Improved Chromakey of Hair Strands via Orientation Filter Convolution

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Figure 1: (a) a photographed subject in front of a green screen, (b) the alpha channel obtained using automatic keying (IBK), with a high-resolution inset, (c) the foreground element corresponding to b, (d) a composite result using b and c. (e) the orientation filter convolution response image corresponding to a, (f) the alpha channel obtained using our approach, combining e and b, with a high-resolution inset, (g) the foreground element corresponding to f, (h) a composite result using f and g.

ABSTRACT

We present a technique for improving the alpha matting of challenging green-screen video sequences involving hair strands. As hair strands are thin and can be semi-translucent, they are especially hard to separate from a background. However, they appear as extended lines and thus have a strong response when convolved with oriented filters, even in the presence of noise. We leverage this oriented filter response to robustly locate hair strands within each frame of an actor's performance filmed in front of a green-screen. We demonstrate using production video footage that individual hair fibers excluded from a coarse artist's matte can be located and then added to the foreground element, qualitatively improving the composite result without added manual labor.

SIGGRAPH '17 Posters, Los Angeles, CA, USA

DOI: 10.1145/3102163.3102200

CCS CONCEPTS

•**Computing methodologies** →**Image processing;**

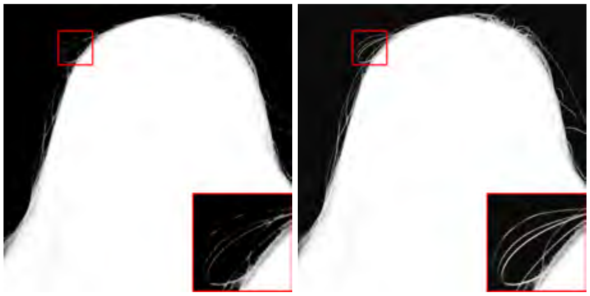
KEYWORDS

Green-screen keying, image matting, hair segmentation

ACM Reference format:
Chloe LeGendre, David Krissman, and Paul Debevec. 2017. Improved Chromakey of Hair Strands via Orientation Filter Convolution. In *Proceedings of SIGGRAPH '17 Posters, Los Angeles, CA, USA, July 30 - August 03, 2017,* 2 pages.
DOI: 10.1145/3102163.3102200

1 INTRODUCTION

Live-action compositing, where an actor filmed in a studio is placed over a novel background plate image, is a common visual effect in television and film. Green-screen keying is used most frequently, due to the relatively simple recording process, wherein an actor is filmed in front of a green (or, alternatively, blue) material using a standard motion picture camera. While filming is straightforward,



(a) traditional keying alpha (b) hair-aware keying alpha

Figure 2: (a) The alpha channel from automatic chromakeying. (b) The alpha channel from our method. Individual hair fibers missed by a coarse matting step can be added back to the alpha channel using the orientation filter strength.

obtaining high-quality mattes and foreground separations is an underconstrained problem, and in practice still requires highly-skilled compositing artists spending hours of time using semi-automated tools. Obtaining good mattes for the actor's hair, a common and important foreground element, is often a challenge.

Typically, compositors will first use several commercial keying software tools like Image-Based Keyer (IBK, from Nuke) or Primatte (from Red Giant) to create a coarse alpha matte. IBK and Primatte are examples of chroma-based or luma-based alpha matting algorithms, which separate foreground and background using color or brightness differences between scene elements. Sometimes, even generating a coarse matte with these tools requires substantial effort. Skilled compositors must tune algorithm parameters, and, as observed by Aksoy et al.[2016], such algorithms can still fail to produce acceptable mattes in regions with intricate object boundaries like hair, and so compositors must make further manual corrections. Light-colored hair is known to be especially difficult to key because of the observed color similarity between the foreground and background, which is further exacerbated by motion blur in the footage. Blond actors are sometimes filmed on a blue screen to maximize color difference to facilitate matting.

