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Interactive Relighting for Stage Use

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Abstract

Re-lighting by combining images taken under known lighting conditions to synthesise new lighting configurations is a simple, but powerful technique capable of producing impressive results. However it has found little practical application. Here we demonstrate the integration of a relighting tool into a typical theatrical lighting system, to provide real time previews both offline when the stage is unavailable, and during performance.

Categories and Subject Descriptors (according to ACM CCS): I.3.8 [Computer Graphics]: Applications

1. Background

Modern theatrical lighting systems can contain hundreds of lights. To program and control these a modern lighting desk is essentially a specialised computer, capable of storing and recalling setting for each light. These settings are transmitted to the lights using a digital serial protocol known as DMX [ANS04]. A typical lighting system is shown in figure 1.

Programming a lighting show is incredibly challenging, as it requires being able to translate a desired visual effect into potentially thousands of control channels on the lighting desk. This difficult task is made more challenging, as the lighting rig itself, and a suitable venue in which to install it may not be available for sufficient time in advance of the performance. A large venue may cost several thousand pounds per hour to hire, so the lighting designer may have to develop most of the show without access to the stage. At smaller venues the facilities are typically in constant use, again making developing a light show difficult.

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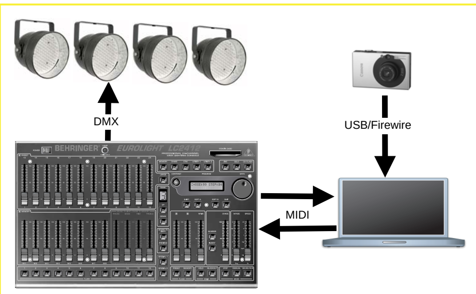

Figure 1: *A Lighting System*

To make designing a show easier high end lighting systems may include a PC which can provide 3D rendered visualisation of the on-stage lighting using commercial software such as “Capture”, “SunLite” or “ESP Vision”. However all of these require the user to model the stage and lighting rig, and the visual quality of these previews is poor. Figure 2 shows a typical image generated by programs of this type. Stage lighting may be highly dependent on participating media, caustics, color bleeding, UV and other effects which are challenging to render and cannot be generated in real time.

Digital relighting of a scene is achieved by recording images of the scene under varying lighting conditions, and then recombining these to simulate the scene under new lighting configurations which may have never existed previously. This is most commonly done using captured images, but ironically the principle of combining images to produce new lighting configurations was proposed in [DAG95] to preview theatrical lighting. They combine computer generated images rendered using radiosity techniques (which would have been too slow to practically render on a per frame basis) to produce an animated sequence. However using captured images of a real scene is quicker and easier.

Relighting Techniques range in complexity [DWT*02,

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Figure 2: *A typical CG Preview*

Figure 3: *The Captured Ambient Light*

Figure 4: *The Captured "Basis" Images*

Deb06,PTMD07], but impressive results can be achieved using the simplest methods. As the technique is image based it does not require any modelling to be performed, but does require brief access to the lit stage to capture the basis images. It is capable of handling all forms of light transport, including those not supported by even the most advanced rendering systems.

The main obstacle to its application is the requirement for full control of the lighting environment to create the initial images. This is not a problem for stage lighting where all lighting is under the control of the lighting desk. Relighting techniques would therefore be ideally suited to the simulation of stage. While it would still be necessary to have access to a venue to capture the required images, once captured the lighting designer could refine the lighting cues for a show without further access to the stage area.

2. Implementation

Most modern lighting desks support a MIDI interface [MID01]. This is shown in figure 1 where the desk is connected to a laptop which can monitor, and control the fader settings. The desk used for our prototype implementation allowed control of 12 lights. In addition a webcam was connected to the laptop, allowing the computer to capture images of the stage.

2.1. Initialisation

An image of the stage area is first captured, under normal ilumination, as shown in figure 3. The light in this image will be present in all subsequent images, so this will allow us to calculate the *extra* light introduced by each stage light.

To capture the required images for relighting each stage light in turn is illuminated to full brightness. and an image of the scene is captured using the webcam. The ambient illumination image is subtracted from each of the captured images. This set of images, as shown in figure 4, form a basis for the possible lighting space that can be produced by this lighting rig.

As both the lighting desk and the camera are under computer control this initialisation process is fully automated, and takes only a few seconds. In addtion, as the ambient light is subtracted there is no need for the stage to be blacked out prior to capturing the images.

