ILLUSTRATIVE RENDERING IN *TEAM FORTRESS 2*

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VALVE

OUTLINE

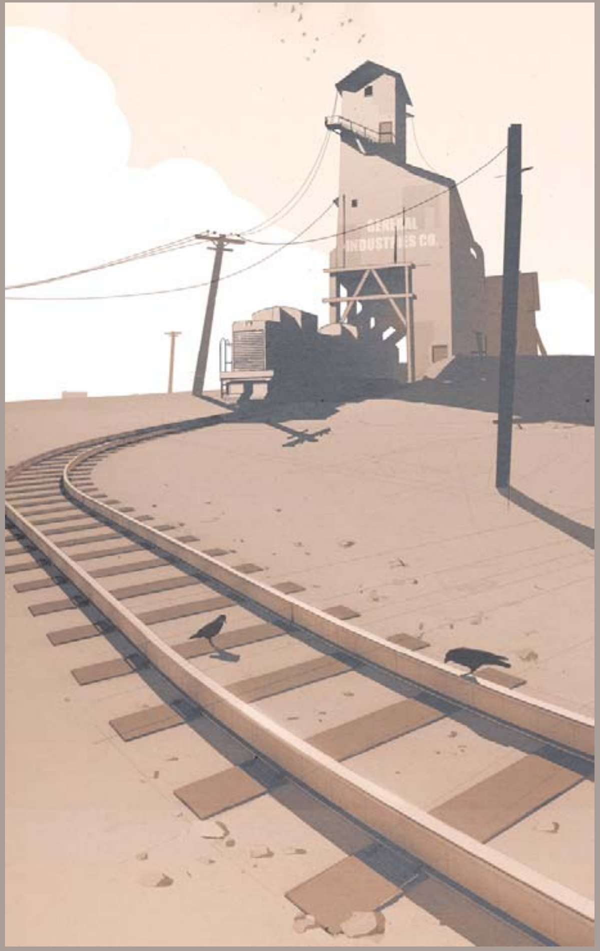
- Motivations and related work
- Environments
- Characters and interactive shading
- Future work

TEAM FORTRESS 2

- Class-based multiplayer combat game which will be released this fall
- Unique visual style
  - **Differentiation** - multiplayer combat games tend to embrace a contemporary photorealistic look
  - **Gameplay** -*Team Fortress* has always featured cartoonish, over-the-top situations
  - **Readability** - Class differentiation is the core of *Team Fortress 2*, hence we needed to be able to clearly differentiate classes visually

Environment Design Principles

- Value contrast
- Simple forms
  - No unnecessarily off-kilter shapes
- Minimize visual noise
  - Texture and geometric
  - Minimize repetition



CONTRASTING TEAM PROPERTIES

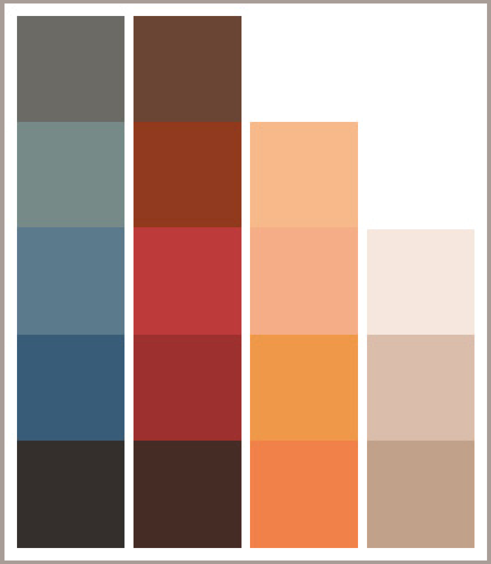
- Red
  - Warm colors
  - Natural materials
  - Angular geometry
- Blue
  - Cool colors
  - Industrial materials
  - Orthogonal forms

