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Removal of Fix Magnitude Impulsive Noise (FMIN) Through Innovative Recursive MDBUTMF Procedure

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ABSTRACT

This article proposes an innovative recursive modified decision based unsymmetrical trimmed median filter (RMDBUTMF) procedure for noisy overriding of digital photographs, which are eminently contaminated by FMIN. The proposed procedure reinstates the noisy photographical basis (which has magnitude at "0" or "255") by trimmed median magnitude (or the mean magnitude of all the free-noise photographical basis) in the computational photographical basis region under the recursive framework. The proposed procedure is experimented on distinctive digital photographs (Lena, Girl, Pepper and F16) on broad noise density and the proposed procedure reveals superior noisy-overridden photographs than the Mean Filter (MF), Median Filter (SMF), Adaptive Median Filter (AMF), Weight Median Filter (WMF), MDBUTMF in both Peak Signal-to-Noise Ratio (PSNR) and photographical quality.

Article information:

Keywords: Image Denoising, MDBUTMF, WMF (Weight Median Filter), AMF (Adaptive Median Filter), SMF Standard Median Filter), MF (Mean Filter)

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1. INTRODUCTION

In the simultaneous duration of computer vision and multi-dimensional processing [1], there are overflowing contemporaneous utilizations for multi-dimensional data (for instant digital photographs) [2-5] in last thirty-five years subsequence and one of the paramount transactions for multi-dimensional data processing [5] such as facial assimilation [6], SR processing of overflowing photographs [7-8], SR processing of sole photographs [9], etc., is the noise overriding procedure on the ground that these multi-dimensional data processing [5-9] are immeasurably impressionable by noise. By the assumption perspective, the noise overriding procedures [10-21] are the paramount transactions, which have to be initially processed in advance of contemporaneous utilizations [5-9] on the ground that the functioning of contemporaneous multi-dimensional data processing is regularly eviscerated when the digital photographs are immeasurably mingled by noise. Proportionately, the noisy overriding processing is regularly the paramount transaction for therapeutic photographs, biometric photographs, undersea photographs and etc.

Unsuccessfully, the noise overriding procedures [10-21] do not regularly override only the noisy photographical basis but also the noise-free photographical basis therefrom the paramount ambition of the noise overriding procedures is to override merely the noisy photographical basis but to retain the noise-free photographical basis on the ground that the noisy photographical basis erroneously prosecutes on the digital photographical quality. Regularly, the impulsive eccentricity in digital photographs is offered by reason of the erroneous communication, erroneous signal obtaining or etc. By the philosophical context, the Fix Magnitude Impulsive Noise (FMIN) [22-26] shall be the maximum magnitude or minimum magnitude in its dynamic range (if the digital photograph is 8-bits dynamic range then the maximum magnitude is "255" and minimum magnitude is "0". The paramount confinement of the impulsive epiphany is to discriminate the noisy photographical basis and the noise-free photographical basis, which shall be positioned in either in both the steady magnitude territory (whereas the contractual photographical basis is nearly equivalent) and the margin magnitude territory (whereas the contractual photographical basis is remarkably dissimilar). For regular digital photographs, the large part of the digital photograph is a steady magnitude territory however the little part of the digital photograph

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is a margin magnitude territory. In last thirty-five years, the overflowing contemporaneous noise overriding procedures [22-26] were researched and analyzed on digital photograph with the impulsive noise.

For overriding FMIN or SPN, W. K. Pratt [10] early asserted the admitted median filter (SMF) and, later, was one of the standard noisy overriding filtering procedures in the course of time. For working on pigmentation digital photographs in 1990, the Vector Median Filter (VMF) that was grounded from admitted SMF was asserted and, later, was one of the standard noisy overriding filtering procedures for pigmentation digital photographs in the course of time. Eventually, an adaptive median filter (AMF) [12], which was asserted from admitted SMF and the considered area is oneself-adjusting changed for FMIN in 1994, was asserted and, later, was one of the standard noisy overriding filtering procedures with immense attainment. In 2017, the noise overriding procedure [13], which is grounded on magnitude retaining cast overriding with swarm optimization, was asserted for working on pigmentation digital photographs. Immediately, the noise overriding procedure [14], which is grounded on self-adjusting computer-aided analysis with SVM rule for working on MRI-cerebrum digital photographs, was asserted in 2017. Succeeding, the noise overriding procedure [15], which is grounded on eccentrically contractual subtraction by adjoining numerical rule, was asserted in 2018. In 2018, the noise overriding procedure [16], which grounded on a capable filtering rule, was asserted for working on pigmentation digital photographs. Afterwhile, the capability of the noise overriding procedure [17], which is grounded on Wiener filtering and Gaussian filtering, was observed by assorting kernel dimension in 2019. At another time, the noise overriding procedure [18], which is grounded on MMG filtering rule, was asserted for working on digital medical photographs in 2019. Bilal Charmouti, *et.al.* [19] observed overflowing contemporaneous noise overriding procedures, which are grounded on overflowing dissimilar rules, and analyzed these analogously capability on the noise overriding context in 2019. In 2020, the distinct noise overriding procedures, which are grounded on dismembered wavelet rule [20], which is grounded on from admitted Haar wavelet rule as dismembered level employing a standard LP dissimilar with the dismembered intermission procedure, was asserted. For overriding the undersea auricular-wave eccentric, the noise overriding procedure [21], grounded on both DWT rule and eccentricity frequency context, was asserted in 2020.

