Geomatics Engineering
International Master Program

Universität
Stuttgart

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Examination Spring 2011
March 31, 2011

Geomatics Methodology

Module 2

Module Section **Signal Processing**

Prof. Fritsch

Student ID

Student's Surname | Other Names

Date | Student's Signature

Examination result
Grading in percentage

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%

Date | Examiner's Signature

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Examination **Signal Processing** - Spring 2011

Question 1: (25%)

There is some similarity between least-squares adjustment using a Gauss-Markov model and random signal processing.

(a) Write down the definition of the Gauss-Markov model and the random signal model in signal processing. Do you see already some similarities?

(b) Which objective functions are used to estimate the unknown parameters in the Gauss-Markov model and the true random signal y(m)?

(c) How can a Wiener filter be implemented?

Question 2: (25%)

The sampling theorem is an important issue when digitizing analog signals x(t) to get x(m).

(a) How is the sampling theorem defined?

(b) What has to be considered to get non-aliased sampling?

(c) What is the ideal interpolator to reconstruct x(t) using samples x(m)? (formula and sketch)

(d) Which frequencies are aliased in the movement of a stage coach in a Western movie?

Question 3: (25%)

Given is the function $x(t) = e^{-|t|}$.

(a) Make a sketch of the function x(t).

(b) Write down the equations for the continuous Fourier transformation (FT) and the inverse Fourier transformation (IFT).

(c) Calculate the Fourier transformation of x(t).

Question 4: (25%)

(a) Using the accelerated computation scheme, compute the convolutions f*x and h*x of the following digital signal x and two filters f and h

x = [0 4 3 4 3 4 0]

f = 0.25 * [1 1 -1-1]

h = [-1 1]

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(b) What is the effect of the filter h?

(c) Determine the filter kernel g such that f=h*g holds. What is the effect of the filter g, what is the effect of the filter f?

Exam
Spring 2011

Q1: a) $l + e = Ax \quad D\{l\} = c_0 P^{-1}$

$x(m) = y(m) + r(m)$ "additive noise"

b) $e^T e \doteq \min$

$E[\{\varepsilon(m) - E[\varepsilon(m)]\}^2 \doteq \min$

c) see slides derivation 3.1.2 following

Q2: a) $f_{sam} > 2 f_{max}$

b) sample with a frequency 2 times larger than maximal original frequency

c) $x(t) = \sum_{k=-\infty}^{\infty} x(k) f(t - k\Delta t)$

$f(t - k\Delta t) = \frac{\sin((\pi/\Delta t)(t - k\Delta t))}{(\pi/\Delta t)(t - k\Delta t)}$

$=$ sinc (sketch)

d) if the frequency of images taken is below 2 times the spoke frequency there will be artefacts

Q3 a) (sketch)

b) FT: $X(j\omega) = \int_{-\infty}^{\infty} x(t)\, e^{-j\omega t}\, dt$

IFT: $x(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(j\omega)\, e^{j\omega t}\, d\omega$

c) $\Rightarrow \frac{2}{1+\omega^2} = X(j\omega)$

Q4: a) $f * x = [0\ 4\ 7\ 3\ 0\ 0\ -3\ -7\ -4\ 0] \cdot 0.25$

$h * x = [0\ -4\ 1\ -1\ 1\ -1\ 4\ 0]$

b) derivative

c) $\cdot 0.5\ [1\ 2\ 1]$ negation, smoothing