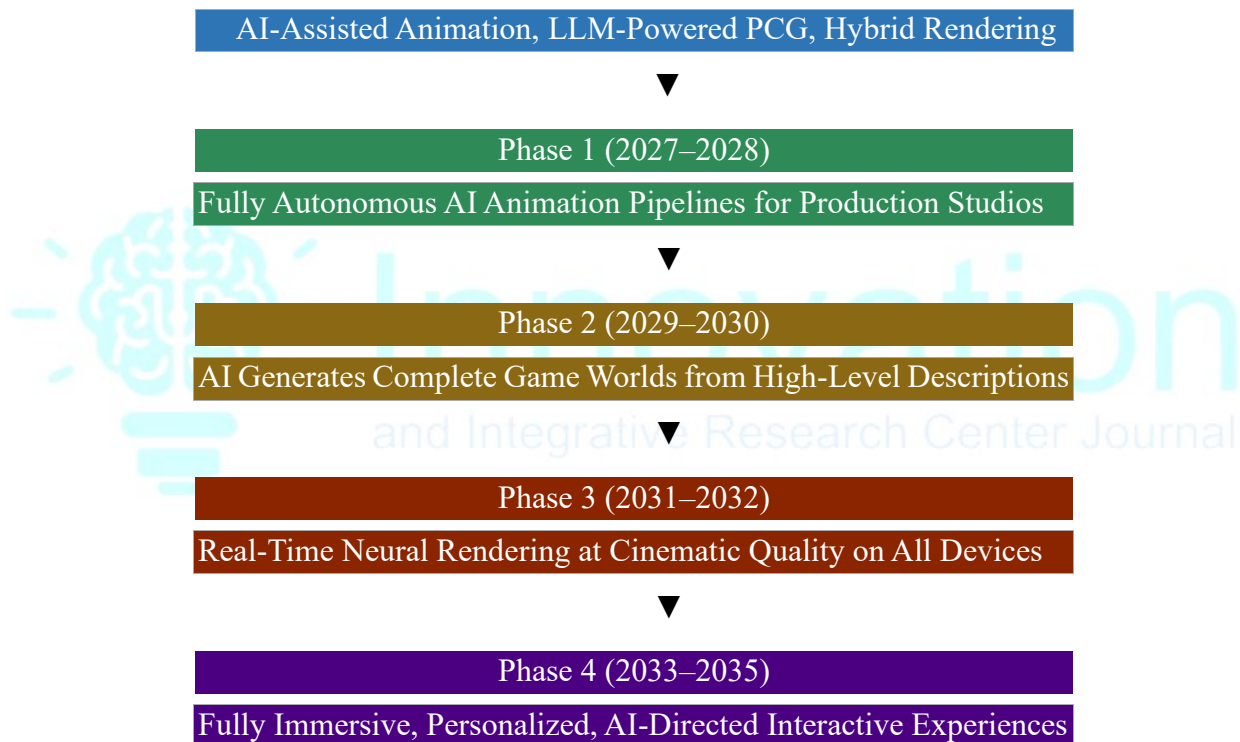


Figure 2: Future Development Roadmap for Gaming and Animation (2026–2035)

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