Nowadays, overflowing noise overriding procedures [22-27], which are typically grounded on the noise revelation procedure and the noise overriding procedure, are asserted as successive. In 2017, the noise overriding procedure [22], which is grounded on compound numerical rule, was asserted for working on FMIN. For working on FMIN at immense density, the distinct noise overriding procedure, so called adaptive decision formed on inverse distance weighted Interpolation (DBIDWI) [23], which was primitively asserted by V. Kishorebabu et al. [23] in 2017, is comprehensively observed this capability [24] on broad noise density in 2019. In 2019, for the reason that overflowing noise overriding procedures are typically grounded on ROAD, ROLD or RORD, the comprehensive experiments [25] of noise overriding procedures on broad noise density of FMIN was asserted. Afterwards, the noise overriding procedures grounded on the MDBUTMF (modified decision based unsymmetrical trimmed median filter) [26] was early asserted by S. Esakkirajan , *et.al.* for working on FMIN in 2011 and, later, was one of the paramount noisy overriding filtering procedures with immense attainment. Therefrom, the comprehensive experiments [27] of this MDBUTMF procedure grounded on MDBUTMF for broad noise density of FMIN was asserted in 2022. In order to improve the noise overriding capability of MDBUTMF filter, this article asserts the novel noise overriding procedure grounded RMDBUTMF filter, which is recovered from the modified MDBUTMF rule with recursive framework, for working on FMIN on broad noise density.

2. THE PHILOSOPHICAL CONTEXT OF MDBUTMF

By the philosophical context, the digital photograph ($\underline{Y}$), which is manufactured by arithmetically processing the digital photograph ($\underline{X}$) and FMIN, is explicated as the computational proclamation

$$\underline{Y} = \underline{X} + \underline{N} \tag{1}$$

Early, the considered photographical basis is processed as a noisy photographical basis or noise-free photographical basis by the MDBUTMF revelation procedure, which is explicated in Fig. 1., where the digital photographical basis magnitude is "0" or "255".

Next, if the considered photographical basis has the maximum magnitude ("255") or the minimum magnitude ("0") then the photographical basis is noisy otherwise the photographical basis is noise-free. Later, if the photographical basis is noisy and some photographical basis under the considered area are noise-free so the overridden photographical basis is the median of all noise-free photographical basis within the considered window. If the photographical basis is noisy and all photographical basis within the considered window are noisy then the overridden photographical basis is the mean of all noisy photographical basis within the considered window. In different circumstances, if the considered photographical basis has a magnitude between the maximum magnitude ("255") and the minimum magnitude ("0") then the

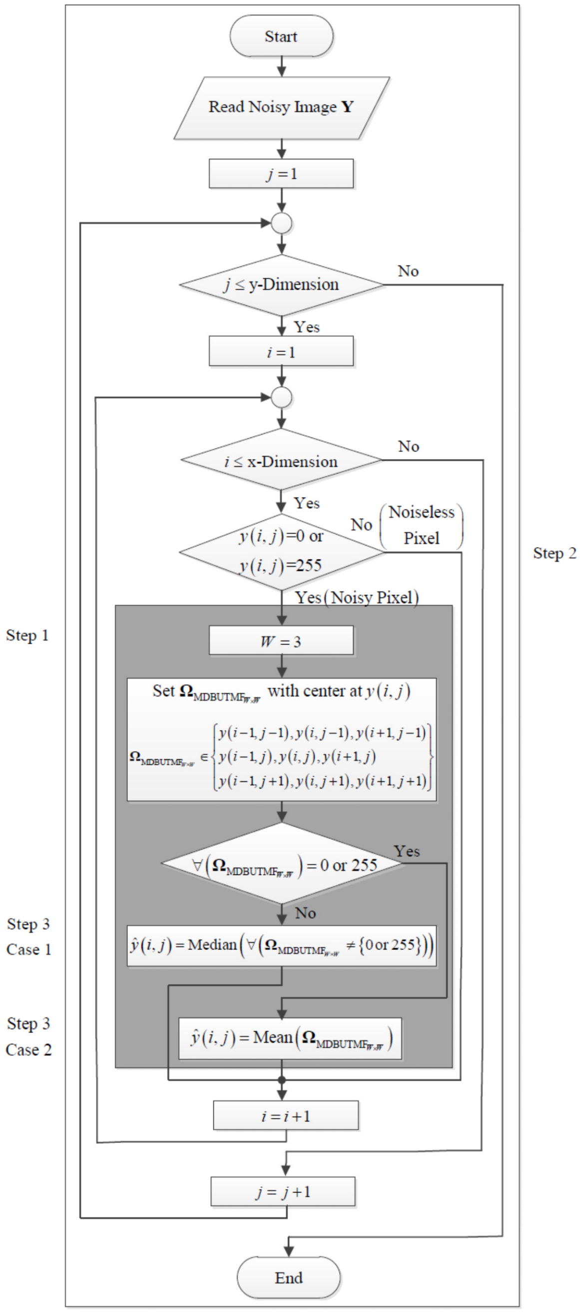

Fig.1: *The MDBUTMF Revelation Procedure.*

considered photographical basis is noise-free photographical basis therefrom the processed photographical basis is not processed. These comprehensive computations of MDBUTMF examples (in distinct cases) are presented as successive three examples. In the first example, if the considered photographical basis is maximum magnitude ("255") and all photographical basis in considered window (3×3) are noisy photographical basis ("0" or "255") therefrom the overridden photographical basis is the mean of all noisy photographical basis within the considered window and the processed computations of MDBUTMF is explicated in the Fig. 2.

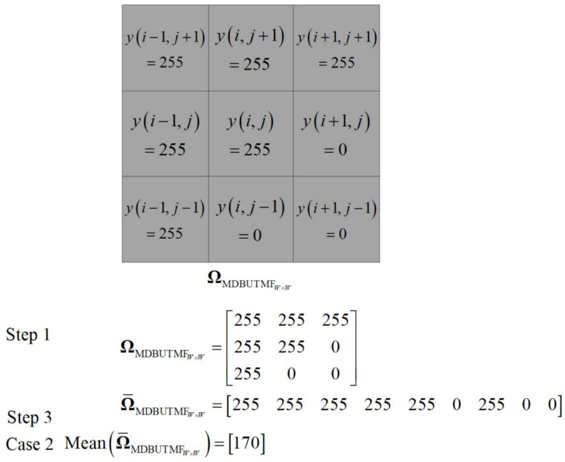

Fig.2: *The Processed Computations of MDBUTMF Example 1.*

In the example 2, if the considered photographical basis is maximum magnitude ("255") but some photographical basis in considered window (3×3) are noise-free photographical basis therefrom the overridden photographical basis is the median of all noise-free photographical basis within the considered window and the processed computations of MDBUTMF is explicated in the Fig. 3. In the example 3, if the considered photographical basis ("118") has between the maximum magnitude ("255") and the minimum magnitude ("0") therefrom the processed photographical basis is not processed and the processed computations of MDBUTMF is explicated in the Fig. 4.

