## Homework \#2

## Due 2:20pm EST, Wednesday, Feb. 7

1. The median $\zeta$, of a set of numbers is such that half the values in the set are below $\zeta$, and the other half are above it. For example, the median of the set of values $\{12,3,8,20,21,75,31\}$ is 20 . Show that an operator that computes the median of a subimage area, S , is nonlinear. (10pts)
Hints: an operator $H$ is linear if $H\left[a_{1} f_{1}(x, y)+a_{2} f_{2}(x, y)\right]=a_{1} H\left[f_{1}(x, y)\right]+a_{2} H\left[f_{2}(x, y)\right]$
2. Image subtraction is used often in industrial applications for detecting missing components in product assembly. The approach is to store a "golden" image that corresponds to a correct assembly; this image is then subtracted from incoming images of the same product. Ideally, the differences would be zero if the new products are assembled correctly. Difference images for products with missing components would be nonzero in the area where they differ from the golden image. What conditions do you think have to be met in practice for this method to work? You need to list at least two major factors that affect the detection performance. (20 pts)
3. Suppose that a digital image is subjected to histogram equalization. Show that a second pass of histogram equalization (on the histogram-equalized image- will produce exactly the same result as the first pass? ( 20 pts )
4. Suppose that a 4-bit image $(\mathrm{L}=16)$ of size $64 * 64$ has the intensity distribution as Table A. It is desired to transform the original histogram to a specified histogram as shown in Table B. What will be the actual histogram after the histogram matching operation? ( 30 pts )

| $r_{k}$ | $n_{k}$ | $Z_{q}$ | $n_{q}$ |
| ---: | ---: | ---: | ---: |
| 0 | 16 | 0 | 64 |
| 1 | 0 | 1 | 128 |
| 2 | 512 | 2 | 512 |
| 3 | 32 | 3 | 512 |
| 4 | 64 | 4 | 1024 |
| 5 | 128 | 5 | 1024 |
| 6 | 64 | 6 | 512 |
| 7 | 1024 | 7 | 128 |
| 8 | 512 | 8 | 128 |
| 9 | 512 | 9 | 64 |
| 10 | 16 | 10 | 0 |
| 11 | 1024 | 11 | 0 |
| 12 | 0 | 12 | 0 |
| 13 | 128 | 13 | 0 |
| 14 | 0 | 14 | 0 |
| 15 | 64 | 15 | 0 |
| Table A | Table B |  |  |

5. An image with intensities in the range [0,L-1] has the pdf $p_{r}(r)$ shown in Figure (a). It is desired to transform the intensity levels of this image so that they will have the specified pdf $p_{z}(z)$ as shown in Figure (b). Assume continuous quantities and find the transformation $z=f(r)$ that will accomplish this. ( 20 pts )

(a)

(b)
