

Special Topics in A3: Non-Photorealistic Rendering

- Introduction To Stylized Rendering
- Non-Photorealistic Shading

Non-Photorealistic Rendering

- Focuses on creativity/expressiveness
 - Not concerned with making **physically-accurate results**
 - Other names:
 - Toon-shading
 - Cel-shading
 - Stylized Rendering
- Use 3D graphics to create 2D stylings
 - Paint-like
 - Sketch-like
 - Comic-like
 - Cartoon-like
- **Idea:** change the way light interacts with geometry
 - Special NPR BRDFs



Arcane (2021) Fortiche Productions

MB

OSCARS 2025 WINNERS



FLOW

BEST ANIMATED FEATURE FILM

The Four Horsemen of **abysmal dogshit**



Depth of Field



Motion Blur



Chromatic Aberration



Lens Flare

Sometimes NPR can go too far...

NPR In Media



NPR In Games



Legend of Genshin or something, idk I don't play video games (2023) Nintendo

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Unpacking The Spot and Hobie's Disruptive Styles in 'Spider-Man: Across the Spider-Verse'

Production designer Patrick O'Keefe dives deep into two of the hit film's most underrated characters, including one who is more 'unnatural disaster' than 'villain' and one based on 'continuous noise' and 1970s London punk rock.

By [Victoria Davis](#) | Wednesday, July 12, 2023 at 1:19pm

In 2D, 3D, Art, CG, Films, People, Visual Effects | [ANIMATIONWorld](#) | Geographic Region: All

NPR In Movies

Los Angeles Times

COMPANY TOWN

'Spider-Man: Across the Spider-Verse' and the Hollywood animation

The New York Times

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How the 'Spider-Verse' Animators Created That Trippy Look

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VULTURE

How *Spider-Man: Into the Spider-Verse* Animation Game

By [Charles Bramesco](#), a freelance film and TV critic



Photo: Sony Pictures Animation

Spider-Man, Spider-Man, he does whatever a spider can — but with the web-slinger's latest feature outing, *Spider-Man: Into the Spider-Verse*, an elite creative team set out to redefine just what a spider could do.

CHALLENGING THE PIXAR LOOK

Vox

How "Spider-Verse" forced animation to evolve

3.3M views • 1 year ago

Non-photorealistic rendering has opened up an alternative to the ubiquitous

CC

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How 'Spider-Man: Across the Spider-Verse' Directors Crafted That Signature Spidey Animation Style

By [Murtada Elfadl](#)

14 Stylized Animated Movies to Watch If You Love 'Spider-Man: Across the Spider-Verse'

"Let's do this one last time."

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Jun 1, 2023 • World

"Spider-Man: Across the Spider-Verse" defies boundaries of animation

Marina E. Franco (Noticias Telemundo for Axios)

Across the Spider-Verse" — one of the most anticipated movies of the summer — is undaries of animation.



ure Losch/Axios. Photo: Sony Pictures Animation.

Across the Spider-Verse" — one of the most anticipated movies of the summer — is undaries of animation.

