Light-Efficient Photography (#466)
Supplementary Material

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1. High-resolution results, and details about each dataset
   - SIMPSONS dataset
   - HAMSTER dataset
   - PORTRAIT dataset (new)



2. Handling motion in the capture sequence

3. Guide to the videos

SIMPSONS dataset: Details

(Fig. 6a-c)

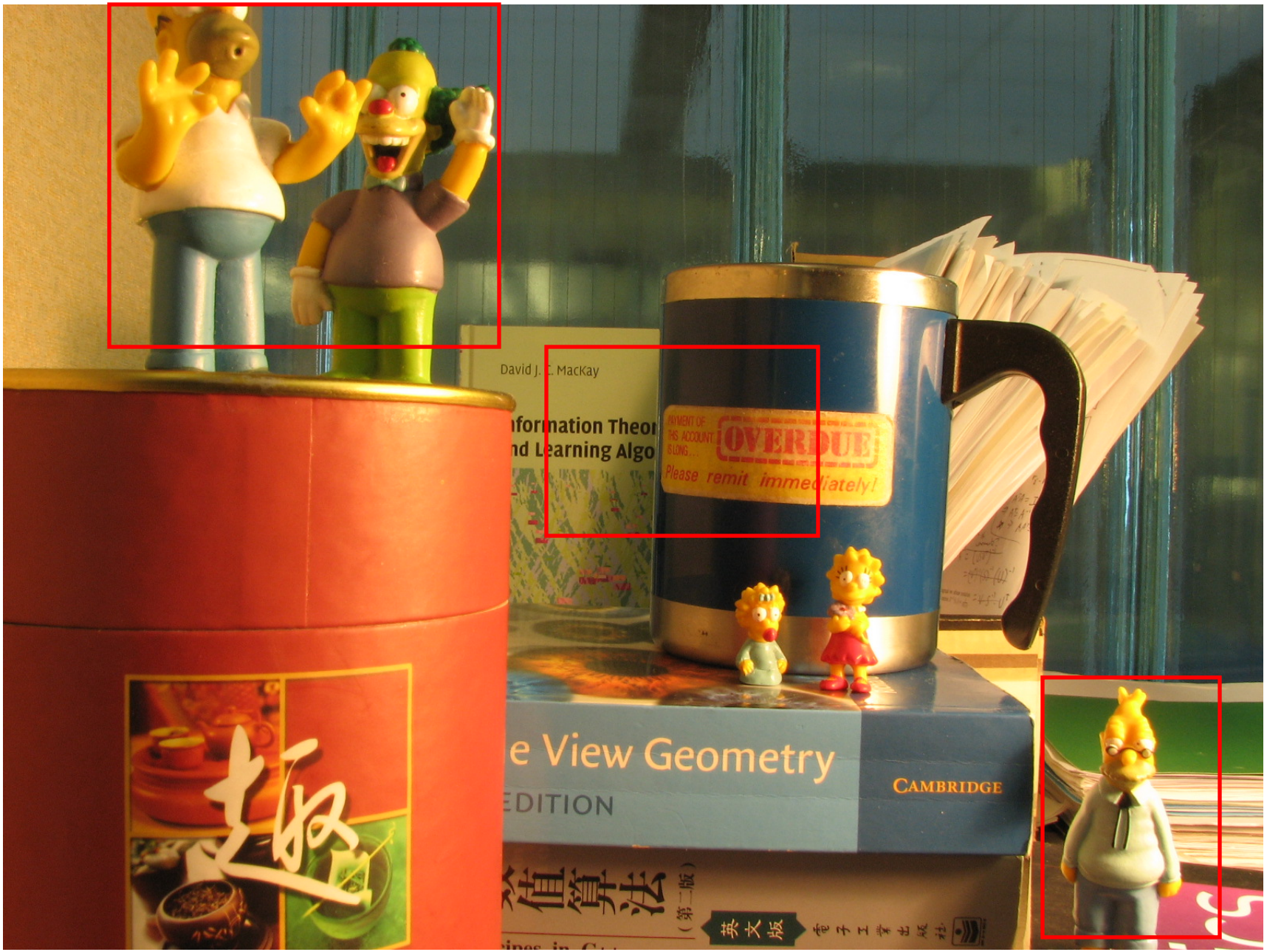
- Near-macro shot of a messy desk (close objects magnified 1:5), covered in books, papers, and tea paraphernalia, on top of which several miniature plastic figures from "The Simpsons" have been arranged.
- DOF extends from red tea canister to the pale green book in the background.

