# Using new AI-driven techniques to ease serious games authoring

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***Abstract*—Serious games are videogames whose purpose goes beyond mere entertainment. However, serious games use in mainstream education is still limited. The development of serious games is an expensive and complex process that requires the participation of different experts (e.g. domain, educators, graphic artists, and programmers). We consider that new generative AI techniques can help in the prototyping of serious games by reducing and automating some of the processes involved. There is increasing evidence that generative AI techniques such as ChatGPT or GitHub Copilot can increase the productivity of writing or coding tasks respectively. In our case, both prototyping and teaching serious games are complex because of the number and diversity of tasks involved and we are currently investigating whether AI techniques can be used to improve and simplify the process. For example, ChatGPT could support the process of creating the game narrative, and other systems such as Stable Diffusion could ease the creation of some of the graphics resources (e.g., for creating more cohesive and coherent backgrounds). Automating some of the costlier processes of game prototyping can contribute to creating better products by allowing the playtesting of different options for more effective games. As the field of generative AI is in continuous change, this paper presents a working methodology to simplify the development of serious games, that has been instantiated with concrete tools. This working methodology has been piloted effectively by one student from a Master of Design for the development of a serious game and will be tested in a serious games development course. In the article we also explore how these AI techniques can be combined with a game authoring environment such as uAdventure to systematize the development of serious games. The use of Generative AI offers great potential for improving the development of serious games and needs to be further researched alongside its applications for game-based learning education.**

***Keywords—serious games, artificial intelligence, game development, serious games authoring***

## I. Introduction

Student learning is usually enhanced by methods that encourage both motivation and active learning. One of these methodologies is Game-Based learning, in which video games are used as an educational tool [1], [2]. Those games that are designed and developed for an objective that goes beyond entertainment, such as an educational purpose, are called serious games (SG) [3]. Serious games combine both educational and playful elements to create a more engaging and interactive learning experience.

Serious games are successfully used in a wide variety of fields, from business to health. In the educational area, games may be designed to teach procedural skills, improve information retention and understanding, as well as to raise awareness of complex social issues [4]. However, serious games development process is still complex and expensive. It requires multidisciplinary teamwork where very different profiles are involved, such as graphic designers, programmers, game designers and domain experts, such as psychologists or educators [5]. That is why new technologies, such as artificial intelligence (AI), are being explored to automate some of these tasks, simplifying the process.

Artificial Intelligences (AIs) are a range of enabling technology that enables machines to perform tasks that previously require human intelligence, such as pattern recognition or decision-making AI is increasingly being used in a wide variety of fields, including education [6], [7].

In SG development, AI can be used to automate a variety of tasks, such as (semi)automatically generating the foundation of virtual worlds, programming scripts or mechanics, or generating graphics. This has great potential as it would reduce the entry barrier of educational games allowing educators to try and prototype games to use as a tool in their classrooms. It would

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also reduce time and costs in the professional development of serious games. And it will also allow educators to improve the teaching of serious game design allowing students to focus more on the learning aspects. For instance, creating high-quality graphics for games is an expensive and time-consuming task that usually requires graphic designers. Using AI to generate graphics can reduce production time and cost, allowing designers to focus on other aspects of the game, such as game mechanics and user experience. AI can also be used to improve the interaction between the player and the game. For example, making non playable characters have more natural and emotional conversations, which finally makes the game more immersive and engaging for students.

Despite the many benefits of AI in serious game development, there are also some challenges that need to be addressed. One of the biggest challenges is the balance between automation and human creativity. While AI can be used to automate many tasks, it is important for serious game designers to maintain some level of creative control over the development process. Another challenge is the need for high-quality data. AI needs large amounts of data to learn and improve, so it is important for serious game developers to have access to a large amount of high-quality data to train AI algorithms (but this could be mitigated by open code pre-train AI models). In addition, data collection can raise privacy and security issues that need to be addressed. Finally, these tools are known for their flexibility and versatility, but this also means that formulating appropriate requests for artificial intelligence can be intricate and requires thorough investigation. To ensure efficient utilization and prevent resource wastage, a systematic and structured approach is necessary to maximize return on investment and avoid undesirable outcomes when interacting with such systems.

The paper is structured as follows. In the next section we explore the related work, recent research around AI and implications in the serious game research field. In section three we present a study case around a proposed working methodology for developing and prototyping serious games assisted by AI. Section four presents future lines of work, integrating the AI with authoring tools. Section five explores the paper's conclusions.