NPR Styles: Low Poly



Lonely Mountains Downhill (2019) Megagon Industries



SuperHot (2016) SuperHot Team



What The Golf (2019) Triband

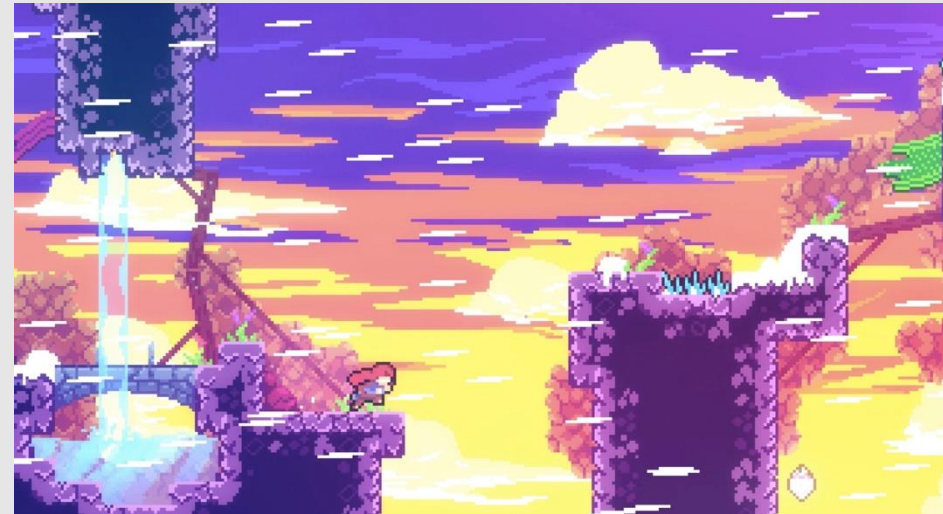


Minecraft (2011) Mojang

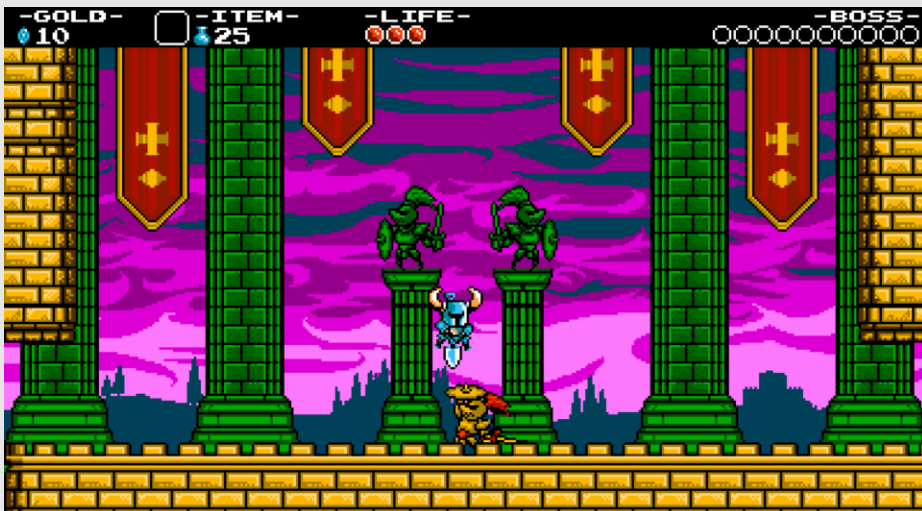
NPR Styles: Pixel Art



Enter the Gungeon (2016) Devolver Digital



Celeste (2018) Maddy Makes Games



Shovel Knight (2014) Yacht Club Games



Stardew Valley (2016) Eric Barone

NPR Styles: 2D Animation



Snow White (1937) Walt Disney Animation Studio



Klaus (2019) SPA Studios



Moana (2016) Walt Disney Animation Studio



The Bad Guys (2022) Dreamworks

NPR Styles: Ghibli Animation



My Neighbor Totoro (1988) Studio Ghibli



Ponyo (2009) Studio Ghibli



Spirited Away (2001) Studio Ghibli



Earwig And The Witch (2020) Studio Ghibli

NPR Styles: Comic Book



Spiderman vs Superman



Peanuts



One Piece Netflix Adaptation



Solo Leveling

Halftone Printing

- Also called **stippling**
- Printing used to require carving out blocks and dipping them in ink to press onto sheets of paper
 - Printing many small dots was easier
 - Like a pixel buffer!
- Subtractive color scheme: print colors on top of each other on white paper to produce darker colors
 - Printing many small CMKY dots produced color prints
 - The alignment offset from printing error was a very 'comic book' style



~~• Introduction to Stylized Rendering~~

- Non-Photorealistic Shading

Non-Photorealistic Rendering

- NPR rendering based off 2D art
 - Solid color
 - Hard shadows
 - Outlines
- Backgrounds often drawn in 2D
 - 3D characters rendered to 2D
 - Compositing done in 2D with 2D SPFX