3. THE PHILOSOPHICAL CONTEXT OF PROPOSED RMDBUTMF (RECURSIVE MODIFIED DECISION BASED UNSYMMETRIC TRIMMED MEDIAN FILTER)

The primary disadvantage of the MDBUTMF [26] cannot correctly estimate the denoisied pixel when all photographical basis in the processing window are noisy photographical basis because this MDBUTMF filter estimates the noisy photographical basis with the mean of all photographical basis in the considered area (noisy photographical basis) therefore this denoisied photographical basis does not mathematically relate to both the processed photographical basis and these neighborhoods. (such as MDBUTMF example 1)

In order to solve this disadvantage of the MDBUTMF filter [26], the proposed RMDBUTMF (Recursive Modified Decision Based Unsymmetric Trimmed Median Filter, which is explicated in Fig. 5., initially estimates the denoisied photographical basis by the median of all noise-free photographical basis in the processing window for nosiy photographical basis.

In the RMDBUTM procedure, if the considered

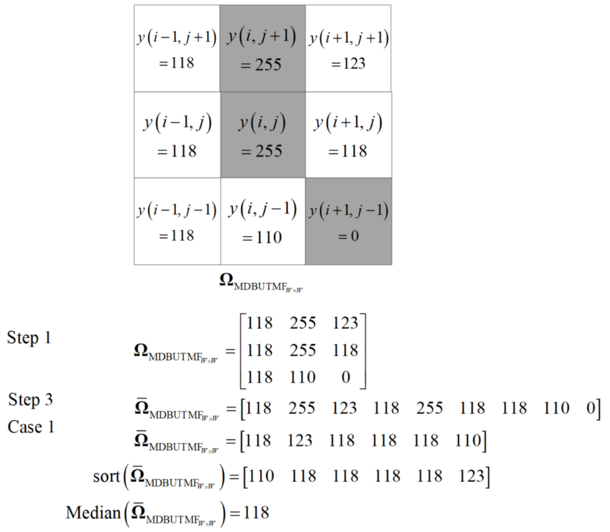

Fig.3: *The Processed Computations of MDBUTMF Example 2.*

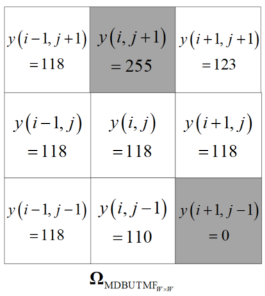

Fig.4: *The Processed Computations of MDBUTMF Example 3.*

photographical basis has the maximum magnitude ("255") or the minimum magnitude ("0") then the photographical basis is noisy otherwise the photographical basis is noise-free. Next, if the photographical basis is noisy and some photographical basis under the considered area are noise-free so the overridden photographical basis is the median of all noise-free photographical basis within the considered window. Otherwise, if the photographical basis is noisy and all photographical basis within the considered window are noisy then the overridden photographical basis is not processed because if the overridden photographical basis is computed from all noisy photographical basis in the considered window then the overridden photographical basis is not related to the original photographical basis. This RMDBUTM procedure is re-computed to the first process again until all considered photographical basis are noise-free photographical basis.

