4D Imaging through Spray-On Optics - Supplemental Results

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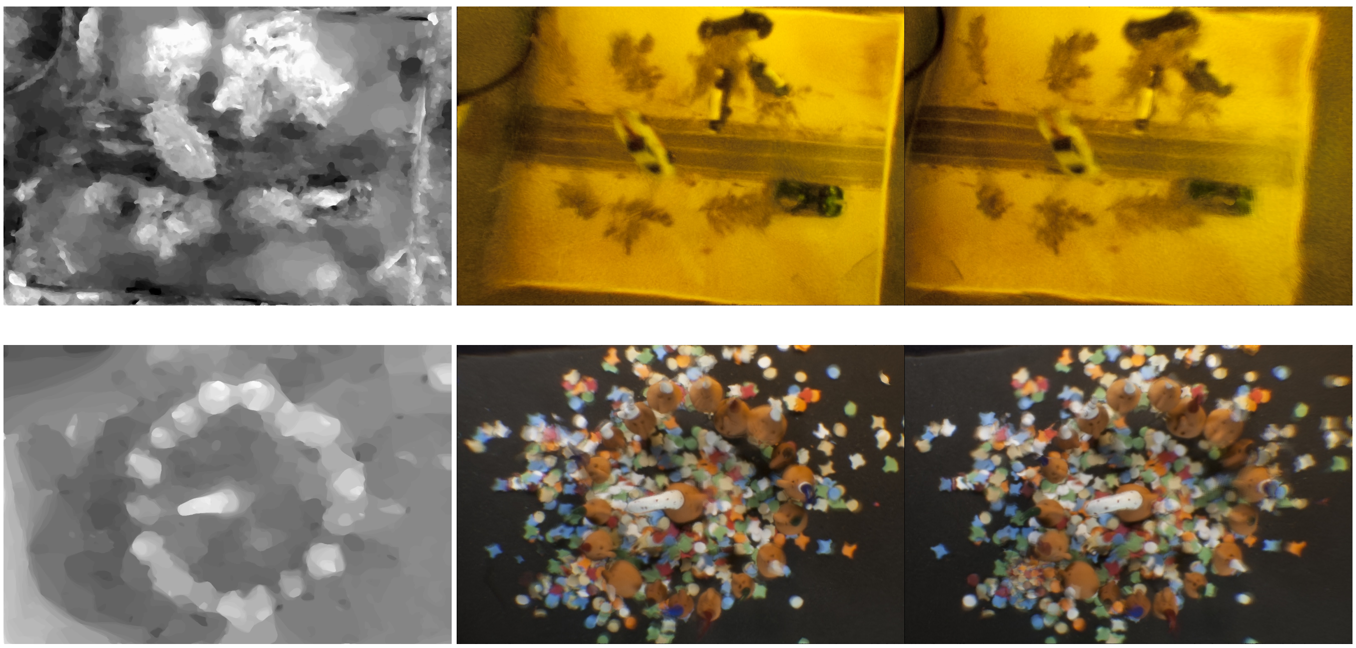

Fig. 1. Additional reconstructions. Depth maps (left column) and stereo pairs (right column, viewable using cross-eye technique) of all-in-focus renderings for the scenes “CarStunts” (top row, imaged through yellow drops) and “Dwarfs” (bottom row).

CCS Concepts: • **Computing methodologies** → **Computational photography**; **3D imaging**; **Reconstruction**; **Physical simulation**;

Additional Key Words and Phrases: Plenoptic imaging, inverse rendering, analysis by synthesis

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1 ADDITIONAL RESULTS

Here we discuss three additional scenes whose light fields we acquired and reconstructed using our technique.

