NTNU
Norges teknisk-naturvitenskapelige universitet

Fakultet for informasjonsteknologi, matematikk og elektroteknikk

Institutt for datateknikk og informasjonsvitenskap

EXAMINATION IN SIF8043 IMAGE TECHNIQUES
THURSDAY MAY 15, 2002
TIME 09:00 – 14:00

Contact persons during examination:

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Permitted facilities:

No printed nor hand written material.
Specific simple calculator permitted.

Examination results to be announced on:

June 5

Answer all 7 problems. Total maximum score is 800 points.

A piece of advice: Read all of the examination paper before starting answering. Thus you may improve your chances for efficient time utilisation and at the same time you may have more questions for the professors when they come on their rounds.

PROBLEM 1 Graphics – Geometric transformations (160 points)

Reflection is a geometric transformation that "pictures" a point symmetrically about a point, a line or a plane.

A line in space (3D) is given. The line goes through the points P_0 and P_1. Work out the transformation that reflects an arbitrary point P_r about this line.

Concatenating the matrices representing the part transformation is not required.

PROBLEM 2 Graphics - Projections (160 points)

a) Work out the matrix for perspective projection in the plane y = 0 when the projection centre is on the negative y-axis at the distance d from the origin.

b) A cube has the corners:

(0, 15, 0)
(5, 15, 0)
(5, 15, 5)
(0, 15, 5)
(0, 20, 0)
(5, 20, 0)
(5, 20, 5)
(0, 20, 5)

Calculate the projection of the cube as specified in part problem a). Consider the way the cube is situated. Make the calculations as simple as possible. Use the value d = 5.

c) Move the projection centre to the origin and let the plane y = 5 be the projection plane. The cube is moved. Work out the projection matrix for this situation, and calculate the projection of the cube in the new plane.

d) Are the projections in part problems a), b) and c) one-point, two-point or three-point perspective projections? Explain your answer.

PROBLEM 3 Graphics – Line clipping (80 points)

Explain and write down Cohen-Sutherlands algorithm for line clipping in 2D.

PROBLEM 4 Image processing – Image processing systems (80 points)

a) Draw a labelled block diagram showing the organisation of the hardware of an image processing work station.

b) Draw a diagram that shows a sequence of steps needed to extract information for the recognition of the shapes of objects that are dark on a light background.

c) A colour image that is 256*256 pixels, and has three planes of byte sized pixels, is to be transmitted along a parallel data path that is 8 bits wide. If the maximum capacity of the path is 100k bytes per second, what is the minimum time to transfer the image?

d) What numerical data type is required for Fourier transform calculations?

OPPGAVE 5 Image processing - Transform methods (120 points)

a) Give a definition of the one dimensional discrete Fourier transform of a function f(x) taken over N points, x=0 to x=N-1.

b) Prove that the discrete Fourier transform of a function, f(x), taken over N points, x=0 to x=N-1, is periodic with period N.

c) A two dimensional image function, f(x,y), x=0 to x=127 and y=0 to y=127, is given by

$$f(x,y) = 100 + 50 \sin(\text{PI } x/8) \cos(\text{PI } x/32).$$

What will be the coordinates of the peaks in the power spectrum when |F(u,v)| is plotted in u, v space?

d) State the sampling theorem.

e) Give a mathematical statement of the convolution theorem.

OPPGAVE 6 Image processing – Segmentation (120 points)

a) Define the morphological operations of erosion and dilation, and opening and closing in black-and-white images.

b) State two methods of emphasising edges in an image.

c) What is a 4-connected region?

d) Draw a diagram to show the decomposition of an image as a quad-tree and indicate a systematic labelling of the components.

e) Write pseudo-code for a procedure that extracts regions by the 'split and merge method' using a quad tree.

OPPGAVE 7 Image processing - Representation and recognition (80 points)

a) Define the Fourier descriptor of a shape.

b) To what extent do regions in an image represent geometrical surfaces of an object?

c) Draw a detailed diagram that shows the structure of a neural net and sketch a typical activation function.