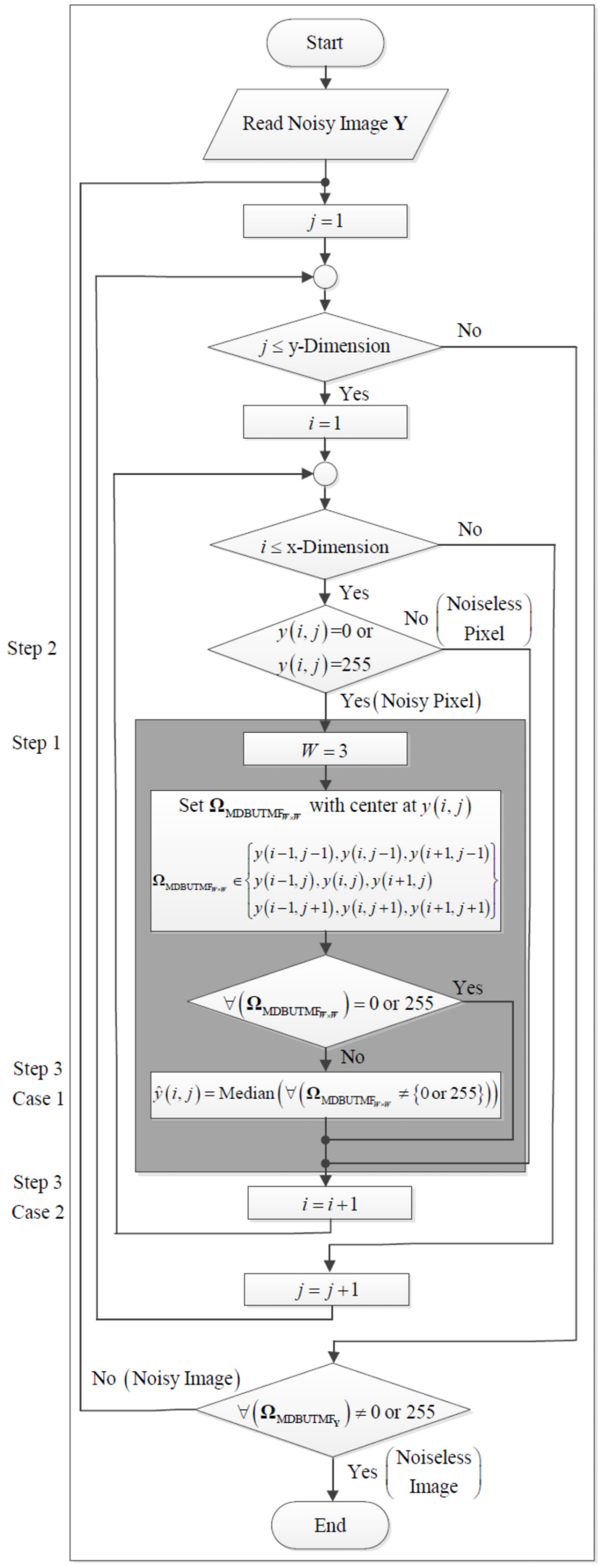

Fig.5: *The Proposed RMDBUTMF Revelation Procedure.*

4. RESULT ANALYSIS

Inside, the simulated testing, the processed code is the MATLAB, which is planted in overflowing PC conducting with i7 HQ processing core at 2.4 GHz and the random- access memory at 16G Byte. (The generosity of processing constant stipulating in this simulated testing is to take all processing constants that realize both superior Peak Signal-to-Noise Ratio (PSNR) and photographical quality. Afterwhile, to realize the verity, all simulated testing are re-simulated overflowing testing situations with distinct magnitudes and the superior simulated execution of all simulated testing are collocated.)

At first, the denoising attainment are quantitatively considered by the PSNR (Peak Signal to Noise Ratio) is explicated in the computational proclamation as Eq.(2).

$$PSNR = 10 \times \log(MAX_I^2/MSE) \tag{2}$$

These simulated testing of the noise overriding procedure grounded RMDBUTMF filter, which is analyzed with SMF (3×3), MF (3×3), AMF (3×3 – 11×11), WMF (3×3), WMF (5×5), MDBUTMF (3×3) and MDBUTMF (5×5) (where the considered window is adjusting changed for 3×3 to 9×9), on Lena, Girl, Pepper and F16 are explicated in Table I – IV respectively.

From this simulated testing, of the noise overriding procedure grounded RMDBUTMF filter has superior capability for overriding the fix magnitude impulsive noise (FMIN) on broad noise density (5%-90%).

From these simulated testing of Lena in Table I, the capability of the proposed noise overriding procedure is distinctly superior than MF (3×3), SMF (3×3), AMF (3×3 – 11×11), WMF (3×3), WMF (5×5), MDBUTMF (3×3) and MDBUTMF (5×5) about 19.0776±1.6648 dB, 14.7232±3.6567 dB, 8.8906±2.5186 dB, 14.0840±4.0148, 10.0699±4.2111, 2.1691±2.9322 and 0.9761±0.5984 dB, respectively.

From these simulated testing of Girl in Table II, the capability of the proposed noise overriding procedure is distinctly superior than MF (3×3), SMF (3×3), AMF (3×3 – 11×11), WMF (3×3), WMF (5×5), MDBUTMF (3×3) and MDBUTMF (5×5) about 22.1066±1.0119 dB, 16.7504±5.2363 dB, 8.9919±3.9708 dB, 15.5356±6.2524, 10.4432±6.2164,

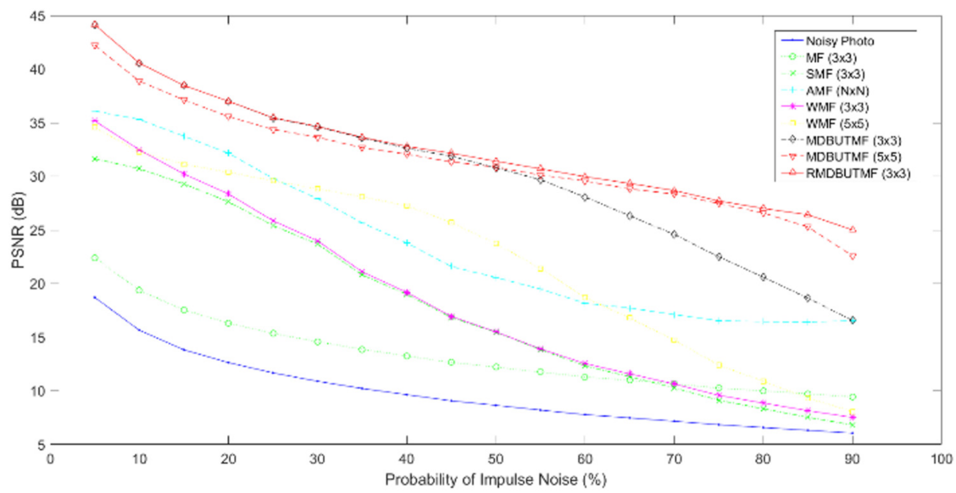

Fig.6: *Noise Removal Result in PSNR Quality (LENA).*

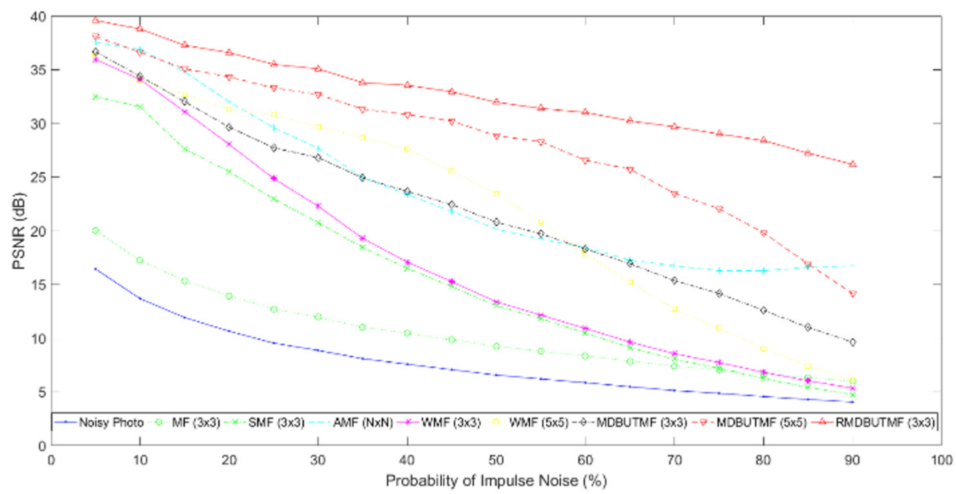

Fig.7: *Noise Removal Result in PSNR Quality (GIRL).*

10.6356±4.1732 and 4.4374±3.1182 dB, respectively.

