Volumetric Skin and Fabric Shading at Framestore

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Existing Skin Shading

- BSSRDF (Normalised diffusion model)
- Single scattering
- Complex layering/blending
- Artist led, ad-hoc approach
Motivation

- Guardians of the Galaxy Vol. 2
- Alien: Covenant
- More general and elegant approach
- Internal structure
- Layers of translucent materials
Abilisk

- Large translucent creature
- Outer skin varying from thick and dense to thin membrane
- Internal structure important for story
- Ridges and wrinkles
Chest Burster

- Multiple layers of translucent material
- Subtle scattering effects to portray scale
- Internal structure of skeleton, veins, arteries and sinew
- Outer layer of mucus and blood
- Need to solve light transport together for realistic appearance
Outline

- Some Theory of Monte-Carlo Subsurface Scattering
- Practice
- Artist Workflow and Parameters
- Results and Problems
- Extending to Fabric Shading
Path-Traced Subsurface Scattering

- Subsurface transport
Path-Traced Subsurface Scattering

- BSSRDF importance sampling (King et al.)
Path-Traced Subsurface Scattering

- Non-trivial geometry
Path-Traced Subsurface Scattering

- Internal objects
Some Theory

- Monte-Carlo subsurface
- Simple, robust and unbiased
A Bit More Theory

- Importance
- Sample extinction
A Bit More Theory

- Importance
  sample extinction

- Ray-Marching
A Bit More Theory

- Importance sample extinction
- Ray-Marching
- Delta Tracking (or Woodcock)
A Bit More Theory

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- Ratio/Residual Tracking
A Bit More Theory

- Importance sample extinction
- Ray-Marching
- Delta Tracking (or Woodcock)
- Ratio/Residual Tracking
- Phase Functions (Henyey-Greenstein)
Practice

- Subsurface transport
Practice

- Sample microfacet to choose between specular or transmission
Practice

- Sample distance with delta tracking
Practice

• Sample direction with phase function
Practice

- Continue path until an intersection is found
- Do next event estimation
Artist Workflow

- Different shader types
- Albedo / attenuation
- Density
- Phase function
- Heterogeneous properties
- Next event estimation
Shader Types

- Absorption
- Homogeneous scattering
- Heterogeneous scattering
- Voxel
Albedo

- Defines the colour of the medium
- Convert from multiple scattering to single scattering (Chiang et al)
Attenuation

- Tinting effect over depth
Density

- Optical thickness of medium
Phase Function

- Direction of scattering
- Isotropic / anisotropic
Heterogeneous Properties

- How to texture a volume?
- Balance -
  - Visual quality
  - Render cost
  - Ease of authoring
Heterogeneous Properties

- Project texture into medium
Heterogeneous Properties

- Parallax projection
Heterogeneous Properties

- Procedural noise
Next Event Estimation

Exit

Interior

MNEE
Next Event Estimation

Exit  Interior  MNEE
Production Results
Considerations/Problems

- What needed to change?
- Artistic considerations
- Modelling/texturing
- Render times
Procedural Fabric Modelling

- Fabric is essentially volumetric
- Use as a heterogeneous input to existing system
- Lots of research on generating procedural yarns
- Generated at render time
Scattering Within Fabric

- Procedural fabric modelling
- Scattering model based on hair shading
Weave Examples

- Standard set of weave patterns
- Use textures / noise for variation
Where Next

- Bounding the extinction coefficient
  - Volume integration that does not require strict bounds
  - Useful for procedural textured media
- Microflakes
  - Shade volumes as surfaces
  - Procedural generated geometry
Thank you

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http://blog.selfshadow.com/publications/s2017-shading-course/