Exam 040601 in Computer Assisted Image Analysis
(Datoriserad Bildanalys TF3 and Datoriserad Bildanalys MN1)

time: 14.00-19.00
place: Polacksbackens skrivsal
tools: calculator
grades:

OBS: Please use drawings and figures to illustrate your answers when suitable. You may write your answers in English or Swedish. I will come by and answer questions at 15.00.
Results will be posted outside the "civilingenjörs kansli" in house 4 at Polacksbacken. Please supply your e-mail address if you want your result mailed to you.

GOOD LUCK!
/ Carolina

1. Point processing

(5p)
You have a dark 4-bit image with the histogram to the right. Explain how the image can be enhanced by
a) Linear contrast enhancement. Describe the transform and draw the new histogram.
b) Histogram equalization. Describe the transform and draw the new histogram.
Be careful with labels and scales on the histogram. The range of the new histogram should be 4-bit, meaning [0 15].

2. Image compression (4p)
Image compression reduces redundancy. Describe two types of redundancy, and methods to reduce the respective types of redundancy without information loss.
3. Labeling  (3p)
Write an algorithm that labels 4-connected objects. How should the algorithm be adjusted for labeling of 8-connected objects?

4. Filtering and the Hough transform  (5p)
You want to analyze images of linear structures. After binarisation, the images look like the one to the right. Before measuring length and orientation, gaps in the lines should be removed.
   a) Describe a method for removing all gaps of ≤3 pixels.
   b) If gaps are varying in size, and lines overlap, the Hough transform is a useful method. Explain the method for detection of straight lines.

5. Image transforms  (4p)
The Fourier transform and the Wavelet transform are often used in image analysis. What transform would you chose in each of the situations below? Motivate your choice.
   a) You want to set up an image data base, where small, low resolution versions of the images can be viewed when searching.
   b) You have an image disturbed by periodic noise.
   c) Your computer is slow, and you need a way to speed up linear filtering of large images.

6. Shape descriptors  (4p)
   a) Calculate the chain code and shape number for the object to the right.
   b) Some binary image operations, such as removal of small protrusions, can be made directly on the chain code. What code sequences should be replaced to get a perfect rectangle as a result after filtering the object to the right?

7. Color image processing  (4p)
Support programs for digital cameras often provide methods for red-eye correction. Such methods are based on pixel-by-pixel classification followed by colour transformation. Red eyes often have the same shade of red, but vary in intensity and colour saturation. What colour space would you use for classification of red-eye pixels? Suggest a method for pixel-by-pixel classification allowing user interaction.
8. Morphological operations

(3p)

Jonatan and his mother take a walk to a lake and find lots of tadpoles (grodyngel). Jonatan wants to know how many there are, and his mother takes an image of the little animals with her digital camera. After thresholding, she can still not label and count them as they sometimes touch. What morphological operations do you suggest she should use? Illustrate the result on the image to the right.

9. System design

(8p)

Fish populations in the wild have to be observed for planning of fishing industry and wildlife protection. A common method is to catch fish in nets, count fish of different species and weigh them. This method is tedious and harmful to the fish. A research team in Scotland has designed a network of canals that fish go through when swimming up the rivers during mating season.

You are asked to design a camera and image analysis system that can be used for automatic observation of fish swimming by a 50x50 cm window in a canal (see illustration). The canals are very narrow (10 cm), so the fish will be close to the glass surface when passing by a window. A photo detector will trig the camera to take a picture just as the nose of a fish reaches the left side of the window. Fish that are small enough to pass through this canal can be assumed to be less than 50 cm long. The fully automatic image processing system should count the fish, measure length and width (which is assumed to be correlated with fish weight), and decide the fish species. Assume two types of fish: spotted and striped. Spots and stripes of interest are about 0.1-0.5 cm in width.

Please include in the description of your solution, the following steps:

1. Image acquisition, such as size of camera (512x512, 1024x1024, 2048x2048 pixels), choice of color of the backside of the canal, color or monochrome camera, image format…
   (2p)
2. Image enhancement and reduction of noise (e.g., pre-processing to ease segmentation…)
   (1p)
3. Segmentation
   (1p)
4. Object description and recognition
   (1p)
5. Classifying fish into spotted or striped species  
   (2p)

Don’t forget to explain the different hypotheses that come along with your solution.  
(1p)

Keep also in mind that the processing should be done without human interaction, and the fish should not be harmed by the imaging device.