

AN INTRODUCTION TO
Stylized Rendering
in Games

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Stylized Rendering in Games

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Course Overview

Games like Prince of Persia and Battlefield Heroes deliver artistic visions beyond standard photo-realistic 3D. In this course, game developers teach the challenges of creating distinctive visual styles for interactive environments and some of their own solutions. Topics include the art pipeline, rendering algorithms, and integrating visuals with gameplay.

Why stylized rendering? As they matured, the visual arts (painting, sculpture, photography, and architecture) all developed new visual-abstraction mechanisms to go beyond "realism". Recent advances in visual effects have put film and games into this transitional state. In a sense, we're like artists at the end of the Renaissance: we've nearly mastered photorealism, but are only at the beginning of our discoveries about expression and perception.

Some effects are subtle, like the color shifts and post-processing in Mirror's Edge. Others, such as the graphic-novel look of Prince of Persia, dominate the entire rendering style. In games, real-time and interactive constraints require more efficient and robust solutions than are employed elsewhere in computer graphics. And to be successful, a stylized renderer must integrate with appropriately stylized models, animation, and audio to form a coherent virtual world and ultimately enhance game play.

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Course Syllabus

Introduction to Stylized Rendering in Games

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Morgan is an assistant professor of Computer Science at Williams College and a consulting member of the NVIDIA Research Group. He is the lead author of [Creating Games: Mechanics, Content and Technology](#) and has previously co-chaired the [Interactive 3D Graphics and Games](#) and the [Non-photorealistic Rendering and Animation](#) conferences. His game credits include the [Titan Quest](#) role playing game and the [Marvel Ultimate Alliance 2](#) action-RPG for Xbox 360.

Ammo, Bacon and Stylized Gameplay of Monday Night Combat

[Chandana "Eka" Ekanayake](#), Uber Entertainment

Eka is the Art Director and Executive Producer at Uber Entertainment on Monday Night Combat for Xbox Live Arcade.

The Illustrative Rendering of Prince of Persia

[Jean-François St-Amour](#), [Ubisoft Montreal](#)

Jean-François is currently working as a Lead 3D Programmer at Ubisoft's Montreal studio. In his time at Ubisoft, he has worked on the graphics technology behind [Assassin's Creed](#) and the [Prince of Persia](#) (2008). Before working on current-gen hardware, Jean-François was working on mobile titles at Gameloft. He has a Master's degree in Computer Graphics from the University of Montreal, where he worked on real-time soft shadow algorithms, as well as GPGPU.

Style and Gameplay in the Mirror's Edge and Cartoon 3D for Battlefield Heroes

Henrik Halén, [Electronic Arts](#)

Henrik was the rendering lead on the [Mirror's Edge](#) and has been with EA DICE since 2006. He now works for Electronic Arts.

Making Concept Art Real for Borderlands

Aaron Thibault and Sean "Zonder" Cavanaugh, [Gearbox Software](#)

Aaron is the Gearbox VP of Product Development. Zoner was the Senior Rendering Engineer on [Borderlands](#).

An Introduction to Stylized Rendering in Games

In this session, you will learn:

1. *The elements of visual style*
2. *Three methods for stylization in the graphics pipeline*
 - a. *With a case study on toon outlines*
3. *A survey of important stylized games*
4. *Unique challenges of stylized rendering*

Stylized Rendering

Figure 1 shows the Prince of Persia character in two games with very different appearances. Both games were developed by the same studio, and both images are representative of the real-time rendering style of the games. The image on the left has cartoon outlines, flattened shading, and painterly backgrounds. It is what we commonly refer to as “Non-Photorealistic”, “Expressive”, or “Stylized” Rendering. The image on the right contains an approximation of physically-correct light transport, including shadows, ambient occlusion, indirect illumination. It is what we commonly call “Photorealistic” or “Physically Based” Rendering.



Figure 1. left: Prince of Persia (Win, PS3, Xbox 360 2008), Ubisoft Montreal, Ubisoft. Right: Prince of Persia: The Forgotten Sands (Win, PS3, Xbox 360 2010) Ubisoft Montreal and Ubisoft Quebec, Ubisoft.

Yet both games are stylized. In fact, **all games exhibit stylized rendering**, because the game developers control the image. Even in the “Photorealistic” image, the developers place the lights, model the geometry, choose the approximation algorithms, and so on. Each of those choices imposes a visual style on the game. That style is present regardless of whether the choices were made explicitly and consciously. In a well-designed game, those choices are made by the team intentionally, according to an explicit shared artistic vision. So the techniques and

issues discussed here remain relevant to any game, including ones with less aggressive visual styles.

