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Research on the Role of AI in Overcoming Resource Constraints in the Field of Indie Game

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Abstract. Overcoming the resource constraints for the indie developers is the key to improve the development of indie game industry. Generative AI offers several advantages, such as substituting the manpower, enhancing efficiency and saving costs. The purpose of this review is to explore various sorts of AI, focusing on solving the shortage of resources that indie game producers may encounter, as well as some challenges the AI may bring to them. According to the literature review, currently generative AI can help producers fulfill the skill gap between ordinary people and experts, use Procedural Content Generation via Machine Learning (PCGML) and General Video Game AI (GVGAI) to help developers generate new content and test potential debug in the game and alleviate financial pressure for developers. Moreover, to reduce the influence of the oversaturation of game market, Procedural Personas are applied to test the novel game mechanisms, which assist developers to create different gaming experience for players. Some challenges of application of AI are found, but in the future, they may be solved by other advanced technologies. Additionally, possible research directions such as Neurosymbolic AI and MultiModal Recommender System (MRS) are mentioned. This review offers a unique complication of the most recent work in the specific area of generative AI for indie game development, focusing on resource constraints and AI used in this field to guide the developers to better produce indie games and improve the prosperity of game industry.

Keywords: Resource constraints, Indie game, Generative AI, Neurosymbolic AI

1. Introduction

Since the development of the digital game industry, it is increasingly possible for independents to produce the indie game on their own. Therefore, more and more indie developers are engaging in this field. According to the data from VGI Global Indie Games Market Report 2024 [1], indie games take up 42% of unites sold in the Steam, while the indie market keeps growing and full game revenue reaches new heights in 2024, with approximately $4.9Billion.

These indie game developers are generally characterized by their autonomy from employment or institutional affiliations with major technology conglomerates or established gaming publishers [2-4]. Many video game enthusiasts are engaging in this field for various reasons, which can be separated to non-profit-driven and profit-driven [4]. However, there are many obstacles that the indie game developers have to overcome, especially for non-profit driven developers. The main

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challenge is the shortage of internal resources such as labors and budget, and the external resources like oversaturation of game market.

The aim of this literature review is to analyze the most recent works about how the generative AI is applied to the development of indie games to overcome the shortage of resources, offering the advice to the developers to help them achieve success and promoting the prosperity of the indie game industry.

At present, review articles have been published on indie game development, but they are mostly focused on current social and capital challenges [5,6] for developers in the process of game production.

This review addresses a critical gap in existing literature by systematically analyzing how generative AI mitigates resource constraints in indie game development—a niche yet rapidly growing sector often overlooked in mainstream technological discourse. While prior studies emphasize sociocultural or financial barriers, this work uniquely integrates AI solutions (e.g., PCGML, procedural personas) to address indie developers' resource constraints. It positions AI as a creative enhancer against labor shortages and market saturation, while proposing hybrid frameworks (e.g., Neurosymbolic AI) to counter homogenization, fostering sustainable ecosystem growth. This study ultimately bridges theoretical AI advancements with practical industry needs, fostering both academic dialogue and real-world applications in digital creative economies.

2. The obstacle of indie game development

2.1. Internal constraints

2.1.1. Shortage of labors

In normal situations, indie game development remains a niche technological domain with low public visibility and institutional recognition, leading practitioners to adopt small-scale collaborations (e.g., 2-4 members) [6]. However, as multimedia, the production of the video games includes 3D models, textures, animations, sound, music, video and so on, which should be created by the collaboration of different fields of experts [7]. Therefore, indie game developers may assume cross-functional responsibilities to fulfill the shortage of labors, leading to the possibility of worser quality and lower efficiency because of the non-specialized and divergent skill allocations.

2.1.2. Financial crisis

In the development of indie game, capital is crucial to access to effective labor, techniques and financial stability [6]. As for indie game developers, they are limited by different sorts of capital from mainstream companies to achieve the development agenda [4,8]. According to the statistical data from Juego Studio (2025), the cost of mid-scale indie games is $1L - $1M, which is not a small fund for indie developers. Therefore, multidimensional resource scarcities — encompassing hardware procurement, network infrastructure maintenance, and software ecosystem governance — chronically constrain indie developers and persistently disrupt developmental continuity.

2.2. External constraints: oversaturation of market

The external resource constraints of indie game development are considered to be the market oversaturation. A previous study [5] has found that too many indie games occupy the market, which leads to great competition between these games. According to the research, in July 2016, Steam

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Greenlight received over 3,400 submissions with a 15.7% approval rate (536 titles). Yet fewer than 0.6% of approved indie games (<20 monthly) achieved profitability due to hypercompetition for user engagement, while the majority faced market oblivion, profoundly demoralizing developers. In result, most of the productions would be ignored if the producers could not find an effective way to advertise their games. Moreover, according to the data from Steam, more than half of the indie games are free to play, which is perceived as one of the main reasons that cause the oversaturation of Steam. Therefore, this phenomenon will lead to bad influence on the development of indie games.