BLUE BASE IN 2FORT MAP

RED BASE IN 2FORT MAP

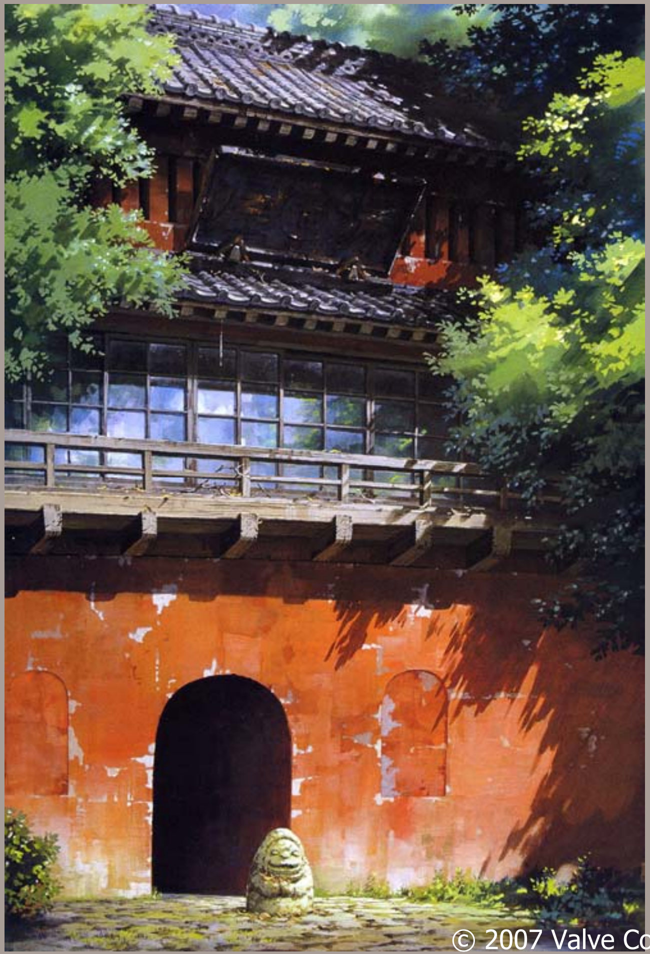
WORLD RENDERING

- Photorealistic techniques from our other games
  - Radiosity-generated light maps
  - Special effects such as reflection and refraction
- Hand-painted textures with minimal noise, applied directly to 3D geometry
  - Loose details with visible brush strokes
  - Inherent solidity and frame-to-frame coherence
  - Hold up under magnification better than photoreference
- Brush strokes appear in perspective, not in the 2D image plane [Miyazaki02]
- High frequency detail in photorealistic games can overpower design



