# DIP (E4830)
# Assignment 4                                               Due: 3/14/08

Note:
*For questions or problems contact Prof. Ebadollahi (shahram@ee.columbia.edu) or the TA (wl2223@columbia.edu)
*Please provide a well-documented copy of your code (MATLAB or any other language of your choice) for the questions that ask you to perform operations on images.
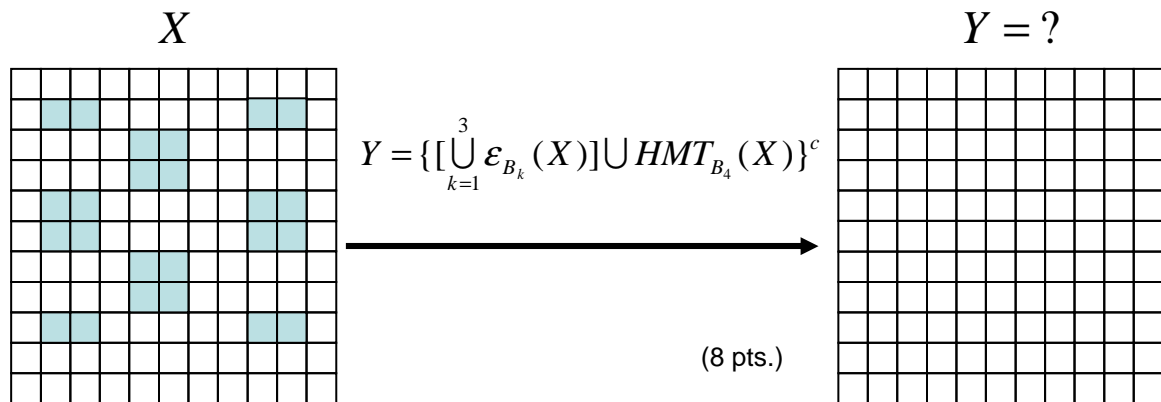*This homework has 20 bonus points.

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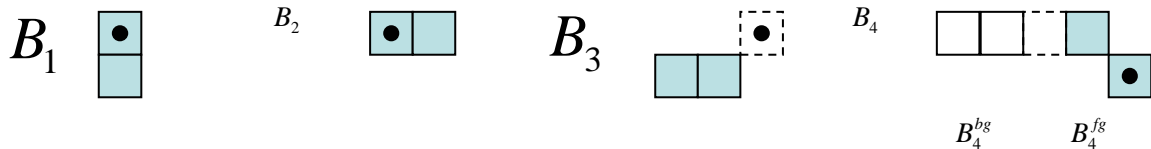
Question 1) [20 pts.]
Solve problem 9.5 of Gonzalez and Wood's textbook. For each of the four cases, report the structuring element and the morphological operation used.
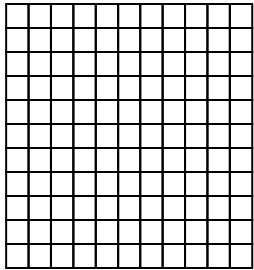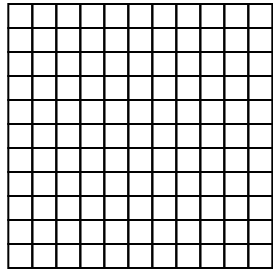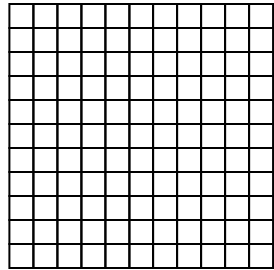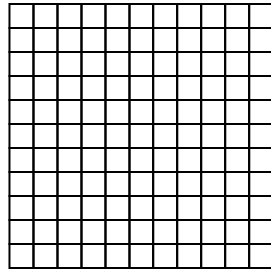
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Question 2) [40 pts.]
Given the binary image X and the four structuring elements {$B_1$, $B_2$, $B_3$, $B_4$} obtain the processed image Y, where Y is defined as the union of four versions of processed X: eroded by $B_1$, $B_2$, and $B_3$, and Hit-or-Miss Transformed by $B_4$, respectively. Use the provided grids for your intermediate answers. Note that the dot in the structuring elements stands for the center of the structuring elements; $B_3$ has its center outside of the structure element, and $B_4$ has a gap of one pixel in between its foreground and background element.