## II. Related Work

The field of AI has been growing exponentially in recent years [8]. Many organizations recognize the potential of incorporating AI into their capabilities and operations to improve their competitive advantage and innovation performance. This exponential growth in AI research and adoption can be attributed to the numerous industries that are actively interested in leveraging AI technologies. Those industries include (but are not limited to) healthcare, finance, transportation, retail, manufacturing and education [8]

In the realm of serious games, AI offers diverse applications that can enhance the effectiveness and educational value of these games. The utilization of big data tools is one of the most extended areas of interest in AI, which can provide valuable insights into player behavior, preferences, and interactions within serious games [9]–[11]. By analyzing the data generated by players, AI algorithms can be used to improve the serious game design, detecting potential opportunities or flaws, creating a more engaging and effective serious game. AI has in fact proven to be an effective method of predicting the effectiveness of serious games in players and used this prediction as part of a semi-automated assessment [12] or to recommend different learning paths. AI recommendations can also be used to make serious games adapt better to the player to, for instance, reinforce specific learning objectives.

Furthermore, AI-driven process innovation and restructuring can benefit serious game development. By automating certain aspects of game creation, such as content generation, adaptive difficulty adjustment, and personalized learning. AI can also streamline workflows and reduce development time. Recent advancements in machine learning have led to the emergence of generative artificial intelligence (GAI). GAI is an unsupervised or partially supervised machine learning framework [13]. In this section, we focus on two GAI machine-learning trends that can be used to assist the process of serious game development. The first line focuses on asset (primarily image) synthesis, focusing on diffusion models. The second line focuses on natural language processing tasks, starting with the general pretrained transformers.

Since the introduction of Generative Adversarial Networks (GANs) in 2014, generative AI has been highly effective in processing image, video, and voice synthesis [14]. Recently, Diffusion Models (DMs) have further improved generative AI capabilities [15]. DALL-E and DALL-E 2 by OpenAI and IMAGEN by Google are remarkable examples of DMs for synthetic image generation with language interpretation abilities, producing complex and creative images. DMs offer easier control and overcome limitations of traditional GANs in image synthesis, thanks to the incorporation of stable distributions that help to maintain consistency and improve control during the image generation process [16]. In addition, the introduction of Latent Spaces to diffusion models led to the development of Latent Diffusion Models (LDM), that reduce the training computational resources and "reach a near-optimal point between complexity reduction and detail preservation, greatly boosting visual fidelity" [17]. One notable LDM is Stable Diffusion by StabilityAI, an open-source pre-trained model, highly regarded for text-to-image generation, in-painting, upscaling, denoising, and more. The open-source nature has allowed the community to create fine-tuning tools like ControlNet, enabling users to produce pre-sketched outputs and characters with poses [18].

On the other hand, since 2018, GPT models leverage large amounts of publicly available digital content data, using natural language processing (NLP), to produce a Large Language Model (LLM) that can produce human-like text in multiple languages. One remarkable breakthrough in this field is the development of GPT-3 and subsequent GPT-4 models, that have demonstrated its ability to perform task-agnostic operations and even outperform prior state-of-the-art approaches. Since the release of ChatGPT, a freely accessible chatbot-like application based on GPT this technology has attracted attention in various fields, including education, engineering, journalism, medicine, economics, and finance [19]. ChatGPT has been trained on a vast amount of data, including text from the internet, books, articles, and other sources, allowing it to have a "broad understanding" of various topics. When asked ChatGPT

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proposed potential uses of ChatGPT to improve education [20], including personalized tutoring, automated essay grading, language translation, interactive learning and adaptive learning. In the same article ChatGPT warns about potential drawbacks such as lack of human interaction, limited "real understanding", bias in training data and privacy among others.

In narrative serious games, such as graphical adventures or visual novels ChatGPT can be used as a storytelling assistant that supports the narrative design and even assists with the creation of conversational or logic puzzles. In fact, LLMs have been widely used for the creation of interactive text-based adventures [21]. Such genres have proven to be especially beneficial to serious games where they provide free exploration and promote problem-solving skills and deduction. This opens possibilities for immersive storytelling and interactive gameplay experiences [13], [22], [23] and even use GPT for AI decision-making and human behavior simulation [24].