- Captured with a Canon S3 IS, at 2MP (1600x1200), at the widest-angle zoom (6mm focal length)
- Acceptable blur diameter of 0.005mm (1.4 pixels)
- DOF in the scene [30cm,70cm]
  - 1 photo at f/8 (exposure time: 500ms)
  - 4 photos at f/2.7 (total exposure time: 200ms)

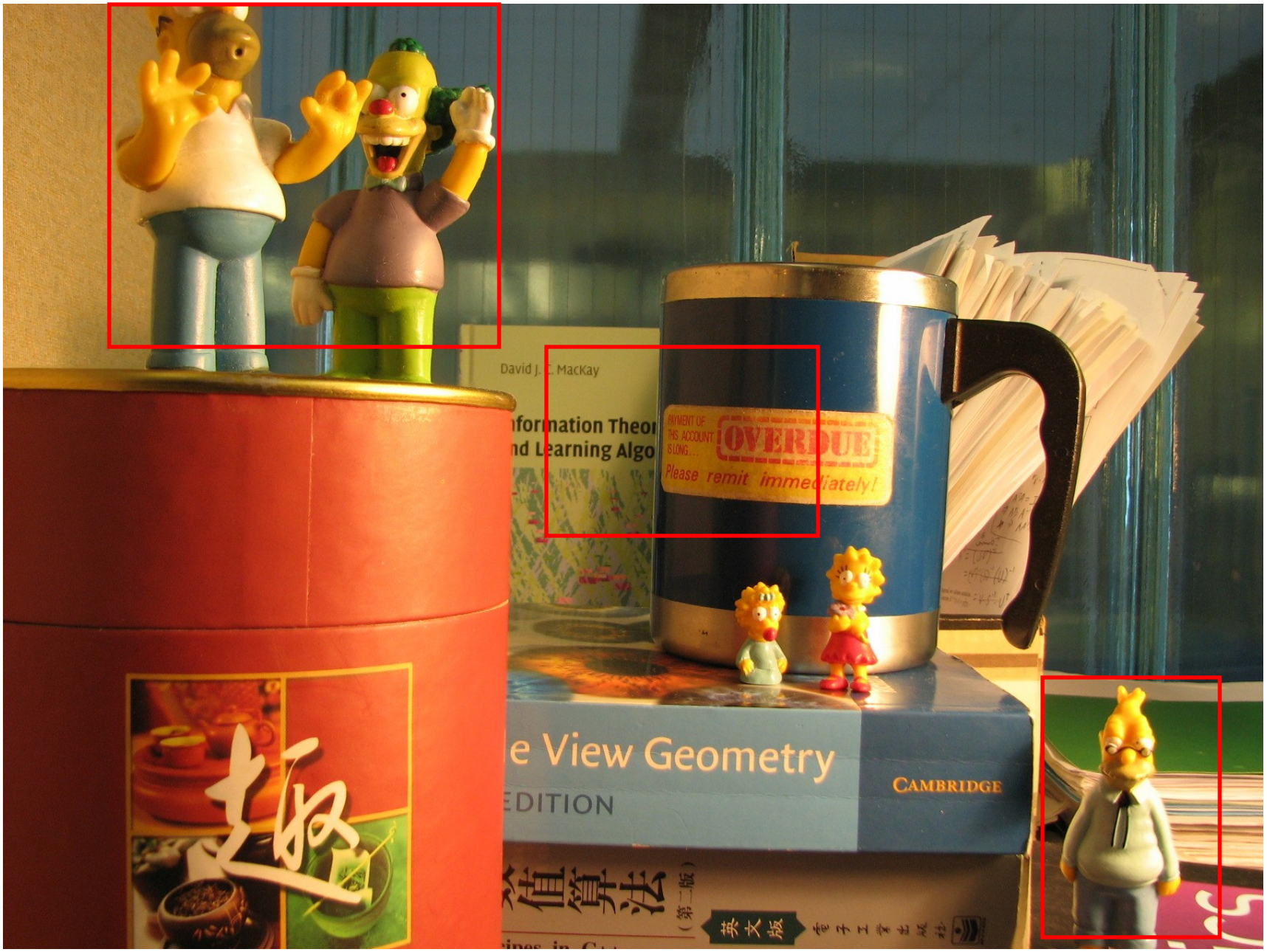
input photo, nearest focus setting (1 of 4)