Aksoy et al.[2016] described a color-unmixing based keying approach to be used in place of algorithms like IBK or Primatte, demonstrating strong performance on intricate object boundaries like hair, using comparatively one-tenth of an artist's time. However, much of an artist's time in *both* the traditional semi-automatic coarse matting *and* the subsequent manual correction stages may be spent resolving intricate hair regions. We propose that orientation detecting image filters can be used to detect hair strand-shaped image features robustly and improve the quality of semi-automatically generated alpha mattes, thereby reducing the time spent in both the coarse matting and correction stages of a traditional compositing workflow. Such filters including first or second derivative-of-Gaussian or Gabor filters have been used to locate hair fibers in images [Beeler et al. 2012; Jakob et al. 2009], but, to the best of our knowledge, no prior work has used them to improve compositing.

2 METHOD

We convolve each input image in the sequence with a bank of 18 oriented second-derivative-of-Gaussian filters (every 10°), with the filters scaled to the expected hair width for the footage ($\sigma = 1.5$ pixels for our experiments). We compute the per-pixel maximum filter response across the orientations, which has a large value only for pixels comprised of lines of the specified hair width. In practice, we filter the green channel only, to reduce the effect of noise for the Bayer pattern sensor. The orientation response image for a radiometrically linear image is also linear, but we square the response image to suppress small pixel values. We compute our final alpha channel as the maximum of the coarse artist-generated matte and the filter response image, which is first scaled by a constant. Besides the hair width, this scale factor is the only parameter for the compositing artist to adjust. The filter response image is effectively another channel that can be used for compositing.

3 RESULTS AND DISCUSSION

We filmed a diffusely-lit subject in front of a green screen as in Fig 1a using a Canon 1DX Mark II, recording 4K resolution motion-JPEG video (23.976 fps, 180° shutter, ISO 500, and aperture f/11). Using the Technicolor Cinestyle log-response picture style and its corresponding linearization table, we recovered radiometrically linear footage. We show the results using our approach in Fig. 1 and Fig. 2, including the hair filter response map in Fig. 1e. We also provide the video results as supplemental material.

Although the small color and brightness differences between the foreground hair strands and green background are a challenge for standard keying algorithms, the oriented filters can detect this weak signal. We demonstrate that hair fibers parsed as background pixels by standard chroma keying algorithms can be recovered with our approach. Additionally, since the filters are designed to detect strand-shaped image features, compression artifacts are not incorrectly identified as hair fibers.

The method performs best when hair strands are in focus and captured with minimal motion blur. Since filters are scaled to the expected width of focused, stationary hairs, moving or out-of-focus fibers produce weaker orientation filter responses. Additionally, the filters are designed to detect light hairs on a dark background, or by inverting the filters, to detect dark hairs on a light background. Subjects with a mixture of dark and light hair strands would be more challenging to key using our approach.

4 ACKNOWLEDGMENTS

The authors wish to thank Randy Hill, Kathleen Haase, Angelika Von Chamier, and Michael Trejo for their important support of this work. This project was sponsored by the U.S. Army Research Laboratory (ARL) under contract W911NF-14-D-0005 and in part by a USC Annenberg Ph.D. Fellowship. The content of the information does not necessarily reflect the position or the policy of the Government, and no official endorsement should be inferred.

REFERENCES

Yağiz Aksoy, Tunç Ozan Aydin, Marc Pollefeys, and Aljoša Smolić. 2016. Interactive High-Quality Green-Screen Keying via Color Unmixing. *ACM Trans. Graph.* 35, 5, Article 152 (Aug. 2016), 12 pages. DOI: http://dx.doi.org/10.1145/2907940

Thabo Beeler, Bernd Bickel, Gioacchino Noris, Paul Beardsley, Steve Marschner, Robert W. Sumner, and Markus Gross. 2012. Coupled 3D Reconstruction of Sparse Facial Hair and Skin. *ACM Trans. Graph.* 31, 4, Article 117 (July 2012), 10 pages. DOI: http://dx.doi.org/10.1145/2185520.2185613

Wenzel Jakob, Jonathan T. Moon, and Steve Marschner. 2009. Capturing Hair Assemblies Fiber by Fiber. *ACM Trans. Graph.* 28, 5, Article 164 (Dec. 2009), 9 pages. DOI: http://dx.doi.org/10.1145/1618452.1618510