Light box experiments procedure

For chromatic aberration correction and spectral reconstruction

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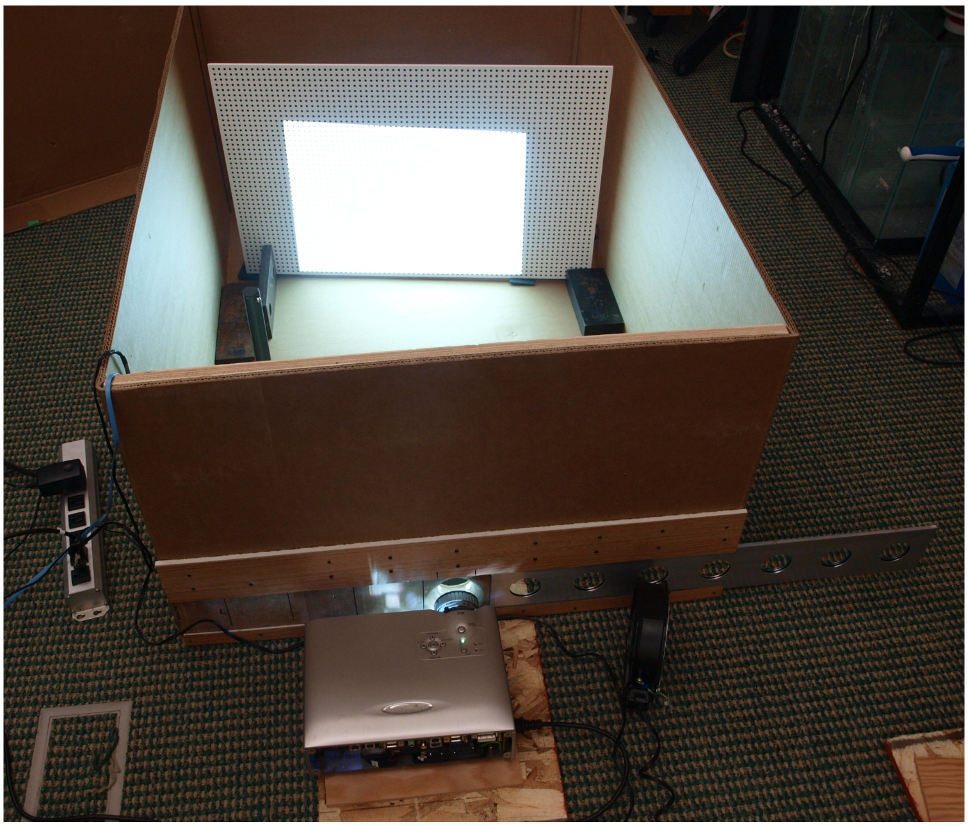
Physical Setup



Box

- Place the box on the floor.
- Put weights in the box to keep it from shifting.

Filters

- Retrieve the 7 optical bandpass filters from their wooden box (labelled "Edmund Optics").
- Insert filters into the filter holder, such that the arrows on their support rings will point away from the box, towards the projector. Preferably put the filters in order by

passband center wavelength.
    - The filter holder has holes drilled in the side, into which screws have been inserted to hold the filters in place. A hex key is needed to tighten the screws once each filter is inserted.
- Slide the filter holder into the track on the front of the box.

Projector (light source)

- The projector (Optoma EP739) needs to be positioned so that it illuminates as much of the inside of the box as possible.
- Place a 1/2” sheet of wood on the floor in front of the hole in the box.
- Place a 1/4” sheet of wood on top of the first sheet.
- Place the projector so that its front end rests on the first sheet, and its back end rests on the second. Its lens should be as close as possible to the hole in the box.
    - This light source was chosen because it is a broadband illuminant (unlike an LED). Note that the colour filter wheel has been removed from the projector.
- Put a fan on the right side of the projector, blowing into the projector, to prevent the projector from overheating. (The projector normally relies on open space in front to vent heat.)

Camera

- Slide the “neck” all the way out of one of the Manfrotto red and grey tripods. Put the neck back on from underneath the tripod, so that the camera will be mounted upside down.
- Put the camera on the tripod, then put the tripod in the box.