By leveraging GAI, serious game developers can streamline content creation and enhance tailored and even adaptive gameplay experiences. GAI's ability to automate aspects of game creation can significantly reduce development time and effort. However, despite the potential benefits and evidence from the community showing the uses of these technologies, there have been no case studies of the production of serious games assisted with AI. There is a need to research the effectiveness of these technologies and discover potential new capabilities.

On top of this, digital platforms play a crucial role in the implementation of AI for innovation in education, including serious games. These platforms offer opportunities for player engagement, feedback collection, and co-creation processes [25], [26]. By integrating AI into digital platforms, serious game developers and educators can leverage AI-powered learning analytics to gain insights into player progress and learning patterns enhancing decision-making processes and fostering creativity [27]. For students, these analytics can be used to design personalized learning interventions and feedback, enhancing the educational impact of serious games.

Authoring tools are one type of digital platform that is used to produce learning content. Some of these tools focus on the production of serious games such as simulations and interactive experiences [28]. Their approach focuses on creating educational value, bringing educational features such as educational standards, learning analytics or validation tools to serious games while aiming to be used by a non-expert audience [5]. They simplify the development of games, and their integration with learning platforms, and in addition to the benefits for developers, using them for teaching game-based learning allows for teachers to focus more on the educational value of serious games rather than the technical and development details. For this reason, they are a convenient target to integrate AI technologies, as they could bring AI tools to game-based learning out-of-the box simplifying its usage for stakeholders such as developers, educators and students.

Overall, as previously described, AI could have significant implications for serious game development. As the field of AI continues to evolve, further exploration and experimentation are crucial to unlocking the full potential of AI in the realm of serious games.

## III. Use of Stable Diffusion in graphics generation for an educational game

Nowadays, it is common that the most popular videogames that occupy the top positions in the lists of the most played are visually attractive videogames, with a very elaborate and well cared visual section, resulting attractive and impressive for the player [29]. However, achieving this visual quality has a high cost (in time and manpower) that is difficult to assume in the development of serious games for very specific contexts with very small work teams. This expectation of the player for high-quality visuals is a barrier that can affect the effectiveness of the game [29], [30]. To overcome this barrier in the development of serious games, it is possible to simplify and automate some of the tasks related to the game art assets while ensuring a minimum quality. This use of GAI can allow to invest more efficiently the project resources, improve the results of the game, make it more attractive to the player, and even allow non-experts and non-artists to prototype a visually attractive game.

LDMs offer the opportunity to simplify the development of a serious game, making it easier to obtain graphic resources. However, its use is not trivial, and it is necessary to exploit this tool correctly to obtain the expected results. We have tested the approach to develop an educational video game of the point and click adventure genre. The mechanics of this genre are limited, mainly involving exploration using only the mouse and engaging in dialogues with non-player characters (NPCs). Due to this type of gameplay, the visual and narrative aspects play a crucial role in attracting players. For this reason, it is an ideal case to study the use of generative artificial intelligences and create a generalizable process for other video game genres.

### *A. Study Case*

To study the workflow when using AI, we have developed a serious game as a study case. The game is a point and click adventure with the main goal of addressing and promoting understanding and support for individuals facing mental health issues. This approach was instantiated in a student of Master of Design final project that creates the game.

From a technical standpoint, the project faces specific challenges, such as generating different character representations that help the players to empathize with the characters. GAI technologies were used to generate the game's graphics. The game design includes 6 characters in third person full-body view, 5 of them 17 years old and a 40-year-old adult. The world design includes the required scenarios to represent the village in the story including protagonist and his friend homes, a restaurant, a doorway, a concert, a bowling, an emblematic place, and the connective scenarios needed to achieve world consistency.

The project developed over a period of 8 months with the aim of achieving a first working prototype. The development ended with a user experiment to validate the achieved finish and gather feedback from players on the appearance of the prototype.

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## B. *Working Methodology*

A working methodology has been developed by the e-UCM research group to generate the desired graphic resources to develop the target serious game. This methodology includes: (1) Scenario generation, to build the world of the serious game, and (2) Character generation, needed for the game's events.

The whole process uses the LDM Stable Diffusion, an open-source tool that allows users to execute and utilize it in various ways[1] [2]. The system takes a description (prompt) of the desired elements in the image as input and allows for specifying a "negative prompt" to indicate elements that should not appear in the result.

To achieve optimal results, it is recommended to use models that expand the default functionality of Stable Diffusion. Some of these models are Textual Inversion [31], DreamBooth [32], and LoRA [33]. In this methodology, a checkpoint merge[3] has been utilized to unify the visual style of the characters, and a specialized textual Inversion model called CharTurner[4] has been employed for generating character concept sheets.