Note: all photos are high-res, please zoom in to see details

input photo, farthest focus setting (4 of 4)



narrow-aperture photo, desired DOF contains the boxed objects



DOF composite synthesized from optimal capture sequence

coarse depth map, from labeling used to create DOF composite

HAMSTER dataset: Details

(Fig. 6d-i)

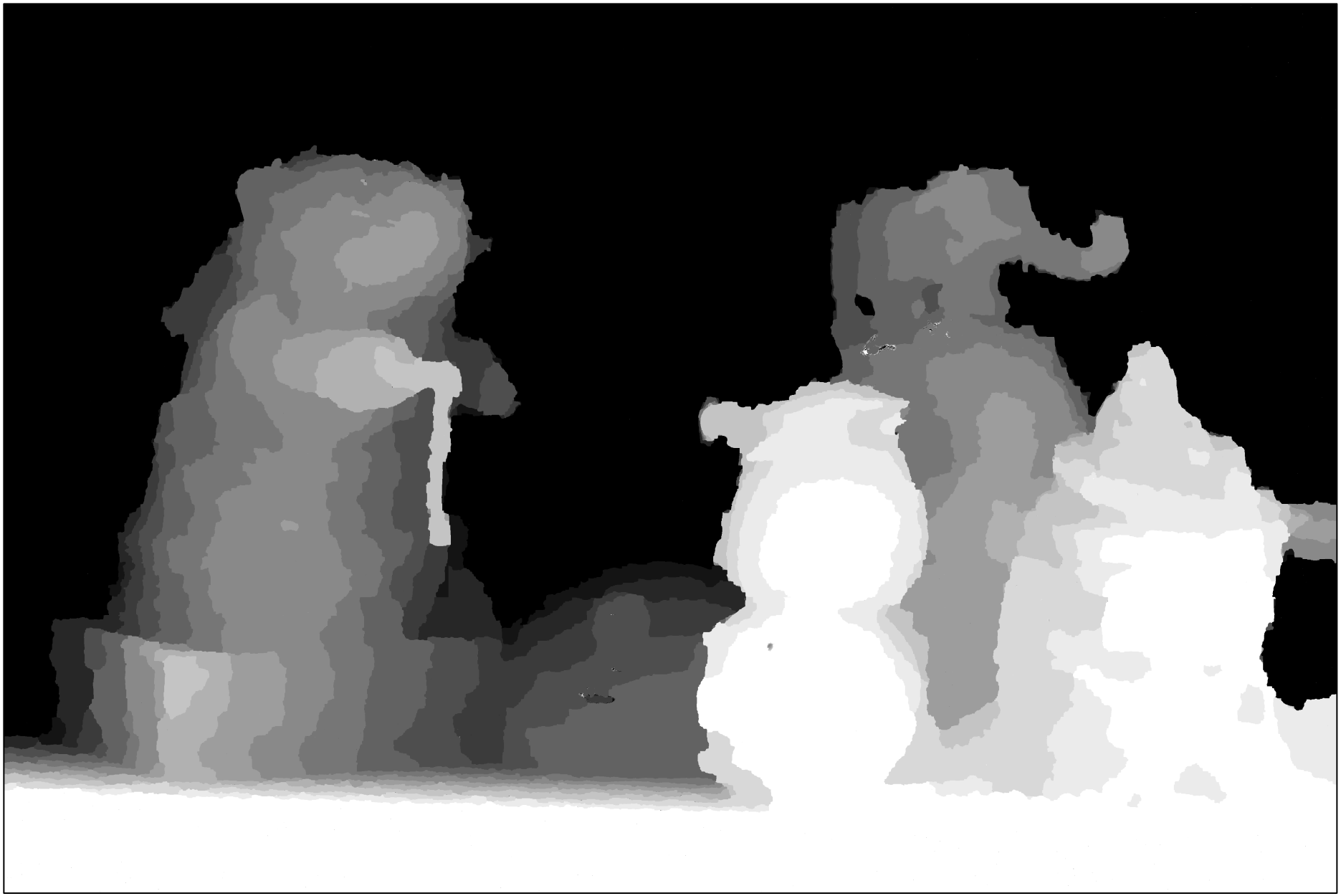
- Still life of a hamster figurine (16cm tall), posed on a table with various small objects, in front of a background (outside the DOF) made from cardboard packing material.
- DOF covers the hamster and all the small objects.

