



## **EFFECTS OF AI-GENERATED CONTENT(AIGC) IN THE GAME DEVELOPMENT**

From traditional PCG to AIGC

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# Abstract

This paper aims to investigate the effect of AI-generated Content (AIGC) when it starts to be applied in game development. AIGC in games refers to the generation of game content through artificial intelligence, a concept that has recently received a high level of attention due to the latest rapid developments in artificial intelligence, and in traditional research, AIGC can be categorized as an advanced approach to Procedural Content Generation (PCG), i.e., Deep Learning Method. Procedural Content Generation is the creation of game content through algorithms with limited or indirect user input. Its traditional approach has been widely used in games. Recently, however, the AIGC method has also started to be used by a large number of game companies, and its impact has exceeded expectations. A questionnaire survey of 40 game developers revealed a general interest in AIGC but also concerns. Further interviews explored the use of AIGC in game development and some of the problems it has encountered and predicted future trends in its development. The results of this study provide guidance on whether and how AIGC needs to be used in future game development.

**Keywords:** AI-generated content, Procedural content generation, Game development

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# 1 Introduction

The concept of AIGC has recently gained a high level of interest due to the rapid development of artificial intelligence like chatgpt and is not an unfamiliar concept in the gaming space. An advanced approach to procedural content generation (PCG), the deep learning method, can cover this concept. Procedural content generation implies the use of algorithms to generate game content. Here, "game content" includes game maps, levels, textures, characters, animations, terrain, and other arbitrary game resources. Procedural content generation is divided into online and offline (Zhang, 2022). Online means that some new game content is generated while the game is running and is usually more closely related to game mechanics, most typically in Roguelike games, which often use randomly generated dungeons to increase playability. Offline means that the game content is created by the algorithm before the game is released. The popular AIGC tools are currently used mainly to generate game resources offline and to speed up the game development process. The latest AIGC tools are not suitable for an online generation due to usage (web or limited use API) and performance limitations, considering the game runtime environment and cost.

In recent years, PCG has been seen as an important means of reducing costs and increasing the speed of development as the cost of producing 3A games continues to rise. One of the most prominent examples in recent years is the SpeedTree system, which has been used to generate trees, grass, and other types of vegetation in hundreds of commercial games (Amato, 2017). Another example is Houdini, which allows designers to procedurally model and dynamically modify art resources in the game engine using multiple nodes. However, these tools require the full involvement of technical artists and the development of rules for generations, which is still very complex.

The use of AI in games was once seen as an experimental solution due to its high cost and limited benefits and was mainly researched and applied by large game companies with strong technical reserves and financial backing, with Tencent training AI to achieve pro-level decision-making in several MOBA games (ye, 2020).

However, with the rapid development of AI big model technologies in recent years, especially the emergence of advanced technologies like ChatGPT and Stable Diffusion, the usability of AIGC has been groundbreakingly improved. These technologies have not only improved the quality of generated content, allowing AIGC to produce more refined, diverse, and creative game elements but have also reduced the cost of implementing AIGC, enabling more game developers to incorporate AIGC into their projects.

While traditional game development methods involve a lot of time and effort in manually creating elements such as characters and scenes, AIGC's batch generation has been a boon to game developers.

From an output quality perspective, by introducing advanced technologies such as deep learning and neural networks, AIGC is able to surpass traditional PCG methods in every aspect. For example, AIGC can produce richer, more interesting, and more challenging content in terms of level and mission generation, story and dialogue generation, game character and behavior generation, as well as music and art resource generation. This helps to increase the appeal and playability of the game, which in turn attracts more players.

In terms of cost, AIGC's intelligent generation method can significantly reduce development costs compared to traditional manual creation methods. With AIGC, game developers can generate large amounts of game content more efficiently, thus reducing the development team's workload and saving human resources and time costs. To a certain extent, this has enabled even small and medium-sized game development companies to try implementing AIGC to improve their products' quality and competitiveness.

However, AIGC also poses some problems. PCG was seen early on as a solution to labor problems (Aleena, 2022) and was used to replace artists rather than help them, as was the original purpose and impetus for AIGC's development. The overuse of AIGC may have suppressed the space for artists to play and their motivation to work. In addition, AIGC is only sometimes reliable in producing game resources.

Therefore, the impact of using AIGC in game development is diverse. Different positions in game development have different views and expectations of AIGC, and the game industry should proactively focus on this difference to understand the thoughts of game developers in different positions and to explore and develop some norms and rules for the use of AIGC.

## 2 Background

### 2.1 Procedural content generation

Procedural content generation (PCG) is defined in the book *Procedural Content Generation in Games*. PCG is the algorithmic creation of game content with limited or indirect user input; in other words, PCG is computer software that can create game content on its own or with one or more human players or designers. The primary purpose of PCG is to increase development efficiency and reduce the time and cost of hand-crafting content while increasing the game's repeatability and content richness. In the past, PCG methods have been divided into traditional method, Search-Based Method, and Deep Learning Method. The Deep Learning Method is identical to the AI-Generated Content (AIGC) method.

#### 2.1.1 Traditional Method

Traditional methods include Random Methods and Rule-based Methods. Random Methods, such as random number generators, are based on random algorithms to generate content. This method is simple to use and requires only simple algorithms and fewer computational resources to generate game content, but the generated content is challenging to control and predict, and non-conforming results may occur. When a wonderful generation result is found, its generation seed is recorded for reuse as if it were a compressed file.

Rule-based Methods generate content based on pre-defined rules, commonly found in growth models, grammar systems, state machines, and so on. Rule methods ensure that the generated game content conforms to the rules and constraints set by the developer, improving the controllability of the content. However, complex game content generation requires the design of a large number of rules and constraints, which increases the difficulty of use, and the generated results may be more homogeneous and need more innovation and diversity.