However, in these notes I'll focus on games like Prince of Persia 2008, where the artistic vision is relatively far from photorealism and the 3D world and characters precludes drawing explicit sprites. Another classic example of this kind of stylized rendering is the Viewtiful Joe character shown in Figure 2 and Figure 3. Like all of the images in this document that are not otherwise notated, these are actual in-game screenshots.



Figure 2. Viewtiful Joe (GC, PS2 2003), Capcom Production Studio 4, Capcom



Figure 3. Tatsunoko Vs. Capcom: Ultimate All-Stars (Wii 2010), Eighting, Capcom

Elements of Visual Style

A classification of the elements of visual style is:

- Lighting
- Geometry
- Color Palette
- Shading
- Object Motion
- Camera Placement and Motion

I'll illustrate these through images and descriptions of exemplary games using those elements.



Figure 4. Stylized lighting (and color) in the Mirror's Edge (Win, PS3, Xbox 360 2008), EA Digital Illusions CE, Electronic Arts



Figure 5. Stylized geometry under photorealistic rendering in Brink (Win, PS3, Xbox360 2011), Splash Damage, Bethesda Softworks, Valve Corporation



Figure 6. A strictly controlled color palette in Mad World (Wii 2009), Platinum Games, Sega



Figure 7. Stylized two-tone shading in Jet Set Radio (DC 2000), Smilebit, Sega



Figure 8. Stylized character motion in God of War III (PS3 2010), Sony Santa Monica, Sony



Figure 9. Stylized camera motion in Burnout Paradise (Win, PS3, Xbox 360 2009), Criterion Games, Electronic Arts

Realism Also Breeds Counter-Realistic Styles in Games and Painting

Most 2D games exhibit extremely stylized rendering. For example, The Legend of Zelda: A Link to the Past (Figure 10) and Super Mario Kart (Figure 11) both demonstrate Nintendo's cartoon aesthetic. This includes dark outlines on objects, enlarged heads and vertical compression of characters, saturated colors, and two-tone shading.



Figure 10. Cartoon style in The Legend of Zelda: A Link to the Past (SNES 1991), Nintendo



Figure 11. Cartoon style in Super Mario Kart (SNES 1992), Nintendo

While there are good reasons to opt for specific visual styles on underpowered platforms, I do not believe that was the primary factor for Nintendo art directors in selecting the style of *A Link to the Past* and *Super Mario Kart*. I suggest two points as evidence of this. First, most aspects of this style have been retained for sequels to these games on the substantially more powerful Nintendo64, GameCube, and Wii platforms. Second, much more photorealistic styles were possible even on the Super NES in 1992.

Midway published *Mortal Kombat* with photorealistic elements, as shown in Figure 12. Since the characters were in fact photos of real actors, they were as photorealistic as possible. Yet Nintendo specifically chose a more abstract visual style for its games; their characters of Mario and Link are not depicted through photographs of actors but through hand-drawn cartoons.

