Exploring how an Unreal composite shader can be used to create a 2D stylised rendering: how automation can be more accessible in game art

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Abstract
This article presents the state of the art of an ongoing research project focused on Non-Photorealistic Rendering (NPR) in game development and the accessibility of tools for these techniques for artists. Stylized graphics offer creative freedom by emphasizing aesthetic appeal rather than realism. However, manually implementing these visuals would be highly time-consuming without tools that enable real-time rendering of a 2D style in 3D environments. Even though AI-based solutions like Neural Style Transfer (NST) are now able to apply an NPR style automatically, shader manipulation remains the preferable option for greater artistic control. While modern game engines like Unity and Unreal Engine offer intuitive interfaces for shader development, applying stylized visuals remains challenging for non-technical artists as this requires a minimum knowledge of computer graphics. This research explores the development of an intuitive hyper shader to simplify the process of applying 2D stylised aesthetics to 3D environments. Therefore, this article aims to study how shader creation can be more user-friendly and transparent, thus empowering artists without technical expertise in game art, where the use technology becomes more and more relevant.

Introduction
This research follows on from the project work for the Master's course in Multimedia at the University of Porto (UP), where it was proposed to develop a hyper-shader in order to create a solution for applying Non Photo-Realistic Rendering (NPR) techniques in a 3D environment for artists with no technical knowledge of computer graphics. The use of (NPR) techniques has grown considerably in recent years, with several use cases in different areas such as games, cinema, television and even special effects. This growth goes hand in hand with the popularity of less realistic AAA[4] video games on the market that use these techniques, especially after the success of games like The Legend of Zelda: Breath of the Wild (Nintendo EPD, 2017) and Valorant (Riot Games, 2020). One of the reasons for this growth is the creative freedom that stylised graphics allow. This approach makes it possible to emphasise the beauty of the game, exploring strong,

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4-In the video games industry, AAA (pronounced 'triple A') is a classification term used for games with the highest development budgets and levels of promotion.

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eye-catching colours, exaggerated shapes, among other aspects designed to appeal to the player's eyes [7]. However, these graphics, inspired by a stylised 2D design, would be too time-consuming to implement if they had to be created manually. Thus, the aforementioned success would not have been possible without the development of tools that make it possible to generate these 2D graphics in real-time 3D game environments.

Nowadays, anyone with a good idea, a lot of dedication and a healthy dose of obsession can create a quality video game [24]. This is possible thanks to free access to very powerful game engines[5] such as Unity (Unity Technologies, 2005) and Unreal Engine (Epic Games, 1995), both standard software in the video game industry [3]. The evolution of technology has allowed these creators to focus more on the concepts and creativity of what they want to express through their video games, rather than being limited by what the technology or even their technical knowledge allows them to create [2]. However, there are still few resources that allow a non-technical artist to apply a 2D style or stylised 3D graphics within game engines such as Unreal Engine or Unity. Despite the fact that some solutions are beginning to emerge that use Artificial Intelligence[6] (AI) for this purpose, such as Neural Style Transfer[7] (NST), the approach that allows the artist the most control over the final look of the image is the manipulation of shaders. Shaders are programmes that define how each pixel should be rendered on the screen. Nowadays, creating shaders is more accessible, not requiring direct contact with code, making it easier for users with less programming experience. However, even though the creation of shaders is essentially a creative process, especially in the context of NPR, it can still be seen as complex by artists, since it requires a deeper knowledge of the software that uses it (such as the aforementioned game engines) and the principles and language of Computer Graphics (CG), which are closer to the engineering development domain. While this process is already facilitated by node systems in the previously mentioned software, their use still requires artists to spend many hours learning concepts outside their area of specialisation [6]. In large-scale production in industry, this problem is mitigated as there is greater division of tasks. Generally, the work of the artist is easily integrated by technical artists, or even engineers, who build specific tools/interfaces to facilitate the use of the software or game engines used. However, such solutions can rarely be reused across other teams, either for reasons of software compatibility or market competition between AAA studios [1]. These coordination procedures between the artistic and development areas mean that the artist's work can only be visible thanks to the tools created by engineers, creating a dependency on them. Even though these tools are designed to simplify the way artists access game engines, the truth is that they sometimes end up hiding the way they work, which in turn also limits their creativity.