Documentation

- Take a picture of the apparatus for reference (if not already done).
- Record the model numbers and serial numbers of the camera and lens

Imaging Setup

Light

- Press the power button to turn on the projector. Wait for it to display a “No Signal” message. Press the power button, then the left arrow twice, and finally the menu button, to enter the service menu. Press the down button twice, then the select button, to activate the white test pattern.

Camera

- This procedure assumes a machine vision camera from PointGrey is being used, with manual control over its image capture settings.
- Set up the camera for image capture. Make sure that it will save RAW images (not

demosaiced images).
  - Either check “save raw bayer pattern...” in the image capture dialog of FlyCapture2, or set the current colour processing algorithm in the image viewer to ‘None’.
- Set the lens aperture so that the image of a mostly white target, such as a pattern of black disks on white, is not overexposed (at a low shutter time) under direct light from the projector (i.e. unfiltered light).

Selecting reference shutter times

- Exposure must be now adjusted using only the shutter speed, not the aperture.
- For each illumination (unfiltered light, and light passing through each optical bandpass filter), find a set of shutter times which result in good exposure of the same scene.
- Use the histogram as a guide: Look for a wide distribution of pixel values, with small numbers of saturated pixels. Note that the current colour processing algorithm must be set to some form of demosaicing before the histogram will show different curves for the individual colour channels.
- For filtered light, each colour channel will often be properly exposed under a different shutter time. The appropriate shutter time will vary depending upon the filter.
- For unfiltered light, shutter times are normally so short that it is prudent to select at least two different shutter times. Even if the longer shutter times may overexpose some pixels, they will be captured with less variability in the shutter time, reducing noise.
- Create final lists of reference shutter times to use for filtered and unfiltered light. When capturing images later, under filtered light, all of the reference shutter times for filtered light must be used with every filter, as it must be possible later to map images taken under different filters to one intensity scale. Images taken under filtered and unfiltered light likely cannot be reliably mapped to a common intensity scale, so separate lists of reference shutter times will be used for these two classes of illumination. In any case, there are different vignetting effects when capturing filtered vs. unfiltered light, so even if the shutter times used were similar, the images are incomparable.

Image Capture

For each camera position, aperture/focus setting, and reference shutter time

- Cover the hole in the box, and capture 5 dark frames

For each scene, and for each reference shutter time

- Capture 5 frames for every bandpass filter, and for the unfiltered projector light.

Desired scenes: Capture 5 frames under each filter, and unfiltered

- Uniform white
- (Dispersion calibration) Disk calibration patterns, at a variety of positions, parallel to the

camera sensor, so as to calibrate all areas of the image plane. Repeat with the calibration pattern at different distances from the camera.
    - Record the distances from the camera.
- ColorChecker chart
- Transparent objects against a disk calibration pattern or chequerboard
    - Flat-sided, or simple object, allowing for calibration of dispersion produced by the object.
    - Complex object
- The same transparent objects against a highly-textured background, and against a colour chart.
- Highly textured object
- CD or DVD, showing a rainbow reflection.
- Printed noise pattern

Dataset Generation Procedure Using MATLAB Code

- Run PreprocessRAWImages.m to produce exposure-blended images (with dark frame subtraction) from the original captured images.
- Run RAWDiskDispersion.m on the exposure-blended images for unfiltered light, to produce models of colour dispersion.
    - First create masks to be used for vignetting correction.
    - Optionally create masks to indicate where to search for disks, if the disk pattern does not cover the entire image.
- Repeat on the exposure-blended images for filtered light, to produce models of spectral dispersion.
- Run RAWBandImagesToDataset.m to combine exposure-blended images into spectral and colour images.

More about creating and using colour images

- The unfiltered light from the projector results in true colour images.
- One can create pseudo-colour images by summing images taken under the different bandpass filters.
- The pseudo-colour images can be input to image estimation algorithms, and the output can then be compared directly with the original bandpass-filtered images.
- The true colour images can be input to image estimation algorithms, but the output cannot be compared with bandpass images. One would need a spatially-varying scaling factor to relate the bandpass illumination with the component of the unfiltered illumination within the passband. Such a scaling factor would also depend on the depth of the scene, because the camera and the projector are not in the same position.