#### 2.1.2 Search-Based Method

The search-based approach is to search for optimal solutions in a well-defined state space using specific search algorithms to generate content that meets specific requirements, such as automatically-generated game levels, characters, terrain, etc., as well as areas such as music and art creation. If the content generated in real time is sufficiently diverse, then it is possible to create genuinely endless games. Especially if this new content happens to fit the gaming style of a particular group of players, or a particular type of player experience such as challenge, novelty, etc., then the game has a degree of infinite replay value. (Togelius, 2011)

#### 2.1.3 AIGC Method

The AIGC method or Deep Learning Generation Method refers to a model that uses neural networks (an artificial intelligence technique) and large amounts of training data to learn to generate game content. The Deep Learning Method has greater generative power and flexibility to generate more complex and creative game content than traditional random and rule-based methods. Creating content automatically or semi-automatically using AI techniques can save time and costs and increase efficiency and quality by automatically generating textual content using large language models, images using prompts, 3D models,

etc. The use of AI for content creation has been around for a long time. The first computer-generated music, "Illiac Suite," was released in 1957. (Zhang, 2023)

In the past, AI models were trained to do specific tasks, and Alphago, a professional Go AI, defeated the then-world champion Go player Lee Sedol in 2016, demonstrating the power of domain-specific deep learning techniques (wang, 2016). However, recently popular AI tools have become more versatile. Thanks to considerable increases in computing power and the training of large amounts of data, AI has become smart enough to do a variety of jobs in different industries. For example, Chatgpt, a text-to-text AIGC tool, can perform tasks in hundreds of professions through different prompts, even including writing code.

AIGC tools such as Chatgpt, Stable diffusion, and Mid Journey are currently in use at many gaming companies. For example, Heartbeat Network, a medium-sized Chinese game company, has used Stable Diffusion to reduce the resource requirements for outsourced art significantly. Mid Journey generated **Figure 1** with prompts Chinese ink painting, masterpiece, highly detailed, Chinese wetland, birds, and wood bridge. They are very fine images, produced to a level that surpasses most junior artists.



**Figure 1** Images generated by Mid Journey

However, while Text-to-text and Text-to-2D products are already abundant in the gaming industry, Text-to-3D is still in the lab stage (Zhang, 2023). 3A games are highly demanded for 3D digital content, such as 3D characters, textures, scenes. However, this requires many professional 3D modelers with artistic and professional 3D modeling training, which implies a huge cost. However, this requires many professional 3D modelers with artistic and

professional 3D modeling training, which implies a huge cost. Using generative AI to generate high-quality, large-scale 3D models makes much sense, and text-to-3D AI modeling can significantly help both novices and professionals achieve the freedom to create 3D content. Text-to-3D has become an emerging and highly active research area due to the development of text-to-image and 3D modeling techniques such as Chenghao (2023) summarises how recent research has combined these fundamental techniques to achieve satisfactory text-to-3D and the use of text-to-3D techniques in a variety of applications, including avatar generation, texture generation, shape transformation, and scene generation.

There are still some issues and challenges with the application of AIGC technology in games, such as how to balance AIGC-generated and hand-crafted elements and how to ensure the consistency of AIGC-generated elements with the overall atmosphere and player expectations of the game. Therefore, it is necessary to study the effects of AIGC on game development.

## 2.2 Problems

As the games industry seeks to leverage AIGC (Artificial Intelligence for Game Creation) or other PCG (Procedurally Generated Content) technologies to meet demand, the potential consequences need to be looked at and thoroughly considered. The following are some possible issues:

Firstly, although AIGC has achieved some success, its technology is still in the developmental stage. In practice, AI-generated game content may achieve a different level of granularity than human-designed content. Text-to-3D is in a state of complete unavailability in actual production, even in full-fledged text-to-2D. Text-to-2D is in a state of complete unavailability in actual production, even in full-fledged text-to-2D. Artificial intelligence is not 100% accurate, and the quality and accuracy of the generated content may vary widely due to the instability of AIGC models, such as the randomness of the STABLE diffusion model. This can lead to inconsistent product styles, a phenomenon not desired in industrial production.

Secondly, the source and responsibility of the training material for the AIGC model may need to be clarified. The AI may imitate existing game works when generating the content, leading to intellectual property and copyright protection issues. It is also regulated differently by the laws of different countries. In addition, uncensored AIGC models may lead to social, political, or cultural polarisation or disruption.

Most importantly, there are concerns about whether AI will cause massive job replacement for game developers and trigger mass unemployment in the gaming industry. These issues are topics of great concern.

In summary, this paper has explored some of the positive and negative effects of AIGC in game development through various methods. These issues should be considered when developing AIGC technology to ensure that it brings about positive change in the games industry.



## 3 Methods

This study used a combination of online surveys and interviews. The aim is to examine the effects of AIGC in game development. The research population covered game developers in different positions to gain a comprehensive view and insight.

Firstly, an online survey was conducted through a carefully designed questionnaire to collect data on the general concerns and practical experiences of game developers with AIGC. The questionnaire included aspects such as experiences, advantages, challenges, and ethical issues related to the use of AIGC.

After collecting and analyzing the data from the online survey, I filtered out a number of topical issues based on the results and conducted in-depth interviews on these issues. Interviews were conducted with game developers with extensive experience and diverse perspectives to gain more valuable information.

Through a comprehensive analysis of the online survey and interview data, I have drawn detailed conclusions and recommendations on the impact of AIGC in game development. These conclusions and recommendations are intended to provide helpful guidance to the games industry for the positive development and application of AIGC technology.

### 3.1 Online survey

The online survey uses Questionnaire Star as the survey platform, and **the authors have carefully prepared approximately 20 questions**, including single-choice, multiple-choice, quantitative scoring, and fill-in-the-blank formats in Table 1. The following questions build on the previous ones and go deeper into the topic. The first question will end the survey if none of the answers are understood. Some questions are shown or hidden depending on the respondent's previous answers. For example, the questions about the company (questions 9 and 10) are only shown if question 3 answers yes (meaning he works for a gaming company). Questions 5, 6, 7, and 8 collect data on the use of and satisfaction with the PCG and AIGC tools. Questions 11, 13, 14, and 15 are quantitative rating questions in which online respondents will rate the advantages of AIGC, such as the degree of job advancement (1-5), and also the degree of concern about the disadvantages of AIGC such as the various social, legal and ethical risks (on a scale of 1-5) to indicate how much they value it. The 19th question allowed respondents to offer new ideas or additional clarification, and the final question allowed respondents to be given the opportunity for further interviews.