Color Palette

Miyazaki - Brush Width Foreshortened

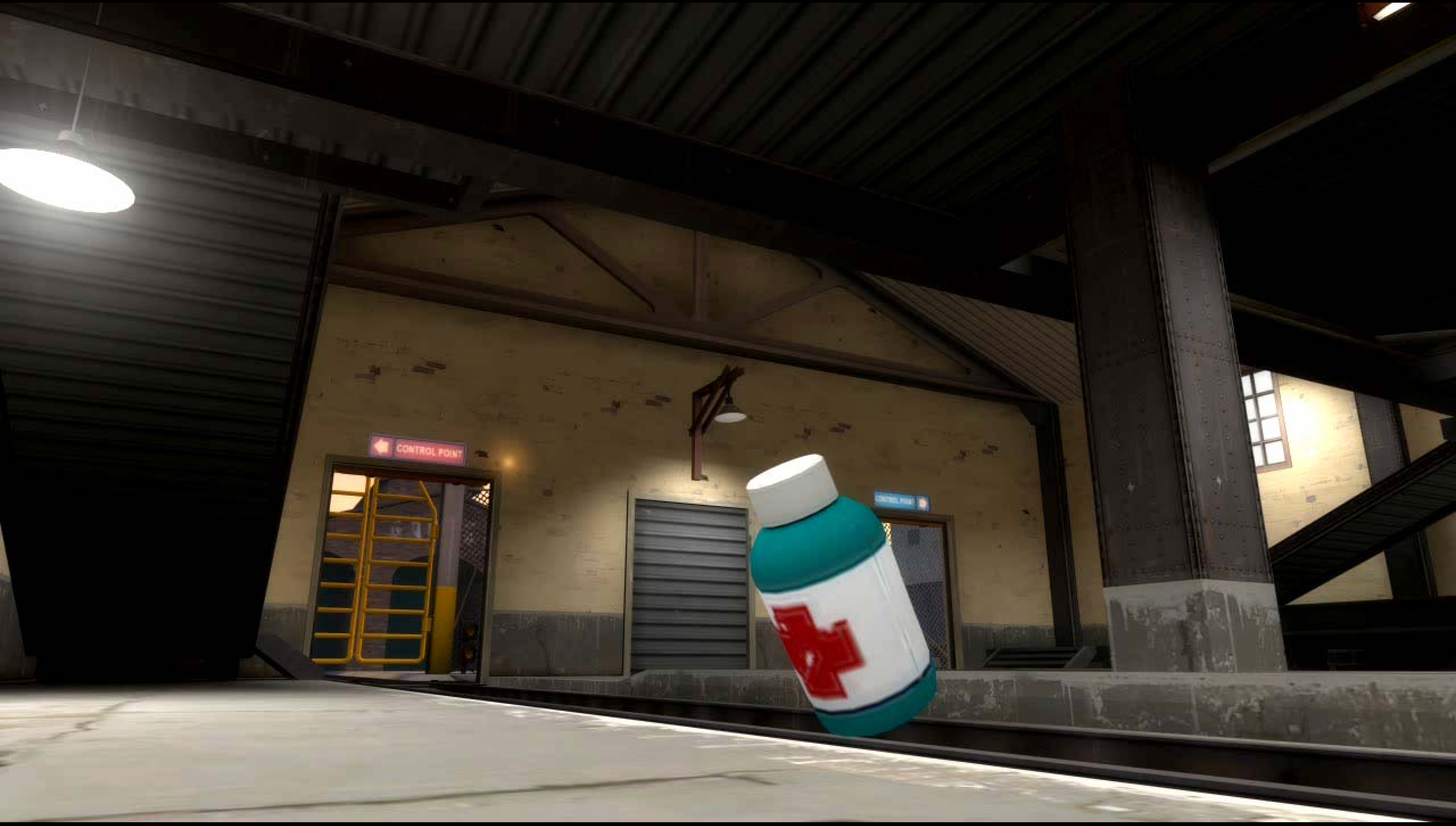


- Can easily imagine a 3D camera move between these 2D views of the same space

Background plates from *Spirited Away*

NEUTRAL ENTITIES

- Variations in **hue** and **saturation** are used to differentiate neutral entities in the game world
  - A **hue** other than red or blue creates disassociation from either team color
  - Increased **saturation** makes these important entities stand out in the desaturated environment
- Equally beneficial or dangerous to either team
  - Beneficial green / cyan health pickups
  - Dangerous yellow train yard gates

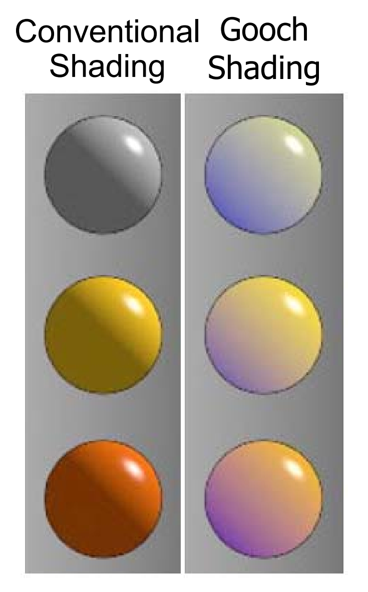

CONTROL POINT

CHARACTER DESIGN GOALS

- Easily visible against environment
- Characters must be readable quickly by other players
- Communicate shape via shading and silhouette under all lighting conditions

Gooch, 1998

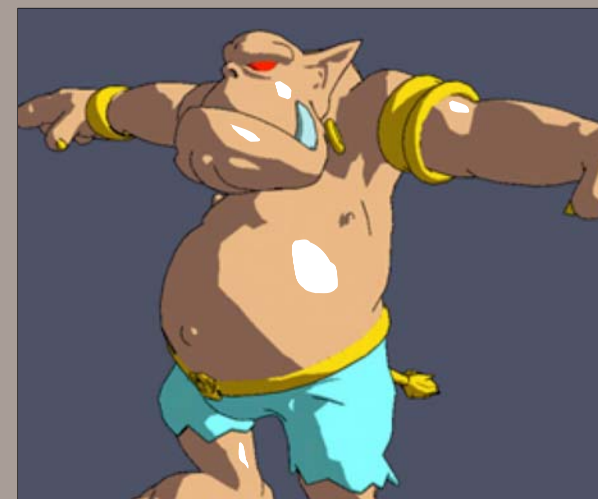
- Hue and luminance shifts indicate surface orientation relative to light
- Blend between warm and cool based upon unclamped Lambertian term, underlying albedo and some free parameters
- Extreme lights and darks are reserved for edge lines and highlights



$$\left(\frac{1}{2}\left(\hat{n}\cdot\hat{l}\right)+\frac{1}{2}\right)\left(k_{blue}+\alpha k_{d}\right)+\left(1-\left(\frac{1}{2}\left(\hat{n}\cdot\hat{l}\right)+\frac{1}{2}\right)\right)\left(k_{yellow}+\beta k_{d}\right)$$

