Advanced Image Processing

Final Exam.

Student No.: 　 　　　　 Name: 　　 　　　 109/12

1. 是非題(T/F test) (30%)

( ) 1. If degradation is systematic (有條理的), it can be suppressed (抑制) by brightness correction. The brightness correction method can be used only if the image degradation process is stable.

( ) 2. The aim of histogram equalization is to create an image with equally distributed brightness levels over the whole brightness scale.

( ) 3. If the area of the image is invariant under a geometric transformation, then its Jacobia determinant J = 1.

( ) 4. Gray-scale transformations depend on the position of the pixel in the image.

( ) 5. The bilinear transformation includes typical geometric transformations such as rotation and translation, but not scaling.

( ) 6. The position error of nearest-neighborhood brightness interpolation is at least half a pixel.

( ) 7. Image smoothing uses redundancy in image data to suppress noise, usually by some form of averaging of brightness values in some neighborhood.

( ) 8. “Averaging according to inverse gradient” is a linear method that avoids edge blurring.

( ) 9. Median filter is a nonlinear smoothing method.

( ) 10. The edge direction is rotated with respect to the gradient direction by .

( ) 11. The Prewitt operator approximates the first derivative. The gradient is estimated in eight (for a  convolution mask) possible directions, and the convolution result of largest magnitude indicates the gradient direction.

( ) 12. Zero-crossings is an edge detection technique using the first derivative.

( ) 13. The definition of Laplacian of Gaussian (LoG) operator is the difference of two Gaussian averaging masks with substantially different variance.

( ) 14. The one response criterion of edge detector indicates that the important edges should not be missed.

( ) 15. The Laplacian operator for edge detection has the same properties in all directions and is therefore invariant to rotation.

( ) 16. Non-maximal suppression is an edge thinning technique.

( ) 17. Edge detectors based on parametric models describe edges more precisely than convolution-based edge detectors. However, their computational requirements are much higher.

( ) 18. Edge can be enhanced by high-pass frequency-domain filtering and noise can be suppressed by low-pass frequency-domain filtering.

( ) 19. Otsu’s algorithm is one kind of optimal thresholding.

( ) 20. Let  be the cut-off frequency coincides with the dispersion ,  be an isotropic (等向的) filter (for example, ), then the Fourier spectrum of the filter  is a high-pass Gaussian filter.

( ) 21. The high-pass filter is created easily from the low-pass filter. If the Fourier frequency spectrum of a low-pass filter is , the high-pass filter can be created by just flipping it vertically .

( ) 22. A corner in an image can be defined as a pixel in whose immediate neighborhood there are two dominant, different edge directions.

( ) 23. Homomorphic filtering is used to remove multiplicative noise.

( ) 24. In Harris corner detector, let  and  be the eigenvalues of the Harris matrix A, a corner has been found if both eigenvalues are small.

( ) 25. Invariance to monotonic transformations is one property of maximally stable extremal Regions (MSERs).

( ) 26. A complete segmentation of an image  is a finite set of regions , where , and

( ) 27. -tile thresholding method uses a prior information to choose a threshold such that of the image area has gray values less than .

( ) 28. The Hough transform was designed to detect straight lines and curves. However, this approach is very sensitive to imperfect data or noise.

( ) 29. Homogeneity (同質性) is an important property of regions. Let be the total number of regions in an image, and be a binary homogeneity evaluation of the region , the criteria for homogeneity can be defined as , and

( ) 30. Region splitting is the opposite of region merging. Region splitting begins with each pixel represented as a single region.

1. 簡答證明題(assay question)
2. (2%) Here shows an edge detection mask, what is the value of *a*?

ANS:

1. (2%) Here shows a smoothing mask, what is the value of *b*?

ANS:

1. (2%) What kind of objects can be detected by the following masks?



ANS:

1. (6%) (a) How to remove the salt-and-pepper noises?

(b) How to remove the periodic (周期性的) noises?

(c) How to remove Gaussian noises?

ANS:

1. (3%) Compare with region merging, region splitting does not result in the same segmentation even if the same homogeneity criteria are used. Why?

ANS:

1. (2%) Hough transform is a very powerful technique for detection. What is the main problem of Hough transform?

ANS:

1. (4%) Corners is one kind of interest points for the correspondence problem.   
   (a) (2%) What is a corner? (please give the definition of a corner)  
   (b) (2%) Corners serves better than edges (lines) when the correspondence problem is to be solved because of the aperture problem (孔徑問題). What is the aperture problem?

ANS:

1. (2%) The following image is one example of corrupted (篡改;塗改) image. How to remove this kind of noise?

1. (4%) What is the meanings of the difference of Gaussian? Can you give an application which can use the convolution masks of the difference of Gaussian?

ANS:

1. (4%) Zero-crossings is an edge detection technique. What is zero-crossings? What is the main advantages of zero-crossings?

ANS:

1. (2%) Three most common brightness interpolation methods are nearest neighbor, linear and bi-cubic. Please explain the nearest neighbor interpolation method.