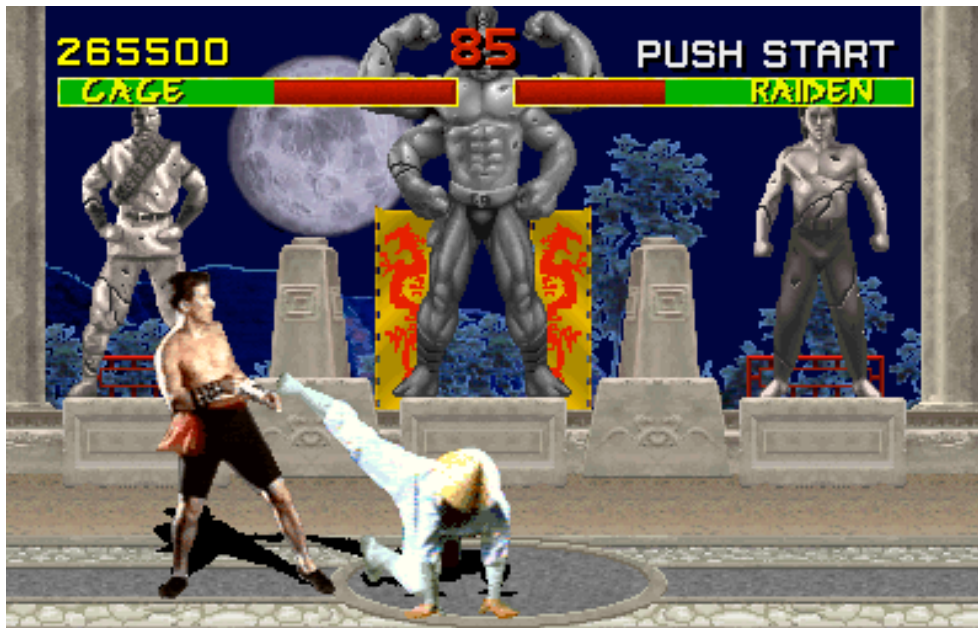


Figure 12. Photographic sprites in *Mortal Kombat*, Sculptured Software / Probe (SNES 1992), Midway (Arcade 1992), Midway, Acclaim.

We observe the same phenomenon in the history of painting. Since the Renaissance, painters have been within striking distance of photorealism. Holbein's portraits from the 16th century, such as Bonifacius Amerbach in Figure 13, essentially *were* the photographs of their day. A century after Holbein, Claeszoon's *Still Life with Pie, Silver Ewer and Crab* (Figure 14) captures photorealistic reflection, shadow, and indirect light. Work by modern photorealists, such as Goings (Figure 15) is indistinguishable from photography from any appreciable distance (yes, that really is an oil painting, not a photograph!) So painters are definitely capable of photorealism.



Figure 13. Portrait of Bonifacius Amerbach, (Oil and tempera on pine 1519), Hans Holbein the Younger



Figure 14. Still Life with Pie, Silver Ewer and Crab (Oil on canvas 1658), Willem Claeszoon



Figure 15. Miss Albany Diner (Oil on linen 1993), Ralph Goings

Yet even after realism was achieved, many painters intentionally diverged from it. In fact, as technique and materials enabled increasingly photographic paintings, the abstraction and impressionism rose in painting in reaction to the increasing realism.

Classic works by Van Gogh (Figure 16) and Picasso (Figure 17) are highly stylized. More recent work by Murakami (Figure 18) reflects as well as influences manga style, which also shares significant overlap with many video game styles.



Figure 16. Starry Night (Oil on canvas 1889), Vincent Van Gogh



Figure 17. Les Femmes d'Alger (1907), Pablo Picasso



Figure 18. Tan Tan Bo Puking (2002), Takashi Murakami, [photo from Galerie Emmanuel Perrotin, Paris and Miami via The New York Times]

Motivation and Application

Why do some game art directors, like the painters before them, choose highly stylized depictions over photorealism? How does this improve the games?

Some motivations for style are:

- Immersion
- Theme
- Consistency
- Differentiation
- **Emphasis through Abstraction**
 - For impact
 - For comprehension

Many concrete (vs. abstract strategy) games rely on players suspending disbelief. In such games, immersion means that the player forms a mental model that is consistent with but not directly based on the game's underlying rules. The player's model is formed by his or her belief in the world and the assumptions that he or she makes from the way the world is presented. This immersion and ability to reason in an intuitive rather than rules-based manner is part of the pleasure of such games.

Most game worlds are fantastic. Players control characters with special abilities or who encounter situations that would be unusual or impossible in the real world. Presenting these in a visual style that mimics the real world can hamper the player's ability to model the virtual world and draw attention to its departures from reality. A visual style that conveys the nature of the virtual world can help here. For

example, the highly stylized rendering of Tron 2.0 shown in Figure 19 makes clear that the characters and objects in that game do not obey the rules that we encounter in the real world. It also conveys their digital, electronic, and transient nature, which inspires the player with possible strengths and weaknesses of the characters met in that world.



Figure 19. Style supports immersion in the fantastic computer-world of Tron 2.0 (Win, Mac 2003; Xbox 2004), Monolith Productions, Buena Vista Interactive



Figure 20 Style communicates the style and theme of Little Big Planet (PS3 2008), Media Molecule, Sony Computer Entertainment Europe

Style can be core to the theme and setting of the game. Little Big Planet's style (Figure 20) says that we're in a toy-like world and that we should experiment. We understand that the facades are just decoration because they are modeled as cardboard cutouts, so we don't try to enter the castle door. The extremely small depth of field and strong ambient occlusion term emphasize the small scale of the characters.