- Captured with Canon EOS-1Ds Mark II, at 16MP (4992x3328), with an EF85mm 1.2L lens
- Acceptable blur diameter of 0.025mm (3.5 pixels)
- DOF in the scene [98cm,108cm]
  - 1 photo at f/16 (exposure time: 800ms)
  - 14 photos at f/1.2 (total exposure time: 70ms)

input photo, focused on brass figure (3 of 14)

narrow-aperture photo, desired DOF contains the boxed objects

DOF composite synthesized from optimal capture sequence



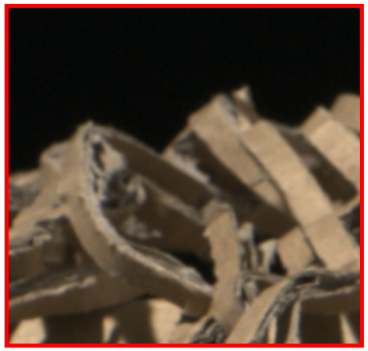
coarse depth map, from labeling used to create DOF composite

Special notes:

- The DOF includes the hamster and the other objects, but *not* the background. Even in the narrow-aperture f/16 photo, the background appears slightly defocused, because it is outside the desired DOF. As expected, the background is even more defocused in the synthetic DOF composite.

- The only noticeable compositing artifact appears at the handle of the pumpkin, which is incorrectly assigned to a further depth. This is an especially challenging area because the handle is: (1) thin, and (2) low-texture compared to the pottery behind it.

