

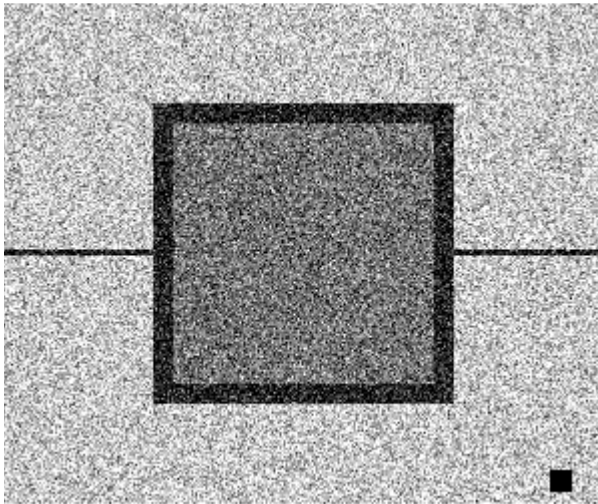
**Midterm Exam**

*Instructions: Answer all questions in the bluebook provided. Open book, notes.*

1. When the image on the left below was filtered using a smoothing filter, the result was the image on the right. The filter used was one of these: 1. Averaging filter; 2. rotating mask averaging filter; 3. Gaussian filter; 4. Median filter. The small black square on the lower right hand corner of the original image shows the size of the mask that was used, that small square is not part of the image.

(a) For each of the four possible filters, give at least one reason why you think it was, or was not, the filter actually used. Note that the mask is the same size as the thickness of the dark border around the square, and twice the thickness of the dark lines on either side of the square.

(b) If the same type of filter you selected in (a) was used but its mask reduced to only half the number of rows and half the number of columns of the mask in (a), how would the appearance of the image after filtering be changed?



Original image. Note: the small black square on the lower right shows the size of the mask, it is not part of the image.

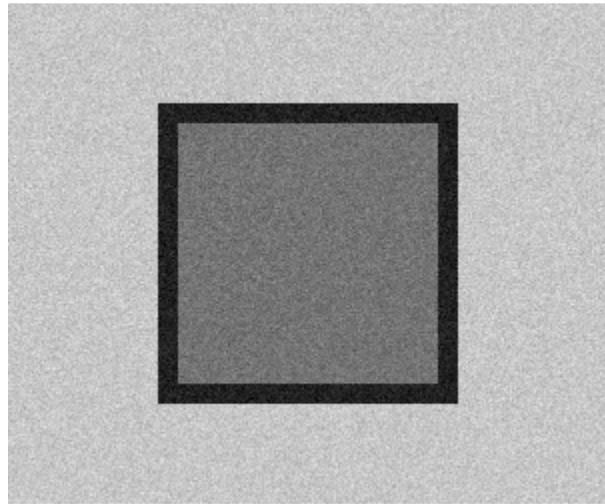
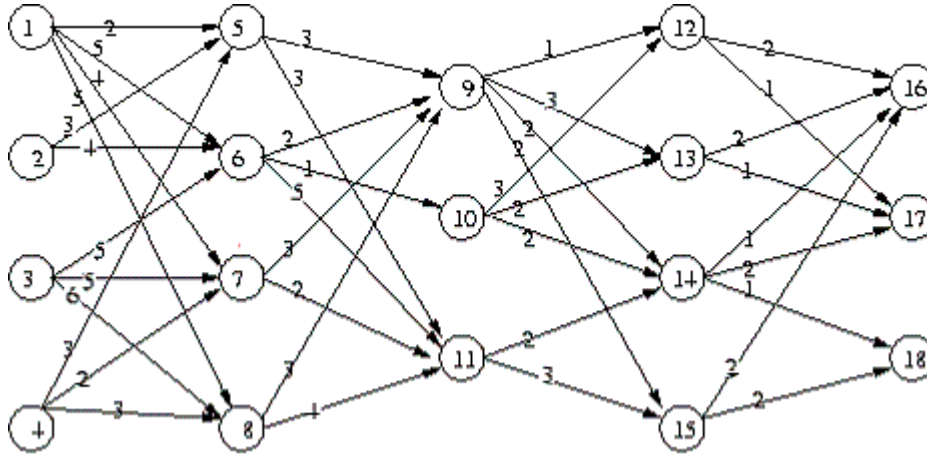
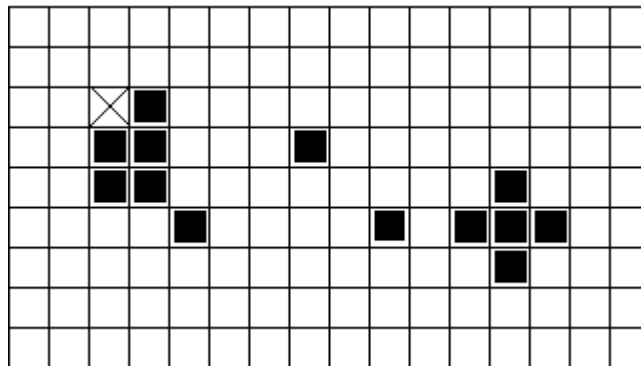


Image after filtering

2. Find the minimum cost path using dynamic programming. The branch costs are shown along each link. Your path must start from one of nodes 1-4, and end at either node 16 or 17. If two or more paths are tied for the minimum, specify all such paths. Show your work.



3. (a) The image X shown below contains four separate 8-connected blobs. Find the smallest structuring element B so that the image  $X(+)\text{B}$  (ie. X dilated by B) consists of just a single 8-connected blob. Smallest means least number of pixels in B. Express B as a set of pixels in  $Z \times Z$ .



*Image X for problem 3(a)*

(b) Let B be the structuring element shown below. Give an example of any image X which, when opened using B, is unchanged, ie the opening of X using this B is just X itself. Then generalizing, state a set of necessary and sufficient conditions on an arbitrary image X for the opening of X using the B below to be just X itself.



*Structuring element B for problem 3(b)*