Important: This is an open book test. You can use any books, notes, or paper, but not exchange anything with other students. You are not allowed to use any electronic/communication devices, including a calculator. *Do not log into the computer during the test. Switch off your cell phones.* Any calculations and rough work can be done on the back side of the test pages. You will lose five points for not writing your name.

1. [6 pt] Briefly describe the role of image processing in angiography. How does angiography differ from a CAT scan?

2. [6 pt] The median, ζ, of a set of numbers is such that half the values in the set are below ζ and the other half are above it. For example, the median of the set of values $\{2, 3, 8, 20, 21, 25, 31\}$ is 20. Show that an operator that computes the median of a subimage area, S, is nonlinear. Recall that a function is linear if it can be described by $O(n)$.

3. [6+4 pt] Consider two 8-bit images whose intensity levels span the full range [0,255].

   (a) Discuss the limiting effect of repeatedly subtracting image (2) from image (1). Assume that the result is represented also in eight bits.

   (b) Would reversing the order of the images yield a different result?

4. [5+5 pt] Computing histograms

   (a) What effect would setting to zero the lower-order bit planes have on the histogram of an image in general?

   (b) What would be the effect on the histogram if we set to zero the higher-order bit-planes instead?

5. [10 pt] Suppose that a digital image is subjected to histogram equalization. Show that a second pass of histogram equlization (on the histogram-equalized image) will produce exactly the same results as the first pass.