key



narrow-aperture photo

synthetic DOF composite

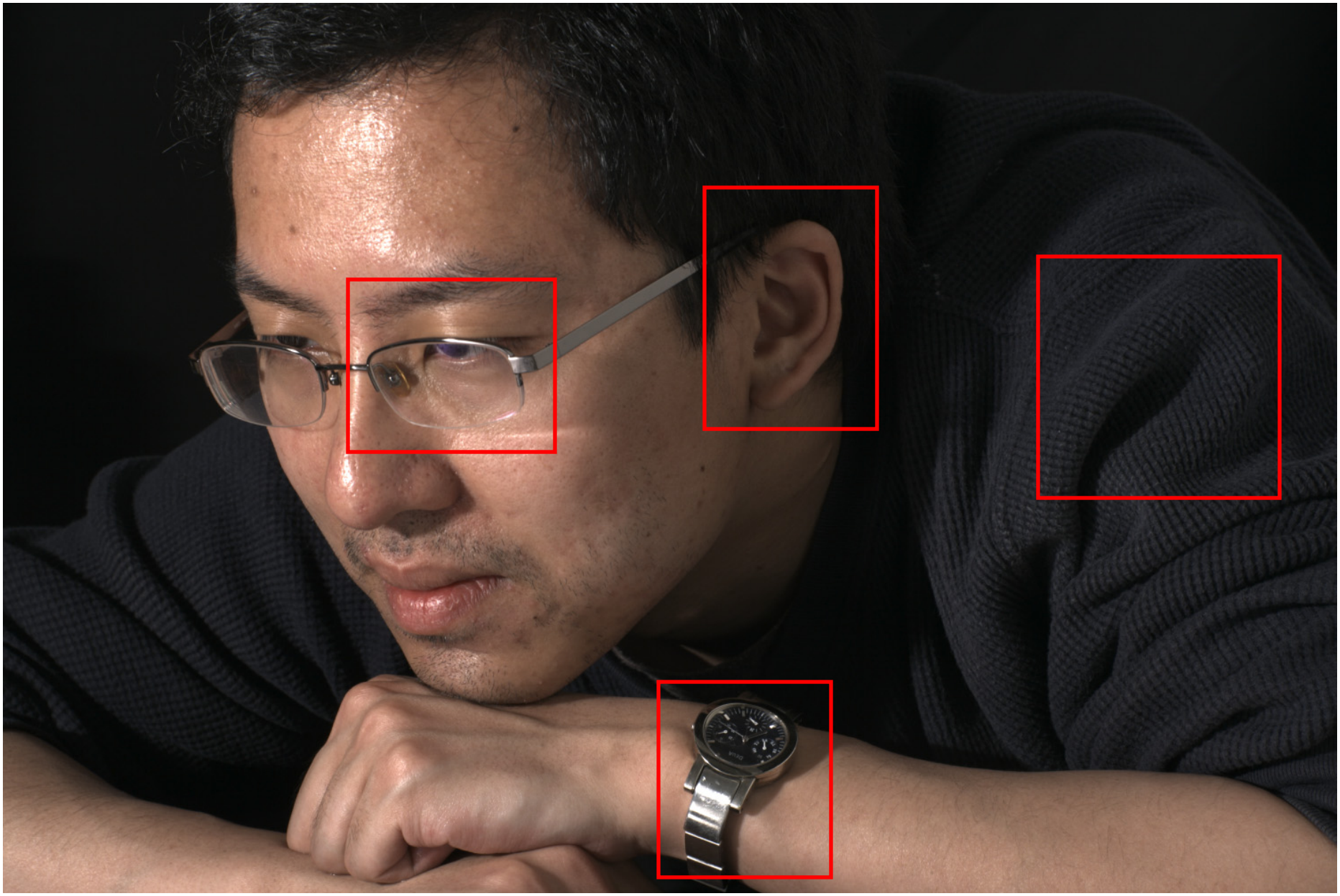
PORTRAIT dataset: Details

(not shown in paper)

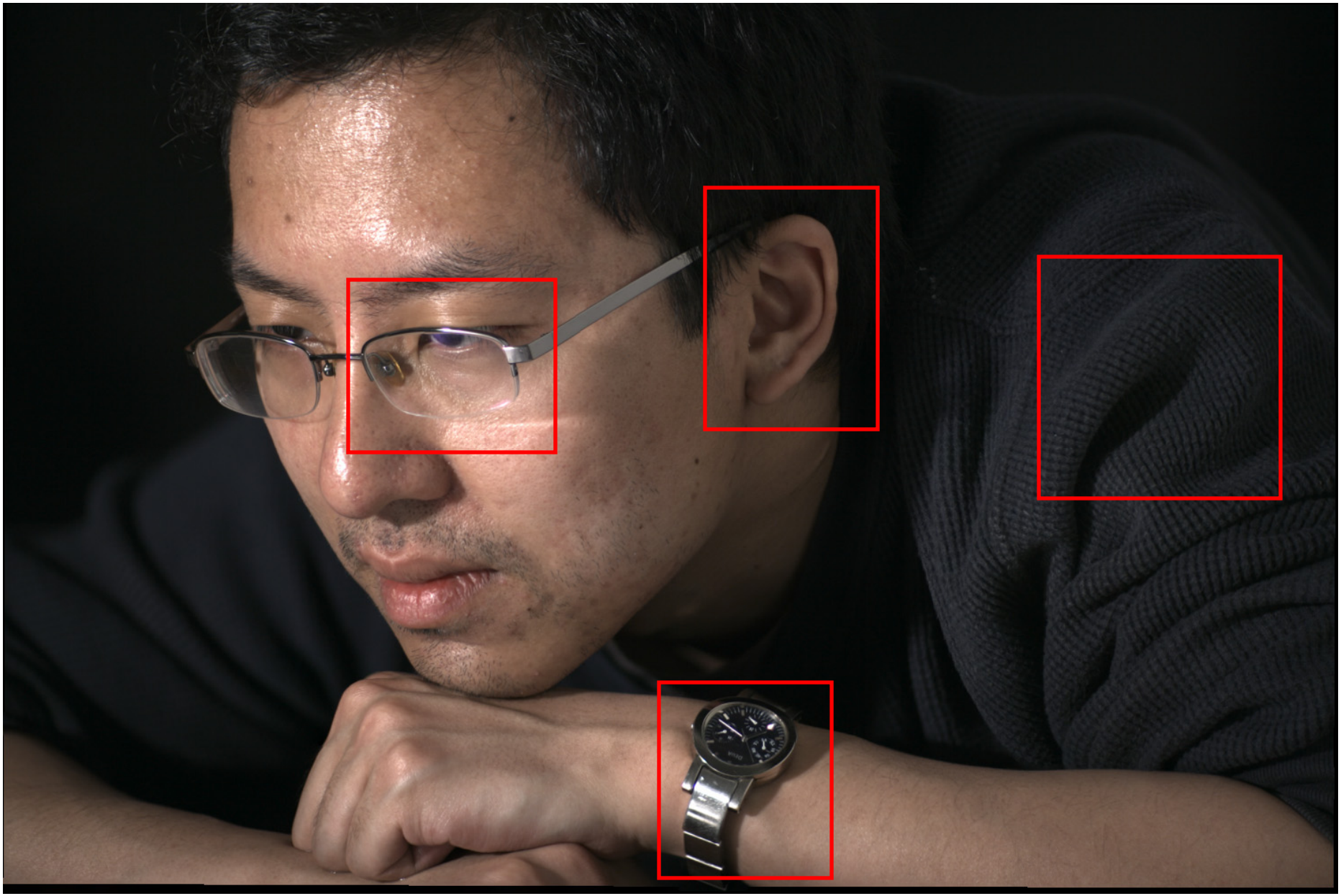
- Studio-style 2/3 facial portrait of a subject wearing glasses, resting his chin on his hands.
- DOF extends over the side of the body closest the camera (face, left arm, and left shoulder).