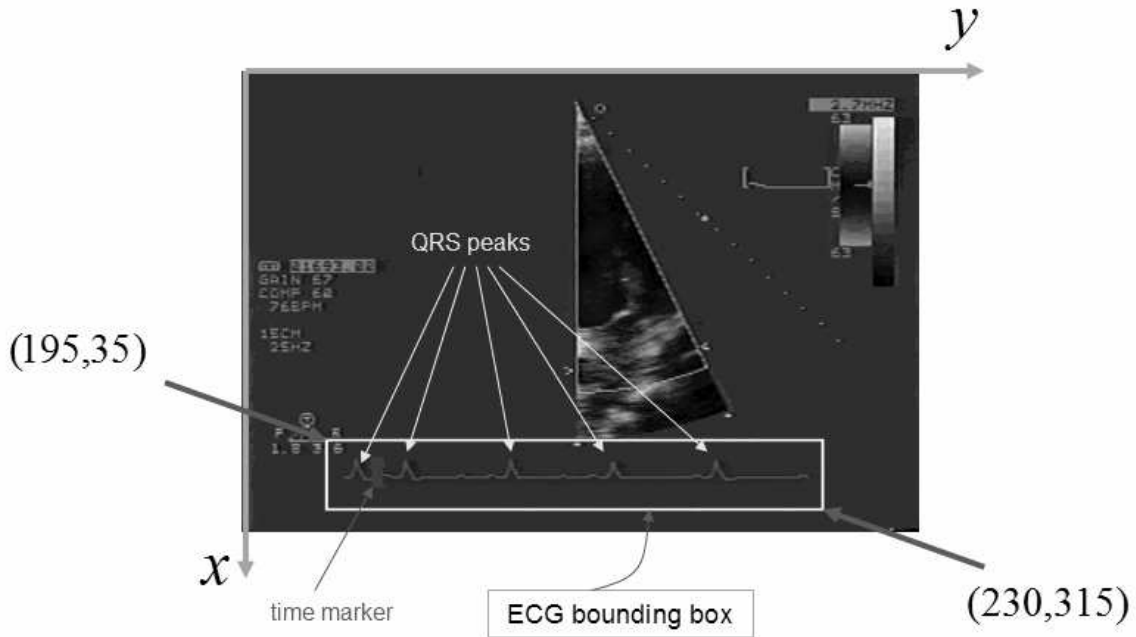$$X \qquad\qquad\qquad\qquad\qquad\qquad\qquad Y = ?$$

$$Y = \{[\bigcup_{k=1}^{3} \varepsilon_{B_k}(X)] \bigcup HMT_{B_4}(X)\}^c$$

(8 pts.)

The following are the "Structuring Elements":



$B_1$        $B_2$        $B_3$        $B_4$

$B_4^{bg}$        $B_4^{fg}$

$$\mathcal{E}_{B_1}(X) \qquad \mathcal{E}_{B_2}(X) \qquad \mathcal{E}_{B_3}(X) \qquad HMT_{B_4}(X)$$

(6 pts.)        (6 pts.)        (10 pts.)        (10 pts.)

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Question 3) [Implementation – 60 pts.]
A sequence of echocardiogram images is provided (echocardiogram.zip available on courseworks). This sequence contains 3 heart beats. At the bottom of each frame you can see the image of an ECG embedded in the frame (see figure). The ECG signal provides the timing information to the cardiologist examining the echocardiogram video, i.e. it roughly shows the boundaries of the different phases of cardiac operation. In this experiment our goal is to characterize the ECG and to extract "key-frames" from the image sequence.



1- [10 pts.] Take the first image in the sequence, extract the box including the ECG and segment the image into foreground (ECG signal) and background. The coordinates of the opposite corners of the box are given in the above figure. For

segmentation, use simple thresholding of the content of the box. Use the histogram of the gray-level image inside the box to obtain an appropriate threshold. Please report the following: (a) [4pts] histogram of the content of the ECG box, (b) [2pts] threshold value for segmentation, (c) [4pts] resulting binary image showing ECG as the foreground.

2- [20 pts.] Develop appropriate morphological filter to extract the "time marker" (rectangular structure that moves from left to right, shown with the arrow in the figure) and apply it to the first image in the sequence. Report the following: (a) [5pts] structuring element you've used, (b) [10 pts] morphological operations you've applied to extract the time marker, (c) [5 pts] image of the time marker and the coordinates of the location of its center of mass relative to the upper-left corner of the white ECG box.

3- [20 pts.] Develop appropriate morphological filter to extract the "QRS peaks" and apply it to the first image in the sequence (note: figure above displays 5 QRS peaks). Report the following: (a) [5pts] structuring element that you use for the subsequent morphological operations, (b) [10pts] morphological operations for locating the QRS peaks using the structuring element in part (a), (c) [5pts] image of the QRS peaks and the coordinates of their center of mass relative to the upper-left corner of the white ECG box. To choose the right structuring element for detecting the QRS peaks, look at the form of those peaks and decide what should be the size and form of the structuring element that you can choose to detect the QRS peak structures.

4- [10 pts.] Now that you are able to process a single frame using the filters that you have developed, apply the algorithm to every image in the sequence. Graph the count of QRS peaks to the left of the time marker vs. the frame number. Report the index of the frames when there is an increase in the count. At those frames heart is at its most expanded state and usually such frames are good points in time to extract a representative frame from the echocardiogram videos.

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