Wish (2023) Walt Disney Pictures

Solid Colors

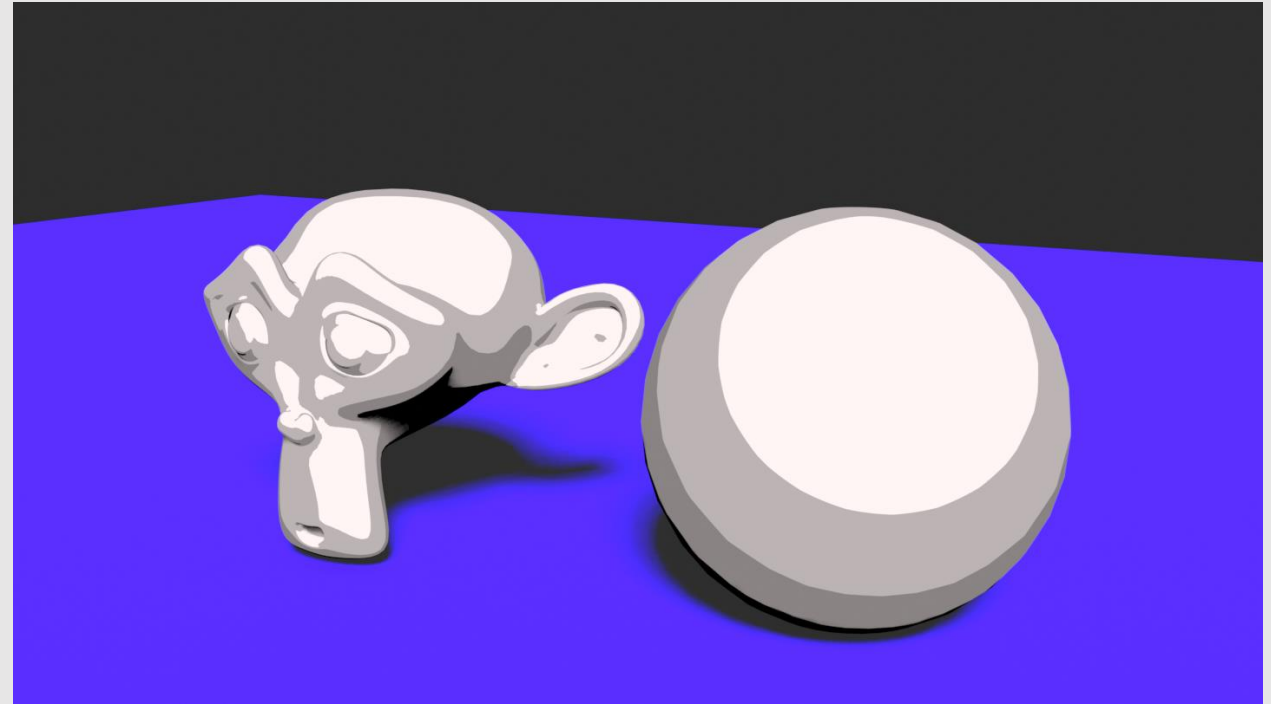
- Rather than interpolating colors at vertices, set solid colors for entire regions
 - Every sample gets average of vertex colors
- Emphasize bold, contrasting colors
 - Want to be able to tell apart different elements from their colors
 - Shadows are baked in
 - Ex: hair



The Legend of Zelda: The Wind Waker (2002) Nintendo

Hard Shadows

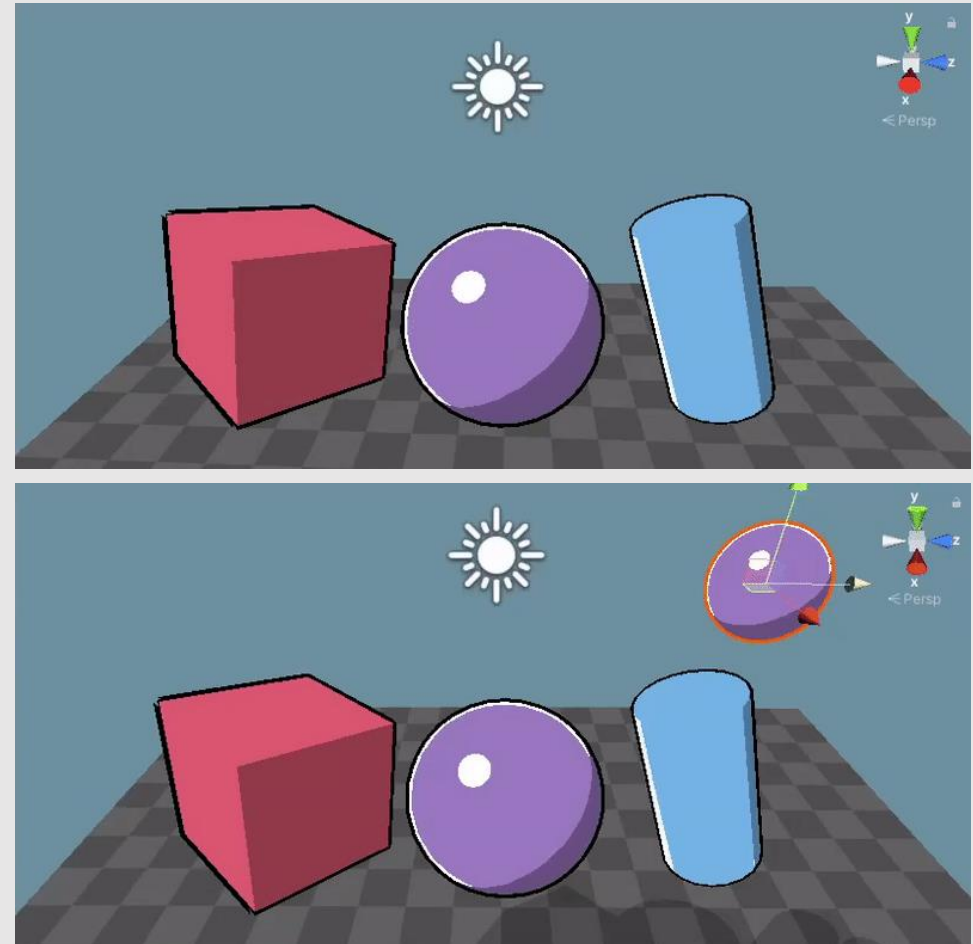
- Shading was expensive in hand-drawn animation
 - Saved time by drawing hard shadow layers instead of shadow gradients
 - Replicated in NPR for the '2D look'
- **Algorithm:**
 - Extract world-space normal
 - Take dot-product with camera look-at direction
 - Threshold values, mapping to 0 or 1
 - Creates a hard shadow binary mask
- The larger the threshold, the larger the shadows
 - Can layer multiple thresholds for multiple hard shadows