From these simulated testing of Pepper in Table III, the capability of the proposed noise overriding procedure is distinctly superior than MF (3×3), SMF (3×3), AMF (3×3 – 11×11), WMF (3×3), WMF (5×5), MDBUTMF (3×3) and MDBUTMF (5×5) about 19.2571±2.0392 dB, 14.9990±3.1390 dB, 9.0067±2.2994 dB, 14.1190±3.6719, 10.2636±3.8583, 2.3074±3.0290 and 1.2549±0.8105 dB, respectively.

From these simulated testing of F16 in Table IV, the capability of the proposed noise overriding procedure is distinctly superior than MF (3×3), SMF (3×3), AMF (3×3 – 11×11), WMF (3×3), WMF (5×5), MDBUTMF (3×3) and MDBUTMF (5×5) about 19.7784±1.5683 dB, 15.2611±3.5393 dB, 9.0173±2.6241 dB, 11.0037±2.8407, 9.0530±2.6015, 2.9243±3.7897 and 1.7920±0.9823 dB, respectively.

From all simulated testing (in Table 1 - 4), the denoised digital photographs the proposed noise overriding procedure grounded RMDBUTMF filter have distinctly superior than MF (3×3), SMF (3×3), AMF (3×3 – 11×11), WMF (3×3), WMF (5×5), MDBUTMF (3×3) and MDBUTMF (5×5).

A comparative plot of PSNR results against noise density (5%-90%) for Lena, Girl, Pepper and F16 explicated in Fig 6 – 9.

As well, the incomplete of the simulated testing results of Lena photo, which is comparatively noisy-overridden by the proposed RMDBUTMF that is comparative with SMF (3×3), MF (3×3), AMF (3×3 – 11×11), WMF (3×3), WMF (5×5), MDBUTMF (3×3) and MDBUTMF (5×5) (where the considered window is adjusting changed for 3×3 to 9×9), are explicated in Fig.10(a), Fig.10(b), Fig.10(c) and Fig.10(d) for noise density 30%, 50%, 70% and 90%, respectively.

For ROI of the Lena photograph at noise density 70% and 90%, the results of the noisy-overridden by the proposed RMDBUTMF, which is comparative with SMF (3×3), MF (3×3), AMF (3×3 – 11×11), WMF (3×3), WMF (5×5), MDBUTMF (3×3) and MDBUTMF (5×5) (where the considered window

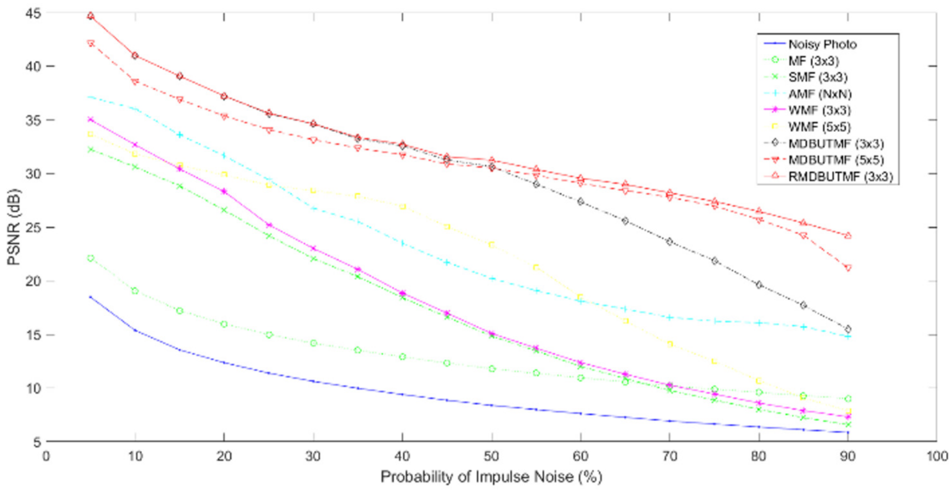

Fig.8: *Noise Removal Result in PSNR Quality (Pepper).*

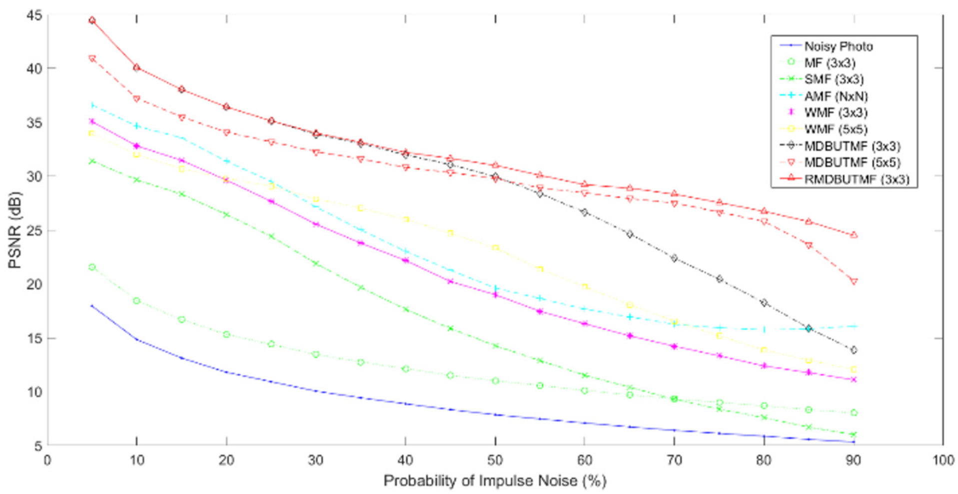

Fig.9: *Noise Removal Result in PSNR Quality (F16).*

is adjusting changed for 3×3 to 9×9), are explicated in Fig.11(a-b) and Fig.11(c-d), respectively. From these results, the RMDBUTMF photograph has finest quality (and is closely similar to the original photograph), comparted with photographs processed by other noisy overriding procedures.