According to The Long Tail theory [9], as the typical Long-tail commodities, indie games should easily have access to the players worldwide through digital platform. However, in reality, market oversaturation in the indie game sector leads to the distraction of users' attention, which diminishes user engagement, download volumes, and revenue streams. Long-tail games struggle to reach target audiences due to visibility deficits, constituting a "long-tail dilemma" in the market, which creates resource constraints for indie developers such as depleted promotional capacity and capital recuperation barriers.

3. The solution offered by AI

3.1. Substitute manpower

As mentioned before, due to the small team of indie developers, they have to wear different hats in the process of game production. Thus, they may encounter the situations where someone is more proficient in the designing and art, but not in the field of coding. However, with the association of generative AI, anyone who is interested in indie games has the potential to begin the game development. In the research [4], the participants of indie producers believe that generative AI is the role of “a powerful force multiplier” in the aspect of fulfilling the large skill gap between ordinary people and experts in game industry, which motivates the engagement of people to the indie game development. As a result, everyone can realize their creative ideas easily and conveniently to broaden the boundary of game industry.

3.2. Enhanced efficiency

The application of creation AI enables the game to describe all kinds of storylines, characters and settings to create a unique game experience in a very short term. For instance, as an AI-generated game, “Future Hell Drawing” was created totally by creation AI within 6 hours [10].

Similarly, Procedural Content Generation via Machine Learning (PCGML) is well-suited for autonomous generations [11]. Through offering the list of representative samples as a model, the algorithm can generate new content in this style, which reduces the complicated step of coding and debugging. Besides, PCGML algorithms can detect what part of area is not playable (unplayable level or unreasonable rule set). In the development of game Super Mario, Summerville and Mateas [12] added a special tile in their training set to mark where an AI would move the player, guiding the algorithm to generate playable content. In result, the application of AI tools can save the developers valuable time and resources to let them think of better ideas.

Additionally, General Video Game AI (GVGAI) framework [13] creates agents that can play in any game defined in Video Game Description Language (VGDL). It can collect information in the game such as game and player’s state, history of events or position of the roles in the level, which can generate plenty of cases that stimulate the players’ action to testify the game logic and balance,

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even detecting potential game exploits. This model can help developers significantly improve the testing efficiency.

3.3. Alleviate financial pressures

According to the research [4], they find that generative AI helps small-scale indie teams to streamline their development processes, resulting in more cost-effective game creation. Compared to hiring people to finish the work, indie game developers believe that generative AI significantly reduces their financial burdens and can better realize their targets. Through this way, solo indie game developers have the ability to make the games with more fun and creation on a smaller budget. Relieved from financial pressures, they also exhibit a willingness to pursue mechanics innovation, rather than compromising creative vision for commercial viability.

Moreover, for individual developers, it's usually costly to hire the voice actors for the game. Hence, they begin to use AI-generated voiceovers [10] to save the cost, which may lack emotional depth but are still good value for money.

3.4. Test the novel game mechanism

To reduce the influence of game market oversaturation, automated playtesting AI can create Procedural Personas [14] to stimulate and predict different sorts of player action in the same level, which can expose the potential problems of the mechanism and evaluate whether the innovation of the mechanism brings about a reasonable difficulty curve. In this article, the researchers defined four characters (Runner, Monster Killer, Treasure Collector and Completionist) to represent four kinds of playing styles of player, and everyone has a unique reward function to be accessed by algorisms. In the end they find that the structure of different levels significantly affects the performance of characters. Hence, this model can be used to assist authors to increase the gaming experience of player, standing out among a host of indie games.

4. Discussion

While generative AI offered great support to the indie game developers to produce the games in terms of resources constraints, there are also some challenges about the application of AI. Thus, indie producers should keep the balance between digging into the potential of AI and reducing its risk to the creativity and human-beings.

4.1. Challenge of AI

Primarily, the over-dependence on generative AI to create content may lead to the lack of originality in indie games [4]. Because of the absence of legal protection of AI's generative copyright now, the problem about potential risk of AI generative repeated contents is concerned by many developers, especially if the AI are trained by plenty of copyright materials. According to the research [4], some indie producers revealed that their games may suffer lawsuit or infringement if the AI generates the voice or some image of others who have not given any permission to them. Furthermore, when the generative AI is actively involved in the development of indie games, AI can also be trained by related contents. Therefore, the creation of developers may be applied to other works, leading to the creative plagiarism and tort. Worse than that, homogeneous content of indie games would further cause the lower market competitiveness. According to the Resource-Based View [15], a company's unique resources (scarce, valuable, hard to replicate, and irreplaceable) are the foundation of

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competitive advantage. Thus, maintaining the unique selling proposition of indie productions is essential for achieving success in the market.