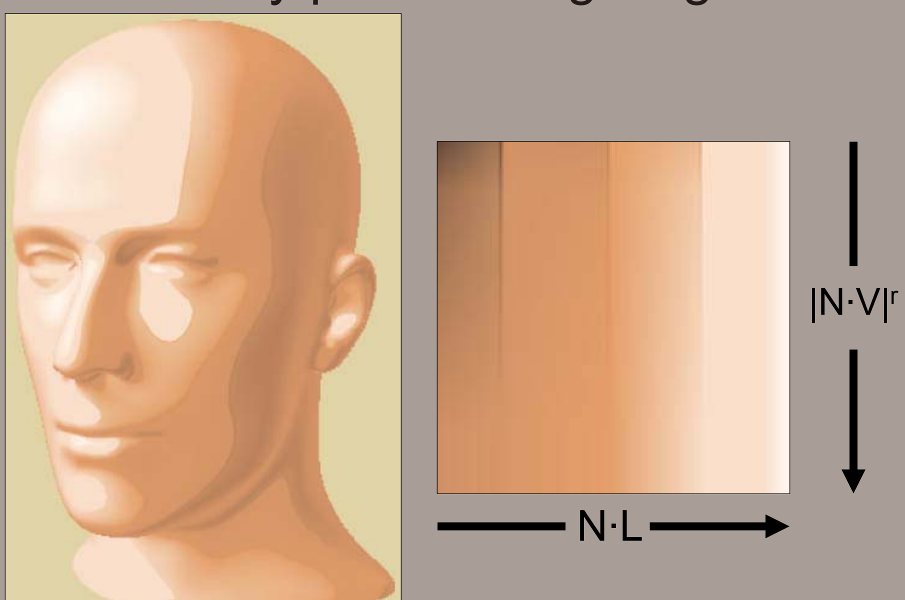
Lake, 2000

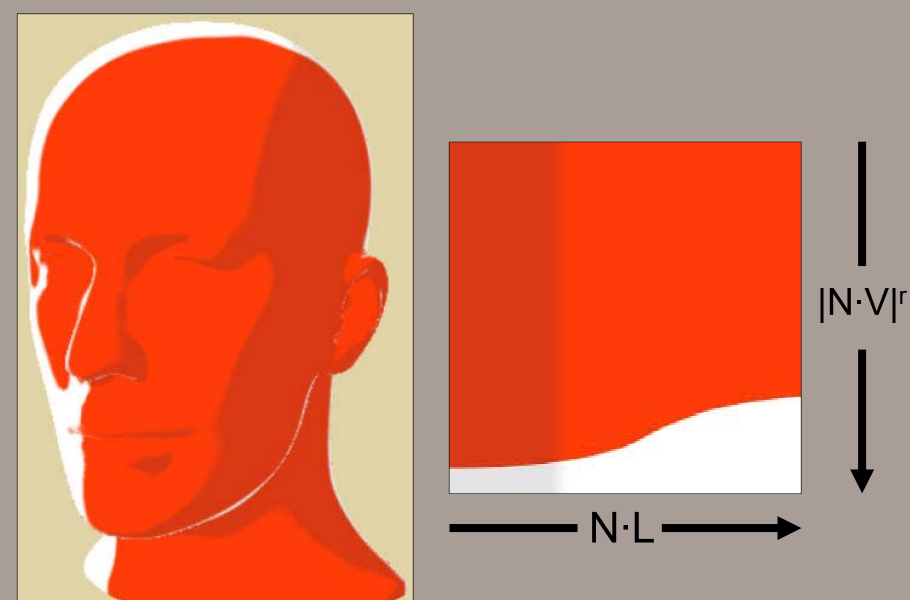
- Lake used a 1D texture lookup based upon the Lambertian term to simulate the limited color palette cartoonists use for painting cels
- Also allows for the inclusion of a view-independent pseudo specular highlight by including a small number of bright texels at the “lit” end of the 1D texture map



Barla, 2006

- Barla has extended this technique by using a 2D texture lookup to incorporate view-dependent and level-of-detail effects.
- Fresnel-like creates a hard "virtual backlight" which is essentially a rim-lighting term, though this term is not designed to correspond to any particular lighting environment.