The link to the questionnaire was posted in several game developer communities to ensure that the majority of respondents were game developers, filtering non-developer responses by setting questions.

**Table 1** Online Survey Questions

1	Are you aware of or have you heard of Procedural Content Generation (PCG) or AI Content Generation (AIGC) tools?
2	What is your position in the games industry?
3	Are you already working (including starting a business) or interning?
4	Have you ever used Procedural Content Generation (PCG) or AI content generation (AIGC) technology?
5	What traditional PCG techniques have you used?
6	What AIGC tools have you used?
7	Which AIGC tools are you more satisfied with?
8	Have you (or your company) used AIGC tools in production? Which ones?
9	Has your company created an AIGC knowledge base or regularly shared relevant content?
10	Has your company set up its own AIGC service? Which ones?
11	How much do you think AIGC has improved your productivity?
12	What steps do you think the AIGC tool can help you to improve your efficiency at work?
13	To what extent are you concerned that AIGC will cause job losses in your position?
14	To what extent are you concerned about copyright issues arising from AIGC?
15	The extent to which you are concerned that AIGC will generate content that violates the law and ethics?
16	What other potential risks do you think the AIGC will pose?
17	What problems have you encountered using AIGC?
18	If you were provided with an AIGC tool that you could use in your work, what are the features you would like to be sure to have?
19	Do you have any suggestions for the development of AIGC in the gaming industry?
20	Would you be interested in participating in further interviews?

## 3.2 Semi-structure Interview

Based on the preliminary results of the online survey, interviews were conducted with some of the developers interviewed as well as some senior developers.

I designed a semi-structured interview guide for the interviews, which included questions on the following areas:

1. the interviewees' knowledge of and experience with AIGC
2. the specific applications of AIGC in the game development process
3. the advantages and enhancements brought by AIGC;
4. the challenges and risks that AIGC may face;
5. the impact of AIGC on the game industry and its future development.

During the interview process, I flexibly adjusted the questions according to the interviewees' answers in order to guide them to explore the relevant topics in depth. The process was very open, and each interviewee was given enough time and freedom to express their views.

### 3.2.1 Interview Implementation

The interviews were conducted using online video conferencing to allow the interviewees to share their views in a comfortable environment. The duration of each interview was approximately 30-60 minutes. To ensure the accuracy of the data, all interviews were recorded with the consent of the interviewees. At the end of the interviews, I transcribed the recordings into written material for subsequent analysis.

### 3.2.2 target

I screened the interviewees to ensure that I covered all positions in game development, including programmers, artists, planners, and technical artists. Six interviewees were finally identified, including one programmer, two artists, one technical artist, and two planners, all of whom had different segments of positions. Three of them were female, and the other three were male.

### 3.2.3 Data Collection

I used a qualitative content analysis approach to analyze the interview data. First, I read the interview transcripts several times to familiarise with and understand the perspectives of the interviewees. Next, I coded the interview transcripts to extract and categorize the relevant information into different themes. See **Figure 2**, the tool used here is Excel, information on the same topic will be combined in a sheet and keywords will be marked in red. Finally, I conducted an in-depth analysis and discussion of the effects of AIGC on game development based on the coding results.

	The maturity of AIGC
1	It's <b>not particularly mature</b> , and at the moment only the original painting position is known
2	<b>Not very mature</b> , but <b>sufficient for personal use</b> , more difficult to use as a regular process
3	<b>Part</b> of this is now <b>available</b> , I'm already using new bing to help with <b>programming</b>
4	I think it is <b>not mature</b> enough to be used on a large scale, and it should still rely more on
5	<b>Not yet</b> ready for large scale use, <b>can be tried</b> on a small scale
6	<b>Part</b> . Stable Diffusion can now be used in batch for <b>some processes such as sketching</b> after

**Figure 2** Interview Data Example

Through this series of interview methods, I gathered valuable information on the effects of AIGC in game development, providing strong support for this study.

### 3.2.4 Privacy

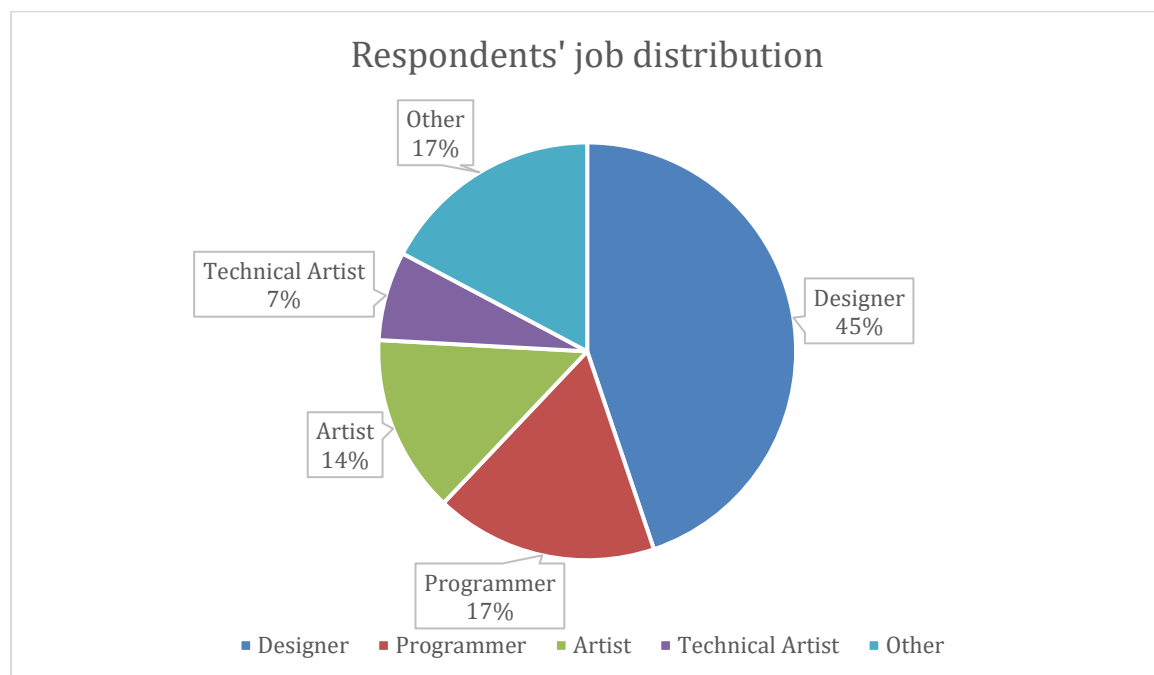
The interviews were anonymized at the request of the interviewees due to the privacy of their work and will not involve specific companies or individuals. Each interviewer will be called a form like Interviewer 1 or Interviewer 2 instead of a real name. The dialogues that have value for discussion and do not reveal the identity of the interviewees will be highlighted for study.

