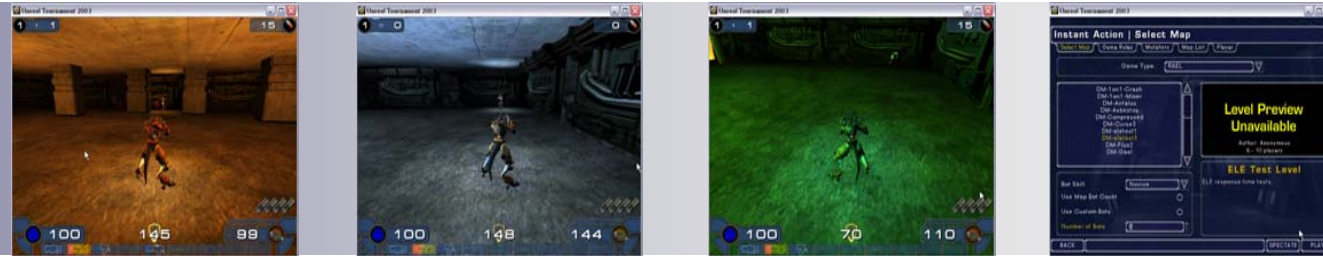


# Light AI

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## Visual composition in games

- Visual composition is a term used to denote:
  - camera placement and movement
  - Character blocking (placement and movements)
  - Light placement, colors, and angles
- Visual composition is important for its aesthetic functions, including:
  - Directing players to important objects
  - Establishing depth of field
  - Establishing emotions, pace, urgency
  - arousing curiosity, suspense



## Problem: unpredictability

- Design parameters for visual composition:
- Camera orientation and position
  - Characters positions and orientations
  - Dramatic intensity
  - Significance of Characters/objects
- Unpredictably change depending on interaction**
- ⇒ **Need continuous redesign or modulation to accommodate all changes**

## Lighting design is an intricate process

- Lighting colors (contrast, warmth, ...)
  - Lights placements
  - Lighting angles
- ↓ Affect
- Visual attention
  - Visual tension
  - Character relationship
  - Depth

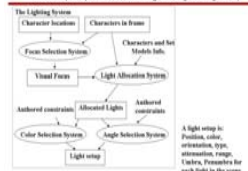
## Lighting design involves balancing many aesthetic and design goals



## ELE (Expressive Lighting Engine)

- An automatic lighting system that sets and adjusts lighting in real-time to satisfy visual design goals 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)



## Results From Interfacing ELE with Unreal Tournament

### Results from interfacing with Unreal

Figure A shows several attributes that we added in the level editing tool *UnrealEd* to allow designers to specify high-level lighting design properties

Designers can:

- manipulate general overall lighting style
- add practical (sources of light in scene)
- Set tension value of the scene
- Set focus point

These parameters can also be manipulated dynamically through the scripting language

### Results from interfacing with Unreal

Figure B shows screenshots from a scene where ELE was configured using the *ELE-Unreal API* to increase tension incrementally every few milliseconds

As shown ELE retains style and general color scheme while increasing tension

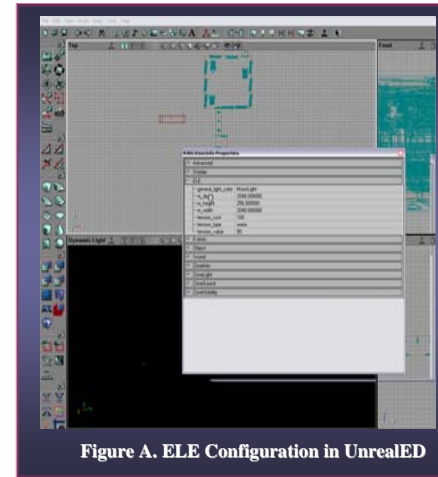


Figure A. ELE Configuration in UnrealED



Figure B. ELE in Unreal Tournament – Increasing Tension

## ELE (Expressive Lighting Engine)

### Light Allocation System – Determines number of lights allocated to each area in the scene

- Calculate visible area
- Divide the visible area into several, differentiating among focus, non-focus, character, foreground, and background areas.
- Allocate lights dynamically according to lighting design goals and their importance minimizing cost for the following formula:

$$p_{opt} = \arg \max_p \left[ \lambda_v V(p) + \lambda_d D(p) + \lambda_m M(p) + \lambda_{vc} VC(p) \right]$$

visibility
depth
modeling
visual continuity

Where  $V(p)$  is the percentage of objects/characters that are visible in the scene,  $D(p)$  is depth, which is calculated as is the difference between the number of lights assigned to the background and foreground areas,  $M(p)$  is modeling which is defined as the average number of lights assigned to character areas, and  $VC(p)$  is visual continuity which is calculated as the difference between the configuration being evaluated and the one used in the previous frame.

### Angle Selection System – Determines angles for each lights in the scene

The angle system uses hill climbing to find best angles minimizing the following cost function:

$$\text{cost}(k, s, k^-, m) = \lambda_v (1 - V(k, s)) + \lambda_c |k - k^-| + \lambda_m |k - m| + \lambda_i \min |k - l_i|$$

visibility & modeling
visual continuity
mood
motivation

Where  $k$  is the key light angle,  $k^-$  is angle previous frame,  $m$  is the mood angle desired,  $V$  is visibility,  $\lambda_v$  is the cost of deviation from best visibility angle,  $\lambda_c$  is the cost of visual continuity,  $\lambda_i$  is the cost of deviation from

### Angle Selection System (cont'd)

realistic direction,  $\lambda_m$  is the cost of deviation from ideal mood angle,  $V$  is visibility and modeling, which is defined based on cinematic theory as:

$$V(k) = \sin(|k - c|) \cos(k - s)$$

Light angle
Camera orientation
Subject facing direction

### Color Selection System – Determines colors for each light

The color system uses constraint-based optimization to select best colors in RGB color space for lights in each area type: focus, background, and foreground areas accommodating the design goals: establishing depth, paralleling plot's dramatic intensity, providing visual focus, and abiding by designer-suggested color constraints, while maintaining visual continuity

Gradient descent is used optimizing the following cost function:

$$\text{cost}(c^t, c^{t-1}) = \lambda_d (D(c^t) - d)^2 + \lambda_c (\text{contrast}_\phi(c^t) - \delta)^2 + p(c^t) + \sum_{i \in \{f, m, b\}} \lambda_{vc} E(c_i^t, c_i^{t-1}) + \sum_{i \in \{f, m, b\}} I(c_i^t)$$

depth
contrast
Palette constraints
Visual continuity
Artist's desired color parameters

## Conclusion & Summary of Contributions

### Contributions of ELE can be summarized as follows:

An automatic lighting design system for interactive entertainment that :

- in real-time modulates tension, sets pace, and evoke emotions.
- in real-time directs players' attention to important areas in an interactive scene
- expedites the design process and allows designers to override and control lighting decisions at a high-level

### Limitations of the approach:

- ELE introduces a new lighting design model which will need to be accepted and learned by designers
- ELE relies on dynamic lights, thus is more costly than current techniques. However, ELE was integrated in Unreal tournament with no noticeable delay in rendering speed.