5 Game engines are specialized software that provide tools for video game development, enabling the creation of graphics, physics, sound and other essential mechanics.

6 Artificial Intelligence refers to the field of computer science that develops systems capable of performing tasks that normally require human intelligence.

7 NST is an AI technique that uses neural networks to apply the visual style of one stylized image to the content of another, generating a new image that combines features from both.

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This phenomenon is known as the black box phenomenon and will be discussed in greater detail in this study [1]. So, with the aim of combining knowledge of computer graphics with a love of illustration, this project is motivated by the need to investigate how the creation of a transparent and intuitive-to-use hyper-shader, capable of rendering a 3D scene in a 2D style, can help an artist without extensive knowledge of computer graphics or advanced shading. Unreal Engine was the main software chosen for this research, as it is widely recognised as a benchmark among game engines in the industry, especially due to its quality in rendering 3D games [3]. This research therefore aims to study how an artist in the field of video games can be empowered in this new era in which the combination of art and technology is not only relevant, but also essential.

NPR and its use in video games

NPR is, as the name suggests, a representation that doesn't try to be faithful to a realistic image as seen, for example, in a photograph. This is a technology that emerged in the 18th century and has grown as one of the branches of image processing in computer graphics. Nowadays, there are numerous techniques that are considered NPR [10]. Their most obvious feature is abstraction, which allows for the deliberate removal of details from an image. These techniques renounce realism, thus giving artistic freedom to simplify an image or emphasise certain elements or visual nuances.

NPR techniques have seen a widespread increase precisely in the video game industry, giving rise to more stylised productions, such as the games: The Legend of Zelda: Breath of the Wild, Tales of Arise (BANDAI NAMCO Entertainment Inc., 2021) and Valorant. One of the video games referenced in the literature as one of the first to use NPR techniques to create a 2D style in a 3D environment in the industry is GuiltyGearXrd's (Arc System Works, 2014). This title was a remake of previous games in the franchise in which 2D sprite[8] -based graphics were used. The aim with this new release was to produce the game in 3D, while keeping the same visual style as the previous games. This change to a 3D environment brought new advantages, such as greater graphic quality and free manipulation of the camera, making it possible to show new angles of the game without compromising the 2D comic book style that is its signature thanks to the NPR techniques that were implemented [9].

But why is a style that distances itself from reality considered appealing to the human eye? It is still not clear empirically why non-realistic styles are appealing or are even favoured by some people [14]. There are, however, several studies that claim that colours affect us psychologically [11]. For example, styles such as pixel art or comics evoke nostalgia in older gamers, connecting them to their first video games and their own personal memories [13]. But there is another difficulty in creating hyper-realistic characters that makes stylisation an advantage. Designing

8 Sprites are small two-dimensional graphic elements used in video games to represent characters, objects or visual effects. Traditionally, they were stored as still images and manipulated by the game engine to create animations and interactions within the digital environment.

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convincing and realistic 3D characters is a difficult task as the slightest imperfection can trigger negative responses in the user. This phenomenon is known as the Uncanny Valley. The authors Chattopadhyay D., MacDorman K. F. (2016) explain that this effect may be related to the human being's innate ability to recognise facial expressions and human gestures since childhood, so there is a high sensitivity in detecting anomalies [29].

However, this phenomenon is not a problem in the field of stylisation. Since the deviation from reality is intentional, the viewer is not surprised when they see a character with proportions that are outside the bounds of what we conceive to be real [8].