## 4 Analysis

The analysis method is a combination of quantitative and qualitative analysis. The online survey and the interview data can complement each other, the online survey has the advantage of quantity, part of the data can be quantified and quantitative analysis can be carried out to identify patterns and trends in the data, while the interview has the advantage of quality, combined with the results of quantitative analysis can be in-depth qualitative analysis.

### 4.1 Quantitative analysis

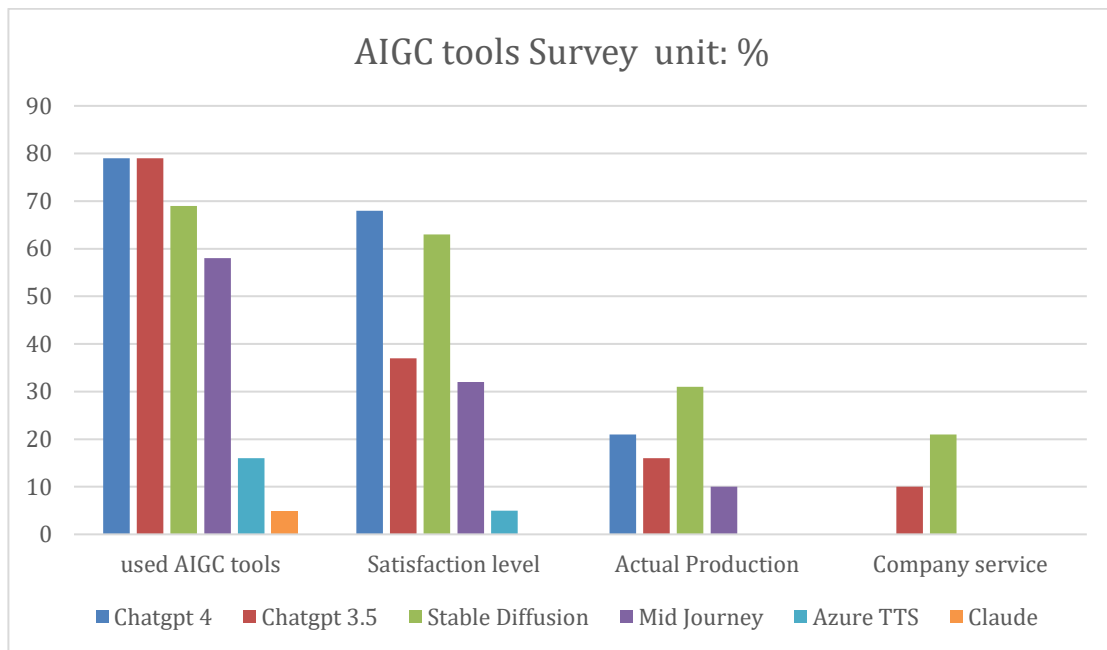
The questionnaire received a total of 40 valid responses and one invalid response (not working or studying in the games industry). Due to the difficulty of controlling for the specific identity of the participants in advance of the questionnaire, the respondents were not evenly distributed across the games industry, and in Figure 3 it can be seen that the vast majority (45%) of respondents were game planners, which means that this finding applies more to them.



**Figure 3** Respondents' job distribution

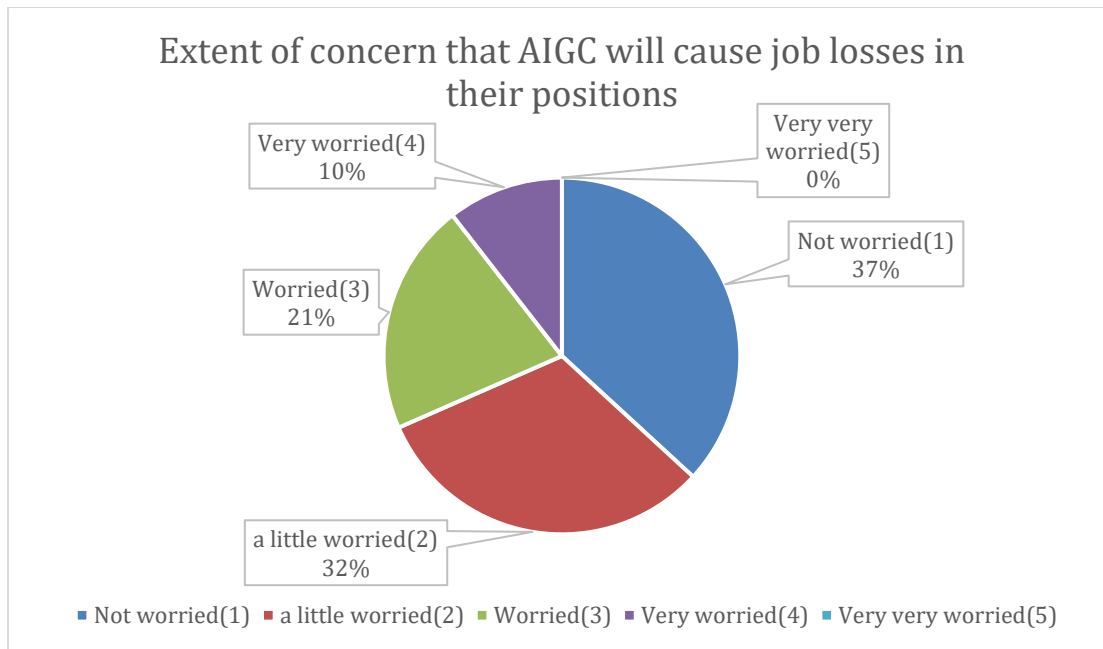
In **Figure 4**, 68% of respondents indicated that they had used the AIGC tool. Among those who had used AIGC tools, Chatgpt, Stable Diffusion, and Mid Jounery were used by 79%, 68%, and 58%, respectively, while the other AIGC tools were largely ignored, and even if game developers had tried them, they would not have put them into production. Stable Diffusion is close to the same level of satisfaction and usage, Chatgpt (gpt 3.5) is only half the level of satisfaction as gpt 4, and if game developers have access to gpt 4, then it is definitely the first choice. Although chatgpt (gpt4) has a higher satisfaction rate, it is not used as much as Stable Diffusion in production game development.