Because AI has cheaper and efficient benefits, many people worry that generative AI may lead to the risk for the indie developers. Since using AI in the game development process harms others opportunities to perform similar work, especially if AI do the better job. For instance, some voice actors have lost their jobs because more people prefer to use AI voice for the advertisement of production [4]. In contrast, John Riccitiello (Unity CEO) believes these generative AI models could not replace the role of most game developers. He suggests that they will eventually produce simple games (like the Flappy Birds) but they can be very hard to produce rich and complex things on their own for the reason of iterative process. “And so when they go back and the team edits it and makes changes, and that iterative process is one that I don’t think goes away.” he said. Therefore, instead of being replaced by AI, creators will be 2 to 10 times more productive than they’ve ever been before with these tools and create more new stuff.

4.2. Future expectations

Some of the challenges about AI application in the indie game development faced by developers seem hard to solve. However, as the technology advanced, it was possible to develop intelligent AI that could generate more creative content with the help of human-beings. In the future, the further development of Hybrid-AI model should be considered. Currently, the most advanced cooperation framework is Neurosymbolic AI [16]. It aims to integrate the perceptual capabilities of neural networks (System 1) with the reasoning capabilities of symbolic systems (System 2), thereby addressing current AI limitations in handling complex cognitive tasks. Neurosymbolic AI can rapidly process the sensory inputs while relying on background knowledge for abstract reasoning, analogy and planning. Therefore, indie game developers can leverage neural networks to generate diverse game content while applying symbolic systems — such as knowledge graphs or logical rules — to constrain the output (e.g., ensuring level difficulty progression and consistent item attributes), achieving near-optimal game design goals.

On the other hand, MRS (MultiModal Recommender System) [17] has great potential to predict indie game market demand, which can offer suggestions for the developers to reduce competitive pressure. MRS can integrate text, images, audio, and other multimodal data to address the data sparsity problem in traditional recommendation systems, thereby improving recommendation accuracy. Through applying this system to the popular game platform like Steam, it can extract plenty of features on the websites such as game promotional images, the text description and even the analysis of player behavior log. This kind of comprehensive information can clearly reveal the current game market situation and players’ preference to reduce the potential competitive risks for indie game developers and promote the diversified development of the game market.

Given the severity of AI-related challenges (copyright risks, creative homogenization, and workforce displacement), this review calls for collaborative efforts between AI experts, legal specialists, and indie industry stakeholders to establish ethical guidelines, shared resource platforms, and technical support systems. Through such coordinated action, generative AI can transcend current limitations to become a truly empowering tool for high-quality, sustainable indie game development.

5. Conclusion

This review systematically investigates how generative AI addresses resource constraints in indie game development. The findings demonstrate that generative AI acts as a transformative force by

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bridging skill gaps (e.g., enabling non-experts to create professional-grade assets), automating content generation (via PCGML), optimizing testing efficiency (through frameworks like GVGAI), and alleviating financial burdens (e.g., AI-generated voiceovers). These capabilities directly counterbalance the internal constraints of labor shortages and capital scarcity, while procedural personas and market analytics tools mitigate external challenges like market oversaturation by enabling differentiated game experiences and data-driven innovation.

However, the adoption of AI introduces critical trade-offs. The homogenization of game content —stemming from over-reliance on similar training datasets—threatens the unique creative identity that defines indie games, potentially eroding their competitive edge. Furthermore, ethical concerns about AI-generated copyright infringement and workforce displacement (e.g., voice actors) remain unresolved. While hybrid frameworks like Neurosymbolic AI show promise in balancing creativity with systematic constraints, their practical implementation in indie contexts requires further validation. Similarly, while MRS offers predictive insights into market trends, its efficacy depends on access to high-quality multimodal data, which may be inaccessible to small-scale developers.

This study has limitations. First, the reviewed literature predominantly focuses on technical feasibility, with limited empirical data on real-world economic impacts. Second, the legal frameworks governing AI-generated content still remain underdeveloped, a gap this review acknowledges but does not resolve. Third, the discussion of market oversaturation primarily addresses visibility challenges, while deeper structural issues—such as platform algorithms favoring established studios—warrant further exploration.

Future research should prioritize deeper studies to assess AI long-term effects on indie game sustainability, alongside interdisciplinary collaborations to address legal and ethical dilemmas. By refining hybrid AI models and democratizing access to advanced tools, the indie sector can take advantage of AI not as a crutch but as a catalyst for equitable innovation, ensuring that resource constraints no longer threaten creative potential in this vital segment of the indie gaming industry.

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