Computer Vision I – Sample Solutions for Final Examination

1. **Number of shortest paths: p 282**

   1. The total number of minimal length paths from a pixel (i,j) to another pixel (k,l). It can be accomplished by using Dijikstra's algorithm.

   2. A neighborhood operator defined by Rosenfeld and Pfaltz which must be applied iteratively to count for each 0-pixel the number of shortest paths to the set that is represented as the binary-1 pixel on a binary image.

2. **Nonmaximum: p284**

   A pixel whose value is the minimum of its neighborhood and that has one neighboring pixel with a value greater than its own.

$$
\begin{aligned}
&\text{Let } a_0 = b_0 = x_0 \text{ and define} \\
&a_n = \min\{a_{n-1}, x_0\} \\
&b_n = \min\{b_{n-1}, x_0\} \\
&n = 1,2,3,4 \\
&\text{nonmaximun}: a_4 = x_0 < b_4
\end{aligned}
$$

3. **Reachability operator: p290**

   1. This operator consist of the decending rechability operator and the ascending reachability operator. The operator works by successively propagating labels from all neighboring pixels that can reach the given pixel by monotonic paths.

   2. An operator determining that is a pixel (i,j) reachable from another pixel (k,l) through some means, i.e., gradient levels, intensity slope…

4. **Distributor over sum:**

   The distributive property of addition.

5. **Correlation: p291**

   A operator dual of convolution.

$$
(f \otimes w)(r,c) = \sum_{\substack{(a,b)\in W \\ (r+a,c+b)\in F}} f(r+a,c+b)w(a,b)
$$

   where W is the kernel and F is the original signal/image.

6. **Noise cleaning: p303**

   Using neighborhood special coherence and neighborhood pixel value homogeneity as its basis for removing noise data. The noise data is replaced by some spacial coherent data or smoothed according to the neighborhood data.

7. **Box filter: p304**

   1. The operator that computes the equally weighted average. It is ease to make and executes quickly.

2. A neighborhood operator which has the shape of a rectangle.

8. Outlier or peak noise: p316

1. The value of the pixel at this position is simply replaced by a random noise value typically having little to do with the underlying pixel's value.

2. A pixel that has a value awkwardly different from its neighbors.

9. Smooth replacement:

1. Replacing a pixel value according to the mean/average of is neighbors.

2. $z = \dfrac{\left|\dfrac{y-\hat{u}}{\hat{\delta}}\right|}{\left|\dfrac{y-\hat{u}}{\hat{\delta}}\right|+K}\hat{u} + \dfrac{K}{\left|\dfrac{y-\hat{u}}{\hat{\delta}}\right|+K}y$

where z is the output pixel consisting of a convex combination of y, the input pixel and the neighborhood mean.

10. k-nearest neighbor average: p317

All the pixel values in the neighborhood are compared with the central pixel value. The k-closest pixel values are used for determining the final value, in this case, the average of these k pixels.

11. Order statistic neighborhood operator: p318

Taking a linear combination of the sorted values of all the niegborhood pixel values $x_1, x_2, \ldots x_N$ into $x_{(1)}, x_{(2)}, \ldots x_{(N)}$ and taking a linear combination of these sorted values. Hence, order statistic operator produces an output value z for the position of the center of the neighborhood that is defined by using:

$$z = \sum_{n=1}^{N} w_n x_{(n)}$$

12. Median root: p319

Repeatedly applying a median filtering operation to a 1-dimentional signal must produce a result that is unchanged by further median filtering operations. This fixed-point results is the median root.

13. Interquartile distance: p. 320

Defined as $Q = X_{\frac{3N+2}{4}} - X_{\frac{N+2}{4}}$, used for truncating values of the extreme.

14. Sobel edge detector: p339.

A gradient edge detector using the following kernels:

$$\begin{bmatrix} -1 & -2 & -1 \\ & & \\ 1 & 2 & 1 \end{bmatrix} \begin{bmatrix} -1 & & 1 \\ -2 & & 2 \\ -1 & & 1 \end{bmatrix}$$

15. **Facet model: p371**

Images can be thought of as an underlying continuum or piecewise continuous gray level intensity surface, which includes piecewise constant (flat facet model, piecewise linear (sloped facet model), piecewise quadratic and piecewise cubic.