Making A NPR Shader In Blender (2021) Maxime Garcia

Hard Shadows

- **Problem:** Hard shadows change as camera moves
 - Instead want hard shadows from light source
- **Algorithm:**
 - Extract world-space normal
 - Take dot-product with ~~camera look-at direction~~ world-space light vector
 - Threshold values, mapping to 0 or 1
 - Creates a hard shadow binary mask
- Can also use for specular highlights + casting shadows!



Cel Shader (2021) Lewis Gadsby

N-dot-V Outline

- Hand-drawn animations contained character outlines to give characters more details
- **Idea:** outlines are areas in the mesh that sit in between areas that face towards us and areas that face away from us
- **Algorithm:**
 - Extract world-space normal
 - Take dot-product with camera look-at direction
 - Look at areas where the dot product is close to 0
 - Shade them darker
- When the dot product is 0, the mesh is in the process of moving towards or away from the camera



Ryner (2015) Lucas Gogol

Inverted Hull Outline

- Hand-drawn animations contained character outlines to give characters more details
- **Idea:** outlines are areas in the mesh that sit in between areas that face towards us and areas that face away from us
- **Algorithm:**
 - Create geometry
 - Duplicate geometry
 - Extrude in all directions
 - Flip normals/Invert hull
 - Enable backface culling
- Outlines are now a separate geometry that sit on top of the original geometry



Cel-Shading (2020) Andrey Torchinsky

Painting

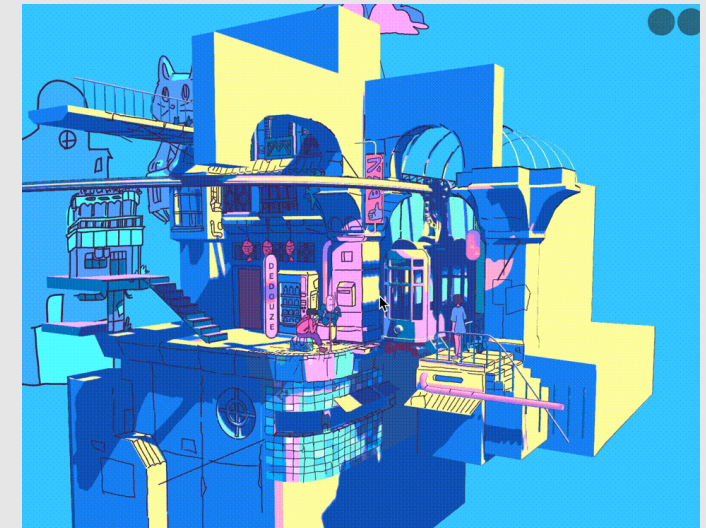
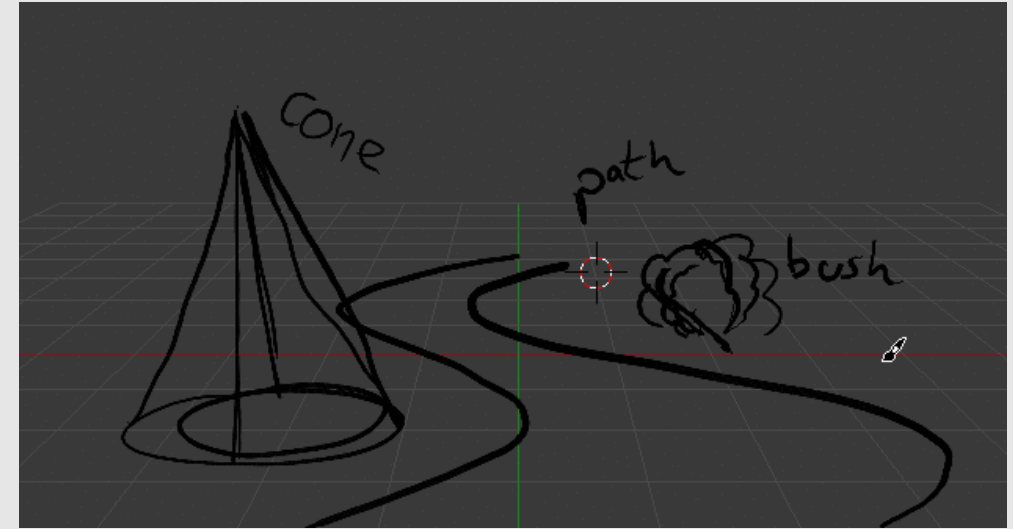