CarStunts: In this dynamic scene, we used a solenoid mechanism to launch four toy cars and timed the camera exposure to capture them flying through the air. The background consists of a desert road printed on office paper, along with grass stalks as “trees” and a fifth car parked on the side of the road. To facilitate the drop segmentation step, we dyed the water drops with a yellow food colorant (tartrazine), which made them clearly visible in the blue color channel. To deal with the rapid motion in the scene, we used a short exposure time (1/250 s) at a high ISO setting. Despite initial concerns that the camera’s rolling shutter would cause a systematic distortion (with drops in different vertical positions sampling the scene at different points in time), we were not able to observe this effect in practice. Still, this scene is particularly challenging because of its distinctly non-heightfield-like geometry with a wide depth range (25 cm). The trees appear blurred out due to defocus, which leads to a semi-transparent appearance; the same holds for the cars due to motion blur. Or algorithm is not capable of recovering multiple depth values per pixel, but it manages to capture the overall structure of the scene: the trees stick out of the plane, and the flying cars can be identified as hovering above the ground. The stereo image pair generated from this light field (Fig. 1, top row) not only conveys a good impression of depth but also occlusion effects on the cars themselves.

Dwarfs: This scene shows a circular arrangement of dwarf figures made of clay, with pointy hats from acrylic paint. The overall depth range of the scene is relatively shallow (8 cm). The dwarfs' intricate facial features fall below the resolution limit of the liquid light field, and both the feature extraction and depth estimation steps are disturbed by the lack of texture and the presence of sharp specular highlights on the hats. Overall, the recovered depth map correctly labels foreground and background and enables reasonably sharp renderings with a decent stereo impression (Fig. 1, bottom row).

Firework: In our final experiment, we took an image of a sparkler (Fig. 2). Like CarStunts, this is a very dynamic scene and hence potentially affected by rolling shutter. However, we suspect that a different factor rendered a reconstruction of this scene impossible. The trajectories of burning particles produce line-like emissive (and hence additive) streaks, which breaks with our implicit assumption that the scene is opaque and Lambertian. While the crossing points of these streaks do not correspond to meaningful 3D locations, SIFT detects them as image-space keypoints. The result are false feature correspondences with a high confidence, and a vastly reduced number of feature clusters overall. Further down the pipeline, the depth estimation step heavily relies on a regularizing term (main paper, Eq. 10), whose primary purpose is to produce smooth depth maps and to remove isolated features exactly like the ones produced by the sparkler. We consider this scene a failure case that illustrates the limitations of our approach and, in particular, of the Lambertian assumption.

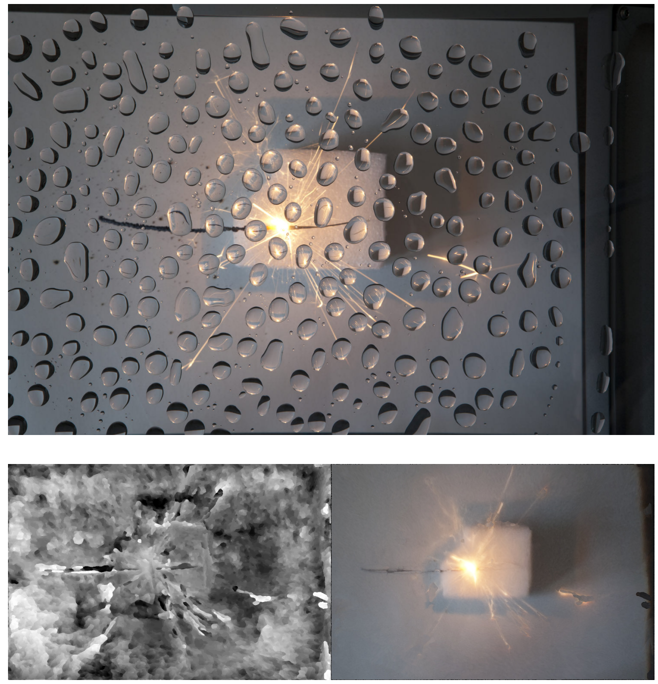

Fig. 2. Failure case: The "Firework" scene is characterized by isolated thin emissive streaks at various depths. Crossing points of these lines in image space are detected as features that do not correspond to 3D scene points. Neither keypoint detector nor renderer are capable of handling this very challenging dataset. Top: input image. Bottom: depth estimate and all-in-focus rendering.