Mother of All Renderers
Radiance in Real-Time?

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MOAR features

- High Fidelity Graphics
  - Physically based global illumination
    - Participating media
  - Fully dynamic scenes
  - Interactive environments

- Parallel Processing
  - Within a node
  - Between nodes

- Visual Perception
  - Selective, time constrained rendering
  - Component based approach

- Partners: Manchester, Bradford, Bournemouth, Zaragoza, Minho, BrightSide, Greg ...
Participating media: Dust
The need for realism

- Computer Graphics allow virtual environments to be “constructed” on a computer in a straightforward manner.
- Computer reconstructions can be easily misleading.
- Realism is *essential* if we are to use these virtual environments as a representation of reality.
The need for real-time

- Computer Graphics has opened up a wide range of simulation and entertainment opportunities
- Real-time requires a minimum of 15 fps
- Real time is necessary for multi-sensory environments
- Real-time is essential if we are to gain the maximum benefit computer graphics has to offer
Realism

Believable Realism!
Scruffy textures
Quantifying reality
Perceptual Match

Correlation to Real

<table>
<thead>
<tr>
<th>Image</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td>0.35</td>
</tr>
<tr>
<td>Rytraced</td>
<td>0.5</td>
</tr>
<tr>
<td>Estimated Materials</td>
<td>0.7</td>
</tr>
<tr>
<td>Radiosity</td>
<td>0.84</td>
</tr>
<tr>
<td>2ab</td>
<td>0.85</td>
</tr>
<tr>
<td>Estimated Light</td>
<td>0.86</td>
</tr>
<tr>
<td>8ab</td>
<td>0.89</td>
</tr>
<tr>
<td>8ab 2</td>
<td>0.89</td>
</tr>
<tr>
<td>Tone Mapped</td>
<td>0.9</td>
</tr>
<tr>
<td>Photograph</td>
<td>0.91</td>
</tr>
</tbody>
</table>
Parallel Rendering

“Parallel processing is like a dog’s walking on its hind legs. It is not done well, but you are surprised to find it done at all”
Steve Fiddes (apologies to Samuel Johnson)

- Co-operation
- Dependencies
- Scalability
- Control
Solution times
Human Visual System

• *Good but not perfect!*

Flaws in the human visual system:

• Change Blindness
• Inattentional Blindness

Avoid wasting computational time
Animations
High Quality vs Low Quality
Inattentional Blindness Results
Kirsten Cater

Percentage of People who did notice the rendering quality difference

Animation Conditions

- HQ+HQ
- HQ+LQ
- LQ+HQ
- HQ+CQ
- CQ+HQ

Watching Animation
Counting Pencils
Visual Attention

- Bottom-up
  - Stimulus driven
    - movement in bush, red apple in green tree etc
  - *Saliency maps*

- Top-down
  - Directed by voluntary control
    - looking for street signs, targets in computer game
  - *Task maps*
1. Free viewing, 2. Judge their ages, 3. Guess what they had been doing before the unexpected visitor’s arrival, 4. Remember the clothes worn by the people, 5. Remember the position of the people and objects in the room & 6. Estimate how long the unexpected visitor had been away from the family [Yarbus 1967].
Importance Maps

Veronica Sundstedt

- **Selective guidance**
  Uses a combination of saliency and a measure of task relevance to direct the rendering computation

- **Selective rendering**
  Corresponds to the traditional rendering computation
  Computational resources are focused on parts of the image which are deemed more important by the selective guidance
Perceptual Rendering Framework

- Scene Input
  - Geometry
  - Lighting
  - View
- Saliency Map
- Task Map
- Knowledge Input
- Task
- Pixel Quality Prioritization
- Selective Render
- Pixel Recompute Priority
- Visual Difference Predictor
- Temporal Coherence
- Display Frame
- Next Frame

- Frame-rate Input
  - Frames per second
- Knowledge Update
  - New task

- Scene Update
  - View Motion

- Next Frame

- New task

- Visual Difference Predictor
Platform Independent Parallelism

- Commercial Modellers
- Plug-in
- Importance Maps
- Pixel Priority List
- Selective Rendering
- System level parallelism
- P-Code level API
- Hardware Resource Allocation
- Node level parallelism

Maya, 3ds Max
Visual attention
Selective Rendering

Kurt Debattista

- 10 sec budget
  - traditional versus visual attention
Flexible computation

- Good approximation in minimum time
Multi-Modal Perception
Julie Mastoropoulou

- Not possible to achieve very realistic graphics in real-time. Interactive environments require a minimum frame-rate e.g. 15fps

- If we can affect the user’s perception of frame rate, then we can render/display less frames per sec without any perceptual difference to the user.

- This would also have major implications to the video compression standards, regarding the control of quality/bit-rate across the audiovisual frames.
Experiment

- **Design**
  - independent samples utilized

- **Participants**
  - 40 students in 4 groups

- **Dependent Variable**
  - perceived motion smootheness (i.e. frame rate)

- **Independent Variable**
  - sound effect/silence
Results Silence/Sound Effect

Performance across the Auditory Background conditions

Paired frame rates (in frames per sec)

- No
- Sound
- Sound Effects
Results for Unfamiliar Subjects

![Bar chart showing performance of unfamiliar subjects across conditions with paired frame rates (in frames per sec). The chart compares performance with and without sound effects.]
Results for Familiar Subjects

![Bar chart showing performance of familiar subjects across different conditions with and without sound effects.](chart.png)
Graphics and Motion

Gavin Ellis

- Exploiting cross-modal interference between the human's visual and vestibular system
### Selective Rendering with Motion

<table>
<thead>
<tr>
<th>Animation</th>
<th>% HQ</th>
<th>Time (min)</th>
<th>Per Frame Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>HQ</td>
<td>100%</td>
<td>775</td>
<td>0%</td>
</tr>
<tr>
<td>SQ</td>
<td>65%</td>
<td>615</td>
<td>20%</td>
</tr>
<tr>
<td>CSQ</td>
<td>60%</td>
<td>600</td>
<td>20%</td>
</tr>
</tbody>
</table>

The table shows the comparison of different rendering qualities in terms of their effect on animation time and per-frame saving. HQ rendering is the highest quality option, taking 775 minutes with no per-frame saving. SQ and CSQ are lower quality options, with SQ offering a 20% per-frame saving at 615 minutes and CSQ offering a similar saving at 600 minutes.
MOAR Applications

- High-Fidelity Applications
  - Simulations
    - Driving, flight
  - Archaeology
  - Architecture
  - Games
SharpEye

- Renderer
  - Ray tracing based
  - Spectral
  - Photon mapping
  - HDR – glint and glare

- Efficient dynamic scenes
  - Spatial and temporal coherence

- Cost Prediction
  - Quotes to clients
  - Time constrained

- Multi-Sensory Rendering
  - Audio
  - Motion
Cost Prediction

- Profiling rays used to determine simple and complex pixels
- Used to approximate total computational effort
Realism in Real-Time

Importance Map → Task scheduling

SharpEye → Data management

Perceived Realism in Real-Time

Visual perception → Model reduction → Quality level
Summary

*It’s all about Perceived Realism!*

- High fidelity computer graphics in real time  
  ➔ innovation
- Possibilities for multi-sensor, multi-user experiences  
  ➔ Mother of All Renderers

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