The Mitchells vs. the Machines (2021) Sony Pictures Animation

- Sometimes it is more work to automate a process than just doing the process
 - More work to write a shader than just draw it
- **Idea:** Draw 2D brushes on top of 3D frames
 - **Issue:** Where do those brush strokes sit in the scene?

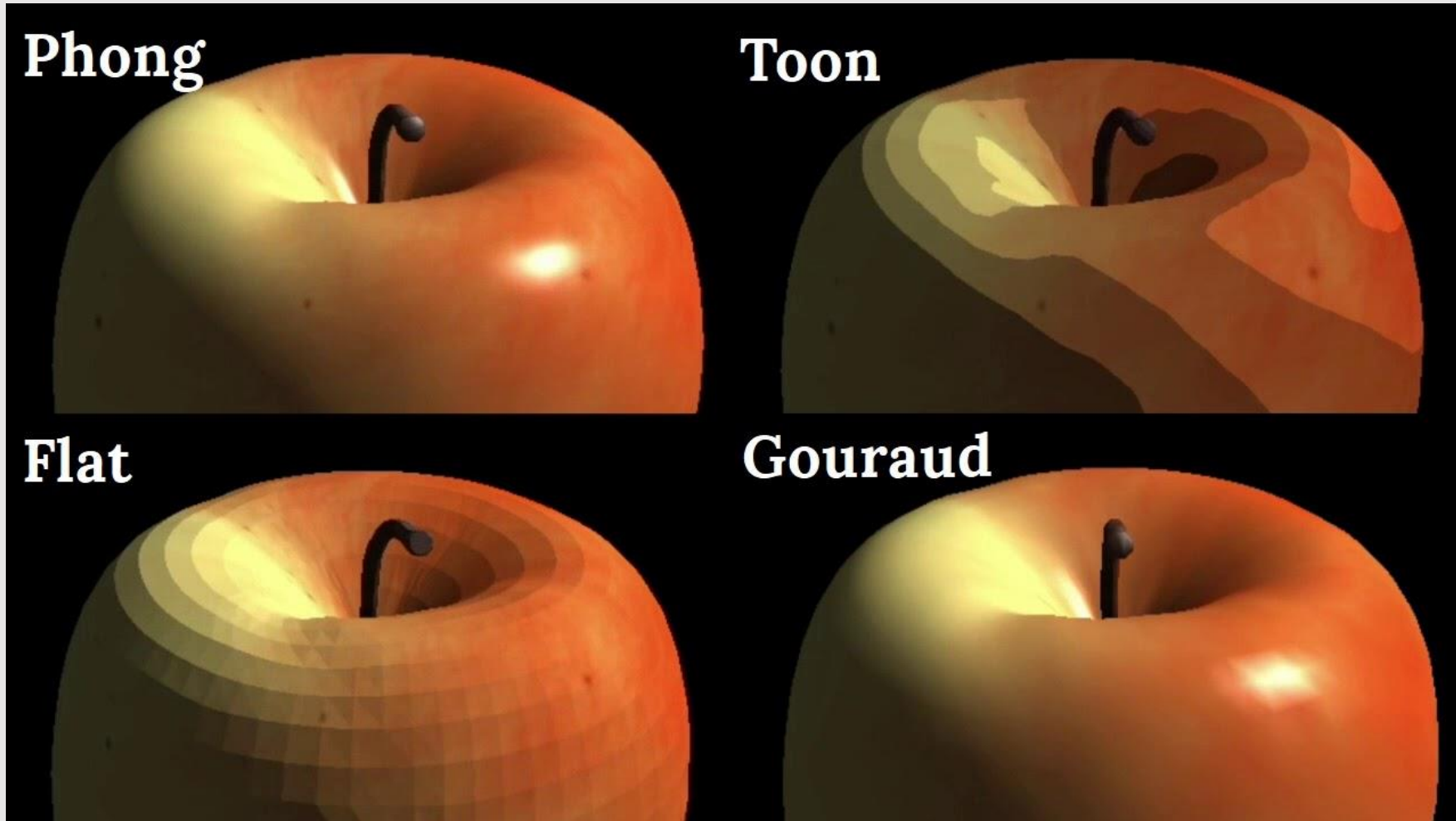
Grease Pencil

- Released in Blender in 2008
- Draw strokes on screen
 - Saved as a collection of points with vector paths passing through
 - Can be warped or manipulated
- Strokes saved to the XZ plane
 - Planes can be transformed in 3D
 - Changing the view of the camera changed where new strokes would be generated
- **Workflow:**
 - Draw strokes
 - Move strokes
 - Repeat