Once this phase is complete, the stage and lighting rig are no longer required by the system. The stage may be used for other tasks, and the captured images can be saved for future use, at a more convenient location.

2.2. Simulation

Once a set of stage lights has been captured, the laptop monitors the desk via MIDI. As faders are adjusted, the cap-

Figure 5: *Synthesized Stage Lighting*

tured images are simply scaled and summed to produce an onscreen preview of the stage lighting. This summation is hardware accelerated using Apple's Core Image framework [App07]. Though the initial image calculation requires n image operations (where n is the number of lighting channels), by summing the images in a binary tree, the image can be updated with only $log(n)$ composites, provided the graphics card has memory to cache $2n$ intermediate images.

It would also be possible to calculate lighting updates by adding or subtracting changes to a single light to the previously calculated image, but any numerical instabilities would rapidly generate errors in a system which is updating at interactive frame rates.

The lighting desk used has two banks of faders, each controlling the same set of lights. While one bank is active, the other can be adjusted to create a new lighting configuration. The user can then cross fade between the two banks. The re-lighting based preview system displays an image for each lighting bank, allowing the effect of each bank to be seen on screen, prior to showing them on stage.

Interactive performance displaying 2 lighting configurations each of 12 lights with a resolution of 640*x*480 is easily achieved on a mid-range laptop, and the system will scale well to greater numbers of channels due to the $log(n)$ complexity of the update operation.

3. Results

Part of the lighting rig for a student theatre production was captured, and the basis images are shown in figure 4. Capturing these images took approximately 12 seconds, as the tungsten lights used in this stage lighting rig were particularly slow to respond, and were allowed time to settle between each image capture (the system includes a user configurable delay between each capture, allowing it to be configured for faster capture when using lights such as LED lights which respond much more immediately).

Figure 5 shows a number of synthesised images using the captured lighting rig. The first simulated image adds the image for one of the stage lights to the house lights to produce an image similar to what was seen during capture. Subsequent images use only the stage lights, to show what the scene will look like with the house lights dimmed. The third image shows that the system handles complex lighting which would be hard or even impossible to render accurately — in this case the complex caustics of a mirror ball.

4. Future Work

The current system is limited by the the lighting desk which supports only 12 channels, and exports only fader positions, with no access to stored scenes or chases. Ongoing work to fully integrate relighting tools full into a more powerful software based lighting desk will make it possible to preview more advanced lighting control features.

The simple relighting approach used for this prototype system is limited to basic dimmable lights. More complex "intelligent" lighting fixtures use the postition of faders to control not just their brightness, but their colour, gobos (projected patterns), orientation, and even position. This makes relighting more complex as the lighting channels are no longer linearly additive. However more advanced relighting techniques have been demonstrated that can support all of these features, including devices as complex as video projectors, at the cost of increased capture time, and computational complexity.

5. Conclusions

We have developed a prototype system which demonstrates the practical application of relighting to simulate theatrical stage lighting. Though currently limited in its scope, the system shows that this is an ideal evironment to apply relighting techniques. The images produced by such techniques are of a quality far in excess of those generated by current preview software, at a fraction of the computational cost, without requiring the scene to be modelled.

References

[ANS04] ANSI: *E1.11 - USITT DMX512-A Asynchronous Serial Digital Data Transmission Standard for Controlling Lighting Equipment and Accessories*. 2004.

[App07] APPLE INC: *Core Image Programming Guide*. 2007.

[DAG95] DORSEY J., ARVO J., GREENBERG D.: Interactive design of complex time-dependent lighting. *IEEE Comput. Graph. Appl. 15*, 2 (1995), 26–36.

[Deb06] DEBEVEC P.: Virtual cinematography: Relighting through computation. *Computer 39*, 8 (2006), 57–65.

[DWT*02] DEBEVEC P., WENGER A., TCHOU C., GARDNER A., WAESE J., HAWKINS T.: A lighting reproduction approach to live-action compositing. In *ACM Transactions on Graphics (SIGGRAPH 2002)* (2002), vol. 21(3), pp. 547–556.

[MID01] MIDI MANUFACTURERS ASSOCIATION: *The Complete MIDI 1.0 Detailed Specification*. 2001.

[PTMD07] PEERS P., TAMURA N., MATUSIK W., DEBEVEC P.: Post-production facial performance relighting using reflectance transfer. *ACM Trans. Graph. 26*, 3 (2007), 52.