Information Statistics II

Part III – Research topics

Lecture 12. Filter optimization by supervised and unsupervised learning

Supervised learning method using layered neural network

— The weighted median filter is expressed by the layered neural network, if the input and output are binarized by the threshold decomposition.

— The optimum weight coefficients are obtained by the optimized weight coefficients of the layered neural network by the supervised learning. An example pair of an input noisy image and its ideal output is offered to the learning procedure.

— Similar methods are applied to cascades of filters using the multilayer network and the error back propagation algorithm.

References:

A. Asano, K. Itoh, and Y. Ichioka, "Optimization of the weighted median filter by learning," *Optical Letters*, **16,** 3, 168-170 (1991).

A. Asano, K. Itoh, and Y. Ichioka, "Optimization of cascaded threshold logic filters for grayscale image processing," *Optics Communications,* **88,** 485-493 (1992).

L. Yin, J. Astola, and Y. Neuvo, "A new class of nonlinear filters — Neural filters," *IEEE Trans. Signal Process.* **41,** 1202-1222 (1993).

Supervised learning method using the simulated annealing or the genetic algorithm

— Morphological filters cannot be expressed by the layered neural network with satulative nonlinear functions.

— Instead of the learning methods of the layered network, trial-and-error methods are introduced. Its basic concept is repeating the following procedures : 1) modifying a parameter of the filter under optimization, 2) evaluating the filter, 3) accepting this modification if the evaluation is better than that before the modification.

References:

A. Asano, T. Yamashita, and S. Yokozeki, "Learning optimization of morphological filters with grayscale structuring elements," *Optical Engineering,* **35,** 8, 2203-2213 (1996).

N. R. Harvey and S. Marshall, "The use of genetic algorithms in morphological filter design," *Signal Processing: Image Communication,* **8,** 55-71 (1996).

Supervised learning for the stack filters

— Stack filter is defined by a decision table, which defines the relationship between each input binary sequence in a window and its binary output. The decision table is optimized by learning.

— The outputs of the decision table are initially all zero. Comparing an example noisy input and its ideal output, the output is increased (decreasesd) if the output of an entry of the table is observed unity (zero) in the example pair. After that the table is tuned to hold the stacking property.

References: Ilya Shumlevich, "Nonlinear Signal Processing," http://www.cs.tut.fi/~ilya/NONLINEAR.htm

Unsupervised learning method using pattern spectrum and genetic algorithm

— Pattern spectrum has the information of size distribution of the target image. Portions of small sizes are naturally regarded as noises. Thus the filter should be optimized to produce an output that supresses portion of small sizes and that preserves portion of large sizes in its original pattern spectrum.

— The conventional pattern spectrum cannot extract approximate shape of an object if there is a spot within the object, since the conventional pattern spectrum is based on the opening, which does not remove such spots of any sizes. Thus a modified pattern spectrum, called the morphological opening/closing spectrum (MOCS) is proposed. MOCS introduces closings into its calculation process, and such spots are removed by closing.

— The filter is optimized by iteration of the following procedures: modifying a filter parameter, comparing the MOCSs of the output of the filter before and after the modification, and accept or reject the modification. These procedures are controlled by the genetic algorithm.

References:

A. Asano and S. Yokozeki, "Morphological multiresolution pattern spectrum," *IEICE Trans. Fundamentals,* **E80-A,** 9, 1662-1666 (1997).

A. Asano, "Unsupervised optimization of nonlinear image processing filters using morphological opening/closing spectrum and genetic algorithm" *IEICE Trans. Fundamentals,* **E83-A,** 2, 275-282 (2000).