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A novel elementary spatial expanding scheme form on SISR method with modifying Geman&McClure function

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Abstract

Because of the feasible and impressive fallout, the classical Super-Resolution Reconstruction (SRR) is the contemporary algorithm for improving spatial information and reducing noise and SISR (Single-Image Super-Resolution) method, which is form on the classical SRR, is solely developed for improving spatial information. Disastrously, deficiency of the classical SISR method is conceptually computed from three specifications (b, h, k) and the simulating calculation of the optimized specifications for interpolating the better and higher spatial information images with highest PSNR is so burdersome. For figuring out this issue, the Geman&McClure function is proposed to replace with the ordinary SISR function because this function is conceptually computed from only one specification (T), contrary to three specifications similar to classical SISR method hence this analytic article focuses to offer a novel elementary spatial expanding scheme form on SISR method with modifying Geman&McClure function. Therefore, the fallout of a proposed spatial expanding scheme approximately matches to classical SISR method. From these reason, a novel elementary spatial expanding scheme is easily implemented for real works.

Keywords*: digital image interpolation, digital image processing, Geman&McClure function, single-image super resolution (SSIR), super-resolution reconstruction (SSR)*

1. Comprementary Investigation

Because of great requirement of contemporary computer vision and image processing [1-5] for more than one and half decades, images with better and higher spatial information is dramatically required however almost recorded images is usually lower spatial information, which are recorded by marketing build-in CCTV or camera. Therefore, the regular digital image interpolation is conceptual idea in order to creating an image with higher spatial information from one image with lower spatial information. The dominant aspiration of spatial expanding scheme form on SISR method, which is developed from the worldwide famous Super-Resolution Reconstruction (SRR) [6-17], is for solely improving spatial information. Conceptually, both SRR and SISR are an ill-posed inversed issue [10, 16] from the reason that copious higher spatial information images can be constituted from only one recorded image with lower spatial information under the identical recording process. In the SISR inquiring in the last two and half decades, one of the most feasible and impressive spatial expanding scheme is the SISR method using boundary constructing techniques, which is originally invented by Bo-Won Jeon [18] in 2006. This method can constitute better and higher spatial information images and, moreover, has low complexity. This SISR method is incorporated by two dominant sub-systems: the boundary constructing sub-system and the regularized function. In the first sub-system, the boundary constructing sub-system is conceptually computed from Laplacian pyramid method [19-23] for constructing boundary and line of the higher spatial information image. In the second sub-system, the regularized function C (x, y) [18] is conceptually computed from three specifications (b, h, k) and the simulating calculation of the optimized specifications [24, 25] for interpolating the better and higher spatial information images with highest PSNR. For figuring out this issue, the Geman&McClure function [26], which has been mathematically guarantee and investigated for more than thirty years thereby the Geman&McClure function has an exhaustive inquiring, is conceptually computed from only one specification (T), contrary to three specifications similar to classical SISR method. Therefore, this analytic article focuses to

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offer a novel elementary spatial expanding scheme form on SISR method and modifying Geman&McClure function.

The analytic article can be adjusted as ensuing. The first organized content is the complementary investigation of the SSR method and SISR method. Next, the second organized content is the classical spatial expanding scheme form on SISR method. Subsequently, the third organized content is the novel spatial expanding scheme form on proposed Geman&McClure SISR method. Later, the forth organized content is computer computation substantiation, which are comparatively assessed to three ordinary spatial expanding schemes: nearest, bilinear and bicubic, on bountiful images. Finally, the fifth organized content is the theatrical concision.

2. The Classical Spatial Expanding Scheme form on SISR Method

This organized content rapidly expounds the algorithmic apprehension of ordinary SISR method [18] using boundary constructing techniques, which is computed from boundary constructing procedure (as exhibit in Figure 1) and Geman&McClure regularization procedure.

2.1. Boundary Constructing Procedure

The vital target of this boundary constructing procedure [18] is for constructing the boundary, detail and edge of the better and higher spatial information images with highest PSNR.

At first, the recorded low spatial information image ($G_0(x,y)$ at $m\times n$) spatially scales down to constructing a class of low spatial information images as $G_1(x,y)$ at $\frac{m}{2}\times\frac{n}{2}$, $G_2(x,y)$ at $\frac{m}{4}\times\frac{n}{4}$, $G_3(x,y)$ at $\frac{m}{8}\times\frac{n}{8}$ and $G_4(x,y)$ at $\frac{m}{16}\times\frac{n}{16}$.