### 1) *Scenario Generation*

Scenarios are a fundamental element in a video game, serving as the world where the game takes place and forming the foundation for other interactive elements such as characters. In point-and-click graphic adventures, scenarios are typically presented as perspective images. In addition, to achieve artistic coherence, different scenarios within the game should share the same visual style. As previously described, the overall resulting quality of the scenarios can positively influence the effectiveness of the game. Transitions between scenarios should also make sense, aligning paths or exits with visually similar environments.

The Fig. 1 illustrates two processes for two scenario creation cases using Stable Diffusion. The first case (A) involves the creation of a new scenario and consists of the following stages:

1. Style definition. The visual style is defined using a comma-separated list of tags, including: (a) visual style names in the format "visual-name style," (b) names of artists with distinct visual styles in the format "by artist-name," (c) references to audiovisual works in the format "reference-name vibes," or even (d) rendering mechanisms like "type-name render" for pre-rendered backgrounds. We recommend using the same style definition throughout all production generations to achieve artistic coherence, but sometimes fine tuning is necessary for optimal results.
2. Type of scenario or location. Particularly necessary when generating outdoor scenarios, it greatly assists in maintaining consistent architectural style. This can be used to promote emotional resonance, immersion and create a more engaging experience. To describe locations, use the format "in location-name city-name". However, it's important to note that this tag may hinder the generation of interior representations.
3. Scenario description. The final information about the desired scenario should specify the place and the elements expected to appear in it. Examples could include "sidewalk in the city" or "bedroom with a white and well-made single bed and a desk."

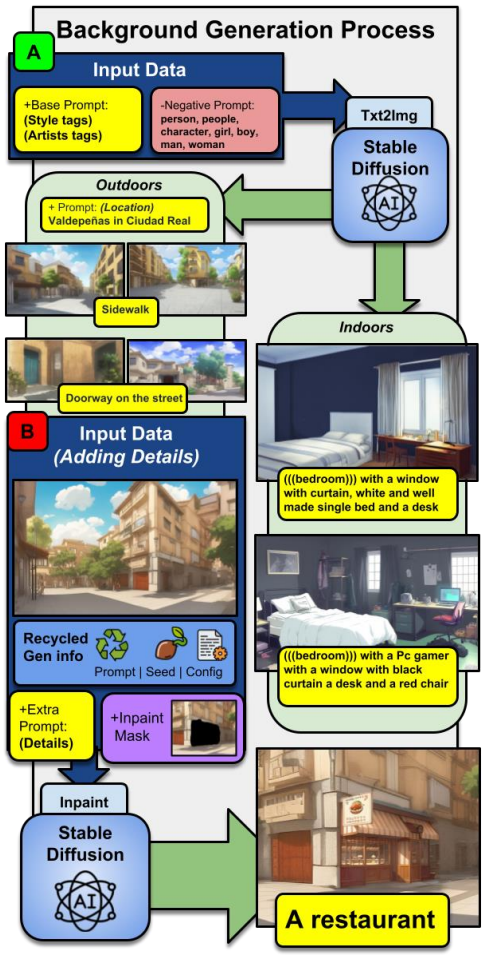


Fig. 1. Description of the scenario generation process, showing: A) background generation and B) fine details manipulation.

The second case (B) of Fig. 1 utilizes the *inpaint* function of Stable Diffusion to modify or to include certain elements of an existing scenario. This function allows for introducing an input image and a mask that defines an area of the image to be regenerated.

When a scenario lacks some necessary elements for the game development, it is possible to incorporate the details afterwards using the *inpaint* tool of Stable Diffusion. To do this, the scenario image and all its generation parameters (prompt, seed, model, configuration, etc.) are reused, and a mask is defined to outline the area where the new element should be generated. Additionally, the information of the new element is

[1] Stable Diffusion Github Repository: https://github.com/CompVis/stable-diffusion

[2] Web UI for Stable Diffusion: https://github.com/AUTOMATIC1111/stable-diffusion-webui

[3] Checkpoint Merge used for this game: https://civitai.com/models/6231?modelVersionId=7307

[4] Character Turnaround Helper Model: https://civitai.com/models/3036/charturner-character-turnaround-helper