Blender Grease Pencil (2019) Nicola Sap, gskinner, Dédouze

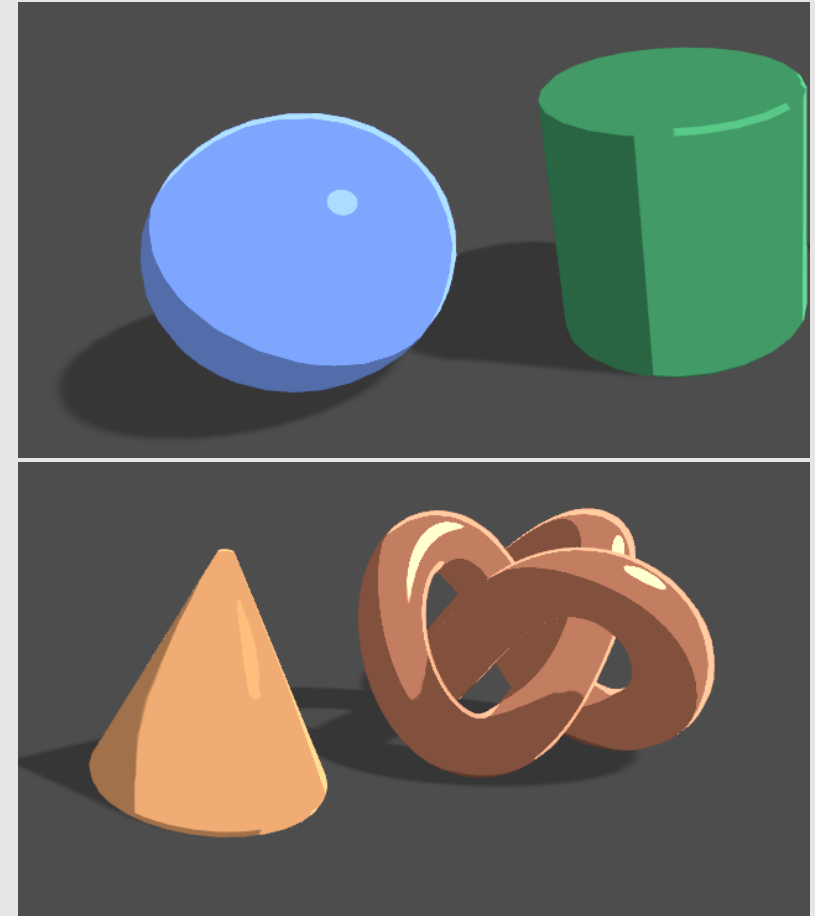
Shading Methods



Phong, Gouraud, Flat, and Toon shading in OpenGL (2017) Chih-Chun Hsu

Shading Methods

- **Flat Shading**
 - Shade entire primitive with the same surface normal
- **Phong Shading**
 - Interpolate normals at vertices using barycentric coordinates, then shade with interpolated normal
- **Gourad Shading**
 - Shade at each vertex with its vertex normal, then interpolate vertex colors using barycentric coordinates
- **Toon Shading**
 - Flat, Phong, or Gourad, with thresholding on lighting/color



What rules of rendering still apply in non-photorealistic rendering

The Rendering Equation

$$L_o(\mathbf{p}, \omega_o) = L_e(\mathbf{p}, \omega_o) + \int_{\mathcal{H}^2} f_r(\mathbf{p}, \omega_i \rightarrow \omega_o) L_i(\mathbf{p}, \omega_i) \cos \theta \, d\omega_i$$

$L_o(\mathbf{p}, \omega_o)$ outgoing radiance at point $\mathbf{p}$ in outgoing direction ω_o

$L_e(\mathbf{p}, \omega_o)$ emitted radiance at point $\mathbf{p}$ in outgoing direction ω_o

$f_r(\mathbf{p}, \omega_i \rightarrow \omega_o)$ scattering function at point $\mathbf{p}$ from incoming direction ω_i to outgoing direction ω_o