- Captured with Canon EOS-1Ds Mark II, at 16MP (4992x3328), with an EF85mm 1.2L lens
- Photos downsampled to 1500x1000
- Acceptable blur diameter of 0.025mm (3.5 pixels)
- DOF in the scene [98cm,108cm]
  - 1 photo at f/16 (exposure time: 800ms)
  - 14 photos at f/1.2 (total exposure time: 70ms)

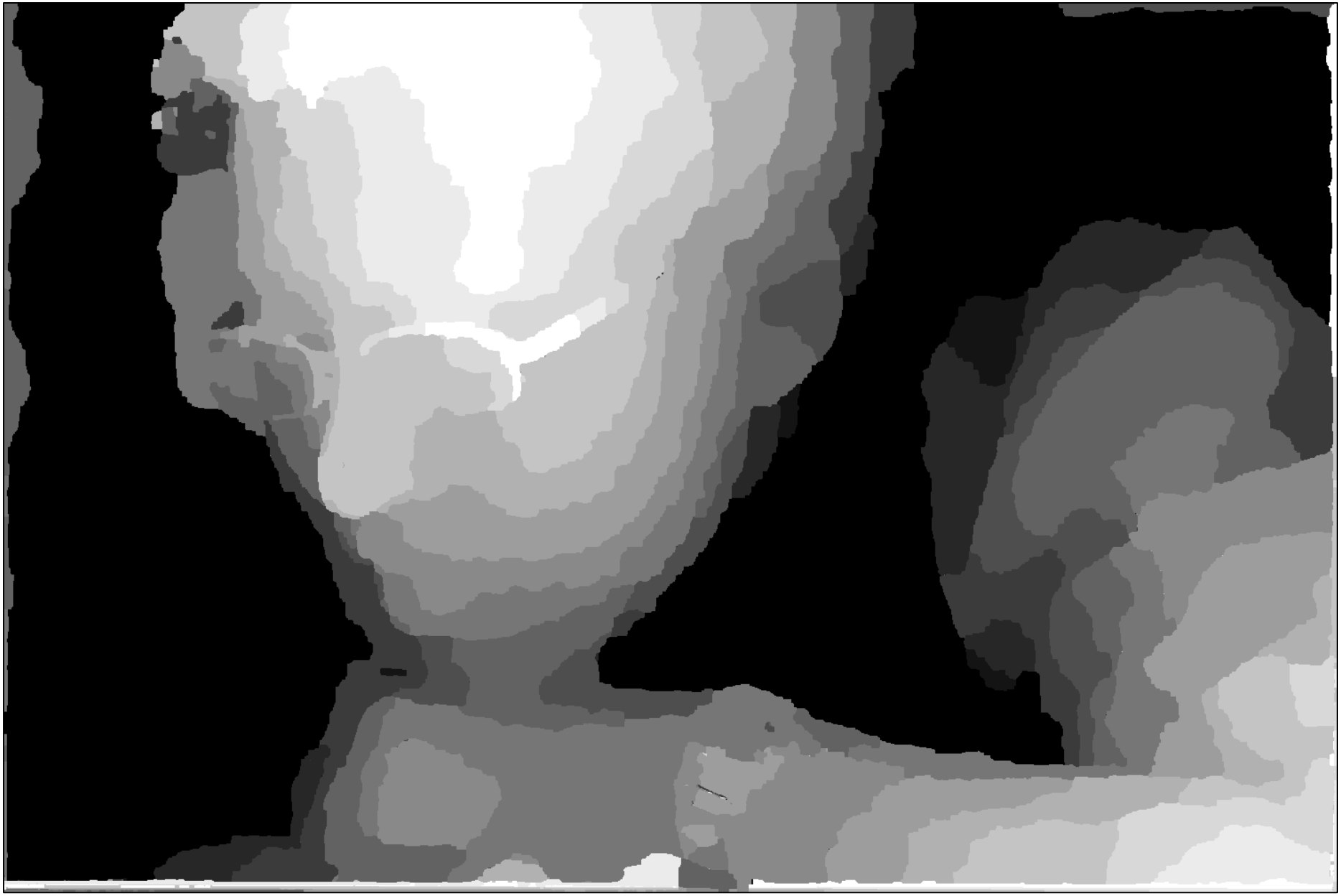
input photo, focused on far eye (6 of 14)