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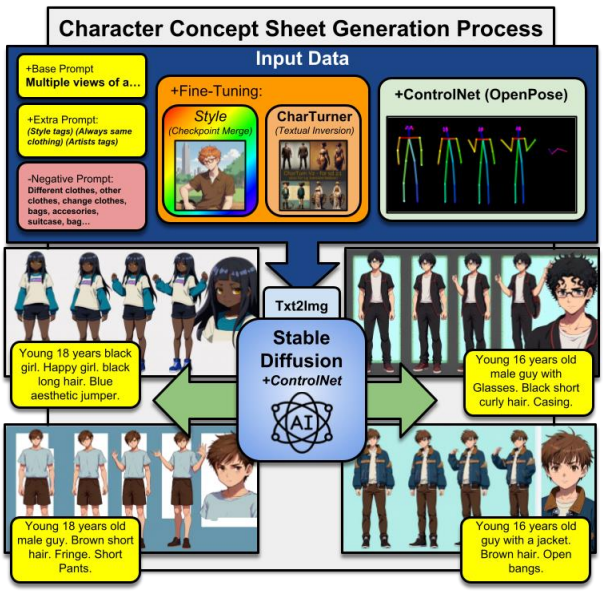


Fig. 2. Character Concept Sheet Generation Process illustrating the usage of fine-tuning models and ControlNet features.

added to the prompt and sent to the *inpaint* utility. The diffusion model fills in the gap defined by the mask to add the necessary design detail.

We suggest generating a batch of backgrounds using the same description and cherry-picking the best results.

### 2) Character Generation

Generating characters for a serious game presents various challenges, such as controlling the character's pose, outfit variations, and keeping their consistent appearance across generations. This methodology (Fig. 2) follows these phases: (1) Concept sheet generation (2) Generating new poses for an existing character and (3) Generating new expressions.

#### a) Creation of a Character Concept Sheet

The character concept sheet serves as a visual reference for a character from which alternative versions will be generated. By default, Stable Diffusion allows pose definition solely through text and has not been trained to generate multiple views. To address pose control in Stable Diffusion, we have used[5] ControlNet [7], a neural network structure designed to control pretrained large diffusion models and support additional input conditions. This integration enables us to employ OpenPose [34], a standard pose format used to define the different views that should be included in the character concept sheet. The process for generating a character concept sheet is as follows:

1. Style definition. The visual style is defined using tags in the prompt. Additionally, to ensure artistic coherence, considering the specificness of a character is recommended to load an alternative checkpoint[3] of the Stable Diffusion model that focuses on specific artistic styles or character generation.
2. Provide the CharTurner[4] model. By using a model specifically trained to generate concept sheets with consistent multiple views, the artistic coherence between all the views is drastically enhanced. This textual inversion model should be loaded into Stable Diffusion and invoked using the keywords "multiple views" or "character turnaround" in the prompt.
3. Pose-set template definition. Using OpenPose create or re-use a set of default poses for the character (using specific pose editors[6] or skeletons[7] is recommended). All generated poses must be included in a black image of the same size as for the concept sheet.
4. Character definition. For each character to be generated, a detailed description of the character should be included in the prompt, its physical features such as age, hair or eye color, complexion, as well as details of its clothing and appearance.

The concept sheet generated at the end of this process integrates as metadata all the details used in its generation such as the prompt or the seed that can be reused to influence subsequent generations to obtain new views of the character with minimal effort.

#### b) Creation of new poses

The character needs to be represented in several different events and situations in the serious games. To achieve consistency between generations so that the character retains its characteristics the "Character Concept Sheet" obtained in part "a)". is used as seed to these new generations. The process (Fig. 4) of creating new poses consist of:

1. Supply the original character concept sheet and its generation parameters. This allows recreating the same conditions under which Stable Diffusion generated the original image, maximizing the chances of obtaining a consistent result with the rest of the representations of the same character. Generation parameters must include the same parameter values (and models), prompt and seed used to generate the character concept sheet.
2. Delimit the inpaint mask. The inpaint mask delimits the area where the new pose is generated. To set this mask generate a black image of the same size and paint white the area designated for the new pose (this area can cover some of the original poses). The denoising strength parameter for this mask should be set to max to remove the original content of the selected area. Finally, the inpaint mask must be attached to the request.