20% of developers have access to the company's deployed LAN Stable Diffusion server, 10% have access to a customized chatgpt server (gpt 3.5), and no companies use gpt4 chatgpt probably because the gpt4 API is still in beta.

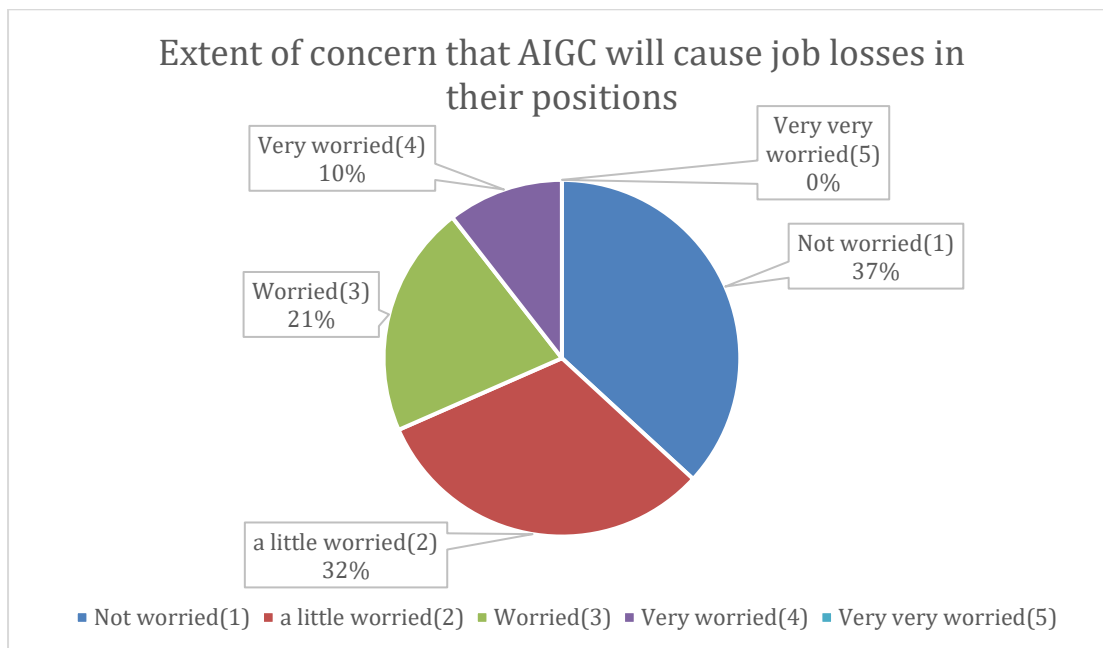


**Figure 4** survey of AIGC tools usage

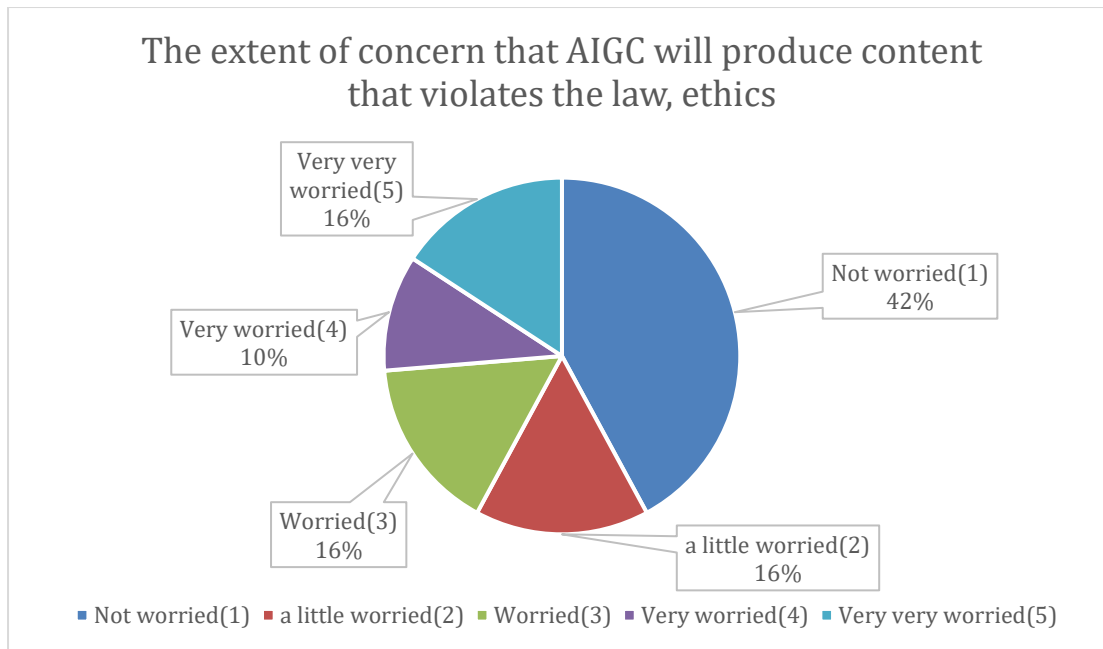
Figures 5, 6 and 7 below show the distribution of respondents' level of concern about possible risks arising from the AIGC respectively. As can be seen, the mean scores for the level of worry about unemployment, copyright, law and ethics are 2.05, 2.95 and 2.42 respectively, out of a possible 5. It is rather surprising that copyright is the most feared component, while the concern about unemployment is the lowest.