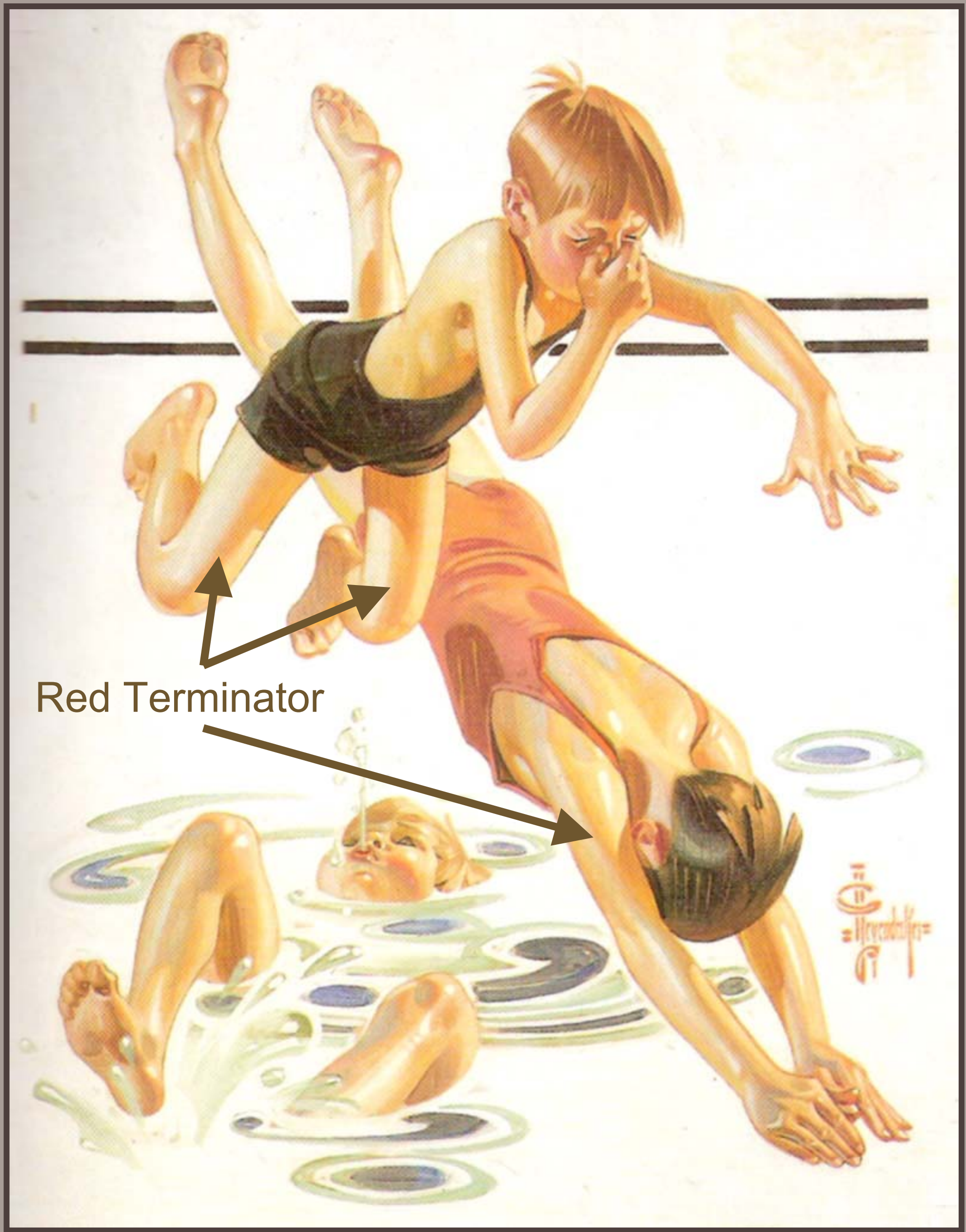




EARLY 20TH CENTURY COMMERCIAL ILLUSTRATION

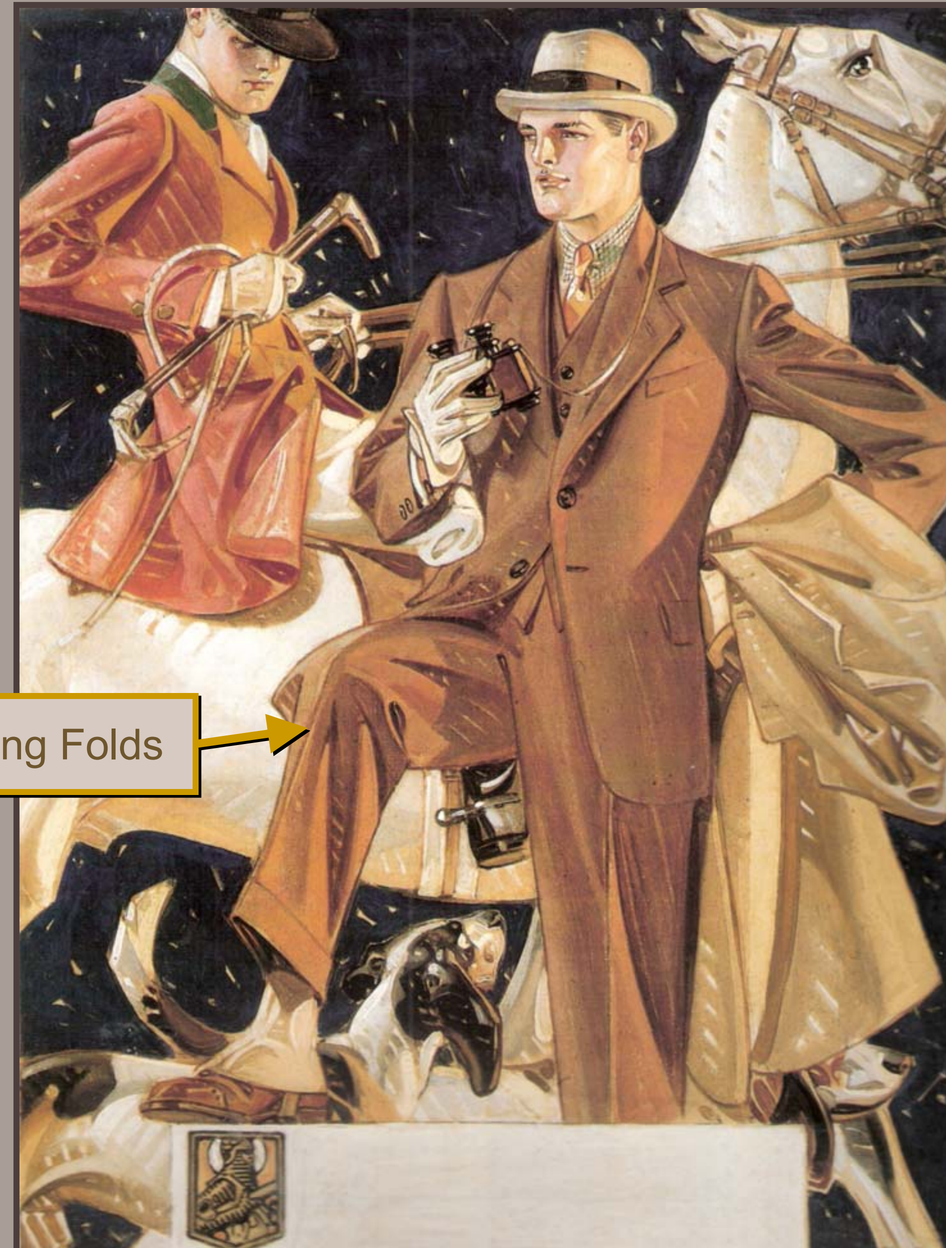
- Chose to adopt specific conventions of the commercial illustrator J. C. Leyendecker:
  - Shading obeys a warm-to-cool hue shift. Shadows go to cool, not black
  - Saturation increases at the terminator with respect to a given light source. The terminator is often reddened.
  - On characters, interior details such as clothing folds are chosen to echo silhouette shapes
  - Silhouettes are often emphasized with rim highlights rather than dark outlines

