

NONLINEAR SIGNAL PROCESSING

FINAL EXAM 18.12.2003

Answer every question.

1. (6 points)

- a) Define: nonlinear filter. (2 points)
- b) Prove that the harmonic mean filter (window size 5) is a nonlinear filter. (2 points)
- c) What are the breakdown points of the median and the flat morphological opening. (2 points)

2. (6 points)

Evaluate (1 to 5 stars) the performance of the following filters regarding: Gaussian noise removal (GNR), impulsive noise removal (INR), detail preservation (DP), and implementation speed (IS). * = very poor, ***** = very good.

	GNR	INR	DP	IS
Identity filter				
Mean filter				
Recursive Median filter				
Wilcoxon filter				
Hachimura-Kuwahara filter				
Stack filter with Boolean function x_1, x_2, \dots, x_N				

3. (6 points)

- a) What is (and why it is) the sufficient and necessary condition for the weights of a weighted ranked order filter to guarantee that single impulses will be removed? (3 points)
- b) Design a multistage median filter, which is able to preserve horizontal and vertical lines of thickness 1 pixel. (3 points)

4. (6 points)

- a) Give the definition of the Average Controlled Local Average Filter. (2 points)
- b) Describe the motivation behind it. (2 points)
- c) What kind of impulse response it has? (2 points)

5. (6 points)

- a) Give the definition of nonlinear mean filters (2 points)
- b) Using the definition in a) define the contraharmonic mean filter. (1 point)
- a) Show, how homomorphic filters can be used to remove multiplicative noise. (3 points)

6. (6 points)

Derive the maximum likelihood estimator

- a) for location, when we have N i.i.d. samples, which are Normally (Gaussian) distributed. (3 points)
- b) for scale, when we have N i.i.d. samples, which are Normally (Gaussian) distributed. (3 points)