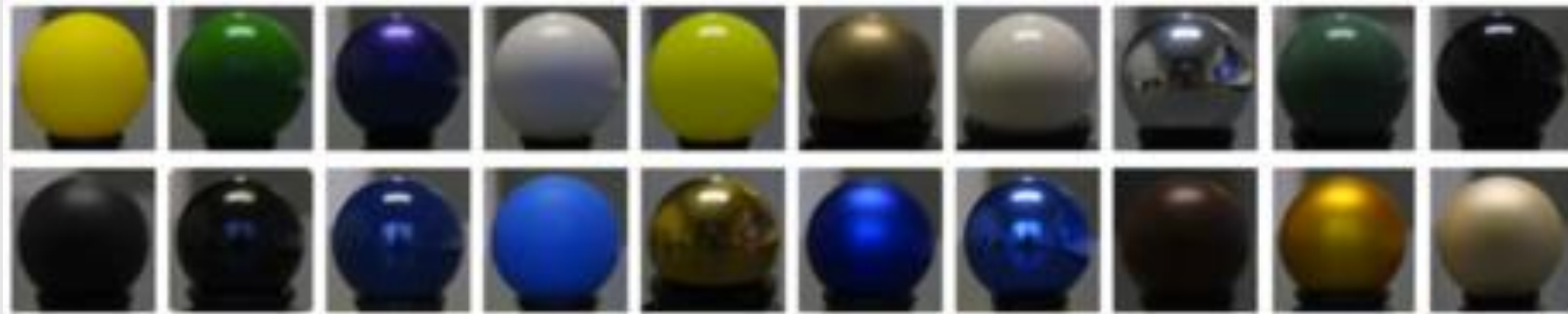
$L_i(\mathbf{p}, \omega_i)$ incoming radiance to point $\mathbf{p}$ from direction ω_i

still the same rendering equation!

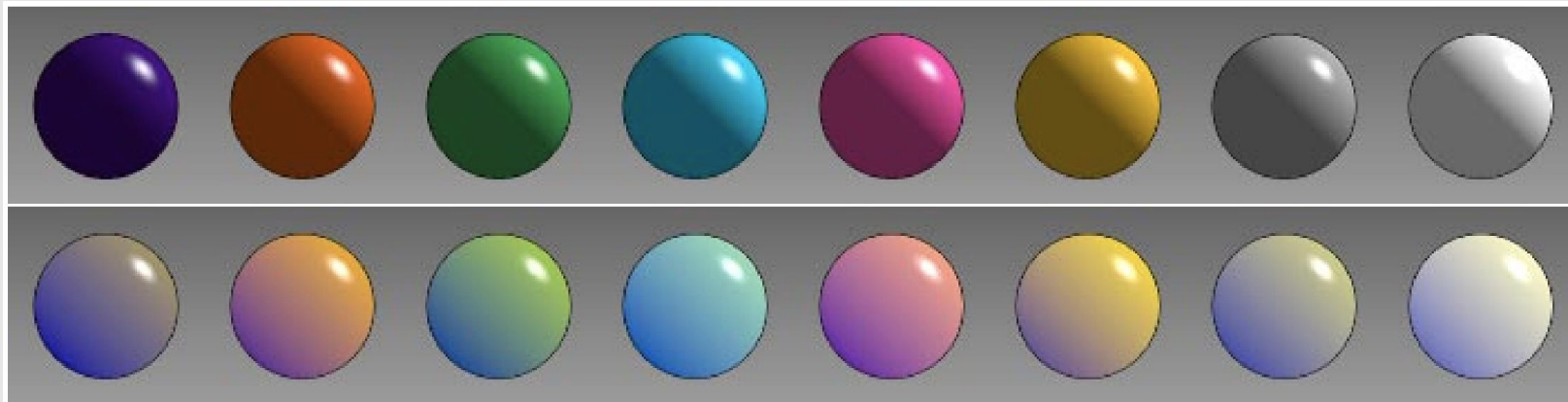
**Rendering equation describes
how light interacts in the volume
between objects, not the objects
themselves!**

Materials

[Photorealistic Materials]



[Non-Photorealistic Materials]



A Non-Photorealistic Lighting Model For Automatic Technical Illustration (1998) A. Gooch, B. Gooch, P. Shirley, E. Cohen

