Exam Computer Vision Master AI

17 December, 2009

Question 1 (8 points)

a – 2p) A sphere is illuminated by a point light source. What is the general shape of the cast shadow on a plane behind the sphere?

b – 3p) Suppose a uniform lambertian sphere, observed from a fixed viewpoint. Given n images of the sphere with varying (known) illumination source vectors, how can the sphere's surface normal be computed at pixel location (x,y)? Give the formulas and explain.

c – 1p) Consider the same setup as in a). Where is the brightest region? Where is the darkest region?

d – 2p) Suppose the sphere has a rough surface texture. Reason about the brightest and darkest regions.

Question 2 (5 points)

a – 2p) Show all computations involved in convolving the image

0	9	0
27	9	0
9	9	81

with a smoothing average filter of size 3x3. All elements outside the image may be considered 0.

Note: - the filter does not include on empty borders.
- the filter is normalized.

b – 3p) The output of the filter's dynamic range is compressed by applying the transformation $o' = a \log o$, o being the filter's output, a being a parameter of the range compressor. After the transformation, the output is projected on a screen with intensity i depending on the output o' by $i = \exp o'$.

Is the whole system a linear system? If not, is there a circumstance under which it becomes so?

Question 3 (11 points)

Given a Gaussian (like) filter $G(x;\sigma) = \exp(-\pi \frac{x^2}{\sigma^2})$

a – 6p) Proof that convolution with two consecutive filters $G(x;\sigma_1)$ and $G(x;\sigma_2)$ is equivalent to filtering once with $\sigma = \sqrt{\sigma_1^2 + \sigma_2^2}$ up to a normalization.

Make use of the following functions and their fourier transforms:

Function	Fourier transform
$\exp(-\pi(x^2 + y^2))$	$\exp(-\pi(u^2 + v^2))$
$f(ax, by)$	$\frac{1}{\quad} F(\frac{u}{\quad}, \frac{v}{\quad})$

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estion 4 (8 points)

4p) What kind of information does a Gabor filter select from an image? Put your answer in context of Fourier analysis. Use no more that four lines.

4p) How could you use a Gabor filter to extend a Laplacian pyramid? What woul this add? Use no more than five lines.

estion 5 (8 points)

Explain the ordering constraints in binocular fusion. You may draw examples. Al explain the direction of points on objects in the foreground and the background w respect to the object of focus.

estion 6 (12 points)

4p) What are the advantages and disadvantages of the Hough transform?

8p) Describe the steps involved in line fitting using RANSAC.

estion 7 (8 points)

Describe an EM algorithm that segments an image into two clusters of intensities

stion 8 (14 points)

4p) Clearly explain the three main problems involved in tracking posed as an abs inference problem.

10p) Give a Kalman filter which describes the dynamic model of an apple falling from a tree.

estion 9 (8 points)

4p) Describe the process by which ambiguity is introduced in object pose estimati using affine or projective camera models.

4p) Discuss model based vision with respect to appearance based vision. Use no m than ten lines.

uestion 10 (8 points)

Draw a schematic representation of a support vector machine.