LAB 6: DE1-SOC CAMERA SYSTEM AND VGA DISPLAY, PART II

I. Introduction
This lab is an extension of Lab 5 with additional image-processing steps beyond what Lab 5 included.

II. Real-Time Image Processing Functions
Implement the following video processing functions, or filters, on the stream of pixels coming from the camera and displayed the VGA monitor in real-time following the same instructions as given in Lab 5.

1. [15 pts] Grayscale conversion with properly-weighted RGB components
   Luminance = 0.2126 red + 0.7152 green + 0.0722 blue
   Use these coefficients instead of the ones given in lecture.
   Implement so that you can easily switch between this mode and the Grayscale mode in Lab 5, problem 3, and compare the two.

2. [30 pts] Contrast
   Using SW switches and appropriate saturation logic, enable four contrast levels: lower contrast, normal, higher contrast, and much higher contrast.

3. [55 pts] Horizontal left-sided blur
   As described in lecture, implement a hardware horizontal blurring filter using the following equation:
   \[ \text{pixel\_out} = \frac{\text{current\_pixel} + \text{SUM(last } N-1 \text{ pixels in the row})}{N} \]
   To remember the last \( N-1 \) pixels, build a pixel buffer with 16 24-bit registers (for RGB data) to support the following values of \( N \):
   a) \( N = 4 \)
   b) \( N = 16 \)
   Pipeline the large \( N-1 \)-input adder if needed to achieve an operating frequency of 50 MHz. Each pipeline register will shift pixels to the right by one pixel; this small shifting is ok.
   Take care to initialize the pixel buffer at the beginning of each row to show something reasonable when there is no pixel history to the left of the screen.