At second, operating a ordinary spatial expanding scheme, a class of more spatial information images are constructed from each low spatial information images (from first procedure) as $L_0(x,y)$ at $m\times n$ from $G_1(x,y)$ at $\frac{m}{2}\times\frac{n}{2}$, $L_1(x,y)$ at $\frac{m}{2}\times\frac{n}{2}$ from $G_2(x,y)$ at $\frac{m}{4}\times\frac{n}{4}$, $L_2(x,y)$ at $\frac{m}{4}\times\frac{n}{4}$ from $G_3(x,y)$ at $\frac{m}{8}\times\frac{n}{8}$ and $L_3(x,y)$ at $\frac{m}{8}\times\frac{n}{8}$ from $G_4(x,y)$ at $\frac{m}{16}\times\frac{n}{16}$.

At third, operating Laplacian histogram computation and Gaussian statistical analysis, the first and second moment statistic fallout at each spatial level of the boundary, detail and edge images are constructed as (μ_0,σ_0) at $m\times n$, (μ_1,σ_1) at $\frac{m}{2}\times\frac{n}{2}$, (μ_2,σ_2) at $\frac{m}{4}\times\frac{n}{4}$ and (μ_3,σ_3) at $\frac{m}{8}\times\frac{n}{8}$.

At fourth, for rapid counting and ramification reduction by using Laplacian statistical analysis, the first and second moment statistic fallouts (μ,σ) are reduced to be one statistic fallout (α) as α_0 at $m\times n$, α_1 at $\frac{m}{2}\times\frac{n}{2}$, α_2 at $\frac{m}{4}\times\frac{n}{4}$ and α_3 at $\frac{m}{4}\times\frac{n}{4}$.

At fifth, by operating the least square interporating scheme, the boundary, detail and edge image of the higher spatial information images $\tilde{L}_{-1}(x,y)$ at $2m\times 2n$ is reconstructed.

2.2. Ordinary Regularization Procedure

The vital target of this boundary constructing procedure is for forceing the upper limitation of the detail and edge image of the higher spatial information ($\beta\cdot C(x,y)$) that is constructed by the boundary constructing procedure with the ordinary regularization procedure as ensuing:

$$C(x,y)=\frac{(M(x,y)+b)}{(k(M(x,y)M(x,y))+h)} \tag{1}$$

where b, k and h are fix specifications

At final, the high spatial information image can be constructed by addng of the boundary, detail and edge image of the higher spatial information images, which are multiypled with the fallout of the regularization procedure ($\hat{L}_{-1}(x,y)=\beta\cdot C(x,y)\cdot\tilde{L}_{-1}(x,y)$) and the higher spatial information image ($\tilde{G}_{-1}(x,y)$) at $2m\times 2n$, which is constructed by operating a ordinary spatial expanding scheme.

3. The Novel Elementary Spatial Expanding Scheme form on SISR Method with Modifying Geman&McClure Function

As expounds in the prevous orgianzied content, the ordinary regularization procedure [18], which is defined in (1), conceptually computed from three specifications (b, h, k) thereby the simulating calculation of the optimized specifications for interpolating the better and higher spatial information images with highest PSNR is so burdersome. For figuring out this issue, the Geman&McClure function [26] is conceptually computed from only one specification (T), contrary to three specifications similar to classical SISR method.

The Geman&McClure function and its gradient is defined as ensuing (2) and (3), respectively:

$$C_{GM}\left(x,y\right)=T_{GM}^{2}\left(\frac{\left(M\left(x,y\right)\right)^{2}}{T_{GM}^{2}+\left(M\left(x,y\right)\right)^{2}}\right) \quad (2)$$

$$C'_{GM}\left(x,y\right)=T_{GM}^{4}\frac{2M\left(x,y\right)}{\left(T_{GM}^{4}+\left(M\left(x,y\right)\right)^{2}\right)^{2}} \quad (3)$$

where T_{GM} is Geman&McClure specification, which is computed by full search method.

4. Computer Computation Substatntiation

This organized content exhaustively expounds substantiation from computer computation, which are covered bountiful images such as Cameraman, Tree, House, Resolution chart, Stream and bridge, Sailboat, Peppers, Tiffany, Baboon, Lena, F-16, Mobile Frame10, Pentagon, Aerial [24, 25] as expound in Table 1 and are computing by MATLAB software. At first, each ordinary image is scaled down and combined with noise for reconstruction the recorded image. Next, the novel elementary spatial expanding SISR scheme, the ordinary spatial expanding SISR scheme, spatial expanding nearest scheme, spatial expanding bilinear scheme and spatial expanding bicubic scheme are operated on each recorded image for comparatively assessing the feasible and impressive fallout of the proposed spatial expanding scheme.

