**NTNU**
**Norges teknisk-naturvitenskapelige universitet**

**Fakultet for fysikk, informatikk og matematikk**

**Institutt for datateknikk og informasjonsvitenskap**

# EXAMINATION IN SIF8039 GRAPHICS, IMAGE PROCESSING AND HUMAN COMPUTER INTERACTION FRIDAY MAY 18, 2001 TIME 09:00 – 14:00

**Contact person during examination:**
Torbjørn Hallgren phone 93679

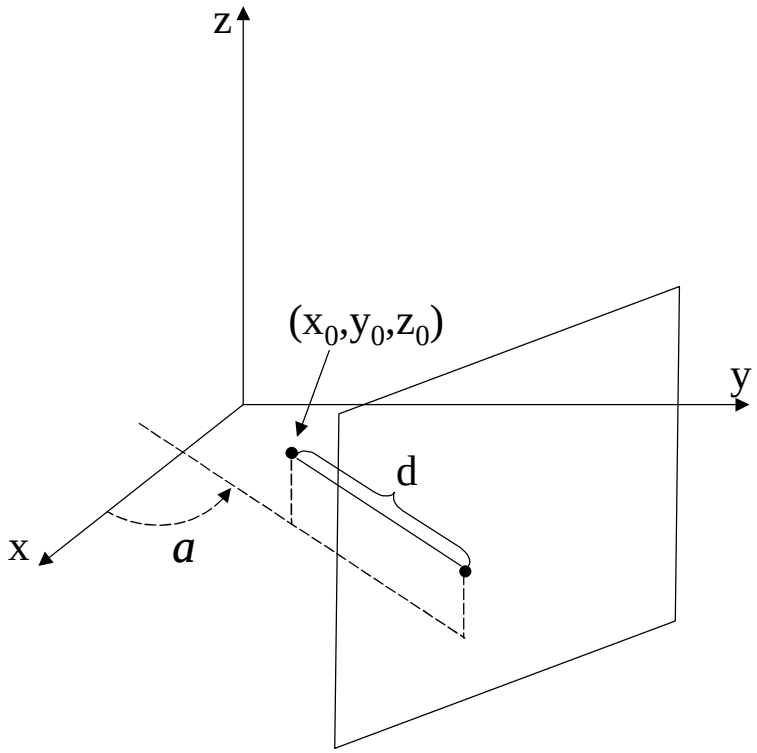
**Permitted facilities:**
No calculator.
No printed nor hand written material.

**Examination results to be announced on:**
June 8

Answer all five problems. Total maximum score is 300 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 professor when he comes on his round.

**Problem 1** **Graphics – projection and transformations** **( 50 points )**




Given av plane of projection that is perpendicular to the plane z=0 at a distance d from the projection centre $(x_0,y_0,z_0)$. The angle between the normal and the x-axis is $a$ .

Find the matrix that you have to use to compute the perspective projection on the plane given.

**Problem 2** **Graphics – line clipping** **( 50 points )**

Explain in detail one of the algorithms for line clopping. Choose between Cohen-Sutherland's algorithm of Liang-Barsky's algorithm for explanation.

**Problem 3 Image processing ( 50 points )**

a) The Fast Fourier Transform (FFT) is an algorithm which reduces the calculation of the 2D discrete Fourier Transform (FT) from order $O(N^4)$ to $O(N^2 \log N)$, where $N^2$ is the image size. What mathematical expression does the FFT calculate?

b) Give algorithms: for the 2D discrete convolution (folding) between image f(x,y) and mask h(x,y); and for the 2D discrete FT of f(x,y).

c) State the convolution theorem, and discuss it in relation with the concepts *ideal lowpass filter*, *fourier transform pair*, and "*ringing*".

d) How can highpass filtering be used in image analysis?

**Problem 4 Image processing ( 50 points )**

Solve only two of the following five problems:

a) For a feedforward neural net with backpropagation learning, derive the update rule for the weights in the output layer. (do not give algorithms)

b) Edge detection can be done by constructing a global model for the target objects. What advantages and limitations follow from using dynamic programming as the optimisation method? (do not give algorithms)

c) Derive the algorithm for homomorphic filtering of the image f(x,y) (assume f(x,y) = i(x,y) r(x,y), respectively the illumination and reflection components). Explain your assumptions.

d) Give a detailed algorithm for histogram equalization (including subalgorithms).

e) Give the algorithm for median filtering of an image and state when this method of filtering is appropriate.

**Problem 5 Human-Computer Interaction ( 100 points )**

a) Usability

I) Discuss the following statement: "Usability can be regarded as a property of an object. As such, usability is different from properties like weight and volume in that an object's usability can not be measured without reference to the object's context."

II) What are the consequences of the above statement for how usability should be measured? How is this perspective incorporated into the current methods for user-centred design?

b) Metaphors

I) Explain the concept "interface metaphor".

II) What are the pros and cons of applying an interface metaphor? What is the alternative?