Visually Directing User's Attention in Interactive 3D Environments

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Lighting is important for visual scenes

- Lighting colors
  (Contrast, warmth, ...)
- Lights placements
- Lighting angles

⇓ Affect

- Visual attention
- Visual tension
- Character relationship
- Depth

Problem: unpredictability

In interactive entertainment, parameters for lighting design:

- Camera orientation and position
- Characters positions and orientations
- Dramatic Intensity
- Significance of Characters/objects

} Unpredictably change depending on interaction

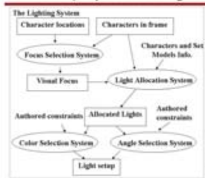
⇒ Need continuous *modulation* to accommodate changes and satisfy visual design goals, including directing viewer's attention to important areas

Lighting design involves balancing many aesthetic and design goals

ELE (Expressive Lighting Engine)

- An automatic lighting system that sets and adjusts lighting in real-time to satisfy several visual design goals including ***directing visual focus*** while maintaining visual continuity and style.
- Uses cinematic conventions mathematically represented as cost functions
- Uses optimization to balance visual design goals

ELE (Expressive Lighting Engine)



A light setup is: Position, color, orientation, type, attenuation, range, Umbra, Penumbra for each light in the scene

ELE (Expressive Lighting Engine)

Light Allocation System

- Identifies a focus area, a background area, a foreground area
  The difference between focus and non-focus areas is key to directing viewer's attention towards the focus area. The color system accounts for that using contrast.
- A character or object *c* is the dramatic focus, if:
  - The camera is in a close-up, medium close-up, medium, or full shot on *c*
  - The only character in view is *c*
  - Character *c* has the most dramatic action

Light Allocation System

ELE uses a greedy algorithm to merge areas for characters that are sufficiently near one another, as follows:

- Step 1. For each character *c* create a new area and assign *c* to it
- Step 2. Repeat
  For each area *a*
  if ∃ *a'* s.t. , and both are focus areas (or non-focus) then merge *a*, *a'*

Color Selection System

- Color (Hue + saturation + intensity)
- Compose colors for different areas:
  - *Focus*
  - *Non-Focus (includes foreground)*
  - *Background*

The differentiation between these area types is important to select colors that bring out the visual focus, and thus direct user to important areas in a 3-D scene.

Color Selection System

Goals accommodate desired:

- Depth
- Intensity
- Visual focus
- Specific designer-suggested
  - Hue, Saturation, Lightness, Warmth
  - Palette restrictions

+ maintain ***visual continuity***

Color Selection System

Optimize:

$$cost(c^t, c^{t-1}) = \lambda_d \left(D(c^t) - d\right)^2 + \quad \textbf{depth}$$

$$\lambda_c \left(\text{contrast}_\phi(c^t) - \delta\right)^2 + \quad \textbf{contrast}$$

$$p(c^t) + \quad \textbf{Palette constraints}$$

$$\sum_{i \in \{f,n,b\}} \lambda_{vc} E(c_i^t, c_i^{t-1}) + \quad \textbf{Visual continuity}$$

$$\sum_{i \in \{f,n,b\}} I(c_i^t), \quad \textbf{Artist's desired color parameters}$$

Color Selection System

$$\text{contrast}_\phi(c) = \sum_{i \ne focus} w_i \left|\phi(c_{focus}) - \phi(c_i)\right|$$

where ϕ is the color component (lightness, warmth, or saturation) over which we're computing contrast, c is a vector of the light colors, c_i is a color for an area type i, where

$$i \in \{focus, non-focus, background\}$$

and *focus* is the index of the dramatic focus area.

Using ELE to selectively direct user's attention

ELE was integrated with Wildtangent (a publicly available web-based game engine) and tested in an interactive story called *Mirage*. This figure shows a screenshot from *Mirage*. In particular, it shows the use of ELE to focus on the characters: the user and Electra.

ELE was integrated in *Unreal Tournament 2003*. These three screenshots show the use of ELE in directing viewer's attention to characters in a first person shooter.

This figure shows the use of ELE in an interactive story called *Mirage*. This screenshot shows the use of lighting to focus on the characters Electra as she unsheathes the sword.

Conclusion & Summary of Contributions

The paper introduces a new automatic lighting system that adapts the lighting in real-time within an interactive scene to direct participants' attention to desired focus while satisfying other visual design goals, including providing necessary visibility, establishing depth, while maintaining visual continuity.