Problem Session 1
Logistics

• See website for all course info (including times and locations of lecture, office hours, etc...)

    stanford.edu/class/ee367/

• Goal of these problem sessions:
  • Explanation of HW and hints
  • Opportunity to ask questions!
Task 1 & 2: Create a pinhole camera

- A simple camera without a lens, effectively a light-proof box with a small hole in one side.
- Also known as camera obscura, or "dark chamber" (Latin)

Optimal pinhole diameter:

\[ d = 2\sqrt{f\lambda} \]

- \( f \): distance from pinhole to image plane
- \( \lambda \): wavelength of light
Task 1 & 2: Create a pinhole camera
Task 1 & 2: Create a pinhole camera

During the Renaissance, pinhole cameras were used to draw realistic views (perhaps used in Vermeer’s paintings)
Task 1 & 2: Create a pinhole camera

- Pinhole
- Camera lens Goes here
- Image is created here
Task 1 & 2: Create a pinhole camera

Check out camera from Lathrop library [https://thehub.stanford.edu/equipment](https://thehub.stanford.edu/equipment)
Task 1 & 2: Create a pinhole camera
Task 1 & 2: Create a pinhole camera
Task 1 & 2: Create a pinhole camera
Task 3: Create a hybrid image

A hybrid image is an image that is perceived in one of two different ways, depending on viewing distance.


http://cvcl.mit.edu/hybrid_gallery/gallery.html
Task 3: Create a hybrid image

→ Contrast sensitivity changes with frequency

For medium frequency you need less contrast than for high or low frequency to detect the sinusoidal fluctuation.
Task 3: Create a hybrid image

Low spatial frequencies of first image + High spatial frequencies of second image = Image with an interpretation that changes with viewing distance

High-pass filter

Low-pass filter
Task 3: Create a hybrid image

- dpi = dots per inch, defines the physical size of a pixel on paper
- Pixels per degree, depends on the distance

\[ \frac{\delta}{2D} = \tan \left( \frac{\theta}{2} \right) \]

\[ \delta = 2D \tan \left( \frac{\theta}{2} \right) \]

To obtain the pixels per degree, \( \theta = 1^\circ \). Calculate \( \delta \) → How many pixels are in \( \delta \)?
Task 3: Create a hybrid image

• Peak of the contrast sensitivity function (CSF) is at 5 cycles per visual degree

\[ 5 \text{ (cycles/degree)} \times \ 'x' \ (\text{degrees/pixel}) = ? \text{ cycles/pixel} \]

• The spatial frequency with peak contrast sensitivity changes with distance D
Task 3: Create a hybrid image

• Image frequency
  • Physical frequency, e.g. cycles per mm, on the page
  • Frequency compared to the maximal (Nyquist) frequency
  • Maximal frequency in units of $\frac{\text{cycles}}{\text{pixel}}$ is 0.5

Nyquist frequency $= \frac{1}{2 \times \text{pixel size} \left[ \frac{\text{cycles}}{\text{mm}} \right]} = \frac{1}{2} \left[ \frac{\text{cycles}}{\text{pixel}} \right]$
Task 3: Create a hybrid image

High-pass and low-pass filters

Helpful Matlab functions: meshgrid, fft2, fftshift, ifft2,
Task 3: Create a hybrid image

Result
Task 3: Advice

• When you load 8 bit images (e.g., jpg or png), they are in the range 0-255, which is often inconvenient and may give you unexpected results for some built-in Matlab functions. Convert them to double and normalize them, for example using Matlab’s `im2double()` function.

• To combine the low- and high-pass filtered spectra, just add the frequency components in the Fourier domain for each color channel.

• Use `fftshift()` / `ifftshift()`. When you call `fft2()` on an image, the frequency axis goes from 0 frequency, up to the highest frequency, and back down to zero. The `fftshift()` function will shift the spectrum so that 0 frequency is in the middle. Likewise, you need to call `ifftshift()` before using `ifft2()`.
Fun additions

• Stereoscope at OMCA (Oakland museum of CA – free every first Sunday)

• Blur visual cues:
  https://www.youtube.com/watch?v=Wf4_bcrJ864