From these simulated testing of distinctive digital photographs (Lena, Girl, Pepper and F16) on broad noise density, the RMDBUTM has the superior noisy-overridden performance for all-range noise density, especially at heavy noise density (about 3-15 dB). For low noise density, there are many noise-free photographical basis in the considered window therefore the overridden photographical basis is computed by all noise-free photographical basis. For heavy noise density, the overridden photographical basis is always computed by some noise-free photographical basis (from the RMDBUTM computation) therefore the overridden photographical basis is related with noise-free photographical basis. The MDBUTMF (5×5) has the high noisy-overridden performance (which is slightly lower than the proposed RMDBUTM) for low noise density (where noise less than 50%) because the considered window is a large size (24 neighbourhood photographical basis) and, as a result, there are many noise-free photographical basis for computing the overridden photographical basis and the noisy-overridden photographical basis is slightly blurred. However, the MDBUTMF (5×5) has the low noisy-overridden performance (which is compared with the proposed RMDBUTM) for heavy noise density (where noise greater than 50%) because the considered window is large size (24 neighbourhood photographical basis) and, as a result, there are few noise-free photographical basis for computing the overridden photographical basis therefore the noisy-overridden photographical basis is closely related to the original photographical basis (as Example 2). In another point of view, the MDBUTMF (3×3) has the high noisy-overridden (which is equal to the proposed RMDBUTM) for low noise density (where noise less than 50%) because the considered window is a small size (8 neighborhood photographical basis) and, as a result, there are few noise-free photographical basis for computing the overridden photographical basis and the noisy-overridden photographical basis is related to the original photographical basis (as Example 2). However, the MDBUTMF (3×3) has the low noisy-overridden (which is lower than the proposed RMDBUTM) for heavy noise density (where noise greater than 50%) because the considered window is a small size (8 neighborhood photographical basis) and, as a result, there are few or no noise-free photographical basis for computing the overridden photographical basis and the noisy-overridden photographical basis is not related to the original photographical basis (as Example 1).

From these above results, the noisy-overridden results of both PSNR and noisy-overridden graphical photo of the proposed RMDBUTMF provides the superior noisy-overridden photographs than other procedures.

5. SUMMARY

This article proposes an innovative recursive modified decision based unsymmetrical trimmed median filter (RMDBUTMF) procedure, which is grounded on MDBUTMF procedure (one of the paramount noise overriding procedures), for noisy overriding of digital photographs, which are manufactured by FMIN or SPN on broad noise density (5%-90%).

In order to certify the quantity and quality attainment, the proposed RMDBUTMF procedure is testing against distinctive digital photographs (Lena, Girl, Pepper and F16) on broad noise density. Afterwhile, the proposed RMDBUTMF procedure reveals superior noisy-overridden photographs than the Standard Median Filter (SMF), Mean Filter (MF), Adaptive Median Filter (AMF), Weight Median Filter (WMF), MDBUTMF. From these simulated testing, the proposed procedure is certified against distinctive digital photographs (Lena, Girl, Pepper and F16) and it grants superior Peak Signal-to-Noise Ratio (PSNR) and photographical quality.

AUTHOR CONTRIBUTIONS

Conceptualization, V.P. and K.T.; methodology, V.P. and K.T.; software, V.P. and K.T.; validation, V.P. and K.T.; formal analysis, V.P. and K.T.; investigation, V.P. and K.T.; data curation, V.P. and K.T.; writing—original draft preparation, V.P. and K.T.; writing—review and editing, V.P. and K.T.; visualization, V.P. and K.T.; supervision, V.P. and K.T. All authors have read and agreed to the published version of the manuscript.

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Table 1: *The noise removal simulated testing in PSNR quality (Lena).*

FMIN Density (%)	Noisy Photo	Recursive MDBUTMF Procedure							
		MF (3x3)	SMF (3x3)	AMF (NxN)	WMF (3x3)	WMF (5x5)	MDBUT MF (3x3)	MDBUT MF (5x5)	RMDBUT MF (3x3)
D=5	18.7139	22.4181	31.6421	36.0907	35.1721	34.5535	44.1315	42.2238	44.1315
D=10	15.6564	19.3812	30.7076	35.3032	32.4698	32.2808	40.5625	38.8778	40.5625
D=15	13.8274	17.5385	29.2982	33.7454	30.2208	31.1339	38.4739	37.1273	38.4739
D=20	12.6389	16.3208	27.6257	32.1558	28.3548	30.3752	37.0049	35.5768	37.0049
D=25	11.6783	15.3526	25.4101	29.8105	25.8645	29.5861	35.4384	34.3698	35.4643
D=30	10.8971	14.5829	23.6811	27.9141	23.9839	28.8233	34.6133	33.6472	34.6572
D=35	10.2240	13.8785	20.8127	25.6654	21.1014	28.1014	33.5761	32.6657	33.6370
D=40	9.6481	13.2479	19.0080	23.7903	19.1825	27.2510	32.6285	32.0617	32.7933
D=45	9.0745	12.6598	16.8389	21.5949	16.9429	25.6878	31.8776	31.3528	32.1548
D=50	8.6553	12.2146	15.4758	20.5725	15.5050	23.7318	30.7968	30.8632	31.4120
D=55	8.2118	11.7609	13.8573	19.4896	13.9115	21.4153	29.6867	30.1177	30.7100
D=60	7.7813	11.2939	12.3280	18.1747	12.5485	18.6948	28.0721	29.5722	29.9663
D=65	7.4884	11.0012	11.3251	17.7283	11.5932	16.7976	26.3301	28.8217	29.3391
D=70	7.1697	10.6509	10.2861	17.1153	10.6427	14.7470	24.5858	28.357	28.6849
D=75	6.8497	10.2599	9.1271	16.5388	9.5848	12.3932	22.5049	27.4665	27.7046
D=80	6.5846	10.0057	8.3331	16.4554	8.8622	10.8970	20.5932	26.5884	27.0114
D=85	6.3241	9.7338	7.5344	16.4230	8.1548	9.3376	18.6368	25.2838	26.4114
D=90	6.0604	9.4356	6.8241	16.5352	7.5261	8.0678	16.5767	22.5899	25.0145