The Beatles: Rock Band (Figure 21) uses varying style through the game to depict the different decades through which the Beatles were popular. The psychedelic style of the Sgt. Pepper's album carries into the game's rendering. Here, the visual style reinforces the music (which is of course core to the Rock Band games), the setting, and the theme. It also is a style that can be achieved on lower-power consoles of the current generation, such as the Wii.



Figure 21. Style drives the psychedelic theme of *The Beatles: Rock Band*, Harmonix (PS3, Xbox 360 2009), Pi Studios (Wii 2009), MTV Games, EA Distribution

Consistency across modeling, rendering, audio, gameplay, and narrative is important in two ways. First, consistent style across elements of the game ties them together and makes the style stronger than if it were in one element alone—this is a “whole is greater than the sum of its parts” phenomenon. Listen to the audio for an explosion, and then watch one without audio. Neither is as compelling as a visual explosion backed by appropriate audio. Much of the mood in film is conveyed through consistent audio and visual stimuli.

Second, consistent style is essential to the perception of quality. The audience perceives the *difference* between the highest and lowest quality elements of a production, and the worst element often seems worse by that difference. For example, we are critical of the abstracted narrative in the *Avatar* film because its

rendering style is so detailed. Disney's Pocahontas film uses essentially the same narrative, but because the abstracted rendering style of that film is consistent with the abstracted narrative, the story seems high quality in Pocohontas. The Rock Band abstracted, visuals match the Rock Band abstracted experience of playing instruments and both seem better for it.

Scribblenauts employs a similar tactic. Objects are rendered in a coarse, abstracted style that is consistent with the accuracy with which their interactions are modeled. We only expect the crudely drawn cow in Figure 22 to interact crudely and stereotypically. Likewise we don't expect much more than basic collision response from the game's physics system. These tie back to the mental model: the player understands that this world is highly abstract and only tries to interact with it at an abstract and clichéd level.

It is worth noting in particular that Okami's main mechanic of painting into the game world is beautifully consistent with the rendering style. This is tight integration of style and gameplay. The in-production title Epic Mickey from Disney follows a similar idea, rendering in cartoon style and granting characters paintbrushes and paint thinner to interact with the world.



Figure 22. Interaction models are consistent with and communicated clearly by the visual style of Scribblenauts (DS 2009), 5th Cell, Warner Bros. Interactive Entertainment

Visual style differentiates games in a genre-driven marketplace. Gearbox's open-world RPG Borderlands has a similar setting to the established Fallout RPG franchise, and similar mechanics to other popular series like Mass Effect. The developers adopted the unique visual style shown in Figure 23, which helps differentiate Borderlands from similar games. The introduction and title sequence

of the game is particularly noteworthy. Not only is the style very prominent because the characters are larger than when typically observed in game, but the credit text is integrated into the 3D environment in a stylized manner similar to that of Grand Theft Auto IV and Splinter Cell: Conviction.



Figure 23. In the crowded RPG genre, unique visual style helps differentiate Borderlands (Xbox 360, PS3, Win 2009), Gearbox Software, 2K Games

The impact and clarity that come from abstraction are perhaps the most powerful factors driving visual style for games.

Abstraction increases the visual contrast of an image by selectively reducing detail. This emphasizes the aspects that are not removed. For example, Okami's sumi-e-inspired style shown in Figure 24 eliminates almost all of the details on the interior of shapes. Strong silhouettes and bold colors are left. The main wolf character stands out from the background, and prominent features of the landscape are emphasized. This kind of abstraction is one way of making an image more powerful and communicative than a realistic one, since that contrast level is higher than achievable in the real world. Van Gogh makes the stars pop and shows their relation to one another in Starry Night; a photograph of a night sky is less evocative with only pin pricks of white against a black or blue background.

The Legend of Zelda: Wind Waker's cartoon style is slightly more representational than Okami but has the same effect (Figure 25), highlighting the characters against the background.



Figure 24. Abstraction increases visual impact in *Okami*, Clover Studio (PS2 2006), *Ready at Dawn* (Wii 2008), Capcom, Activision



Figure 25. Abstraction increases visual impact in *The Legend of Zelda: The Wind Waker* (GC 2002), Nintendo EAD, Nintendo

If properly applied, this kind of abstraction makes images easier to understand, and quick comprehension is essential in many video games. The challenge is making abstraction meaningful, which is something that is hard to automate since the meaning of an image comes from the human creator and viewers.