Nowadays, the proportion of realistic 3D video games in AAA productions remains dominant over those with stylised graphics. However, this trend might change. In fact, there are professionals in the field who believe that stylisation could gain more ground in the video game market over hyper-realistic styles. At the Game Developers Conference (GDC) 2017, Andrew Maximov from the Naughty Dog studio gave a talk in which he reflected on the future of video game production. His prediction was that production will be increasingly equipped with automated processes, meaning that hyper-realism, which today is synonymous with the graphic quality of a AAA video games, will become accessible to smaller studios and, consequently, more widespread. As a result, this style, which is basically intrinsic to technological evolution, will no longer feature prominently in AAA productions, so it's possible that these studios may gravitate towards less realistic styles in the future [2]. This reflection supports the notion that the longevity inherent in stylised graphics allows them to be relevant for longer, even several years after their release.

Interfaces and tools for NPR techniques

One of the most popular and ubiquitous techniques, even referred to as its own artistic style, is cel-shading, also known as toon-shading [12]. Cel-shading is an NPR technique characterised by the use of colour bands, reducing gradients and highlighting contours with marked strokes, creating a look similar to cartoons or comic book illustrations. Some of the most recent examples of its highly successful use in the video games medium were the aforementioned The Legend of Zelda: Breath of the Wild, as well as in the cinema with the film Spider Man: Across the Spider-Verse (Sony Pictures, 2023). Currently, different rendering software such as Blender (Blender Foundation, 1994) or Maya (Autodesk, Inc., 1998) have their own tools or processes for creating this

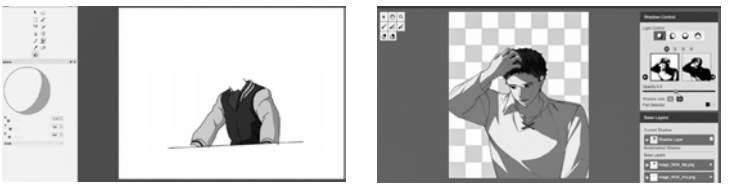


Fig. 1. Pencil2D interface using the 2DToonShade tool [16]; ShadowMagic interface [21]

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technique. In addition, with a simple online search, there are numerous tutorials that explain these processes in different softwares for users who want to recreate the effect; or, for those who just want the final product, there is no shortage of shaders developed by independent creators that can be purchased online for a low cost. An example of an intuitive application of cel-shading is 2DToonShade, a tool incorporated within the Pencil2D interface, a free, open-source software for creating hand-drawn animations first developed by authors Patrick Corrieri and Pascal Naidon in 2005 [26]. 2DToonShade, which can be selected via the tools panel as shown on the left in figure 1, is a semi-automatic approach that has made it easier to apply shadows.

A task that used to require the user to manually paint their own shadows is now simplified by simply selecting the direction of the shadow to be applied and selecting a well-defined area of the image under construction. The process of applying shadows therefore becomes intuitive, as the Pencil2D interface resembles a traditional 2D drawing process [16]. Other similar tools have also been explored recently, such as ShadowMagic, which uses AI to generate different shadows on a 3D model according to different lighting source positions. In this case, ShadowMagic provides its own interface, which is designed to facilitate interaction with the user by simplifying the way the different settings are presented, as illustrated on the right side in figure 1. This is also a hybrid approach because, in addition to using AI, there are also manual options that allow the user to adjust the result generated by the algorithms [21].

However, these are tools that only allow you to apply one NPR technique. So what solutions are there for applying various techniques in a production environment interactively by artists? The SteamRoller Animation studio faced this problem and developed an interesting process to create its feature film Spice Frontier, which has a stylised 2D look.

In a talk on how the studio's approach works, the technical director introduced the problems that led to this development, namely how the artists involved could create a stylised 2D feature film with the Unreal Engine in such a way that the visual aspect of each frame could be controllable at an artistic level. The aim was therefore to honour their philosophy of 'Shot is King', which involves treating each frame as an independent unit in order to perfect it as much as possible. The solution found for this project was to use post-processing volumes within the Unreal Engine, a shader that allows visual effects to be applied to the scene, such as colour adjustments, blur and other filters, dynamically altering the appearance of the final rendering without directly modifying the scene's assets.