Table 1. The Computer Computation Substantiation

Image Name	Resolution	Image Name	Resolution
Cameraman	256 x 256	Tiffany	512 x 512
Tree	256 x 256	Baboon	512 x 512
House	256 x 256	Lena	512 x 512
Resolution chart	256 x 256	F-16	512 x 512
Steam & bridge	512 x 512	Mobile Frame10	704 x 480
Sailboat	512 x 512	Pentagon	1024 x 1024
Peppers	512 x 512	Aerial	1024 x 1024

4.1. No Outlier

At first, the organized sub-content expounds the optimization of Geman&McClure specification (T_{GM}) that is modified during 0 to 2000 for interpolating the better and higher spatial information images with highest PSNR. The computer computation substantiation of no outlier is expounded in the Figure 2. From this substantiation in this figure, it can be firmed that the Geman&McClure specification is fix to be optimized at 900-1050 for normal images and the Geman&McClure specification is fix to be optimized at 1250-1450 for image with bountiful boundary, detail and edge information. The global computation substantiation in PSNR is expounded in Table 2 for no outlier. The feasible and impressive fallout of the novel elementary spatial expanding scheme approximately matches to classical SISR method nevertheless the simulating calculation of the optimized specification is so readily and rapidly compared with classical SISR method (with three specification).

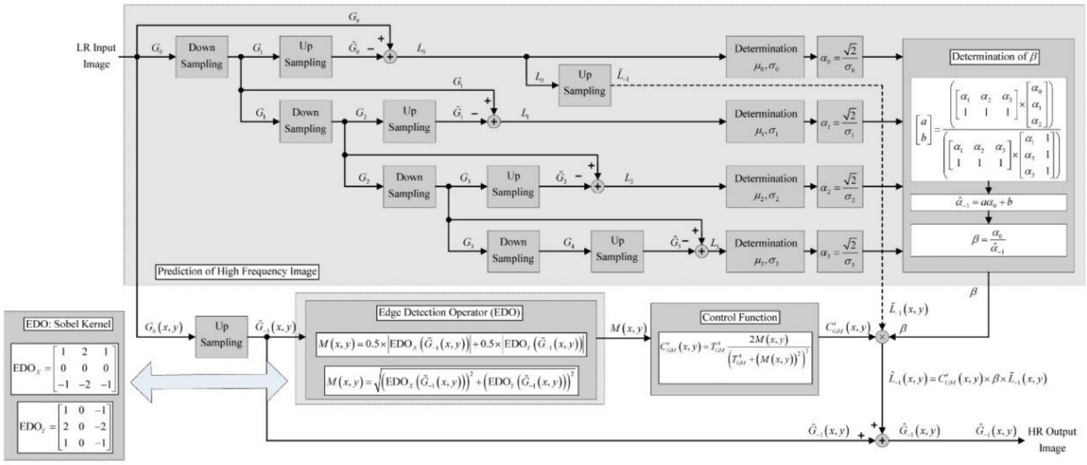

Figure 1. A novel elementary spatial expanding scheme form on SISR method with boundary

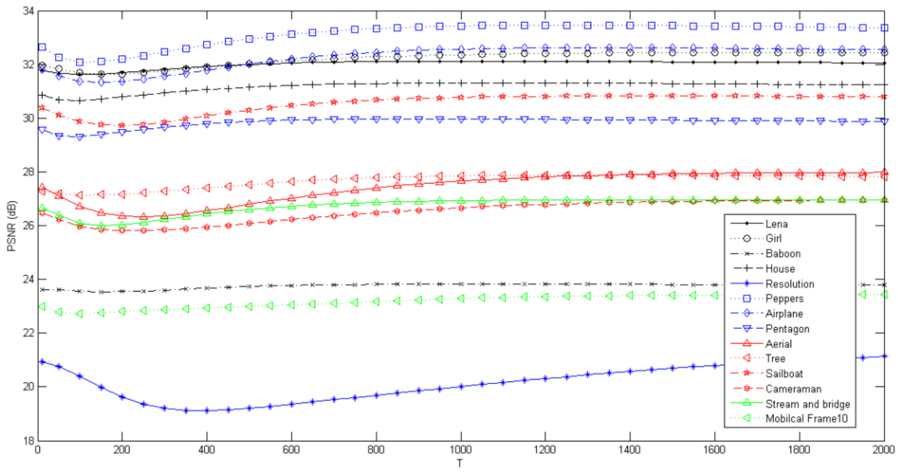

Figure 2. The computer computation substantiation of the Geman&McClure specification and the feasible fallout of a novel elementary spatial expanding scheme at no outlier