[5] ControlNet Plugin for Stable Diffusion: https://github.com/Mikubill/sd-webui-controlnet

[6] OpenPose Editor: https://github.com/fkunn1326/openpose-editor

[7] Concept Sheet template example: https://civitai.com/models/17012/character-turnaround-openpose

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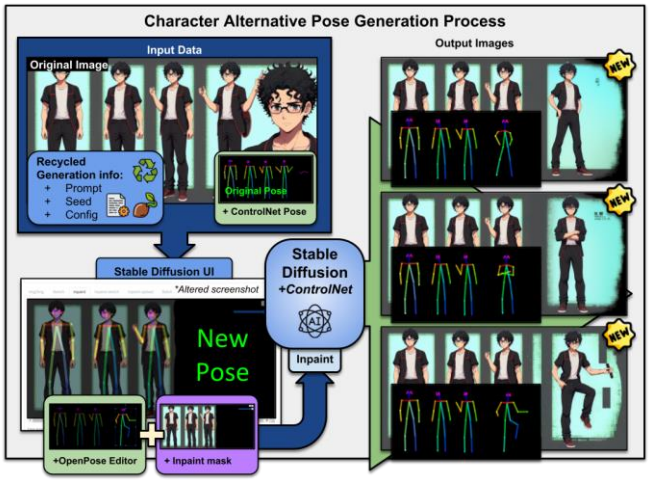


Fig. 4. The Character Alternative Pose Generation Process uses the previously generated character sheet to generate alternative expressions.

3. Define the new pose. Modify the original character concept sheet pose template including the new pose to be generated in the space delimited by the inpaint mask. For this task it is advisable to use an editor[6] that allows to obtain the new pose in OpenPose format.

When the image is generated after this process the new ones will replace the old ones in the inpaint area.

*c) Generation of new facial expressions*

Character expressions can foster player empathy and increase the effectiveness of a serious game. To obtain new expressions for an existing character it is necessary to add additional details to the original prompt. The process of obtaining new expressions for generated characters is shown in Fig. 3 and consists of:

1. Reuse from the character concept sheet and its original pose. Similar to the case of generating new poses, reusing the same generation parameters and the original pose allows to obtain consistency in the appearance of the character to be modified.
2. Delimit the inpaint mask. This allows to replace only the facial expression of the character, thus avoiding that other parts can be modified. The content of the delimited area will be reinterpreted by Stable Diffusion to rebuild the image with the new expression of the character.
3. Modify the prompt by describing the character's expression. For example, by a phrase such as "The character has an expression-name expression". Modifying the prompt text usually has consequences on the generation results, and the consistency of the character details may be lost.
4. Negative prompting. If the generated image shows inconsistent elements, it is possible to include a negative prompt to prevent such features.

These processes allow the creation of more expressive game characters using Stable Diffusion.

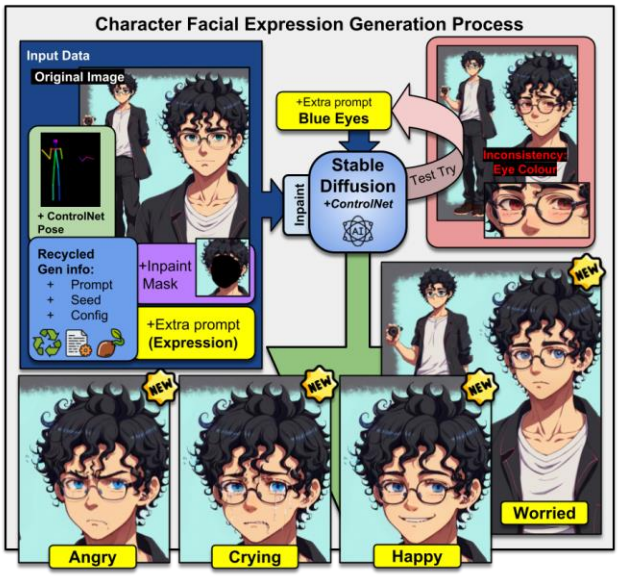


Fig. 3. The Character Facial Expression Generation Process uses the inpaint feature to generate alternative character emotions.

## C. Results

As a result, a prototype of a serious game has been generated with a play time of 30 minutes (Fig. 5). A total of 20 scenarios, 5 characters, 8 cutscenes, and some other required assets have been produced. The obtained results satisfy the quality objectives and present an artistic coherence between them. This approach was instantiated in a student of Master of Design final project that creates the game.