In this context, in order to be able to adjust one of the most important elements of their visual style: the rim lighting, a post-processing volume was created so that it allowed artists to adjust various parameters of this light, such as the angle, intensity, colour, among other details, allowing them to focus on the creativity of the process rather than on the technical details [22, 23]. Figure 2 illustrates the interface with some of the controls of this shader.

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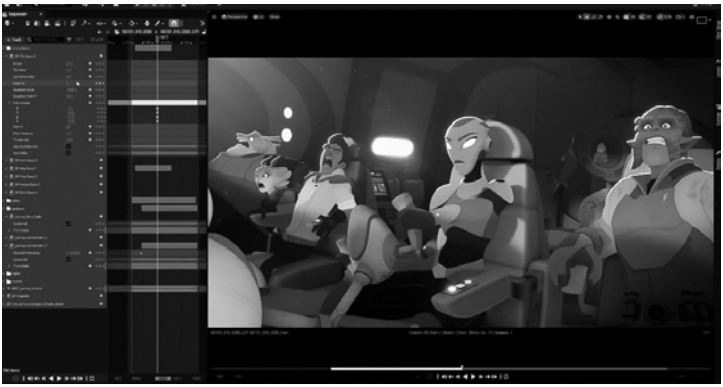


Fig. 2. Unreal Engine interface of the post-processing volume [38]

On the left side of the image, we can see the set of available options that adjust the visual style of the image while being able to see these changes in real time. Another interesting feature of this approach is that each character can be adjusted individually, which allows for greater control over the final image. The use of post-processing volumes was also the solution found by the artist Delphine Decuyper to replicate an artistic style from a reference illustration created by Oswaldo KATO (2022) [25] in a 3D environment. The aim of this work was to automate a system for recreating a highly stylised image within a game production environment, in this case Unreal Engine. Her work describes numerous NPR techniques that were needed to achieve the final look, such as watercolour textures, paper textures, outlining, cel-shading, among others. The end result was a hyper-shader capable of applying these different techniques in a customisable way, as illustrated in figure 3:



Fig. 3. Shader interface created by Delphine Decuyper [6]

However, one of the limitations presented by the artist was the fact that this shader is limited to the techniques implemented. In fact, as future work, the artist mentions exploring new artistic styles in 3D environments. However, the very process of implementing this type of shader is described by the artist as an experience with a substantial learning curve, especially for those inexperienced in the field [6].

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To conclude the section, it's also important to discuss which fully automated techniques exist that rely mainly on AI. One such technique is Neural Style Transfer (NST), which applies artistic styles to images according to a reference figure. The authors H. Park, N.Baek (2024) proposed an NST algorithm capable of transferring an artistic style to a game engine (in this case Unity) that could be visualised in real time, making it easy to integrate this technique into video game production [15]. While it is a powerful tool, the main disadvantage of this approach is the lack of control over the process, since the end result is dependent on the mathematical workings of algorithms rather than the creativity of the user. In fact, one of the main uses of this type of tool is its ability to generate multiple new ideas, which is an advantage in the ideation process [27]. This approach is referred to in the literature as 'prompt based creation', which means creating content (whether images or text) based on a few words that summarise the user's intention. As such, this can be an appropriate solution for users who want to generate visual content quickly and automatically, so they don't need as much control over the end result.

Practical Work

In order to create a solution that would fill this gap, we developed a hyper-shader in Unreal Engine (UE), with the primary goal of automating the process of applying NPR techniques for artists. We called this shader a hyper-shader because we combined several NPR techniques into a single shader. The first phase of development involved analysing which NPR techniques were most relevant in the field of video games, which required a review of some stylised titles. Some of the video games analysed were the aforementioned The Legend of Zelda: Breath of the Wild, Okami (Clover Studio, 2006), Borderlands (Gearbox Software, 2009), Journey (Thatgamecompany, 2012), among others. With this analysis, we identified five main techniques that would be essential for our hyper-shader: cel-shading, consisting of well-defined outlines and flat areas of colour, without smooth gradients; outlining, which is the contours of the objects in the scene; gradient control, i.e. the possibility of manipulating the colour palette used in the scene; and, finally, hatching, which consists of using lines to reinforce shadow areas.