J.C. Leyendecker
Arrow collar advertisement, 1929



J.C. Leyendecker
Swimmin' Hole, 1935

J.C. Leyendecker
Thanksgiving 1628-1928



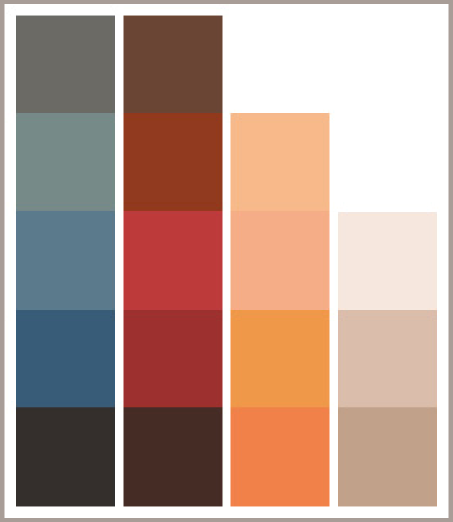
J.C. Leyendecker
Tally-Ho, 1930

ENGINEER CONCEPT

RIM HIGHLIGHTING: BEFORE

RIM HIGHLIGHTING: AFTER

- Players must be able to quickly identify other players by team, class and selected weapon at a variety of distances and viewpoints
- We think of this in terms of a visual “read hierarchy”
- Design Goals
  - Team – *Friend or Foe?*
    - Color
  - Class – *Run or Attack?*
    - Distinctive silhouettes
    - Body proportions
    - Weapons
    - Shoes, hats and clothing folds
  - Selected weapon – *What’s he packin’?*
    - Highest contrast at chest level, where weapon is held
    - Gradient from dark feet to light chest



Color Palette

CHARACTER LIGHTING EQUATION

VIEW INDEPENDENT

$$k_d\left[a(\hat{n})+\sum_{i=1}^{L}c_i w\left(\left(\alpha\left(\hat{n}\cdot\hat{l}_i\right)+\beta\right)^{\gamma}\right)\right]+$$

$$\sum_{i=1}^{L}\left[c_i k_s max\left(f_s\left(\hat{v}\cdot\hat{r}_i\right)^{k_{spec}}, f_r k_r\left(\hat{v}\cdot\hat{r}_i\right)^{k_{rim}}\right)\right]+\left(\hat{n}\cdot\hat{u}\right)f_r k_r a(\hat{v})$$

VIEW-DEPENDENT

View Independent Terms

$$k_d\left[a(\hat{n})+\sum_{i=1}^{L}c_i w\left(\left(\alpha\left(\hat{n}\cdot\hat{l}_i\right)+\beta\right)^{\gamma}\right)\right]$$

- Spatially-varying directional ambient

VIEW INDEPENDENT TERMS

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- Spatially-varying directional ambient
- Modified Lambertian terms
  - Unclamped Lambertian term
  - Scale, bias and exponent

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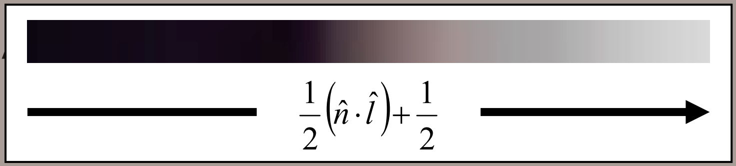
- Spatially-varying directional ambient
- Modified Lambertian terms
  - Unclamped Lambertian term
  - Scale, bias and exponent
  - Warping function



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AMBIENT CUBE

- Grounds characters in game worlds
- Pre-compute irradiance samples throughout the environment
- Variable density *irradiance volume* [Greger98] where each sample defines an irradiance environment map [Ramamoorthi01]
- Directional ambient term which includes only indirect light
- Lights beyond the first four can be added to the ambient cube
- Used in a novel way in rim lighting, which we'll discuss in a moment