16. **Zero-crossing edge detector: p346**

The nonmaxima suppression can be incorporated into and made an integral part of the edge operator. The place where the first derivative of the step is maximum is exactly the place where the second derivative of the step has a zero crossing.

17. **Discrete orthogonal polynomial: p393**

A basis set of size *N* has polynomials from degree 0 to *N-1*. Sometimes called the Chebyshev polynomials.

Define $P_0(r) = 1$ and suppose $P_0(r), P_1(r), ..., P_{n=1}(r)$ has been defined.

$$P_n(r) = r^n + a_{n-1}r^{n-1} + ... + a_1 r + a_o$$

$P_n(r)$ must be orthogonal to each polynomial $P_0(r), P_1(r), ..., P_{n=1}(r)$, and thus we have the *n* equations:

$$\sum_{r \in R} P_k(r)(r^n + a_{n-1}r^{n-1} + ... + a_1 r + a_o) = 0, \text{ where } k = 0,1,...,n-1$$

18. **Directional derivative edge finder: p396**

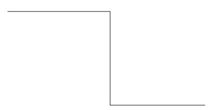
The operator that places an edge in all pixels having a negatively sloped zero crossing of the second directional derivative taken in the direction of the gradient.

19. **Polar coordinates:**

A transformation of the (x,y) or (x,y,z) Cartesian coordinate system into a form using r and θ, ($r\sin\theta$,$r\cos\theta$) and ($r\sin\theta$,$r\cos\theta$,z) respectively.

20. **Step edge:**

Edges having the following looks:



21 **Corner points: p562**

1. The endpoints of arcs subsequences.
2. As commonly defined, i.e., of a rectangle.

22. **Peak: p433**

A peak/knob occurs where there is a local maximum in all directions.

$\|\nabla f\| = 0, \lambda_1 < 0, \lambda_2 < 0$

23. Ravine: p435

A ravine occurs on a ravine line, a curve consisting of a series of ravine points. The points to the left and right of the ravine line are higher than the ravine points on the ravine line.

A ravine is identical to a ridge except that it is a local minimum in one direction.

$\|\nabla f\| \neq 0, \lambda_1 > 0, \nabla f \bullet \omega^{(1)} = 0$ or

$\|\nabla f\| \neq 0, \lambda_2 > 0, \nabla f \bullet \omega^{(2)} = 0$ or

$\|\nabla f\| = 0, \lambda_1 < 0, \lambda_2 = 0$ or $\|\nabla f\| = 0, \lambda_1 = 0, \lambda_2 < 0$

24. Texture: p453

1. A repetitive pattern occurring in an image.
2. Listing some measurement/properties in Chap. 9.

25. Generative model: p482.

A approach of generation of synthetic texture images, i.e., fractals.

26. Texture segmentation: p481.

Splitting the images so that each region has a homogeneous texture, such as that arising from a frontal view, and that each pair of adjacent regions is differently textured.

27. Autocorrelation function: p464

1. Correlating the image with itself to find textures.
2. Mathematically defined as:

$$p(x,y) = \frac{\dfrac{1}{(L_x - |x|)(L_y - |y|)} \int \int_{-\infty}^{\infty} I(u,v) I(u+x, v+y) dudv}{\dfrac{1}{L_x L_y} \int \int_{-\infty}^{\infty} I^2(u,v) dudv}, |x| < L_x \text{ and } |y| < L_y$$

where *I(u,v)* is the transmission of an image transparency at position *(u,v,)* [0,L_x] to [0,L_y] is a rectangular region and *(x,y)* is the translation amount.

28. Edgeness per unit area: p469

#of edges per unit area (or window).

Used to detect textures.

29. Mosaic model: p480

Consists of 2 steps: first tessellating a plane into cells and then assigns a property vale to each cell. (mosaic – blocks/cells)

30. Coarseness: p457.

The variance inside of of the texture, whether large or small. Coarse texture has small variance and the distribution changes only slightly with distance.

