Postproduction Re-Illumination of Live Action Using Time-Multiplexed Lighting

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Postproduction Re-Illumination of Live Action Using Time-Multiplexed Lighting

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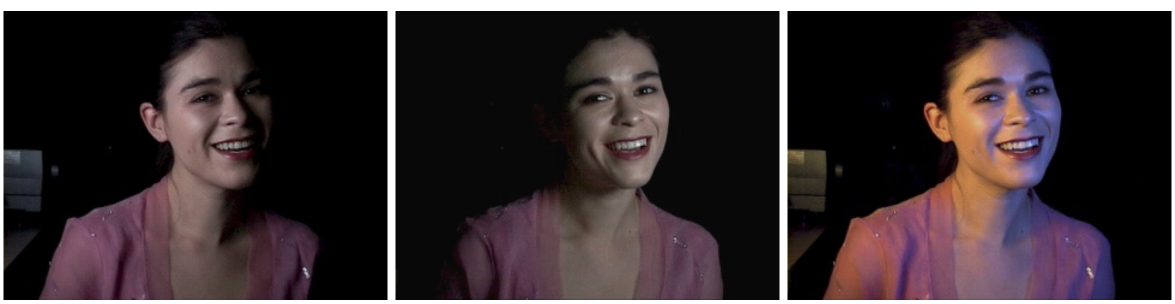
Abstract

In this work, we present a technique for capturing a time-varying human performance in such a way that it can be re-illuminated in postproduction. The key idea is to illuminate the subject with a variety of rapidly changing time-multiplexed basis lighting conditions, and to record these lighting conditions with a fast enough video camera so that several or many different basis lighting conditions are recorded during the span of the final video's desired frame rate. In this poster we present two versions of such a system and propose plans for creating a complete, production-ready device.

1. Relighting Using Interlaced Video Patterns



(a) (b) (c)

Fig 1. An actress lit (a) from the left and (b) from the right by interlaced television patterns. (c) A linear combination of the two images produces a novel lighting condition. A 30fps sequence of this result is included in the video.

Our first experiment uses two interlaced television monitors showing patterns of just even and just odd lines to light a performance alternately from the left and right at 60fps. A standard interlaced video camera records the performance so that the even lines of the video show the subject illuminated from the left and the odd lines show the subject illuminated from the right. We de-interlace the video into two 30fps progressive streams and take linear combinations of the lighting configurations to produce a novel illumination of the performance at 30fps (Fig. 1).

2. Relighting Using an Interleaved Spherical Harmonic Basis

Our second experiment uses a two meter sphere of inward-pointing LED lights similar to [Debevec et al, SIGGRAPH 2002] to rapidly cast a sequence of ten basis lighting environments on an actor's live performance. In this experiment, we used the first nine terms of the Spherical Harmonic (SH) basis, plus one directional light source. Since all but the first element of the SH basis are negative in some directions, we offset and scale each basis function to range between 0 and 1, seen in the bottom row of Fig. 1, and the resulting images of the actor are later re-scaled by the inverse transformations using the DC component lighting image to provide the offset amount. The LED patterns are synchronized with a progressive video camera so that each frame captures a single element of the lighting basis. This process yields a series of ten-frame sets we call extended frames, such as those seen in the top three rows of (Fig. 2).

Using this lighting basis, we can re-illuminate the actor's performance according to a captured lighting environment (such as the one seen in the lower right of Fig. 2) by first computing the SH basis coefficients of that lighting environment. We form linear combinations of the color channels of the basis images according to these coefficients to produce the re-illuminated images similar to those seen at the right of (Fig. 2). The process is similar to that described in [Debevec et al, SIGGRAPH 2000], except using a different lighting basis.

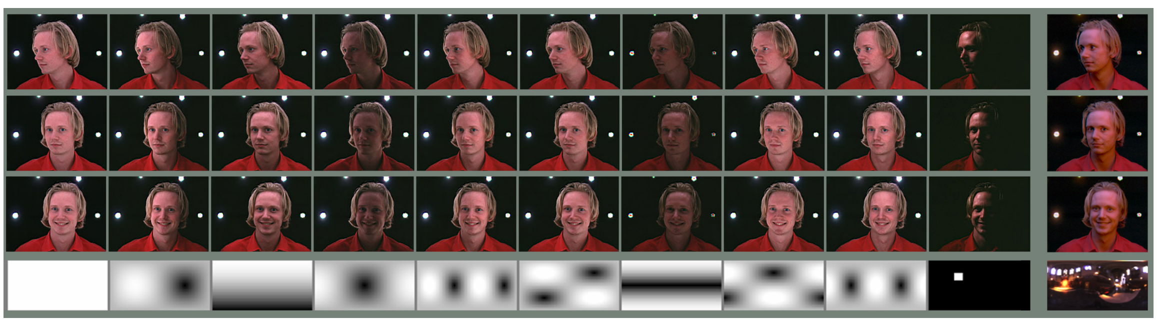


Fig. 2: An actor stands within a sphere of inward-pointing LED lights as elements of the spherical harmonic lighting basis (bottom) are projected in rapid succession during each extended frame. Linear combinations of the frames produce novel illumination on the performance according to a sampled lighting environment (right).

Since the frames making up an extended frame are not taken at precisely the same time, the subject may move noticeably from frame to frame, causing ghosting in the re-illuminated sequence. We compensate for the subject movement using an optic flow-based image tracking program to estimate the motion between the captured frames, and then warp each image into alignment with the first image of each extended frame. This largely eliminates the ghosting effect. Since the video camera used in this experiment ran at 60fps, the extended frames could be captured at no more than 6fps. Thus we used the optic flow technique to generate intermediate frames to create a 30fps sequence.

Our next experiment will use a video camera running at over 1,000fps to record the actor with a larger set of basis lighting conditions per extended frame, and to produce a 30fps sequence without requiring frame interpolation. The larger number of basis lighting conditions (which will include additional directional lighting conditions) will allow environments with high-frequency lighting components to be reproduced more accurately. We are also developing a user interface to allow a lighting designer to intuitively adjust the final illumination manually. The result will be a sufficiently high degree of control for matching the subject realistically and aesthetically into most illumination environments.

Other interleaved lighting conditions could provide additional data also useful for relighting or otherwise transforming the actor's performance. These conditions could include structured light patterns produced, for example, by a video projector or a laser, that would allow a three-dimensional model of the actor to be derived for each frame. The conditions could also include a basis image in which the actor is silhouetted by a field of light behind them; such an image could be used to form an alpha channel, or matte, for the actor in order to facilitate compositing them into a scene.

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