DeCarlo and Santella's 2002 SIGGRAPH paper, *Stylization and Abstraction of Photographs* demonstrates this. Figure 26 shows a photograph they used in their experiments. Figure 27 (left) shows a *meaningless* abstraction of the photograph obtained by applying a painterly filter to the entire image with constant parameters. It superficially resembles an oil painting, but lacks any of the control over composition that makes for a good painting. Figure 27 (right) shows a meaningful abstraction. Most viewers of the original photograph find their eyes drawn to the man in the foreground. The meaningful abstraction provides positive feedback to this effect by abstracting detail (in the form of color and high frequencies) from the background, thus highlighting the man. This helps to direct our visual interest where it would go anyway, which hopefully makes the stylized version more interesting and powerful than the original photograph.



Figure 26. Photograph of a man with other people in the background.



Figure 27. Left) painterly filter applied uniformly across a photograph. Right) Increased abstraction through larger brush strokes in areas of less visual interest.

Enhancing Visual Cues through Style

Some visual cues that help us to understand images are, in order of decreasing perceptual significance:

1. (Motion)

2. Silhouette
3. Value (brightness)
4. Color (hue)

We can often identify an out of focus or obscured person solely by his or her motion. This is one reason the animator and motion capture actor's jobs are so important on a game team. For static images, perception is dominated by silhouette (this is why military snipers wear ghillie suits with foliage attached to break up their outlines). Much less significant is the value of an object, and least important is its color. Of course, there are exceptions. For example, in a monochrome world like Mad World, the sudden presence of red blood allows color to trump all other cues.

A game's rendering style should exploit these cues to make images easier for the player to understand. For example, on encountering a character in the world, the player must quickly determine several properties of that character, such as:

1. Team
2. Direction
3. Identity
4. Intent

This is called "reading" the character. Realistic characters are hard to read because they all have approximately the same shape and palette. Good games use style to depart from this and ensure that characters are easy to read, even in a distance or when partly obscured.

For example, consider the character whose silhouette is shown in Figure 28. We can instantly determine this character's direction, gender, equipment (none but a hat!), and intent. Even if you haven't played the game, you probably can determine this character's identity: Mario, in this case from New Super Mario Bros (DS 2006), Nintendo EAD, Nintendo.



Figure 28. This character's stylized silhouette helps players to "read" it.



Figure 29 . Stylized silhouettes help make the characters read clearly in Team Fortress 2 (Win, Xbox 360, PS3 2007, Mac 2010), Valve Corporation, Steam, Electronic Arts.

Style and the Graphics Pipeline

- a. Post-process
- b. Shading
- c. Alternative 3D geometry
- d. Alternative 2D geometry

Case study: contours (“toon outlines”/local silhouettes)

- e. Edge filter on depth map
- f. $N \cdot E$ threshold in pixel shader
- g. Detect front-face meets back-face in geometry shader
- h. Stroking algorithms

Challenges

Stylized rendering tightly couples artists and programmers, and places them outside their core competence. Physically-based rendering offers a clear distinction between data and algorithm. Artists control, e.g., reflectivity, geometry, light intensity, and programmers directly implement approximations of light transport. Under stylized rendering, this distinction breaks down. Programmers must implement the artists’ vision, rather than the rules of physics. How do you parameterize these algorithms? Artists must express their vision quantitatively and programmers must implement qualitative specifications. Both of these are outside the established workflow for many developers, and qualified joint programmer-artists are hard to find.

“Temporal coherence” – ill defined, but generally, we need to ensure that stylized elements like brush strokes don’t introduce artificial secondary motion or flickering. This is hard, especially when algorithms are sensitive to small changes to the scene or leverage randomness.

Because stylized effects are phenomenological, there are many ways to achieve the same look. As we saw in the toon outline case study, algorithms that produce comparable output for one scene may have very different properties for another. This complicates the process of developing stylized rendering algorithms. Furthermore, each style is more-or-less unique. Expertise that we develop on rendering in a manga style may not inform how we render in the style of an oil painting or a noir film.

We’ve seen that robustness can be a major challenge for stylized rendering algorithms. When there are no first principles underlying the development of an algorithm, it is hard to predict where it will break down or how sensitive it will be to various parameters.

Risk/reward: games that vary from established styles can stand out in the marketplace, but they can also fail if the style alienates players or fails to appeal to the targeted demographic. Increasing stylization therefore increases the stakes when marketing a game.

Customization: How do we allow players to create within our style?

- i. Spore
- j. Little Big Planet
- k. 3D Dot Game Heroes

1. Brink