31. Granulation: p474

1. The size of the grains in the texture, whether large of small.

2. Define by $G(d) = 1 - \frac{\#F \circ H_d}{\#F}$

32. Vector dispersion: p470.

In this technique, the image texture is divided into mutually exclusive neighborhoods, and a sloped plane fit to the gray levels is performed for each neighborhood. A normal vector is calculated for each of the planes.

33. Boundaries simple: p509

Boundaries of each segment must not be ragged and must be spatially accurate.

34. Clustering: p510

1. In pattern recognition, it is the process of partitioning a set of pattern vectors into subsets.

2. Grouping items with similar properties together into a subset.

35. Recursive histogram-directed spatial clustering: p516,518

Define a mask selecting all pixels on the image. Given any mask, a histogram of the masked image is computed. Measurement-space clustering enables the separation of one mode of the histogram set from another mode. Pixels on the image are then identified with the cluster to which they belong. If there is only one measurement-space cluster, then the mask is terminated. If there is more than one cluster, then each connected component of all pixels with the same cluster in used to generate a mask in turn that is placed on a mask stack. During successive iterations the next mask in the stack selects pixels in the histogram computation process. This process is repeated for each new mask until the stack is empty.

36. Edge detection by a threshold:

a

37. Average contrst of all edges detected by the threshold: p521

Given by $\frac{C(T)}{\#E(T)}$ where

$C(T) = \sum_{[(i,j)(k,l)] \in E(T)} \min\{|I(i,j) - T|, |I(k,l) - T|\}$ and

$E(T) = \{[(i,j),(k,l)] \mid \text{pixels } (i,j)(k,l) \text{ are neighbors or}$
$\min\{I(i,j), I(k,l)\} \le T < \max\{I(i,j), I(k,l)\}\}$

38. Forward-looking infra red: p522

FLIR image, a type of image obtained by cameras that uses the infra red channel

39. Spatial reduntdancy:

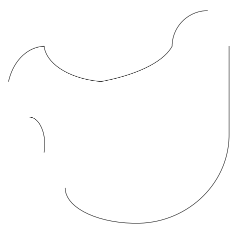
Excessive space used, usually before data compression.

40. Centroid-linkage region growing: p532

Image is scanned in some predetermined manner. Pixel value is compared with the mean of an already existing but not necessarily completed neighboring segment. If the value and the segment's mean value are close enough, then the pixel is added to this segment and the segment's mean value is recomputed. If means of 2 segments are close enough, then the 2 segments are merged. The mean value is also recomputed. If no neighboring region has a close-enough mean value, then a new segment is established having the given pixel's value as its first member.

41. Edge gap results in excessive merging: p527

A region cannot be declared a segment unless it is completely surrounded by edge pixels. Edge image with gaps in the edges that can cause problems in a segmentation performed by taking connected components of nonedge pixels.



42. Global method: handout 11.1

Global methods incorporates domain knowledge into cost function, are more robust to noisy data, but has a relatively high computation cost.

43. Noisy edge data:

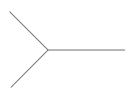
A edge image containing excessive noise, usually resulting from unsuitable detectors and threshold values.

44. Border-tracking algorithm: p556

An algorithm that follows the border of a segmented image to extract boundary pixels.

45. Junction:

Point where lines, arcs, segments meet.

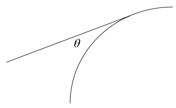


46. Simple arc segment: p563

Arcs segment that is a straight line segment or one that is a curved-arc segment containing no straight-line segments.

47. Tangential angle deflection: p565

Segmentation of an arc sequence by identifying the locations where two line segments meet and form an angle.



48. Uniform bounded-error approximation: p569

Segmenting the arc sequence into maximal pieces whose points deviate from a line-segment fit by no more than a given amount (bounded-error).

49. Breakpoint optimization: p571

Shifting the breakpoints of the arc sequence to produce a better arc segmentation. Repetitively do the following until no improvement:

Shift the odd number points and see if the maximum error is reduced, if yes then keep the shift, otherwise try shifting the even number points.

50. Hyperbola:

A type of formulation in the conic section. It produces 2 mirror-image parabolas (curves).