**Figure 5** Extent of concern that AIGC will cause job losses in their positions



**Figure 6** The extent to which there is concern that AIGC will create copyright issues



**Figure 7** The extent of concern that AIGC will produce content that violates the law, ethics

The AIGC rating of 3.63 out of 5 indicates that the AIGC tools are now very powerful and can effectively improve the productivity of a game developer's work, but of course this is for the individual developer. The data in Figure 4 indicates that the efficiency gains of individual workflows cannot be directly applied to the development process of a game project, which needs more exploration.



## 4.2 Qualitative analysis

There are some interesting things to consider in the quantitative analysis, such as the fact that we can find that while there is the loudest online discussion about unemployment. And while the results of the survey show that game developers are instead the least worried about losing their jobs, these questions and the questions and concerns of some of the respondents piqued my interest. During the interview phase, I discussed these questions with game developers and analyzed them here in the hope that I would come to interesting and realistic conclusions.

### 4.2.1 Specific applications

AIGC has a broad application prospect in all industries, which is also true in game development. Theoretically, integrating AI into game development will revolutionise the entire industry, and developers and game artists will be provided with powerful tools to enhance creativity, streamline workflow, and fully dedicate themselves to game development to create a better gaming experience.

However, the reality may not be the same as the imagination. The specific application of AIGC in the game development process does not cover all the work and can only change part of the process. AIGC can only change many small processes. In this way, AIGC is gradually penetrating the game industry in many small ways, quietly providing a powerful impetus to game development.

Every occupation in the games industry has needs to use AIGC. For example, Interviewees 1 and 2 have different occupations, but they can use the same software to create their work, even if they do not have the same purpose or starting point. Art designers can use text-to-2D AIGC tools such as Stable Diffusion to assist with composition and adding elements, creating drafts quickly, and working on refinements; level planners can use it to easily communicate with art designers to convey accurate design ideas and requirements.

I know that it can be practised on the ground in terms of game concept creation, a lot of scene concept art can be generated directly at scale using Stable Diffusion, then the concept designer can quickly access the material and ideas that may be needed, including composition and camera placement, which saves a lot of time spent on creative ideas.

Interviewee 1

As a level planner, I need to give the art the requirements of the scene. In the past, it was very difficult for me to make the art understand my ideas accurately, and it was very difficult to express my ideas clearly, and the slightest misunderstanding may lead to a huge deviation in the work, which may lead to

reworking and wasting of resources. Now that I can use Stable Diffusion to create reference artwork that is close to my ideas quickly and at a level of art that I am far from being able to achieve, I have a very strong incentive to design the level, and the art can more easily realize the effects that I need.

Interviewee 2

It is striking that code can also be generated with good quality, and Interviewee 3 mentioned using New Bing, Microsoft's version of Chatgpt with networking capabilities, to generate code to speed up development. Interviewee 4, a programmer who shares the same programming needs as Interviewee 3, said that when he knew that New Bing could generate a lot of usable code, he said if this were true, he would consider trying out this type of AIGC tool to help improve productivity.

I'm a technical artist, and I've been a heavy user of New Bing for a while now. I use New Bing first to generate code or suggestions in my work, and it's already got a pretty high accuracy rate. I can get my work done on time very easily.

Interviewee 3

I know a lot of games use PCG (procedural content generation) to generate maps, terrain, and other content. Compared to manual configuration, PCG can create more diversified game content more easily when used properly. I don't know much about AIGC. Maybe in the future, some game art resources can be generated by AI.

Interviewee 4

Text-to-text type of AIGC is the most widely used. Basically, all writers will try to use it. Interviewee 6, a writer, said that the emergence of Chatgpt has facilitated his work very much.

The dialogues in the game used to be written by people, writing as many branching dialogues as the number of bridges produced, which must be limited in number, but in the future, branching dialogues can be produced in batches with the help of AI, which will result in more complex and interesting scenes.

Interviewee 6

Text-to-3D type of AIGC tools are not accessible for the time being, but it is highly expected. Interviewee 5, a 3D artist, hoped that there would be AIGC tools that could help him with boring but time-consuming tasks, such as quickly generating 3D base models, while he only had to do his favourite animation work.

I haven't heard that AI can generate 3D assets for a while, but I hope that day will come soon, right now making 3D assets is a highly complex process, first you have to make the model, unfold the UVs, paint the textures, and then you can make the animation, which is obviously not something that a person can do quickly. I often have ideas for very interesting 3D scenes, but the cost of making them is too high. It would be great to have AI to assist me with that.

Interviewee 5

It is easy to notice that the needs of each position in the game industry are very different, but what is the same is that most of the game industry practitioners would like to have powerful AIGC tools to help them with their complex work, because the work in the game industry is tedious, even though creating a game itself is an exciting thing. So the most significant advantage of AIGC is that it can provide tailor-made assistance service for every game industry practitioner to deal with those elementary tasks, just like an obedient assistant. Of course, the satisfaction of the service depends on the development of AIGC technology. When the more mature the technology is, the more the penetration of AIGC tools in the game industry will be.

#### **4.2.2 The maturity of AIGC**

Whether AIGC is mature or not determines whether it can actually enter the game development process to be used on a large scale. Despite the expectations of almost everyone, most suggested that it was not mature, while others thought it was only partially mature.

Interviewee 1, a UI designer, believes that the current use of AIGC in original art production leads to hand errors, which is the most difficult part of the AI to train, meaning that the art resources generated by AIGC cannot be used directly, but need to be re-tuned and optimised by the designer. Other interviewees expressed similar views, such as the lack of consistency in the quality of AIGC.

It's not particularly mature, and at the moment only the original painting position is known. However, even if the original artwork can be used, there are still many limitations to the technology, such as the tendency for the hand to be misplaced. The model requires a lot of time to train before it can be formally produced, which is probably about the same time as an original artist would spend on a serious drawing.

Interviewee 1

In fact, the use of AIGC is still in the exploratory stage. There is no unified standard, so every developer uses it in different environments and needs, and it is not easy to incorporate it into a fixed process for actual production.

Interviewee 2

It isn't mature enough to be used on a large scale. It should still be more dependent on manual adjustment and configuration, and directly replacing it with AI will lead to serious problems.

