Mittuniversitetet
MID SWEDEN UNIVERSITY

Försättsblad Prov Original

Kurskod	Provkod	Tentamensdatum
EL050A	T101	2018-11-01
Kursnamn	Elektronik AV, Signalbehandling och analys	
Provnamn	Skriftlig tentamen	
Ort	Sundsvall	
Termin	H18	
Ämne	Elektronik	

E2050A

Exam for Signal Processing and Analysis, 1st November 2018

Aids: Lexicon, electronic calculator, pens, ruler (=linjal)
Max: 100 credits
Scheduled time: max 4 hours

Instructions!
Use hand writing with high readability!!!!!!!!
You will lose credits if I have problems to read your hand writing!!!
Write only on one side of each paper.
Demonstrate all steps of calculations, analysis and assumptions.
Draw nice pictures with high readability!
Write answers in English or Swedish.

1. This is the system function for a filter, $H[Z] = \frac{z-2}{(z-0.5)(z^2+z+0.5)}$

   a) Develop the difference equation for this filter

   (5 p)

   b) Draw a diagram showing the corresponding Signal Flow Graph for its simplest direct implementation form I

   (5 p)

   c) Define the numerical values of filter coefficients

   (5 p)

   d) Draw a diagram showing SFG for direct form IIt

   (5 p)

   e) What type of filter is this, FIR or IIR?

   (5 p)

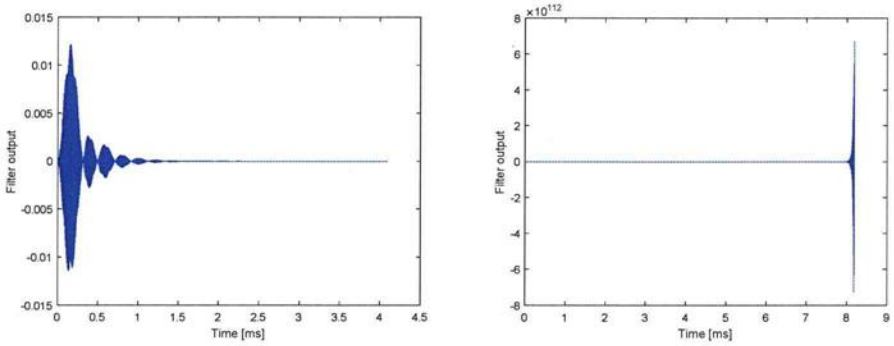
   f) What order K has this filter?

   (5 p)

   g) Draw a zero-pole diagram. Is this filter stable?

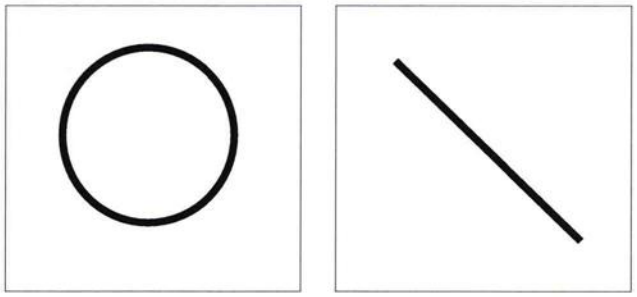
   (5 p)

2. Graphs below are showing filter output signals after simulation where the unity impulse has been used as input. What kind of conclusions can you make about those two graphs?



(5 p)

3. An Edge Histogram Descriptor EHD is computed on the two pictures shown below.



Picture A

Picture B

Estimate and illustrate EHD for the two pictures A and B. Explain what the diagrams show and why they look like they do.

(7 p)

4. Explain how the K-means clustering works, preferably as pseudo code describing the clustering.

(10 p)

5. Image (2) was processed by *Histogram equalisation* to create image (1).
   a) Which one of the histograms A and B correspond to image (1) and (2)? Explain and motivate

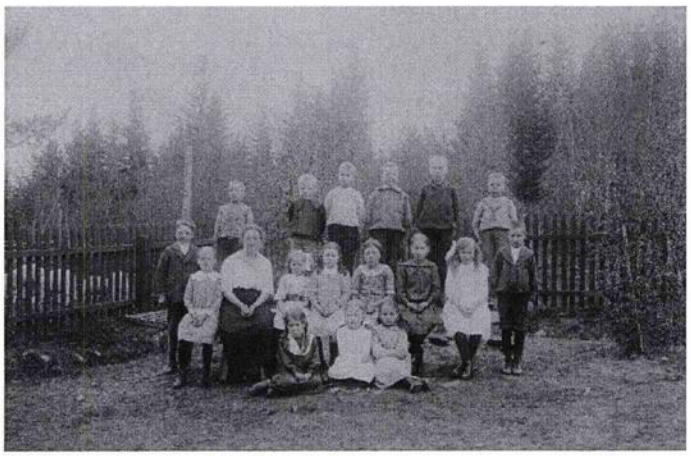
(5 p)

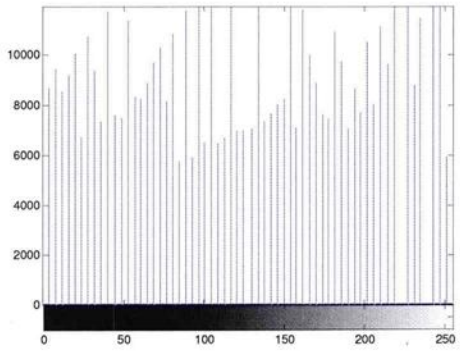
   b) How is the graylevel transformation function computed for Histogram equalisation?