Table 2: *The noise removal simulated testing in PSNR quality (Girl).*

FMIN Density (%)	Noisy Photo	Recursive MDBUTMF Procedure							
		MF (3x3)	SMF (3x3)	AMF (NxN)	WMF (3x3)	WMF (5x5)	MDBUT MF (3x3)	MDBUT MF (5x5)	RMDBUT MF (3x3)
D=5	16.4490	20.0454	32.4867	37.5518	35.9690	36.3119	36.6788	38.1006	39.5918
D=10	13.6890	17.2530	31.5583	36.8900	34.0977	34.1081	34.3960	36.6369	38.7975
D=15	11.9287	15.3515	27.6179	34.8060	31.1067	32.7037	32.0364	35.0880	37.2816
D=20	10.6567	13.9593	25.5153	32.0377	28.0604	31.3171	29.6565	34.3384	36.5920
D=25	9.5498	12.7248	22.9614	29.6044	24.8722	30.8000	27.7375	33.3051	35.5081
D=30	8.8677	11.9599	20.7738	27.6911	22.2937	29.7153	26.8156	32.7026	35.0815
D=35	8.0984	11.0501	18.4410	24.9701	19.3002	28.6972	24.9210	31.3341	33.7959
D=40	7.5798	10.4543	16.5146	23.3733	17.0943	27.6109	23.6733	30.8249	33.5510
D=45	7.0728	9.8471	14.8145	21.8116	15.2681	25.5460	22.4427	30.2229	32.9547
D=50	6.5712	9.2367	13.0319	20.1711	13.3881	23.4389	20.8036	28.8444	31.9787
D=55	6.2085	8.7895	11.8226	19.2184	12.1602	20.8704	19.7238	28.3155	31.3979
D=60	5.8609	8.3590	10.4981	18.4518	10.9121	17.8824	18.3129	26.5673	31.0289
D=65	5.4832	7.8712	9.1396	17.2740	9.6478	15.1961	16.9325	25.7517	30.2395
D=70	5.1311	7.4271	8.0463	16.7334	8.5653	12.7541	15.3649	23.4947	29.6888
D=75	4.8712	7.0814	7.1994	16.2921	7.7377	10.9117	14.1581	22.0584	29.0250
D=80	4.5674	6.6881	6.2520	16.2795	6.8373	9.0411	12.6009	19.8211	28.4069
D=85	4.3054	6.3340	5.4218	16.5924	6.0352	7.4206	11.0131	16.9198	27.2354
D=90	4.0573	5.9986	4.7465	16.7463	5.3617	6.0460	9.6412	14.1492	26.1938

Table 3: *The noise removal simulated testing in PSNR quality (Pepper).*

FMIN Density (%)	Noisy Photo	Recursive MDBUTMF Procedure							
		MF (3x3)	SMF (3x3)	AMF (NxN)	WMF (3x3)	WMF (5x5)	MDBUT MF (3x3)	MDBUT MF (5x5)	RMDBUT MF (3x3)
D=5	18.4752	22.1408	32.2578	37.1145	35.0049	33.6748	44.6687	42.1887	44.6687
D=10	15.3798	19.0677	30.6116	36.0391	32.6811	31.8203	41.0008	38.6175	41.0008
D=15	13.5570	17.2234	28.8470	33.6095	30.4266	30.7565	39.0807	36.9122	39.0807
D=20	12.3593	15.9804	26.5888	31.6485	28.3098	29.8638	37.2270	35.3677	37.2270
D=25	11.3929	14.9986	24.2073	29.4205	25.2232	28.9233	35.5706	34.0940	35.6215
D=30	10.6242	14.1748	22.0663	26.7650	23.0148	28.4090	34.6143	33.1551	34.6236
D=35	9.9742	13.5209	20.3774	25.5249	21.0650	27.8691	33.2333	32.3768	33.3685
D=40	9.3998	12.9076	18.4321	23.4995	18.8546	26.9506	32.5794	31.7456	32.7225
D=45	8.8599	12.3275	16.6168	21.7177	16.9821	25.0508	31.2599	30.8880	31.5632
D=50	8.3843	11.8117	14.8506	20.2203	15.0906	23.3417	30.6386	30.5154	31.2512
D=55	7.9930	11.3720	13.4655	19.0894	13.7177	21.2505	29.0061	29.8211	30.3740
D=60	7.6189	10.9563	12.0128	18.1116	12.3715	18.5046	27.3471	29.0890	29.5545
D=65	7.2684	10.5758	10.8920	17.3657	11.2881	16.2700	25.6020	28.4077	28.9791
D=70	6.9246	10.2039	9.7704	16.5923	10.2656	14.0814	23.6403	27.7867	28.2002
D=75	6.6418	9.8955	8.8751	16.2338	9.4361	12.5170	21.8703	26.9649	27.3900
D=80	6.3710	9.5853	8.0166	16.0896	8.6043	10.6953	19.6195	25.7234	26.4636
D=85	6.1097	9.2949	7.2402	15.7200	7.8970	9.0864	17.6942	24.2343	25.3814
D=90	5.8582	9.0214	6.5767	14.8051	7.3127	7.8774	15.5010	21.2108	24.2164