VIEW-DEPENDENT TERMS

$$\sum_{i=1}^{L}\left[c_i k_s max\left(f_s\left(\hat{v}\cdot\hat{r}_i\right)^{k_{spec}}, f_r k_r\left(\hat{v}\cdot\hat{r}_i\right)^{k_{rim}}\right)\right]+\left(\hat{n}\cdot\hat{u}\right)f_r k_r a\left(\hat{v}\right)$$

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- Multiple Phong terms per light

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- Multiple Phong terms per light
  - k_{rim} broad, constant exponent

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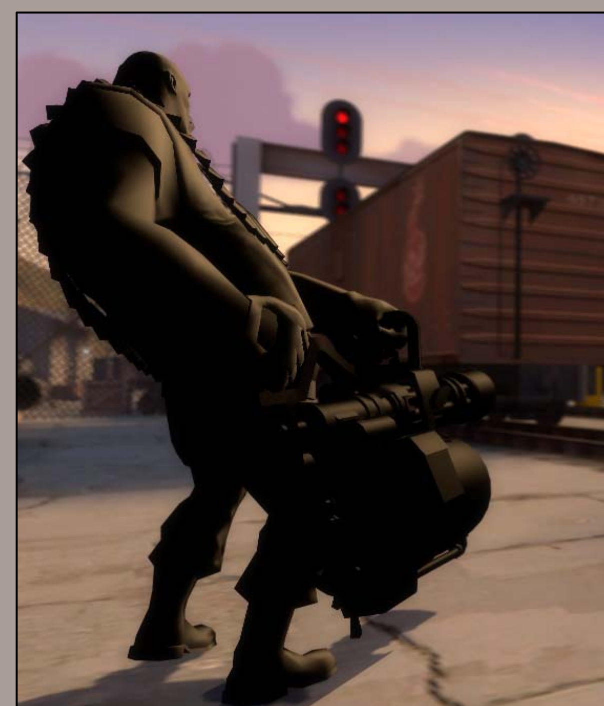

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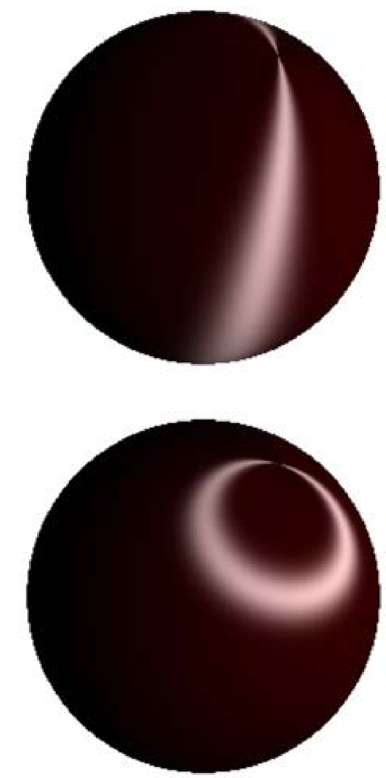
FUTURE WORK

- More flexible specular
  - Anisotropic highlights [Heidrich98] [Gooch98]



[Heidrich98]

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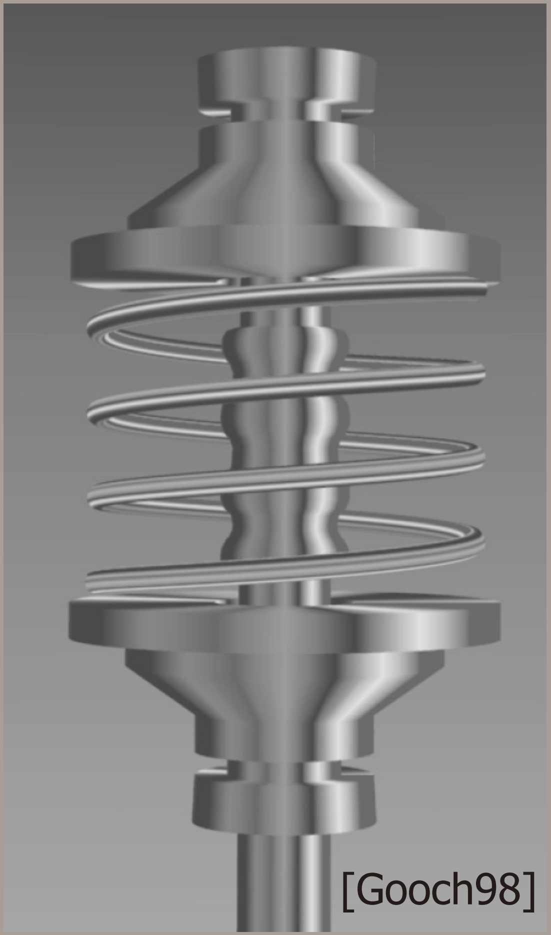

[Gooch98]