The game was tested as part of a workshop at faculty of psychology of the university of Lisbon, in Portugal. A total of 5 teachers with profiles close to the serious games field participated in the workshop and filled out a survey upon completion of the session. Regarding the visual results, the average responses on a scale of 1 to 5 indicated that: (1) The scenarios and characters have been generated with AI technology. Do you like the artistic style that results from this process? 4.4; (2) Do you think the game is visually appealing? 4.2; (3) Do you think the scenery and characters are recognizable? 4.4. These results indicate a high degree of satisfaction with the graphic quality achieved.

The effort in game graphic art creation was greatly reduced. Estimating an approximate of 6h for each scenario and 15h for each character, the effort required can reach around 195h of work (excluding cutscenes). These hours must be worked by a professional whose cost will rise when requesting specially worked visual quality. By using LDM but with expert assistance, the graphic part has been produced in a period of 4 months, 4 hours per week, reaching approx. 72 hours of work. Nevertheless, this time saving of 63% includes the refinement of the working methodology that we present, and we roughly estimate that with a consolidated process this time could be reduced in half potentially resulting in 86% (36h) time saving.

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Fig. 5. Screenshots of the developed game game using GAI assets.

### D. Discussion

The use of AI technology in generative projects has both advantages and disadvantages, depending on the type of project. In projects carried out by a limited number of participants, IA can be beneficial by offering speed, creative ability superior to that of a non-specialized artist, autonomy in image generation, and the ability to rapidly iterate and prototype different graphic styles. In projects with a larger development team and a specific artistic focus, GAI still faces some challenges such as that of the variability in the degree of accuracy, the presence of occasional glitches in image generation and biases, and the technological setup complexity.

In relation to the prompts used in the generative process, we observed some biases in the generations when including specific styles present in both scenarios and characters. For example, in the case of anime style, the generated scenarios tend to present a strongly oriental style. To prevent this bias, we introduced the second step in the scenario generation, Type of scenario or location. By adding the location "Valdepeñas", we can keep the style while controlling the architectural, cultural, and environmental aspects. We have also experienced a similar bias in the character description parameters related to the style. Perhaps this is derived from the fact that GAI models are usually pre-trained with extreme representations of characters, but further research should be conducted to determine it.

Finally, it is important to note that despite the promising results this technology offers for the authoring of serious games, the results that we present are limited. There is a need to further research and experiment with this working methodology to prove both the showcased satisfaction (average 4.3/5 score) and effectiveness (producing 86% time saving).

## IV. AI Assistant For Serious Games Development

In the previous section, we explored both proven and suggested methods that utilize GAI as an external content generation method for serious games. To simplify the process even further, it is possible to develop a Copilot tool automating this methodology, with AI, into an authoring tool for the creation of serious games. The so-called Copilot tools that aim to integrate AI directly into the tools itself interacting the content directly, providing users, and in this case, the educators and students with the ability to create or modify serious games using human-like instructions.

This way, AI can be useful in all stages of a serious game's lifecycle, such as enabling rapid prototyping during the creation phase; and also in game-based learning education, by allowing to focus more in the educational value rather than in content production or technical details. Such lifecycle benefits also affect the reusability of games, making it easy to adapt and customize games to specific situations. Educators and students can download games that address topics of interest and consult with AI for possible modifications without having to understand the intricacies of game implementation. In this section, we will explore how such tools can be directly integrated into authoring tools exploring the integration case for the uAdventure (uA) authoring tool. uA is an authoring tool developed by the e-UCM research group at the Complutense University of Madrid that focuses on adventure and location-based serious games [35]. uA is optimized for creating point and click games, with conversation branches, questions, and answers, cutscenes, and other visual elements.

### A. Art Generation

As we have seen, chart generation is a complex process and requires a comprehensive set of tools to maintain consistency. It is important that the Copilot tool mitigates the technological barrier, making the technology easily accessible and usable. In this regard, the tool should automate the installation and configuration of those generation resources, and in addition, it should include new editors to manipulate the configurations and configuration context. Below we will analyze the integration case in scenarios, objects, character and cutscene generation.

To generate scenarios the working methodology described three steps. The latest, Scenario Description could be integrated in the uA scenario editor. To achieve a unified direction and prevent biased we will also provide editors for the Geological Referencing and Style Definition. Those settings would be manipulated through a global parameters window that would serve as a wizard. Then, uA will use all three pieces to generate the image. An additional inpaint tool will be added to the scene editor to facilitate the modification of specific details in the specific scene. When it comes to characters, a unique new editor window would be used to control the Character Reference Sheet. Once the reference is set, the character editor will provide a skeleton-based editor to generate new poses using ControlNet. Finally, a section in the global parameters window will be added to control character styling (e.g., anime, cartoon, realistic, etc.).