Interviewee 4

AIGC's involvement in the game development process is far from mature, and forcing it into the traditional process as a fixed link may lead to disaster or even be counterproductive. However, for some individuals, some AIGC software has already met some of their needs, and as a tool, it is close to maturity, and it is worthwhile for developers to add AIGC tools to their own workflow according to their own situation. Developers can choose not to use it, which means less efficiency and competitiveness. It's worth noting that some companies have begun attempts to train artists in groups, with specific use cases to show game company bosses that AIGC tools can't be used to replace artists, but they can be used to improve their efficiency. Maybe in the future, AIGC will be a necessary skill point for all professions, just like Word and PowerPoint.

In fact, our company has corresponding AI labs exploring the use of AIGC tools in the game production process, setting up public stable diffusion servers, and they are trying to communicate with the project team to train some artists to learn AIGC tools to assist them in a drawing.

Interviewee 1

As far as I know, some companies have made using AIGC tools a skill item for recruitment.

Interviewee 3

So, even if AIGC is not very mature, all game developers should be aware of the trends that AIGC may lead to and actively prepare for them.

### **4.2.3 Challenges and risks**

AIGC may lead to many problems, such as unemployment, copyright, and ethics violation. The data from the online survey shows the highest level of concern about copyright. In the interviews, copyright issues were also the focus of discussion.

A basic consensus is that the current law is unclear on whether AIGC is infringing. This is very vague, so most of the use of AIGC may be in a legal grey area because most of the training data they use comes from the web. There are also questions about whether the work produced by users on the AIGC platform belongs to the user or the platform. After in-depth interviews, we realized that this legal ambiguity could hinder the growth of AIGC.

A direct jigsaw puzzle is prone to copyright issues because it is a patchwork of many original works. For example, an artist has a particular artistic style. When you use his images as a model to train the same work style, how do you determine whether you plagiarize? Whether this is an infringement or not may need to rely on the law to stipulate.

Interviewee 1

I think most of the current AIGC tools have copyright issues, the data they use claim to be from the web, so isn't there a copyright on web data?

Interviewee 2

When an AI model trained by one company is leaked, is it copyright infringement for another company to use that model? If the images used to train the AI model belong to the company, then it is copyright infringement. Of course, if the law says the opposite, then it is not an infringement. It would not be very clear if a court in one district ruled that it was legal to train an AI model using web data and a court in another district ruled that it was not. In order to avoid possible legal risks, companies or individuals will begin to distance themselves from AIGC tools.

Interviewee 6

There is no significant concern about the risk of leading to unemployment, which is in line with the survey results. The answer has already been given in the discussion about the maturity of AIGC that this AIGC software can't completely replace people but can only be used as a supplement to the tools of the game developers to enhance their productivity. Of course, AIGC tools are only that friendly to some. Employees of outsourcing companies and freelance painters may be affected.

Outsourcing companies may be affected. For game companies, AIGC tools can reduce the need for outsourcing as their art output becomes more efficient.

And for those freelance artists, it may cost thousands of dollars to sell a small picture, now with this AI, especially after the customers also know that they

have it, they may only be willing to pay hundreds of dollars to buy it, then the labor cost of freelance artists becomes lower.

Interviewee 3

I think the people who might be more affected are the amateur artists; they might not be going in that direction anymore; they feel that the cost they pay is not proportional to what they get anymore, they pay a lot, but they get relatively less because later on, you might have to grow up to the top level of artistry before you can outperform your competitors - the Artificial Intelligence, otherwise even people who haven't studied art can be born to generate very beautiful images through a reasonable PROMPT.

Interviewee 5

The causes of other risks and their solutions are also being discussed.

Cloud AIGC models like Mid Journey and chatgpt still have the risk of compromise even though it claims that the advanced version is private. The only way to do this is to build a local AIGC model, like stable diffusion.

Interviewee 3

In general, we all remain optimistic about these risks; the AIGC is, after all, a new object, and the law is bound to be modified and adapted to the needs of society and the market. And unemployment means a change in the industrial structure, just as we couldn't stop artisans from losing their jobs in the course of the Industrial Revolution. The fact that some people lose their jobs also means that new jobs will be created, and the whole game industry will gain further development. For example, higher production efficiency may result in new categories of games.

There is a need to develop a new management system and legal system because this thing is something that has not existed before, so now there is definitely a need to create an additional new department to oversee this thing. This aspect is problematic now, and there is still a need for the law to be slowly improved and some better policies on AI to be introduced.

Interviewee 1

Unemployment is a good thing. Unemployment represents an economic structure that needs to be modified, actually changed.

Interviewee 3.

#### 4.2.4 The effects and future of AIGC

The effects of AIGC on the gaming industry will be multi-faceted. The use of AIGC in the gaming industry is growing rapidly and is shaping the future of the entire gaming industry while changing game design and player experience.

First of all, AIGC can create brand-new game mechanics. For example, the NPC system can get a complete upgrade. Previously, NPC words were written in advance by the copywriter inside the thesaurus and triggered randomly. But now, it is possible to 'feed' ChatGPT with copywriting materials such as game-related worldviews, character dialogues, plots, etc., and then provide its NPCs with character settings, and on this basis, realize natural language communication and answering. Playability of games will be enhanced.

Secondly, job requirements will change, with some junior positions becoming less demanding and senior positions more demanding.

In the future, there may be some AI artist and AI planner positions, their professional requirements may not be so high, but they are more skilled than others in mastering the skills of AIGC to produce works. So the competition for traditional developers has become more intense, and they either have to become one of them or try to improve their professional level to enter senior positions.

Interviewee 1

The exchange and convergence of ideas on the copyright issue led us to a reasonably satisfactory solution as a future policy. All training data used by each AIGC model should be provided or copyrighted by the trainer, and the company should own ownership of the resources generated by that AIGC model. That means that if a game company wants to train a specific AIGC model, all training data should be provided or at least copyrighted by the game company. If the AIGC model generates resources directly from a third-party company, then that third-party company also has to prove that all the training data is copyrighted and then license the model to the game company. Thus, all AIGC models and their generated assets would be ensured to have copyright certification. This method eliminates the problem of copyright infringement, and the policy has a high upfront running cost, but in the long run, this can promote the standardization and healthy development of the AIGC industry.