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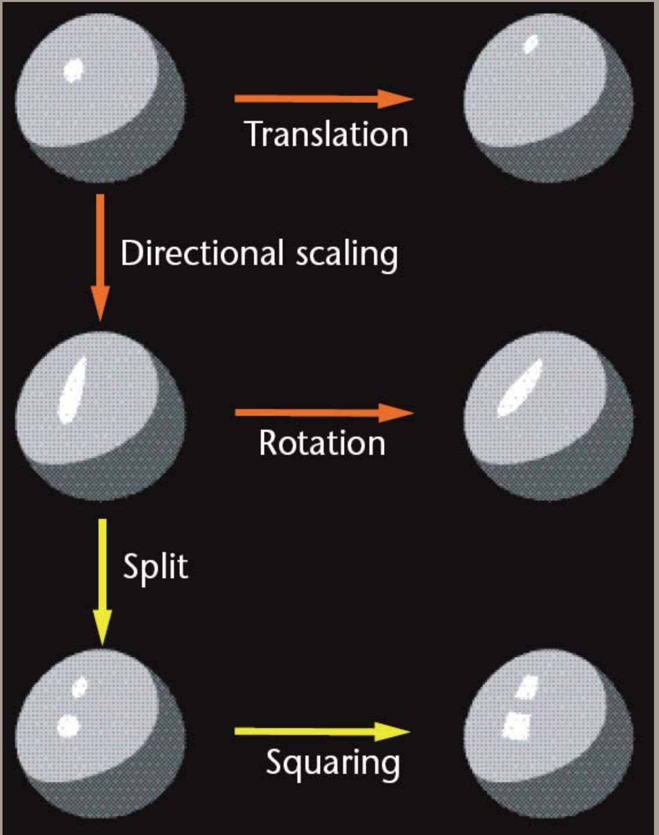

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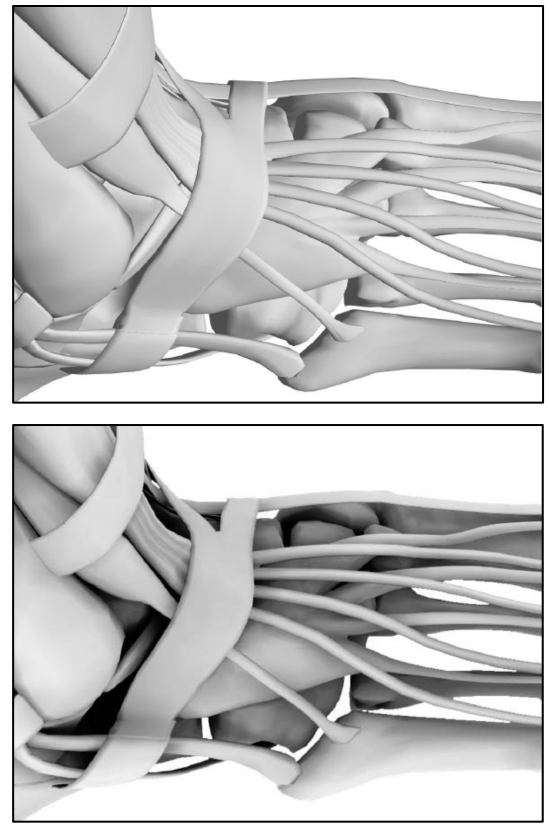

[Luft06]

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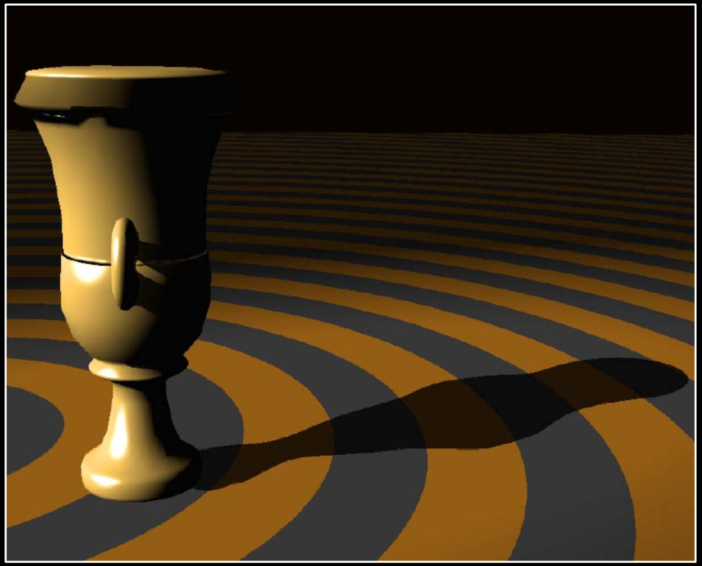
- Image-space contrast enhancement [Luft06]
- Abstracted shadows [DeCoro07]



[DeCoro07]

CONCLUSION

- Motivations and related work
- Environments
- Characters and interactive shading
- Future work