Once the techniques had been defined, we also determined some design objectives that would be important for the target audience we wanted to reach, namely artists. Thus, the main user objectives defined were: automation of the interface, i.e. there is no need for any kind of implementation, either by node systems or code, to apply the techniques mentioned above; independence, in the sense that the artist can handle the tool without needing a third party; and finally freedom to experiment, in the sense that this is a tool with room for evolution if the artist wishes to expand the shader.

After this work, we moved on to the practical implementation in the UE. As this was a task in which the authors did not have a great deal of technical experience, the implementation was heavily based on approaches from previously developed work, comparison of results and even

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some personal experimentation. Our research revealed that in order to preserve the work done in 3D, NPR effects are usually applied as the last step of image rendering in the post-processing stage. Post-processing effects are used by artists to define the overall look of the scene through shaders and a series of parameters that affect properties such as colours, lighting and more.

In UE we can also easily build an interface by exposing certain parameters of the node system. The figure below illustrates the interface generated (left) from the implementation (right).

The interface, as we can see, is divided into sections for organisational reasons. The main techniques are presented in the first section under "General Settings" and, as they are activated, new sections appear with the parameters that are specific to the activated technique. In addition, to make it more intuitive, the parameter descriptions are kept consistent from section to section and with expressions that are easily recognisable by artists.

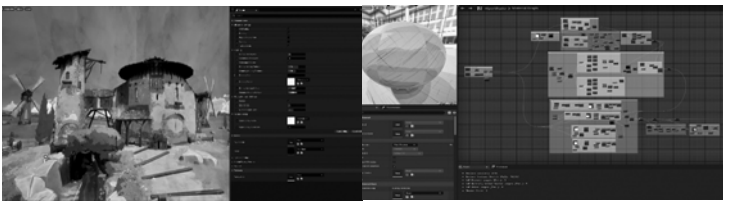


Fig. 4. Shader interface and shader implementation in the UE node system, respectively

During this process, we also tried to get some feedback from people with experience in this field in order to adjust the product developed so far. We therefore drew up a questionnaire in which we received some suggestions for improving the interface. However, since the UE interface doesn't allow for major changes, we were only able to implement one of the suggestions, which was to define some presets, i.e. set some parameters with specific styles beforehand. Figure 5 shows the visual application of some of these presets.

In addition to this questionnaire, we contacted video game artist Marco Vale, who, during an interview, suggested some shader improvements more focused on artistic direction, as well as smaller adjustments based on his interaction with the interface.

So, until the end of the project, we still intend to gather more feedback through other interviews in order to improve the interaction with the final user. Once the implementation is complete, there will also be a validation of the developed solution with our target audience, where artists with no technical training in shader construction will test and evaluate our hyper-shader.

Conclusion

We can therefore conclude that there is a lack of a practical, universal solution for artists without technical knowledge to apply a 2D style in a 3D production environment. We found that there are several tools and

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interfaces that allow you to apply NPR techniques, but they are only focused on one technique or are created for a specific project. This research also contains a practical component where, so far, we have developed an automated tool with an accessible interface for artists. To complement this development, we have contacted individuals with experience in this area who have guided us and suggested refinements in order to improve the interface and the user experience. Finally, although the final solution may not be suitable for all 2D graphic styles, it is intended that the main techniques used in video games will be covered by the hyper-shader. Furthermore, given that the authors have no previous in-depth practical knowledge of designing shaders in this game engine, the project could also help to clarify the difficulties encountered by artists going through the same process.

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