# HW3, Problem 3.7. EECS 203A. UCI. Fall 2004

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When performing any of these arithmetic operations on the images, we do it pixel by pixel. i.e. when we add image $f$ to image $g$ we are adding the gray level at pixel $i$ image $f$ to the gray level at pixel $i$ in image $g$. In all these case I assume the images are of the same size.

This problem gave a very hard time. At first I thought that we need to put conditions on the probability distribution of gray levels in each image. But even if $p_f$ and $p_g$ are both uniform, I can not say that the probability distribution of image $f+g$ will be uniform. So I am putting conditions instead on the image itself

(a) $\boldsymbol{f+g}$: It is possible to find histogram of $f+g$ in terms of $h_g$ and $h_f$ under any one of these conditions:

1. $f=g$ (i.e two images are same size and same gray level)
Steps to find histogram $h_{f+g}$ for this condition:
For each peak in $h_g$ at gray level $i$ move it to the right to gray level $2i$
The result is $h_{f+g}$

2. $f$ is a binary image (2 gray levels only), and $g$ is the binary inverse image of $f$ (i.e. if pixel $i$ is 0 in image $f$ then the same pixel $i$ is 1 in image $g$)
Steps to find histogram $h_{f+g}$ for this condition:
$h_{f+g}$ will have one peak, at gray level 1 that is twice as large (twice the frequency) as peak of gray level 1 (or 0) in $h_g$ (or $h_f$)

3. $g=N\times f$ where $N$ is some integer. i.e. the images differ from each others only by the intensity level. i.e $h_g$ peaks are shifted to the right version of $h_f$ peaks and the peaks in $h_g$ are spread out.
Steps to find histogram $h_{f+g}$ for this condition:
Starting from left to right in $h_f$, number each peak. Call this number $n=1..K$ where $K$ is the total number of peaks.
Both $h_g$ and $h_f$ will have the same $K$ but will be located at different gray levels.
Then For each peak $n$ in $h_f$, with gray level $h_f(n)$ add a new peak in $h_{f+g}$ with same height (frequency) as peak $n$, but at a gray level of $h_f(n)+N\,h_f(n)$

(b) $\boldsymbol{f-g}$ This case is the same as case (a), since we can let $g'=-g$ and then consider $f+g'$, where $g'$ is the negative of image $g$

(c) $\boldsymbol{f\times g}$ It is possible to find histogram of $f+g$ in terms of $h_g$ and $h_f$ under any one of these conditions:

1. $f=g$ (i.e two images are same size and same gray level)**.**
To build the histogram $h_{f+g}$ do:
Starting from left to right in $h_f$, number each peak. Call this number $n=1..K$ where $K$ is the number of peaks.
Both $h_g$ and $h_f$ will have the same $K$ since the same image.
Then For each peak $n$ in $h_f$, with gray level $h_f(n)$ build a new peak in $h_{f+g}$ with same height (frequency) as peak $n$, but at

gray level shifted to the right to new gray level of $h_f(n) \times h_f(n)$

2. $f$ is a binary image (2 gray levels only), and $g$ is the binary inverse image of $f$ (i.e. if pixel $i$ is 0 in image $f$ then the same pixel $i$ is 1 in image $g$) .
Then histogram $h_{f+g}$ will be one peak at gray level 0 (all black image)

(d) $\boldsymbol{f \div g}$ It is possible to find histogram of $f + g$ in terms of $h_g$ and $h_f$ under any one of these conditions:

1. $f = g$ (i.e two images are same size and same gray level)**.**
The histogram $h_{f+g}$ in this case will be all at one gray level 1. (All black) (Assuming black is at gray level 1.)
If Black is at gray level 0 and white at 255, then it is not possible to divide any 2 images with each others since we will get a divide by zero error.

2. Can not divide binary images (assuming we assign 0 and 1 for the gray level)