narrow-aperture photo, desired DOF contains the boxed areas



DOF composite synthesized from optimal capture sequence



coarse depth map, from labeling used to create DOF composite

Handling motion in the capture sequence

- Because of the high overhead due to our focus control mechanisms, we observed scene motion in two of our capture sequences:
  - The SIMPSONS dataset shows a subtle change in brightness above MacKay's book. This is because the person taking the picture moved during acquisition, casting a *moving shadow* on the wall. This is not an artifact and did not affect our processing.
  - For the PORTRAIT dataset, the *subject moved slightly* during acquisition of the optimal capture sequence. To account for this motion, we performed a global rigid 2D alignment between successive images using Lucas-Kanade registration. Despite this motion, our approach of Section 5 for creating images with a synthetic DOF generates photos that are entirely free of artifacts.
- The effects of this inter-frame motion are *only* possible to see in the videos, where images are created for novel aperture and focus settings. Specifically, while each still of the video appears free of artifacts, successive stills contain a slight but noticeable amount of motion.
- We emphasize the following two points:
  - had we been able to exploit the internal focus control mechanism of the camera (a feature that the recently released Canon EOS-1Ds Mark III provides), the inter-frame motion for portrait photos would be negligible, making the above registration step unnecessary;
  - even with fast internal focus control, residual motions would occur when photographing fast-moving subjects; our results in this sequence suggest that even in that case, our simple merging method should be sufficient to handle such motions with little or no image degradation.

Guide to the videos

- Videos are encoded in Quicktime (`mov`). If you experience codec problems with your regular player, try VLC Media Player (`http://videolan.org`).
- For each dataset (`simpsons`, `hamster`, `portrait`) we provide two videos:

  1. `videos/DATASET-varyaper-focusXX.mov`
     - interpolates smoothly between the widest and narrowest aperture, fixed at the focus setting corresponding to input image XX

  2. `videos/DATASET-varyfocs-fXX.mov`
     - interpolates smoothly between the front and back of the DOF, using a synthetic aperture of f/XX.

- For the HAMSTER dataset, we also provide videos for a cropped region of the scene at full 16MP resolution (`hamsterCrop`).
- To best appreciate the effects of changing aperture and refocusing, viewing the video at full screen (Ctrl-F in QuickTime Player) is recommended.
- The synthesized videos for the SIMPSONS dataset show relatively subtle variations, because the widest aperture on the compact camera was still fairly narrow. While it might be possible to use a “defocus magnification” technique to get more pronounced DOF variations, we did not attempt this here.