LUNDS TEKNISKA HÖGSKOLA
MATEMATIK

TENTAMENSSKRIVNING
Image Analysis
2020 HOME EXAM

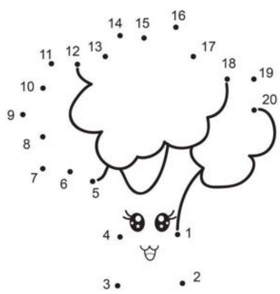
Home Exam

You may use any books and computer programs (e.g. Matlab and Maple), but it is not permitted to get help from other persons. It is ok to use existing implementations of known methods, but the methods used should be explained in detail. Note that since the exam is only for grade 3 to 5, the normal scale (3 points = grade 3, 4 points = grade 4 etc.) will **not** *necessarily be used.*
The exam should be uploaded via the Canvas homepage, at the latest
72 hours after pick up.
In a number of the problems there is additional data and images available in the file
`http://www2.maths.lth.se/matematiklth/personal/magnuso/gecs.zip`

1. In the file `longbeach.png` an image is given (also shown here to the right). In the processing of the image some errors have occurred. The colours have been much reduced and there are some stripes in the image. Try to remove the stripes and adjust the colours automatically.

2. An image of blood cells is given in the variable `blood.png`. Use methods from mathematical morphology (or some other method) to construct an algorithm that counts the number of cells in such an image.

3. In the file `dots.jpg` an image is given (also shown here to the right). Make the drawing complete by connecting the dots that have corresponding consecutive numbers with a line. Make your method as automatic as possible.



Please turn the page!

4. Assume that we are given a task of training a classification method. The input is 40×40 grayscale images, and we want to classify them into 10 classes. We are given $1,000$ training images (each of size 40×40). We will use the pixel values as features to input to our chosen method. We have three choices of models:

1. A Naïve Bayes classifier, where we assume that all input pixels are independent and that all classes are equally likely to occur in general, and that each class can be described with a multivariate Gaussian distribution.

2. A KNN-model with K=5.

3. A CNN-model with the following layers: Convolution layer with 3×3 kernel and 32 output channels, A RelU layer, a 2×2 Max pooling layer, a fully connected layer from $20 \times 20 \times 32$ input nodes to 10 output nodes, and finally a Softmax layer.

a) For each of the three models calculate how many parameters we need to find and store for the model.
b) For each of the three models describe the process of finding the parameters from the training data (in your own words, no formulas are needed).

5. Let

$$G_t(x, y) = \frac{1}{2\pi t} e^{-(x^2+y^2)/2t}$$

and $I(x, y)$ be an image (using the continous model).
a) Find an explicit expression of

$$h_a(x, y) = -\frac{1}{2} \int_a^\infty \Delta G_t(x, y) dt,$$

where Δ is the Laplace operator on (x, y) and $a > 0$.
b) Does

$$I_a(x, y) = I(x, y) * h_a(x, y)$$

define a scale-space representation of $I(x, y)$ with respect to the scale a (here $*$ denotes convolution)?
c) Simplify

$$\lim_{a \to 0} I_a(x, y).$$

6. In this problem the object is to use machine learning to do image processing. In the files `fruitoriginal_left.png` and `fruitlowres_left.png` two images are given of the same scene, but where the latter has much lower image resolution. Use this data to train some method that produces a full resolution image (4×4 upsampling) from the low resolution input. Note that even though there's only one ground truth image, one can look at many patches within an image. In the file `fruitlowres_right.png` a new image is given. Apply your method to this image, and compare it to the ground truth result `fruitoriginal_right.png`. Give your result as PSNR between your output and the ground truth image.

Good Luck!