Table 2. The Global Computation Substantiation in PSNR of No Outlier

PSNR (in dB)	Classical Spatial Expanding Scheme			Spatial Expanding Scheme Using SISR	
	nearest	bilinear	bicubic	Ordinary	G&M
Lena 256	30.7847	31.0305	31.8281	32.0759	32.1160
Girl 256	30.9354	31.4602	31.9997	32.7268	32.4405
Baboon 256	23.2556	23.0546	23.6142	23.8215	23.8227
House 128	29.5053	30.1135	30.8944	31.0975	31.3119
Resolution chart	19.5643	20.0143	20.9699	21.4676	21.1320
Peppers 256	30.9254	31.7835	32.6814	32.9623	33.4568
Airplane 256	30.2861	31.0802	31.8515	32.7594	32.6160
Pentagon 512	28.8039	28.8569	29.6345	29.8987	29.9707
Aerial 512	25.6730	26.2025	27.4839	27.8944	27.9815
Tree 128	25.5058	26.2121	27.3201	27.9077	27.8771
Sailboat on lake	28.7881	29.3006	30.3990	30.7170	30.8227
Cameraman	25.4884	25.6590	26.5267	26.8735	26.9472
Steam & bridge	25.6787	25.8533	26.6535	26.9202	26.9655
Mobilcal Frame	22.0863	22.1223	23.0333	23.3324	23.4334

4.2. Gaussian Outlier

At first, for Gaussian outlier at 35 dB, the vital target of this computation substantiation is the calculation of the optimized specifications which is modified during 0 to 2000 for interpolating the better and higher spatial information images with highest PSNR as expounded in the Figure 3. From this substantiation in this figure, it can be firmed that the Geman&McClure specification is fix to be optimized at 1050-1250 for normal images and the Geman&McClure specification is fix to be optimized at 1400-1600 for image with bountiful boundary, detail and edge information. The global computation substantiation in PSNR is expounded in Table 3 for 35dB Gaussian outlier. The feasible and impressive fallout of the novel elementary spatial expanding scheme approximately matches to classical SISR method nevertheless the simulating calculation of the optimized specification is so readily and rapidly compared with classical SISR method (with three specification).

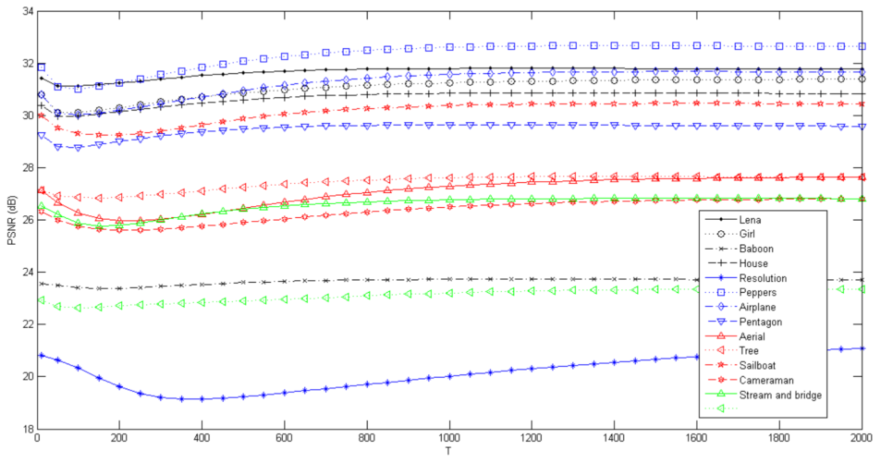

Figure 3. The computer computation substantiation of the Geman&McClure specification and the feasible fallout of a novel elementary spatial expanding scheme at 35dB Gaussian outlier

Table 3. The Global Computation Substantiation in PSNR of 35dB Gaussian Outlier

PSNR (in dB)	Classical Spatial Expanding Scheme			Spatial Expanding Scheme Using SISR	
	nearest	bilinear	bicubic	Ordinary	G&M
Lena 256	30.7847	31.0305	31.8281	31.7766	31.7998
Girl 256	30.9354	31.4602	31.9997	31.6288	31.3811
Baboon 256	23.2556	23.0546	23.6142	23.7324	23.7284
House 128	29.5053	30.1135	30.8944	30.6766	30.8621
Resolution chart	19.5643	20.0143	20.9699	21.3702	21.0833
Peppers 256	30.9254	31.7835	32.6814	32.2512	32.6705
Airplane 256	30.2861	31.0802	31.8515	31.7989	31.6775
Pentagon 512	28.8039	28.8569	29.6345	29.5919	29.6356
Aerial 512	25.6730	26.2025	27.4839	27.5565	27.6348
Tree 128	25.5058	26.2121	27.3201	27.6981	27.6617
Sailboat on lake	28.7881	29.3006	30.3990	30.3552	30.4563
Cameraman	25.4884	25.6590	26.5267	26.7378	26.8038
Steam & bridge	25.6787	25.8533	26.6535	26.7787	26.8259
Mobilcal Frame	22.0863	22.1223	23.0333	23.2646	23.3630