ANS:

1. (3%) Please explain what the hysteresis (滯後作用) approach used by Canny edge detection is.

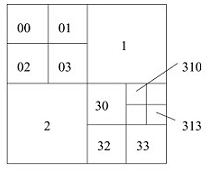
ANS:

1. (2%) A straight line can be represented by the equation with two the parameters and . Why this equation is not suitable to represent a straight line in Hough transforms?

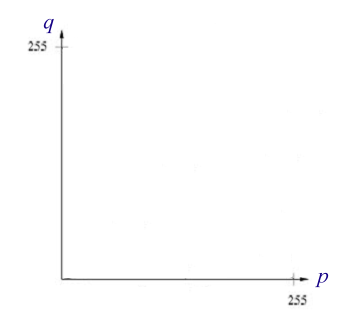
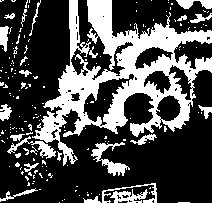
ANS:

1. (4%) (a) (2%) Please draw the corresponding quadtree of the following image.

(b) (2%) What is the **drawback** of segmentation quadtree?

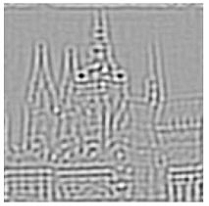


1. (2%) A transformation  of original brightness  from scale  into brightness  from a new scale  is given by . Given an original image as Figure (a), can you draw the transformation  if the output image is (b)?

1. original image Function *T* (b) output image
2. (4%) (1) (2%) Figure (a) shows the original image, and Figure (b) shows the filtered image. What kind of filters is used in the frequency domain? Low-pass filters? High-pass filters? Band-pass filters? Or homomorphic filtering? ANS:

(2) (2%) If the filtered image is shown in Figure (c), then what kind of the filters is used in the frequency domain? ANS:

(a) (b) (c)

1. (4%) Here shows Otsu’s threshold detection algorithm, please fill in the blanks.

**Algorithm 6.2 Otsu’s threshold detection**

1. For an image  on  gray levels, compute the gray-level histogram . Normalize the histogram by dividing through by the number of pixels in –the histogram now represents the probability of each gray level.

2. For each possible threshold partition the histogram into background  (gray-levels less than or equal to ), and foreground  (gray-levels more than ).

3. Compute , , the variance of the background and foreground gray-levels. Compute the probability of a pixel being background

 and  similarly. Set



and select as threshold  .

1. (3%) Here shows a histogram equalization algorithm, please fill in the blanks.

**Algorithm 5.1 Histogram equalization**

1. For an  image of  gray-levels, initialize an array  of length  to 0.

2. From the image histogram: Scan every pixel  – if it has intensity , perform



Then let  be the minimum  for which .

3. Form the cumulative image histogram :



 ,

Let .

4. Set



5. Rescan the image and write an output image with gray-levels , setting



1. (4%) Given a 2D Gaussian filter



where  is the standard deviation. Please derive , and the Laplacian of Gaussian . ( PS. )

1. (2%) A geometric transform is a vector function  that maps the pixel  to a new position . , where ,. The geometric transform can be approximated by an affine transform.

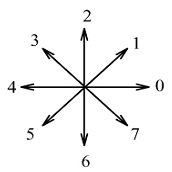
A Jacobia determinant  can provides information about how the co-ordinate system changes.

Please show the Jacobia determinant for the transform.

1. (6%) Given an inner boundary tracing algorithm as follows.

**Algorithm: Inner boundary tracing in 8-connectivity**

1. Search the image from top left until a pixel  of a new region is found; this has the minimum column value of all pixels of that region having the minimum row value.  is a starting pixel of the region border.

Define a variable  which stores the direction of the previous move along the border from the previous border element to the current border elements. Assign   
 if the border is detected in 8-connectivity.

2. Search the  neighborhood of the current pixel in   
an anti-clockwise direction, beginning the neighborhood   
search in the pixel positioned in the direction

 if  is even. (8-connectivity)

 if  is odd. (8-connectivity)

The first pixel found with the same value as the current  
pixel is a new boundary element . Update the  value.

3. If the current boundary element  is equal to the second border element , and if the previous border element  is equal to , stop. Otherwise repeat step 2.

4. Pixels  are now the detected inner border.

**Questions:**

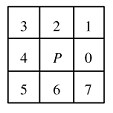
1. (2%) What are the values at *P*1and *P*2?

ANS:

1. (4%) What is the starting search pixel after *P*1and *P*2? Please mark them in the image.

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|  |  |  |  |  |  |  |  | *P*2 |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  | *P*1 |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |

1. (3%) Here define four kind of inner boundary pixels of a region :

If denote outside the region , then pixel is

a LEFT pixel of if

a RIGHT pixel of if

an UPPER pixel of if

a LOWER pixel of if

For example, denotes the pixel immediately to the left of pixel .

Let represent the corresponding subsets of . How to define the extended boundary ?

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