Stanford CS248: Interactive Computer Graphics
Participation Exercise 6

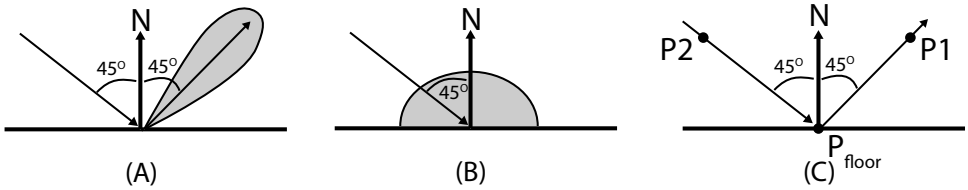
Problem 1: Miscellaneous Short Problems

A. Which image do you think will be compressed to a smaller file size using JPG compression? Please describe why. Your explanation should reference the state of the coefficient matrix after the quantization step. What properties of each image make one more compressible than the other?

A

B

B. Imagine an interesting surface that reflects wavelengths that appear red to humans like a skuffed mirror, as shown in distribution (A) below. But the surface reflects light in wavelengths that appear green and blue **equally in all directions** as illustrated by distribution (B). Be careful, the magnitude of the amount of reflection matters in this problem, so pay attention to the scale of the amount of reflection in the two diagrams.



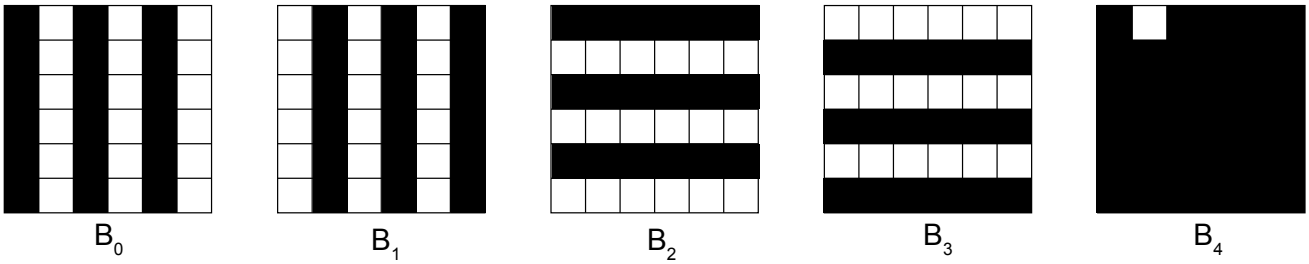
You are standing in a room with the floor made of this surface, with white light (equal power in all wavelengths) shining on the floor from a 45 degree angle as shown in the figure. Describe what color the floor will look when viewing the point P_{floor} on the floor from point $P1$ in figure (C). Also describe the appearance of the floor from point $P2$. Briefly justify your answer.

C. Give one reason why color representations that explicitly separate the luminance (brightness) and chroma components of a color (e.g., Y'CbCr or hue-saturation-brightness (HSB)) can be useful representations compared to RGB.

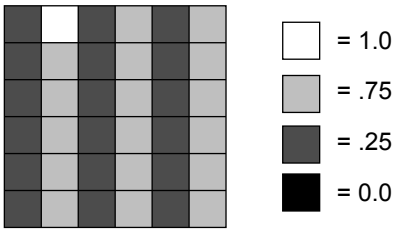
D. Describe the biological reason why, even though a spectrum may contain power over all wavelengths, human perception of color is only three-dimensional. We'd like to see the phrase "response function" in your answer.

Problem 2: A Weird Compression Scheme

In class we talked about how JPG compression represents 8×8 pixel image patches in the 2D *cosine basis*. Now consider a very different image representation scheme that represents 6×6 pixel patches in terms of a linear combination of these five base patches.



A. Consider representing the following 6×6 image in terms of the base patches above. What are the coefficients of the image under this representation? Explain why, **for the specific case of this image**, we have devised a very efficient image compression scheme. (Hint: what is the size of the 6×6 image in the pixel basis? What about the size of the representation in terms of the image patches above?)



B. Although the compression scheme in part A can be very efficient for some images, the problem with the scheme is that is cannot accurately represent all 6×6 images. Draw one example of an image that cannot be represented as a combination of the provided "basis" images.

Problem 3: More Short Problems (THIS PROBLEM IS OPTIONAL AND NOT REQUIRED FOR PARTICIPATION CREDIT)

A. To celebrate the upcoming end of the quarter and you decide to hold a party on Zoom! You call your party "yellow light night", and ask all your friends to set up the room they are calling in from to be illuminated in yellow light (recall yellow is a mixure of red and green primaries). Your friend, who is in a glum mood, says, "I find it hard to party because I'm so sad that CS248 is over! I wish I could wear black to show off my feelings, but I only have red shirts and blue shirts to choose from." You tell your friend, "Oh you can still look like you are wearing black!" Which shirt to you advise your friend to wear, and why?

B. Consider the compressing the image below using the JPG compression scheme as discussed in class. Please point to one region of the image that should compress extremely well using JPG compression. Point to one region of the image that JPG should struggle to compress well (by well, I mean retaining high accuracy while significantly reducing the amount of information that must be retained.) In both cases please explain why the region does or does not compress well?

C. Imagine if all three types of cone cells in your eye had *the same spectral response function*. If this were the case, would you have color vision (the ability to differentiate different colors)? Why or why not?

D. You are asked to implement an auto-exposure algorithm for the new iPhone. Your input is a grayscale image with 14-bit pixel values (in the range 0 to $2^{14} - 1$). You need to output 8-bit pixel values in the range 0 to $2^8 - 1$. You already know from class that it's efficient to run the input values through a non-linear function (like $f(x) \propto x^{.45}$) prior to saving to the 8-bit image.

But in addition to compressing the dynamic range you wanted to implement a setting where you simulate an *under-exposed* photograph. In other words, you need to spread the top 50% of measured intensity values over the range of values representable by 8-bit numbers, clipping the bottom 50% to black. On the figure below, sketch a function that meets the exposure constraint AND also makes efficient use of all representable output values.