Relighting Human Locomotion with Flowed Reflectance Fields

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Overview We present an image-based approach for capturing the appearance of a walking or running person so they can be rendered realistically under variable viewpoint and illumination. Considerable work has addressed aspects of postproduction control of viewpoint and illumination of a human performance. Most proposed systems address only one of those two aspects e.g. [Wilburn et al. 2005], [Wenger et al. 2005]. [Theobalt et al. 2005] addressed control both of the viewpoint and illumination, however the approach is challenge by low sampling of both lighting and view dimensions. We take a step toward an image-based approach to obtaining post-production control over both viewpoint and illumination of cyclic full-body human motion by combining the performance relighting technique of [Wenger et al. 2005] with a novel view generation technique based on a *flowed reflectance field*. By restricting our consideration to cyclic motion such as walking and running, we are able to acquire a 2D array of views by slowly rotating the subject in front of a 1D vertical array of three high speed cameras and segmenting the data per motion cycle. We then use a combination of light field rendering and view interpolation based on optical flow to render the subject from new viewpoints.

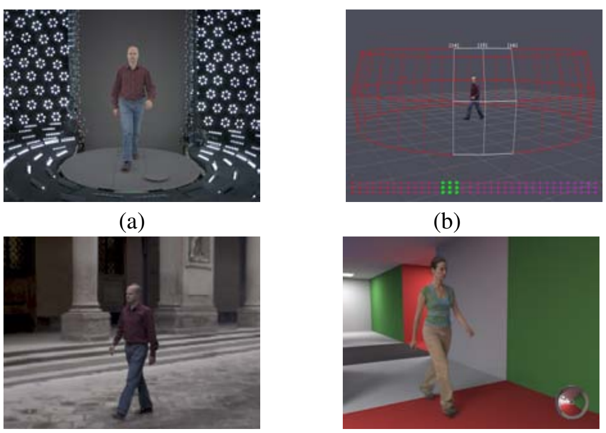
(a) (b) (c) (d)

Figure 1: (a) Capture (b) Real-time rendering showing the virtual camera array (c,d) Results showing novel illumination and viewpoint

Capture The data were captured using an 8m lighting apparatus related to [Wenger et al. 2005] but designed for full human body capture (Fig.1(a)). We programmed the device with a 33-frame lighting sequence with 26 basis lighting conditions, three evenly-spaced tracking frames, three corresponding matte frames and a stripe frame (not used at present). We capture the subject using a high speed camera with the lighting basis running at 30 fps/s that give us a a total frequency of 990Hz. At this frame rate, we can capture 36 motion cycles at 320x448 pixels within the 8 GB memory capacity of the high speed camera. For each motion cycle we have 32 and 25 lighting sequences for walking and running data sets respectively. The 36 locomotion cycles recorded by the three cameras, if assumed identical, yield 108 relightable views of the walk cylcle.

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Registration Once the data is captured we first compute the alpha channels and pre-matte the dataset; this increases the compression ratio and also helps the optical flow algorithm. We then compute optical flow to spatially register the dataset, similar to [Wilburn et al. 2005]. The images are temporally registered in each lighting sequence using a process similar to [Wenger et al. 2005]. The registration is performed by warping all the frames within a lighting sequence toward the tracking frame in the middle of the sequence. After registration we have the equivalent of a 36×3 grid (Fig. 1 (b)) of 4D reflectance fields. To create the flowed reflectance field, we compute flow fields between each viewpoint and its 4-neighbors.

Rendering Our rendering process consists of five steps: lighting, image warping, light field interpolation, shadow rendering, and compositing. We first relight the reflectance field with the user specified image-based lighting environment properly oriented according to the subject pose. The flowed reflectance field becomes a flowed light field consisting of a set of 36×3 arrays of pre-lit images, one for each point in time in the locomotion cycle (Fig. 1 (b)). Like [Wilburn et al. 2005], we use optical flow to interpolate between images of the camera array; for any point lying on a quad of the array we can create an interpolated view using a bilinear warping process. We extend this approach to allow the creation of views in front or behind the camera array using a light field rendering approach. We use the optical flows when creating a new view to get correct correspondences between existing rays and each target camera ray; where prior techniques would require depth information or depth approximation to get those correspondences. Moreover our approach has a straightforward graphics hardware implementation which we utilized fully in our renderings. To improve the realism of the composition we use an image-based technique to compute view independent shadow maps per lighting condition for each frame in the walkcycle. We derive basic geometry using volumetric intersection of the matte images. The shadow maps are then relit and finally rendered as attenuation maps.

Results and Future Work We demonstrate our technique with three different data sets of people walking and running, Fig. 1(c) Fig. 1(d). The results have been rendered using a GPU implementation of the rendering algorithm, Fig. 1(b) shows a screenshot of the renderer with the camera array shown in wireframe. Some artifacts are introduced by the optical flow in regions where there are occlusions and few texture or mismatch between different motion cycle. This direct us to investigate in better optical flow techniques and ways to drive them to best fit our data. As we will require better illumination resolution to simulate higher frequency lighting environment, as well as more cameras to overcome the cyclic motion constraint; we will focus on data compression techniques to deal with the large amount of captured data.

References

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