Exercises, Part II, Intelligent Multimedia Systems

Master AI, 2009

Exercise 1. Edge Classification

Edge classification is used to detect and classify transitions based on their physical nature. One possible transition type is a shadow one. An example is shown in Figure 1 where the R, G and B values of a small image are as follows:

R=G=B=

20	20	40	40
20	20	40	40
20	20	40	40

Figure 1 *The R, G and B values of a small image containing a shadow transition.*

a) Compute the derivative, of the image in Figure 1, in the x-direction by the use of a simple differential filter [-1 1]. The origin is the left pixel.
b) Compute the normalized red (r) response of the image.
c) Calculate the derivative in the x-direction for r.
d) How can you classify the transition to be of a shadow type?
e) With the same procedure, could you distinguish shadow edges from geometry edges? Please explain.
f) With the same procedure, how can highlights be classified? Do you need more than two color features? Which ones?
g) Edge classification can be used as a pre-process for image/video retrieval. What are the remaining steps?
h) For image and video retrieval, do you prefer to use local descriptors or global descriptors? Explain why.

Exercise 2. Color Constancy

Color constancy is an important issue when recognizing an object independent of the color of the light source. Two simple color constancy algorithms are based on the white patch assumption and the grey-world hypothesis. The R, G and B channels of a small image are as follows:

R=

120	120	120
120	120	120
180	180	180

G=

70	80	70
70	70	80
80	230	70

B=

100	50	30
90	220	20
150	120	80

Figure 2 *The R, G and B channels of a small image.*

a) Give an example of an image for which the white patch method will fail. Please explain.
b) Explain in words how these color constancy methods work.
c) Calculate the results of both algorithms for the image shown in Figure 2.
d) What is the grey-edge assumption?
e) Give an example of an image when the grey-edge assumption does not hold.
f) What are natural image statistics and how can they be used for color constancy?

Exercise 3. Error propagation

Color invariants become unstable for certain imaging conditions. One way to handle instabilities is by error propagation. Consider a pixel having the following values R=20, G=40, B=60 with σ=4.

a) Show that intensity I=R+G+B is a color feature which is stable.
b) Show that the color feature 1/R becomes unstable when the intensity is decreasing.
c) Under which circumstances do you think that normalized color and hue will become unstable?
d) How can error propagation be used for histogram construction for image retrieval? Please explain.

Exercise 4. Boolean and extended Boolean queries

a) Consider the Boolean query (A AND B) OR (A AND C). Show that this query is the Disjunctive Normal Form (DNF) is of A AND (B OR C) and therefore logical equivalent.
b) Show that the set of document that are found with (A AND B) OR (A AND C) differ from the set (A OR B) AND (A OR C)
c) Consider the following sets:

A = {1,4,5,10,11,15,17,18,19,23}

B = {1,2,4,5,7,8,10,13,17,22}

Take the absolute value as a measure of difference (distance) between two numbers. Compute the set corresponding to the following expression:

A0.8 OR B0.4

where 0.8 and 0.4 are the weights of the symbols.

Exercise 5. Retrieval Effectiveness Measures

Given are two different image retrieval systems with the following characteristics. Firstly, the image database consists of 1000 images. The number of relevant images with respect to a given query is 10 composed of the following set (A, B, C, D, E, F, G, H, I, J). The number of images shown to the user is 15 (Answer Set). Further, the order of the 15 highest ranked images of the two different image retrieval systems (for the same image query) is as follows:

System 1		System 2
1.	A	1. K
2.	L	2. A
3.	B	3. M

4.	N	4. N
5.	O	5. O
6.	P	6. B
7.	Q	7. Q
8.	C	8. R
9.	S	9. S
10.	T	10. T
11.	D	11. C
12.	V	12. V
13.	W	13. W
14.	X	14. X
15.	Y	15. D

a) Calculate the precision and recall.
b) Compute the precision-recall graph for the two different image retrieval systems.
c) Compute the R-Precision.
d) Compute the R-precision histograms.

Exercise 6. Relevance Feedback

Assume the following initial query and its corresponding feature weights Q0 = (0.3, 0.7, 0.7, 0.1). Then, two relevant images are selected by the user on input after the first search session, with the following feature weights R1 = (0.4, 0.6, 0.8, 0.2) and R2 = (0.6, 0.2, 0.9, 0.5).

a) What is the new search query Q1 based on the positive feedback strategy (i.e. mean)?
b) What is the new search query Q1 based on the median-oriented feedback strategy?
c) Which strategy is, according to you, better and why?

Exercise 7. Tracking

Tracking people is important for various applications. One technique is the mean shift algorithm based on color histograms

a. What is mean shift and how does it work?
b. When the movement of the object is rather large between two consecutive frames, what would happen?
c. Which color space would you select for tracking in the context of player tracking in football videos?
d. And for people tracking in railway stations?
e. What will happen when the appearance of the object (person) changes over time?
f. Could you solve this? Please explain how.