To enhance the cinematic experience within serious games, a cutscene generation feature would be incorporated. This feature would enable the creation of cinematic sequences comprising different images where characters interact more

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closely. For cutscenes showing the game characters in specific scenes, uA could automate the creation of a LoRA [33] to improve the generation consistency.

### B. Text Integration

Language models can be used to construct the narrative structure that facilitates learning within the game. In the authoring tool in this research, uA, this narrative structure is referred to as the high-level game model. The model includes elements such as scenes, characters, objects, conversations, and a high-level programming model consisting of conditions (variables) and high-level effects, such as "change scene" or "move character.".

During the creation process, a Large Language Model (LLM) can be used to retrieve the necessary information to generate or manipulate this model within our authoring tool, uA. For instance, when querying an uA "Copilot" assistant, we could request the LLM to create a scene where two characters engage in a conversation about a specific topic. To utilize the LLM for this purpose, it is necessary to provide a prompt with additional contextual data. The prompt is typically given in natural language. Continuing with the previous example, we could ask the Copilot to "Create a scene with a character to discuss biology-related matters within the learning objectives of this game.". This prompt alone would not produce an appropriate result to be interpreted by the authoring tool. The prompt tuning pre-processes the request, including the relevant model and additional information for the prompt and the appropriate response format, as well as all extra code of conduct and rules. In this context, the authoring tool would tune the prompt by appending this model information along with the serious game metadata (e.g., summary, educational objectives and theme).

While this communication format could enable the design of a complete Copilot-like tool to manipulate the model, further research is necessary to evaluate the effectiveness and the potential issues (e.g., such as bugs or logical inconsistencies).

To tackle these challenges, the system could include two different pieces: 1) a validation system and 2) a fine-tuning model for the LLM. The validation system would work as an automated “gameplay” tester that would simulate the game exploring possible branches guaranteeing that the game is completable and the learning objectives are completed within the gameplay [12]. The fine-tuning model would be used to specialize the LLM for the creation of serious games. The model could be trained with a highly limited set of cases (pre-trained models have shown great effectiveness when specialized using a very limited dataset [36]), using the uA game repository as reference. By combining both systems, it would be possible to build a reinforcement learning system, rewarding models that pass validation tests enhancing the effectiveness of the fine-tuning model.

The integration of generative AI in serious game authoring tools, holds great potential for the improvement and diffusion of serious games, and further research is needed to explore its full capabilities.

## V. CONCLUSSIONS

The use of AI tools presents great opportunities for simplifying the prototyping and development of serious games. We are researching to create a methodology that incorporates generative AI (GAI) in the production of high-quality artistic content. This methodology addresses the most common cases for the generation of graphical resources needed in the development of point and click adventures, including: (1) the creation of scenarios, and (2) the creation of characters. This methodology has been put into practice in a case study showing evidence of the potential of this type of technology. It speeds up the development and customization process of serious games. It is of special interest for projects with small teams and limited resources where cost-reduction is a priority. This methodology can also improve serious games teaching and research, allowing students to rapidly prototype games focusing on the pedagogical design and study their effectiveness instead of focusing in low-level technical and artistic tasks.

Even if the methodology was effective there are still many open issues about the usage of GAI in serious game development. The correct prompt-building plays a critical role, presenting high variability of results with small changes. While our use case was positive, we believe that the potential of AI for serious games is much greater. For example, generative AI models can be integrated into serious games authoring tools to simplify the usage of AI and automate the process even more. Managing an LDM through serious game authoring tools would avoid misusage and misconfiguration, preventing undesired results and facilitating the adoption of these new technologies. In addition, there is a whole field in AI-powered analysis of players interaction data to improve aspects such as automated player evaluation (i.e., learning analytics) or game adaptation (e.g., content, gameplay) based on user performance.

The presented methodology and its benefits for production and education in game-based learning will be further tested in the Serious Games course of the Bachelor in Video Game Development at Complutense University of Madrid.

We consider that this approach is clearly included in fair academic use for not-for-profit educational purposes and the models used are based on open-source technologies, facilitating the access and adoption of GAI in the systematic process of developing serious games. With this study we open the door to one of the ways of exploiting the potential of flexible GAI, illustrating in this case, its potential in serious games. Ethical [37] and legal aspects such as the intellectual property of the resources created, or the possible final licenses of the software produced are still open issues that will need further study.

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