Adaptive Iterative Smoothing Method for Unsharp Masking Algorithms

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Abstract – **Adaptive iterative algorithm for smooth images is proposed. It takes into consideration local characteristics and preference to bigger space constants of surround function.**

Keywords – **Unsharp Masking, Smoothing, Mach Bands, Image Processing.**

I. Introduction

The main task for unsharp masking algorithms, a general view is Eq. (1), and most related procedures is local contrast enhancement.

$$out = \bar{L} + \alpha \cdot (L - \bar{L}) \ , \qquad (1)$$

where L is an image; $\bar{L} = F * L$ is the smooth image, where $*$ means a convolution and F is a surround function; α is a constant and out is the output of procedure.

It is necessary to determine a certain surround function, in relation to which a transformation is applied. This function has to be as wide as possible (to cover a large area) on one side, and from another to be enough limited to eliminate Mach bands effect, that arise in areas of significant differences in intensity. By a covering of a large area a global effect (relativity to remote areas) is achieved. Certain combination of blurred images with local selection criteria has been proposed to use. Such criteria correlate to differences in intensity. Adaptive iterative algorithm for smooth image and proper distribution of space constants has been developed. Adaptability means that local characteristics, local standard deviation, are taken into consideration due to Mach bands effect. Operator for spatial weight image based on local standard deviation distribution is proposed. It is used iterative procedure for providing priority in favor of bigger spatial constants of surround function.

II. Algorithm

Proposed output image is the superposition of N (good choice is [5…20]) smoothed images (certain set of space constants is used), that are weighted by spatial masks. Such masks are determined on the basis of selection criteria and the remaining quotas. The Gaussian function is chosen for surround function:

$$F_n(x, y) = K \cdot e^{-(x^2+y^2)/\sigma_n{}^2} \ , \qquad (2)$$

where σ_n is the space constant and K is selected such that $\iint F_n(x, y)\,dx\,dy = 1$. The set of spatial constants should be chosen linearly in logarithmic scale. See Eq. (3).

$$s_n = s_{\max}{}^{n/N} - 1 \, , \qquad (3)$$

where $n \in [1..N]$ and $\sigma_{\max}$ is equal sixth of bigger side of image.

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So, iterative method for proposed smooth image $\bar{L}$ is described by pseudo-code (4).

$$
\begin{aligned}
& Norm = 0 \quad \bar{L} = 0 \\
& \text{for } (n = N;\ n > 0;\ n = n - 1) \\
& \qquad Sm_n = F_n * L \\
& \qquad Dev_n = \sqrt{F_n * L^2 - (F_n * L)^2} \\
& \qquad W_n = (1 - Norm) \cdot FTO(Dev_n) \\
& \qquad \bar{L} = \bar{L} + Sm_n \cdot W_n \\
& \qquad Norm = Norm + W_n \\
& \bar{L} = \bar{L} / Norm \, , \qquad (4)
\end{aligned}
$$

where $Norm$ means quotas that has been used for superposition, Sm_n is a smooth image, Dev_n is a local standard deviation image, W_n is a spatial mask for Sm_n. FTO means a fuzzy threshold operator, see Eq. (5).

$$FTO(x) = e^{-x^2/2 \cdot th^2} \ , \qquad (5)$$

where th is a threshold. It is proposed to choose th according to Eq. (6).

$$th = \beta \cdot std(L) \ , \qquad (6)$$

where β is a constant $std(L)$ means standard deviation of L.

Fig. 1 shows 1-D modeling results in comparison with standard Gaussian smooth.

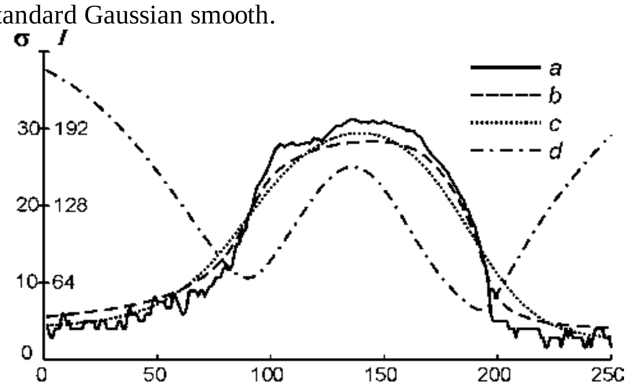

Fig.1 1-D modeling results. Curve ***a*** is the input data, ***b*** is the proposed smooth curve for N=20 and β=0.3, ***c*** is the Gaussian smooth (space constant equal to 24) and ***d*** is the space constant distribution curve of ***b***. ***I*** is a standard grayscale [0…255] for curves ***a***-***c*** and **σ** is a scale for ***d***.

III. Conclusion

New smoothing method for unsharp masking type algorithms is given. There are only two intuitive parameters N and β. Proposed technique is good compromise for purposes of relativity to remote areas and eliminating Mach bands effect.