At second, for Gaussian outlier at 30 dB, the vital target of this computation substantiation is the calculation of the optimized specifications which is modified during 0 to 2000 for interpolating the better and higher spatial information images with highest PSNR as expounded in the Figure 4. From this substantiation in this figure, it can be firmed that the Geman&McClure specification is fix to be optimized at 1600-1650 for normal images and the Geman&McClure specification is fix to be optimized at 1900-2000 for image with bountiful boundary, detail and edge information. The global computation substantiation in PSNR is expounded in Table 4 for 30 dB Gaussian outlier. The feasible and impressive fallout of the novel elementary spatial expanding scheme approximately matches to classical SISR method nevertheless the simulating calculation of the optimized specification is so readily and rapidly compared with classical SISR method (with three specification).

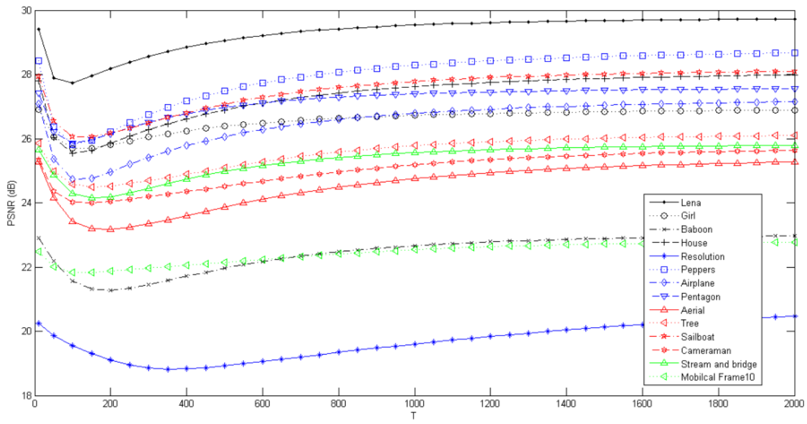

Figure 4. The computer computation substantiation of the Geman&McClure specification and the feasible fallout of a novel elementary spatial expanding scheme at 30dB Gaussian outlier

Table 4. The Global Computation Substantiation in PSNR of 30dB Gaussian Outlier

PSNR (in dB)	Classical Spatial Expanding Scheme			Spatial Expanding Scheme Using SISR	
	nearest	bilinear	bicubic	Ordinary	G&M
Lena 256	29.8834	30.6228	31.0558	31.1859	31.1858
Girl 256	28.3650	29.9100	29.6382	29.7120	29.6869
Baboon 256	22.9560	22.9394	23.3984	23.5359	23.5360
House 128	28.3219	29.5568	29.8302	30.0055	30.0063
Resolution chart	19.3609	19.8073	20.7091	21.2386	20.9155
Peppers 256	29.2480	30.8899	31.0236	31.3112	31.3134
Airplane 256	28.2036	29.9570	29.8565	30.0975	30.0955
Pentagon 512	27.8858	28.4586	28.8821	29.0009	29.0008
Aerial 512	24.8993	25.8372	26.7127	26.9680	26.9405
Tree 128	25.0357	25.9789	26.8435	27.2191	27.2192
Sailboat on lake	27.9077	28.8840	29.5562	29.7565	29.7561
Cameraman	25.0797	25.4869	26.1808	26.5104	26.4952
Steam & bridge	25.3003	25.6880	26.3351	26.5466	26.5465
Mobilcal Frame	21.8914	22.0470	22.8758	23.2144	23.2130

5. Conclusion

In this analytic assessing, this analytic article focuses to offer a novel elementary spatial expanding scheme form on SISR method with modifying Geman&McClure function that is conceptually computed from only one specification (T), contrary to three specifications (b, h, k) similar to classical SISR method. By examining on bountiful images, which are debased by copious outlier patterns, in analytical observation section, the impressive fallout of a novel elementary spatial expanding scheme approximately matches to classical SISR method nevertheless the simulating calculation of the optimized specification (which is based on $2x10^3$ search points) is so readily and rapidly compared with classical SISR method (which is based on $8x10^9$ search points). From these reason, a novel elementary spatial expanding scheme is easily implemented for real works.

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