Exercises: Image Filtering & Subsampling

The following tasks can be implemented in MATLAB.

1. Consider the following 2D filter mask:

\[
h = \frac{1}{256} \begin{bmatrix}
1 & 4 & 6 & 4 & 1 \\
4 & 16 & 24 & 16 & 4 \\
6 & 24 & 36 & 24 & 6 \\
4 & 16 & 24 & 16 & 4 \\
1 & 4 & 6 & 4 & 1
\end{bmatrix}
\]

(a) Show that \( h \) is a separable filter.
(b) Is the filter \( h \) a High Pass Filter or a Low Pass Filter? Justify your decision.
(c) Consider the following 2D filter mask:

\[
h = \begin{bmatrix}
0 & 1 & 0 \\
1 & -4 & 1 \\
0 & 1 & 0
\end{bmatrix}
\]

Why can not this be a low pass filter?

2. Download the sample picture from the homepage

\[\text{http://r0k.us/graphics/kodak/kodim08.html}\]

(a) Read the image and convert it into the \( YCbCr \) color space.
(b) Develop and implement a way to filter an image according to the filter \( h \) by two simpler filtering steps. Think about how you can handle the pixels at the image border to avoid visible side effects.
   i. **Luma vs. Chroma**
      For the given sample, filter the Luma channel \( Y \) and combine it with the unfiltered Chroma channels. Then, filter the Chroma channels \( Cb \) and \( Cr \) and combine them with the unfiltered Luma channel. Can you see a difference?
   ii. **Subsampling vs. No Subsampling**
      For the given sample, take the unfiltered original and the result from above with the filtered Chroma channels. For both, subsample the Chroma channels \( Cb \) and \( Cr \) by omitting every second row and column respectively. Compare your results with the original.

Hint: You may use existing functions, e.g. `rgb2ycbcr`, `imfilter`, `downsample`, `transpose`, `kron` in MATLAB: For calculating, convert your image matrix into double. To display the images resize the subsampled chroma parts, convert the image back to RGB and then to uint8.
3. Repeat Exercise 2 for the artificial checkerboard image $I$ as defined in the following code:

```matlab
A = ones(8);
B = [1 1 1 0 0; 1 1 1 0 0; 1 1 1 0 0; 0 0 0 1 1; 0 0 0 1 1; 0 0 0 1 1];
checkerboard = kron(A,B);
I = 0.9*checkerboard;
I(:, :, 2) = 0.7*checkerboard;
I(:, :, 3) = 0.3*checkerboard;
I = uint8(I*255);
```