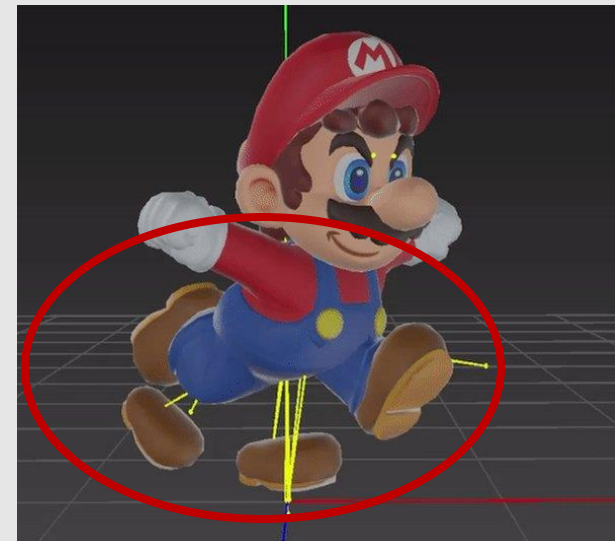
Smear Frames

- Draw paths to exaggerate motion
 - Replicates motion blur
- Another way to Smear: duplication
 - Multiple body parts give the illusion that the part is moving faster than we think
- **Q:** Why not increase the speed of the body part?
 - Requires increasing framerate: bad!
 - Requires larger distance between frames
 - Hard to make out body part motion



Tom & Jerry (1940) MGM Studio

multiple shoes



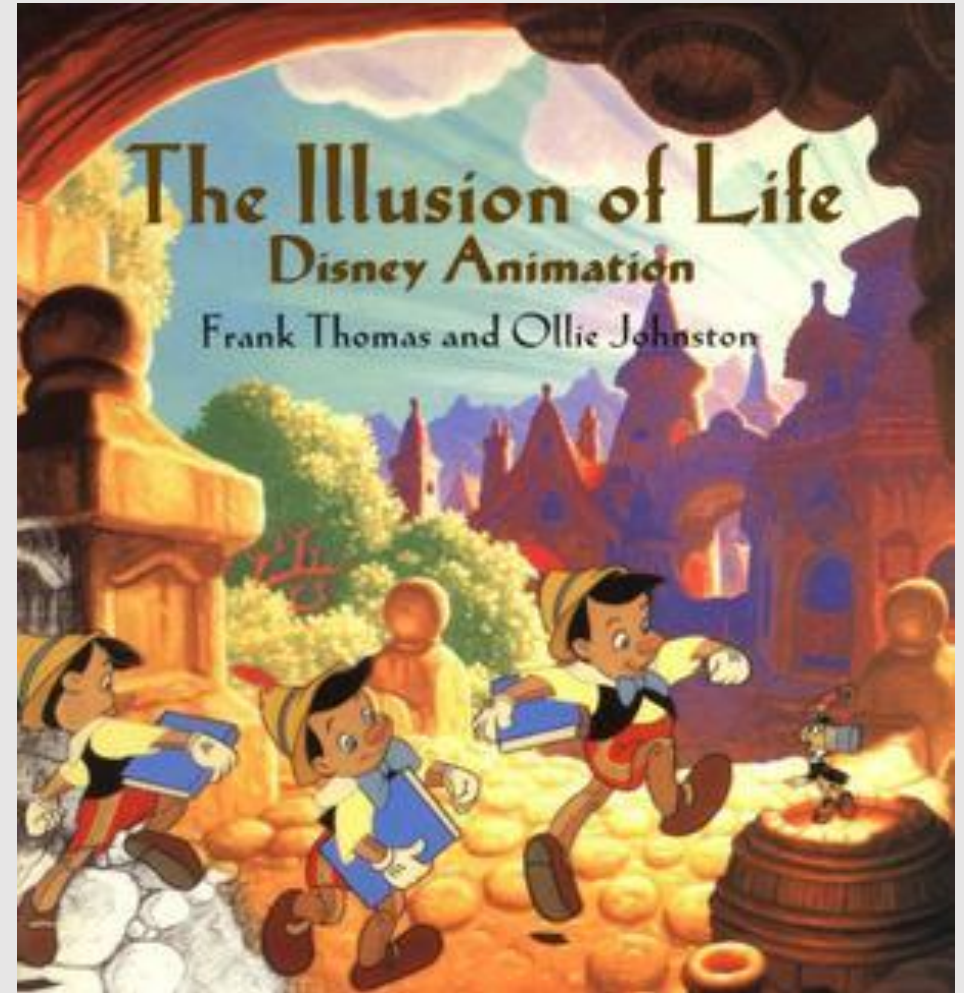
Super Mario Wonder (2023) Nintendo

Movement

- Biggest component of stylized rendering
 - Stylized character designs are meaningless if their movement is too real life
- 12 Principles of Animation
 - Will discuss further next lecture!



Across the Spiderverse (2023) Sony Pictures



Course Roadmap



[A1: Rasterization]



[A2: MeshEdit]



[A3: PathTracer]



Next Time

[A4: Animation]