Answers:

- Assuming the size of kernel is 3x3

  A. After median filter

167	170	93	183
178	178	162	162
184	190	183	162
190	190	162	129

  B. After threshold T=165

0	255	0	255	0	0
255	255	255	0	0	255
255	0	0	255	255	255
255	255	255	0	0	0
0	255	255	0	255	0
255	0	255	0	0	255

  C. Connected components after labelling operation on (B)

Assuming the traversing inclusive of all 8 adjacent directions.

0	1	0	1	0	0
1	1	1	0	0	1
1	0	0	1	1	1
1	1	1	0	0	0
0	1	1	0	2	0
1	0	1	0	0	2

  D. Erosion with custom structuring element on (B)

0	0	0	0	0	0
0	255	0	0	0	0
0	0	0	0	255	0
0	255	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

2.

- Store global mapping of texton as key, colour as value. Map each unique texton to a new random or selected colour. Map<texton, colour>.
- Plot out the textons in a scatter plot, dx and dy. Apply clustering algorithm for each clusters, then assign a colour to each of those clusters. If the texton belongs to that cluster, apply the colour to that texton.
- For each texton split them into R,G,B channels, then take the histogram of that texton, average the histogram of R,G,B. Then merge and apply the colour into (avgR, avgG, avgB) for that texton.

3.

a) Image 1 and Image 2 (elephant and the buffalo) are the most similar in-terms of chi squared distance which is 0.5, as compared with 2 other longer distance which are 1.5 and 2.

For the steps I used to get the answer, refer to my working draft down below.

b)

1. Chi squared distance can return negative values, as compare to Euclidean distance which does not return negative values.

2. Absolute value of chi of image 1 and image 2, and absolute value chi of image 2 and image 1 are the same. |x^2(img2, img1)| == |x^2(img1, img2)|, where Euclidean distance based on histogram of image 2 and image 1 will give the same result as image 1 and image 2.

3. Chi formula only allows use of 2 comparison, where Euclidean distance allow you to have more than 2 comparison with more than 2 different dimensions.

$$\text{2D: } distance = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$
$$\text{3D: } distance = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

Steps:

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1a) Assuming the size of kernel is 3X3

After filter:

167	170	193	183
178	178	162	162
184	190	183	162
196	190	162	129

select idx = 9/2 = 4

row 1, col 1 = 65, 76, 85, 88, $\boxed{167}$, 169, 170, 178, 182 → 167

row 1, col 2 = 65, 76, 88, 93, $\boxed{170}$, 178, 196, 237

row 1, col 3 = 36, 65, 69, 88, $\boxed{193}$, ~~182~~, 183, 196, 237

row 1, col 4 = 36, 69, 93, 147, $\boxed{183}$, 196, 199, 201, 237

row 2, col 1 = 65, 76, 167, 169, $\boxed{178}$, 182, 184, 203, 222

row 2, col 2 = 65, 76, 93, 162, $\boxed{178}$, 182, 196, 203, 222

row 2, col 3 = 36, 65, 93, 161, $\boxed{162}$, ~~182~~, 183, 196, 222

row 2, col 4 = 36, 77, 93, 161, $\boxed{162}$, 183, 196, 199, 201

row 3, col 1 = 65, 76, 157, 167, 184

row 3, col 2 = 65, 76, 129, 162, 190

row 3, col 3 = 65, 129, 161, 162, 183

row 3, col 4 = 25, 77, 129, 161, 162

row 4, col 1 = 131, 157, 173, 184, 190

row 4, col 2 = 100, 129, 131, 162, 190

row 4, col 3 = 52, 100, 129, 161, 162

row 4, col 4 = 25, 52, 77, 100, 124

b) After threshold $\boxed{T=165}$

0	255	0	255	0	0
255	255	255	0	0	255
255	0	0	255	255	255
255	255	255	0	0	0
0	255	255	0	255	0
255	0	255	0	0	255

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c) Assuming the traversing algorithm for connected components inclusive of all 8 adjacent directions.

0	1	0	1	0	0
1	1	1	0	0	1
1	0	0	1	1	1
1	1	1	0	0	0
0	1	1	0	2	0
1	0	1	0	0	2

d)

0	0	0	0	0	0
0	255	0	0	0	0
0	0	0	0	255	0
0	255	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

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3a) $I1 = 8, 5, 3, 0, 3, 4.$
$I2 = 6, 5, 4, 1, 1, 5$
$I3 = 5, 0, 4, 2, 3, 5.$

k from 1 to 6

$$\chi^2(I1, I2) = \frac{1}{2}\sum_{k=1}^{6} \frac{[I1(k) - I2(k)]^2}{I1(k) - I2(k)}$$

$I1(k) - I2(k) = 2, 0, -1, -1, 2, -1.$

$$= \frac{1}{2}\left(\frac{4}{2} + \frac{0}{0.001} + \left(\frac{1}{-1}\right) + \left(\frac{1}{-1}\right) + \left(\frac{4}{2}\right) + \left(\frac{1}{-1}\right)\right)$$

very small number. $= 0.$

$$= \frac{1}{2}(2 - 1 - 1 + 2 - 1) = 0.5.$$

k from 1 to 6.

$$\chi^2(I1, I3) = \frac{1}{2}\left(\frac{9}{3} + \frac{25}{5} - \frac{1}{1} - \frac{4}{2} + \frac{0}{0.0001} - \frac{1}{1}\right)$$

$I1(k) - I3(k) = 3, 5, -1, -2, 0, -1.$

small number.

$$= \frac{1}{2}(3 + 5 - 1 - 2 - 1) = 2.$$

$$\chi^2(I2, I1) = \frac{1}{2}\left(-\frac{4}{2} + \frac{0}{0.0001} + 1 + 1 - 2 + 1\right).$$

$I2(k) - I1(k)$ k from 1 to 6.
$= -2, 0, 1, 1, -2, 1.$

very small num

$$= \frac{1}{2}(-2 + 0 + 1 + 1 - 2 + 1) = -0.5$$

$I2(k) - I3(k)$ k from 1 to 6.
$= 1, 5, 0, -1 -2, 0.$

$$\chi^2(I2, I3) = \frac{1}{2}(1 + 5 + 0 - 1 - 2 + 0)$$
$$= 1.5.$$

$I3(k) - I1(k)$ k from 1 to 6.
$= -3, -5, 1, 2, 0, 1$

$$\chi^2(I3, I1) = \frac{1}{2}(-3 - 5 + 1 + 2 + 0 + 1)$$
$$= -2$$

$I3(k) - I2(k)$ k from 1 to 6.
$= -1, -5, 0, 1, 2, 0.$

$$\chi^2(I3, I2) = \frac{1}{2}(-1 - 5 + 0 + 1 + 2 + 0)$$
$$= \frac{1}{2}(-3) = -1.5.$$

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b) Image 1 and Image 2 are the most similar images. because they have least difference values.

b)

b) 1. can only compare two histograms, unlike euclidean distance where you can add more dimensions. to the equation.

2. Chi can have negative values and euclidean distance cannot have negative values.

3. Absolute difference of chi of histogram 1 and 2 will return the same difference. As compared to difference of histogram 2 and 1.

$|\chi^2(I1, I2)| = |\chi^2(I2, I1)|$.

Euclidean difference of histogram 1 and 2 will give same result as histogram 2 and 1.