# Extended Dimensional Threshold Filtering and It's Application to Image Signal Processing

Maekawa Yasuaki

School of Information Science,
Japan Advanced Institute of Science and Technology

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Linear filters are the major filter class of signal processing, due mainly to their strong connections to the theory of signal analysis and to the theory of linear systems. Despite their elegant system theory, linear filters are not almighty. Linear filters tend to blur sharp edges and fail to remove heavy tailed distribution noise effectively. On the other hand, nonlinear methods tend to be *ad hoc* and application specific due to the lack of underlying theory. A good underlying theory covering various nonlinear filters is needed for engineers to have common foundation and to design high performance signal processing.

Edge preservation is essential in image processing due to the nature of visual perception. A nonlinear filter class that has been proven very useful is the class of median based filters. The success of median filters is based on edge preservation and efficient noise attenuation with robustness against impulsive noise. However the median filter uses only rank–order information of the input data, and discards its temporal–order information. Various nonlinear filters such as FIR–median hybrid filters, weighted median filters, weighted order statistic filters, stack filters, and Boolean filters have been developed.

In this research, a subclass of nonlinear filter: Extended–Dimensional Threshold(EDT) Filtering, which contain several nonlinear filters and linear FIR filter as subclasses and may enable us to discuss the properties of these filters with a single framework, is proposed and some properties of it are investigated.

The Extended Dimensional Threshold(EDT) Filtering is considered as a subclass of homomorphic filtering. The transformation adopted is just similar to "Threshold Decompositions" for Median filters or Stack filters, but each decomposed signal will be arranged along a new(the third) axis to form an extended dimensional signal. In the next step, we will apply three–dimensional filtering(called core-filtering) to get filtered extended–dimensional signal. Finally the resultant signal will be inverse–transformed into a two–dimensional signal by using a threshold operation.

First we investigate the relation between EDT filtering and some other linear/nonlinear filtering. As a result, Median filter, Weighted median filter and some other median–type non–linear filters are contained in EDT filter as its subclasses. Furthermore, the linear FIR filter is also shown to be contained in EDT filter while EDT filter contains nonlinear threshold operations.

In general, it is believed that frequency analysis and impulse response have no meaning in median–type nonlinear filtering. However, since a linear three–dimensional filtering(core–filtering) plays a central role for determining the output of EDT filtering, the frequency characteristics of this core–filtering will give us an insight into the behavior of EDT filtering. In this point of view, we characterize each filter class contained in EDT filter by the frequency characteristics of a corresponding core–filter. As a result, median–type filters possess low pass characteristics in the first and second directions and flat in the third direction. On the other hand, linear FIR filter is shown to possess narrow low pass characteristics in the third direction while the characteristics in the first and second directions coincide with the one of original two–dimensional FIR filter.

Finally, the relation between frequency characteristics and EDT filter outputs is investigated through practical applications of EDT filters to noise reduction of images.

Further investigation on the relation between output characteristics of EDT filtering and characteristics of its core–filtering is remained as a major future work.