NTNU
Institutt for datateknikk
og informasjonsvitenskap

EXAMINATION IN
TDT4195 IMAGE TECHNIQUES
WEDNESDAY JUNE 2, 2010
TIME 09:00 – 13:00

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Permitted facilities – code D:
No printed nor hand written material permitted.
Specified simple calculator permitted.

Examination results to be announced on: June 23

Answer all the six themes. Total maximum score is 440 points.

- Read all of the examination paper before starting answering. Thus you may improve your chances for efficient time utilization and at the same time you may have more questions for the professors when they come on their rounds.
- Give short and precise answers.
- The questions of the part problems may most often be answered independently of each other.
- If you think the problem is insufficiently explained it may be wise to make assumptions. Possible assumptions have to be explained.

THEME 1 Graphics – Viewing (70 points)

We have a model in the world coordinate system. The axis of the world coordinate system are *x, y* and *z*. The camera coordinate system has axis *u*, *v* and *n*. The origin of the camera coordinate system is (x_c, y_c, z_c) in the world coordinate system. The unit vectors along the *u* axis and the *n* axis referred to the world coordinate system are $(0, 0, -1)$ and $(\frac{1}{2}\sqrt{3}, \frac{1}{2}, 0)$ respectively.

a) Find the matrix for converting world coordinates to camera coordinates and give the numerical values of the matrix elements.
(30 points)

b) The view-plane is perpendicular to the *n* axis of the camera coordinate system. The view-plane cuts the axis at the point $(0, 0, -d), d > 0$. Find the view matrix for perspective projection with the origin of the camera coordinate system as the projection centre. The matrix is to be used for camera coordinates resulting in camera coordinates.
(20 points)

c) The view-plane is as described in point b). An object point has world coordinates (x_p, y_p, z_p). Find expressions to compute the image of the object point in camera coordinates as well as in world coordinates. The expressions are should not be concatenated.
(20 points)

THEME 2 Graphics – Colours and light (70 points)

a) Answer the following questions on colours and colour systems. Give brief answers:
1. What is the physiological basis for the tristimulus system of colours?
2. What is a colour gamut?
3. What are the applications of the additive and the subtractive colour models respectively?
4. What is the difference between the RGBA model and the RGB model?
5. What is the difference between the CMYK model and the CMY model?

(20 points)

b) List up to five types of light sources that are used in computer graphics. Show how each of them can be modelled mathematically.
(30 points)

c) How is the reflection from a specular surface modelled in Phong's reflection model?
(20 points)

THEME 3 Graphics – Rasterization (80 points)

a) What is the basic idea behind Bresenham's algorithm for rasterization of a straight line? (20 points)

b) What are the outcodes of Cohen-Sutherland's algorithm used for and how are they used? (20 points)

c) Two tests for determining whether a point is inside or outside a polygon are the crossing (odd-even) test and the winding test. Describe each of the tests briefly and show an example that they may produce different results.
(20 points)

d) How does back-face removal work and how can this algorithm be useful together with other algorithms for determining visible surfaces?
(20 points)

THEME 4 Image processing – Basic concepts (80 points)

a) What is meant by the point spread function? Illustrate your answer with an informative sketch.
(20 points)

b) What quantisations are made when an image is captured?
(20 points)

c) What parameters of the image capture can be changed to improve the image's precision?
(20 points)

d) Draw a diagram that shows the steps in processing an image for the purpose of recognition.
(20 points)

THEME 5 Image processing – Region based methods (80 points)

a) What is meant by thresholding?
(20 points)

b) Name three methods of thresholding.
(20 points)

c) Give details of one method of thresholding and state what assumptions are made when the method is used for segmentation.
(20 points)

d) Define two different features that can be used to describe a region.
(20 points)

THEME 6 Image processing – Fourier domain methods (60 points)

Assume the definition of the 2D Fourier transform of image function $f(x, y)$ on a $N \times N$ grid of pixels yielding the frequency domain representation $F(u, v)$ is:

$$F(u,v) = \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} e^{-\frac{2\pi j(ux+vy)}{N}} f(x,y)$$

a) What assumption is made about $f(x, y)$ by using this definition?
(20 points)

b) The image function has its origin shifted to (x_0, y_0) becoming $f(x - x_0, y - y_0)$. Use the definition to determine the new transform in terms of $F(u, v)$. (Hint: this can be done in about 5 lines of working.)
(20 points)

c) How can low pass filtering be implemented by limiting the summation range in computing the inverse of $F(u, v)$? (Hint: Consider what the indices mean in terms of frequency. You could also think of the properties of the Fourier Descriptor used as a feature.)
(20 points)