(5 p)

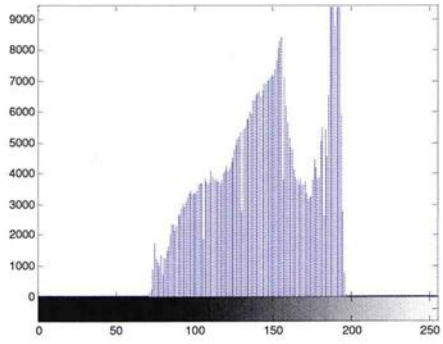
Image (1)

Image (2)





Histogram A



Histogram B

6. A linear classifier is described by a hyperplane (or hyperline if 2D) according to the following equation, $\bar{W} \cdot \bar{X} + b = 0$. The following parameters are given for the classifier:

   - $\bar{W} = (0.5\,, 1)$ and $b = -7$

The three input data vectors, $\bar{X}_a$ to $\bar{X}_c$ should be classified by the classifier above. Do this manual calculation and find out which group of two vectors out of three is belonging to the same class?

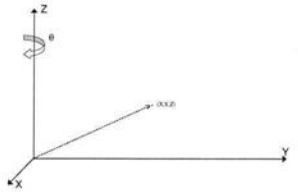
   - $\bar{X}_a = (6\,, 5)\,, \bar{X}_b = (1\,, 4)\,, \bar{X}_c = (5\,, 3)$

Finally, prepare a graph that illustrates the relevant feature space, the separating hyperline, and the three data vectors, $\bar{X}_a$ to $\bar{X}_c$.

(13 p)

7. A rotation around z-axis by angle θ is defined by the geometric affine transformation R_Z.

$$R_Z = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



A translation T by vector $(-X_0, -Y_0, -Z_0)$ is defined as,

$$T = \begin{bmatrix} 1 & 0 & 0 & -X_0 \\ 0 & 1 & 0 & -Y_0 \\ 0 & 0 & 1 & -Z_0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

a) Compute a transformation matrix that is a combination of firstly a rotation R_Z and then a translation T.

(5 p)

b) Compute a transformation matrix that is a combination of firstly a translation T and then a rotation R_Z.

(5 p)

8. Figure 1 depicts a schematic setup for stereo imaging based on two image sensors and an object *W* at distance *Z* given by $Z = \lambda - \dfrac{\lambda B}{x_2 - x_1}$. The object *W* is projected onto the image sensors 1 and 2 at position (x_1, y_1) and (x_2, y_2) respectively. Explain what kind of image processing is necessary in order to measure the distance Z from the two sensors to the object *W*. Relate your explanation to the given expression for *Z*.

(10 p)

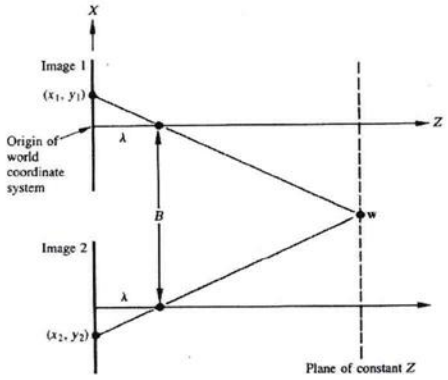


Figure 1. Stereo imaging.

Good Luck
Benny

Formulas:

Z-transforms,

Operation	$x[n]$	$X[z]$
Single sided Z-transform for causal systems	$x[n]$	$\sum_{n=0}^{\infty} x[n] \cdot z^{-n} \ for \ \lvert z \rvert > R_+$
Right shift	$x[n-m]$	$z^{-m}X[z] + \sum_{i=1}^{m} x[-i] \cdot z^{i-m}$
Left shift	$x[n+m]$	$z^{m}X[z] - \sum_{i=0}^{m-1} x[i] \cdot z^{m-i}$

Group delay, $t_g \equiv -\frac{d\,arg\{H(\Omega)\}}{d\Omega}$

Convolution, $y[n] = x[n] * h[n] \equiv \sum_{i=0}^{\infty} x[n-i] \cdot h[i] = \sum_{i=0}^{\infty} x[i] \cdot h[n-i]$