NONLINEAR SIGNAL PROCESSING
FINAL EXAM 19.12.2002

Answer every question.

1. (6 points)

a) Define: nonlinear filter. (2 points)

b) Prove that the Wilcoxon filter (window size 5) is a nonlinear filter. (2 points)

c) Give the definition of the Weighted Majority of m values with Minimum Range Filter ($\mathbf{WMMR^m}$). (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				
Median filter				
Harmonic mean filter				
Flat morphological opening				
L-filter with weights (½,0,0,…,0,½)				

3. (6 points)

a) Define three edge-enhancing filters. Describe why these filters can enhance edges. (3 points)

b) Pick one of those filters. Consider the noisy case, where just before the distorted step edge there is an impulse, e.g., the signal is …,1, 1, 1, 1, 1, 100, 3, 4, 5, 6, 7, 7, 7, 7, 7, 7,… What kind of effect the impulse has on the results? Will the edge be enhanced now? (3 points)

4. (6 points)

a) Describe the architecture of the stack filter based on threshold decomposition. (3 points)

b) How can a stack filter be implemented directly without using the architecture based on threshold decomposition? (3 points)

5. (6 points)

Consider the random filter (sorry, is was not mentioned at all in the course). It is a moving window operation where the output is taken randomly (same probably for every input) from the inputs inside the window.

a) How good this filter would be concerning: impulse removal, Gaussian noise removal, implementation speed, and detail preservation? (1 point)

b) If we generalize the random filter by defining the output to be the mean of two randomly picked samples from the window, do we obtain any better filter? (1 point)

c) Generalize the random filter further by finding a way to include spatial/temporal order information as well as to include some nonlinear operation. You should still keep the idea of randomly picked samples in Your filter. (3 points)

d) Compare Your own filter with the previous ones. (1 point)

6. (6 points)

a) Give definitions and motivations for LUM smoother, LUM sharpener, and LUM filter. (3 points)

b) Show that the LUM smoother with parameter s, $1 \le s \le k+1$ is identical to a center weighted median filter. Give the relation between s and the central weight. (3 points)