ABSTRACT

Removal of additive noise is one of the most important tasks in image processing. In images, edges very often contain valuable information and are important for visual perception. Furthermore, fine detail retention is considered quite essential in many applications (e.g., machine vision, remote sensing, computer tomography and X-ray imaging systems), where the preservation of signal structure is not to be compromised. Therefore, the filters designed for image processing are required to reduce noise sufficiently without losing the high frequency content of edges and fine details. This thesis introduces some nonlinear filtering strategies based on order-statistics. The proposed filters are useful in enhancing the images confounded by additive white noise and/or impulse noise, while exhibiting good edge and fine detail preserving characteristics.

Simple nonlinear highpass filter algorithms for detecting edge structures in one- and two-dimensional signals are introduced. A one-dimensional highpass filter detects and preserves signal edges by sliding a 3-point wide time-ordered window over the input signal sequence. A high level structure for VLSI implementation of one-dimensional highpass filter is developed. Simulation results obtained using the one-dimensional highpass filter are presented. A two-dimensional highpass filter slides a time-ordered
window of size 3x3 over the image signals for detecting and preserving their edges. The filter is shown to be effective in detecting the edges of all orientations (horizontal, vertical, left diagonal and right diagonal) in both noisy and noise-free environments with less computational complexity.

Four nonlinear image filtering schemes, referred to as, New Filter I, New Filter II, New Filter III and New Filter IV are proposed. A two-dimensional highpass filter algorithm forms the basis for these new filters. New Filter I suppresses the medium tailed Gaussian noise quite well. New Filter II is effective in discarding impulses and reducing Gaussian noise. New Filter III provides adequate attenuation for noise having uniform probability density function. New Filter IV is robust against impulse noise and removes uniform noise sufficiently. The proposed filters are designed to have good edge preserving characteristics. The filters are evaluated for their performance in terms of two objective quality measures, namely, image enhancement factor obtained at different noise levels and Mean Square Error (MSE)/pixel produced at the output with windows of various sizes. Besides, the results of filtering of noisy images are presented for subjective evaluation.

A new class of midpoint-type nonlinear filters, which is useful for recovering the images contaminated by uniform and impulse noise, is presented. First, the Alpha Trimmed Midpoint (ATMP) filter is introduced. The ATMP filter sorts out the samples, trims (removes) a few and equal number of them from both the ends and then performs midpoint filtering. The filter rejects
impulses and suppresses uniform noise quite well. Next, the Adaptive Alpha Trimmed Midpoint (AATMP) filter is described. This filter performs its function in an adaptive manner using edge information. It operates as an ATMP filter in the homogeneous regions for suppressing noise components and works as a median filter (with the same window size as that of the ATMP filter) in the neighbourhood of edges for preserving them. The Modified Adaptive Alpha Trimmed Midpoint (MAATMP) filter, presented in the end, is similar to the AATMP filter except that it operates as a median filter of window size 3x3 in the neighbourhood of edges, irrespective of the window size of the ATMP filter. This filter allows simultaneous removal of uniform and impulse noise, preserves edge information and retains fine details. The proposed filters are evaluated for their performance by applying them to test images corrupted by different levels of noise and using windows of various sizes. The extensive results obtained are presented and discussed.

A technique for improving the performance of median smoothers at the signal corners, characterized by low order polynomials is introduced. It is a fact that the median filters with larger windows provide greater smoothing for non-impulsive noise components and are more robust against impulse noise than the median filters with smaller windows. However, larger median filters (median filters with larger windows) fail to track low order polynomial trends in the signal. Due to this, constant regions are produced at signal corners leading to the loss of fine details. The proposed scheme, called combination smoother, consists of a 3-point median smoother and a larger median smoother
with a window of desired length in parallel; besides, it has a combiner to combine the outputs of median filters appropriately. The combiner algorithm combines the detail preserving characteristics of the 3-point smoother and the better noise filtering characteristics of the larger smoother. The efficacy of the proposed combination smoother is illustrated both objectively and subjectively by applying it to a test image corrupted by different levels of impulse and/or non-impulse noise.

The salient features of the proposed filtering strategies are highlighted. The major contribution of this research work is summarized and the possible directions for future work are indicated.