For large companies, they have the funds and ability to establish a professional art team to carry out the drawing of the essential atlas to ensure that the entire model is controllable. It is unrealistic and extremely expensive for small companies to rebuild the AIGC model completely. This triggers the need for a base atlas or base model. These needs will be fulfilled by professional third-party AIGC modeling companies, which will employ many artists to draw various materials for the AIGC model.

As a result, on the one hand, artists will no longer be unemployed, but their job opportunities become more and more, and AIGC models of any drawing style will need a large number of works to be maintained, and the quality of the models will become better and better. On the other hand, art materials and AIGC models will become real productivity tools, promoting the revolutionary development of the art production system in the game industry, and games will

no longer be limited by inefficient art production. They can become larger and more immersive experiences.

The discourse of the AIGC leading to a revolution in the gaming industry sparked a vast imagination, and many additions were made by the interviewees, such as the use of blockchain technology for copyright protection of material and the advancement of the implementation of laws and policies is possible.

Even if the idea is not implemented in law, the argument can give us new perspectives for development. First of all, it is necessary for game companies to build local AIGC model material libraries, which facilitates the designation and unification of art styles, and also allows users to reuse assets across project teams, and as a side feature, the risk of leakage of the cloud model is also solved. This is something that some companies have already begun to implement. Secondly, the need to provide copyrighted material and models are bound to be a vast market, legally secured or not, as evidenced by the existing licensing mechanism of MidJourney, which is still a generic model with a leakage risk.



## 5 Result

Based on the results of the analysis, the following positive and negative impacts of AIGC on game development have been compiled.

### 5.1 Positive Effects

1. As an advanced PCG tool, AIGC can generate a large amount of different game content based on specific prompts, thus increasing the diversity and innovation of the content and providing a better experience for the user. It is simpler to use than other PCG algorithms with complex rules.
2. AIGC can reduce the time and cost of specific game development processes such as first draft design and programming prototypes, significantly increasing productivity and quality, which can speed up game development and drive a technological revolution in the entire gaming industry.
3. AIGC can unify art styles in the form of local repositories, which can be easily reused and modified, increasing the repeatability and reusability of content.
4. New jobs will be created as game companies free up productivity and have the energy for a more fine-grained division of labour, focusing on improving the overall quality of the game and polishing the user experience.

### 5.2 Negative Effects

1. AIGC cloud services are mostly generic large models that are not optimised for specific production processes, producing results that are difficult to fully control and predict and may not meet the required results and still require subsequent manual tuning and optimisation.
2. AIGC it produces results that are usually dependent on the quality of the algorithms, computing power and datasets, high-quality local AIGC deployment for project optimisation is very costly and not friendly to small companies. The use of AIGC cloud services on a large scale can be commercially risky due to project leakage and copyright ownership issues.
3. Although AIGC is not a complete replacement for manual creation, the demand for some entry-level jobs in the game industry, such as junior art, has dropped significantly, and a certain degree of unemployment is inevitable, while the training cycle for professional art will be lengthened.

## 6 Conclusions

### 6.1 Summary

In summary, the AIGC has profoundly impacted game development, bringing more positive effects than potential adverse effects, such as copyright ownership and unemployment. AIGC enhances the game experience, enriches game content, and brings innovation to game design. With the further development of AI technology, the application of AIGC in game development will become more extensive and deeper.

Until the emergence of true strong AI, applying AIGC tools such as chatgpt and stable diffusion as intelligent enhancement aids in game development can achieve mutual benefits for game developers and AIGC. As an advanced procedural content generation tool that inherits the advantages of PCG technology while significantly lowering the threshold of use, the productivity of game development will increase dramatically as the originally complex algorithms and rules are replaced by prompts. Although it is inevitable that some entry-level jobs will be lost when AI matures further, in the long run game development will become more detailed and user experience oriented, and there will be more emerging job demands, which is essentially a revolution in the gaming industry.

Of course, some legal and other issues will inevitably arise in the course of the game revolution, and these will be resolved in practice. We cannot completely reject new innovations because of the risks involved.

Many of the risks of AIGC can be hedged by localizing the technical and market instruments of the AIGC model.

Suppose good policy tools can be utilized to clarify the copyright issue of AIGC, for example, to ensure by law that all training data used by each AIGC model should be provided or copyrighted by the trainer and that the ownership of the resources generated by that AIGC model belongs to that company. Then ideally, the AIGC industry represented by text-to-2D and the future text-to-3D genres will make a great development, thus further promoting the industrial revolution and progress of games. This is essentially more of a revolutionary development for the entire gaming industry.

## **6.2 Discussion**

The policy options discussed above have only been theoretically justified, and whether they are effective remains to be practically verified and further refined, and it does not exclude that there are better options that could be chosen. In addition to the legal and policy implications and their possible counterproductive effects, many other aspects of AIGC's impact could be discussed.

Chatgpt-like forms of API access will not only be available for offline generation of game content, but rapid online generation is also becoming feasible. Understanding and responding to player input more naturally makes game characters more realistic and communicative. This not only increases the playability and appeal of games, but also opens up new creative opportunities for game developers. For example, in role-playing games (RPGs), AIGC can enable non-player characters (NPCs) to have richer conversational content and greater language comprehension. By interacting with these intelligent NPCs, players can gain greater insight into the game world, character backgrounds and plot threads. In MMO games, AIGC can also be used to create intelligent teammates that are highly collaborative and strategic, providing a more challenging and fun gaming experience for players.

With the further development of AIGC technology, we can foresee a future in which games offer a more personalized experience. AIGC generates unique game content based on each player's behavior and preferences, making the gaming experience unique for each player.

## **6.3 Future Work**

The sample size of this study may be limited, and the study is limited to Swedish game developers in China. The conclusion may not be suitable for the game development industry and all game companies in all countries, and the scope of the study will be further expanded in the future to increase the credibility as much as possible. In addition, the main subject of this study is still offline AIGC, in fact online AIGC will have more room for development and innovation opportunities, which will be the direction of future research.

We have reason to believe that AIGC will play an increasingly important role in the future of the gaming industry.

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