Table 4: *The noise removal simulated testing in PSNR quality (F16).*

FMIN Density (%)	Noisy Photo	Recursive MDBUTMF Procedure							
		MF (3x3)	SMF (3x3)	AMF (NxN)	WMF (3x3)	WMF (5x5)	MDBUT MF (3x3)	MDBUT MF (5x5)	RMDBUT MF (3x3)
D=5	17.9498	21.5802	31.4106	36.6062	35.0562	33.9410	44.4443	40.9273	44.4443
D=10	14.8320	18.4426	29.6532	34.6310	32.8038	32.0086	40.0806	37.2340	40.0806
D=15	13.1197	16.6870	28.3176	33.5561	31.4609	30.6870	38.0268	35.4912	38.0268
D=20	11.8045	15.3181	26.4356	31.3844	29.6277	29.7829	36.4176	34.0856	36.4176
D=25	10.9272	14.3866	24.4147	29.5029	27.6540	29.0736	35.1299	33.1837	35.1299
D=30	10.0510	13.4526	21.8862	27.1347	25.5386	27.8733	33.8690	32.2614	33.9935
D=35	9.4325	12.7646	19.6835	25.0118	23.7815	27.0371	33.0256	31.5923	33.1372
D=40	8.8735	12.1397	17.6412	23.0147	22.1737	25.9942	31.9731	30.8140	32.1985
D=45	8.3344	11.5224	15.8686	21.2768	20.2179	24.7055	31.0675	30.3237	31.6430
D=50	7.8600	11.0091	14.2697	19.6201	19.0001	23.3418	29.9588	29.7673	30.9970
D=55	7.4696	10.5769	12.8823	18.6408	17.4576	21.3622	28.3789	28.9114	30.0763
D=60	7.0920	10.1202	11.5290	17.6586	16.2979	19.7167	26.6506	28.4467	29.2010
D=65	6.7276	9.7008	10.4080	16.9400	15.1766	18.0660	24.6590	27.9178	28.8834
D=70	6.4128	9.3238	9.3042	16.2514	14.2170	16.5416	22.3885	27.5011	28.3226
D=75	6.1274	9.0020	8.3797	15.9223	13.3259	15.1864	20.4203	26.6712	27.5449
D=80	5.8647	8.6893	7.5835	15.7428	12.3822	13.8615	18.2508	25.7860	26.7285
D=85	5.5768	8.3346	6.7043	15.8098	11.7633	12.9123	15.8811	23.6530	25.7753
D=90	5.3335	8.0381	6.0278	16.0834	11.0983	12.0537	13.8408	20.2767	24.4996

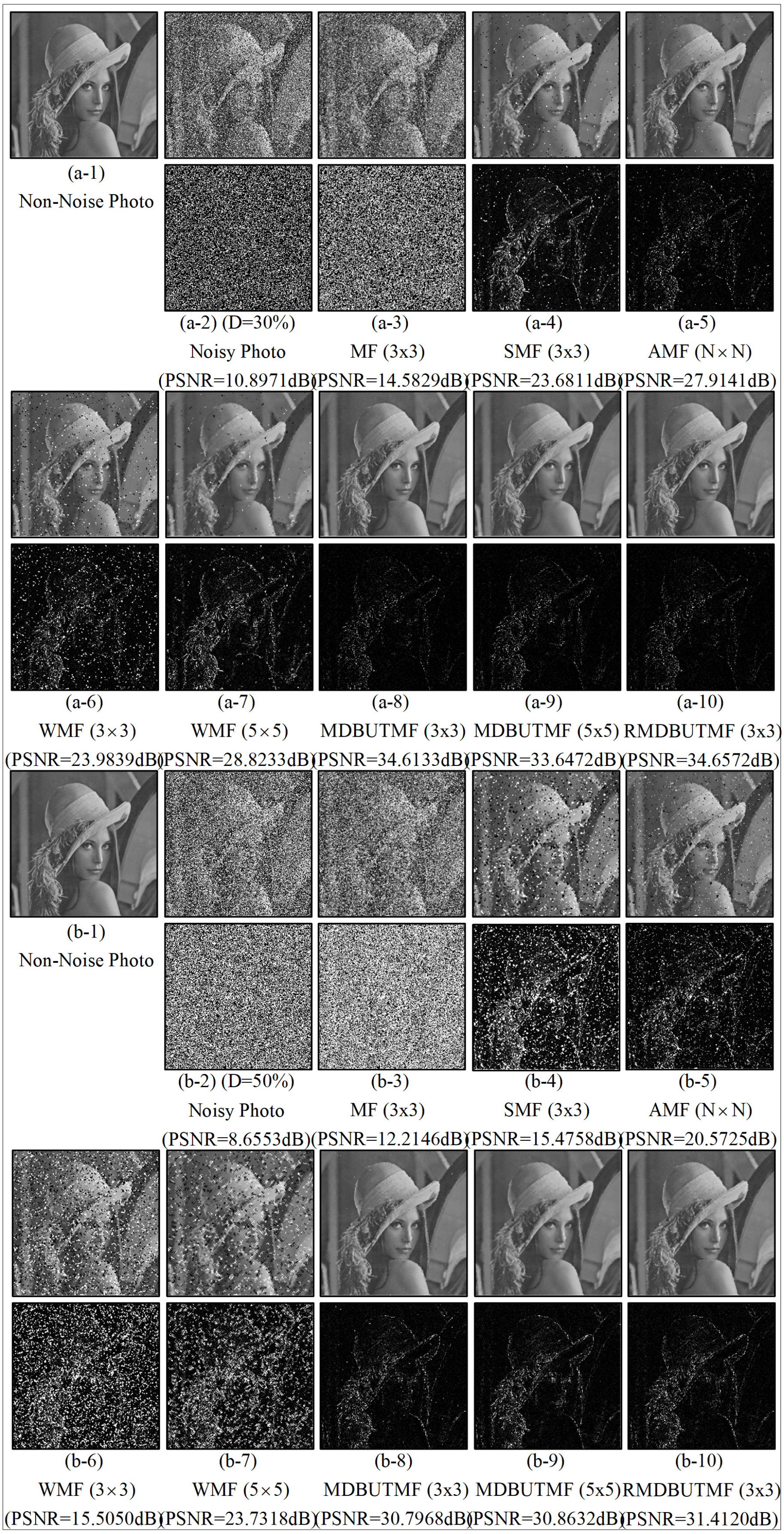

Fig.10: *Noise Removal Result in Graphical Quality (Lena).*

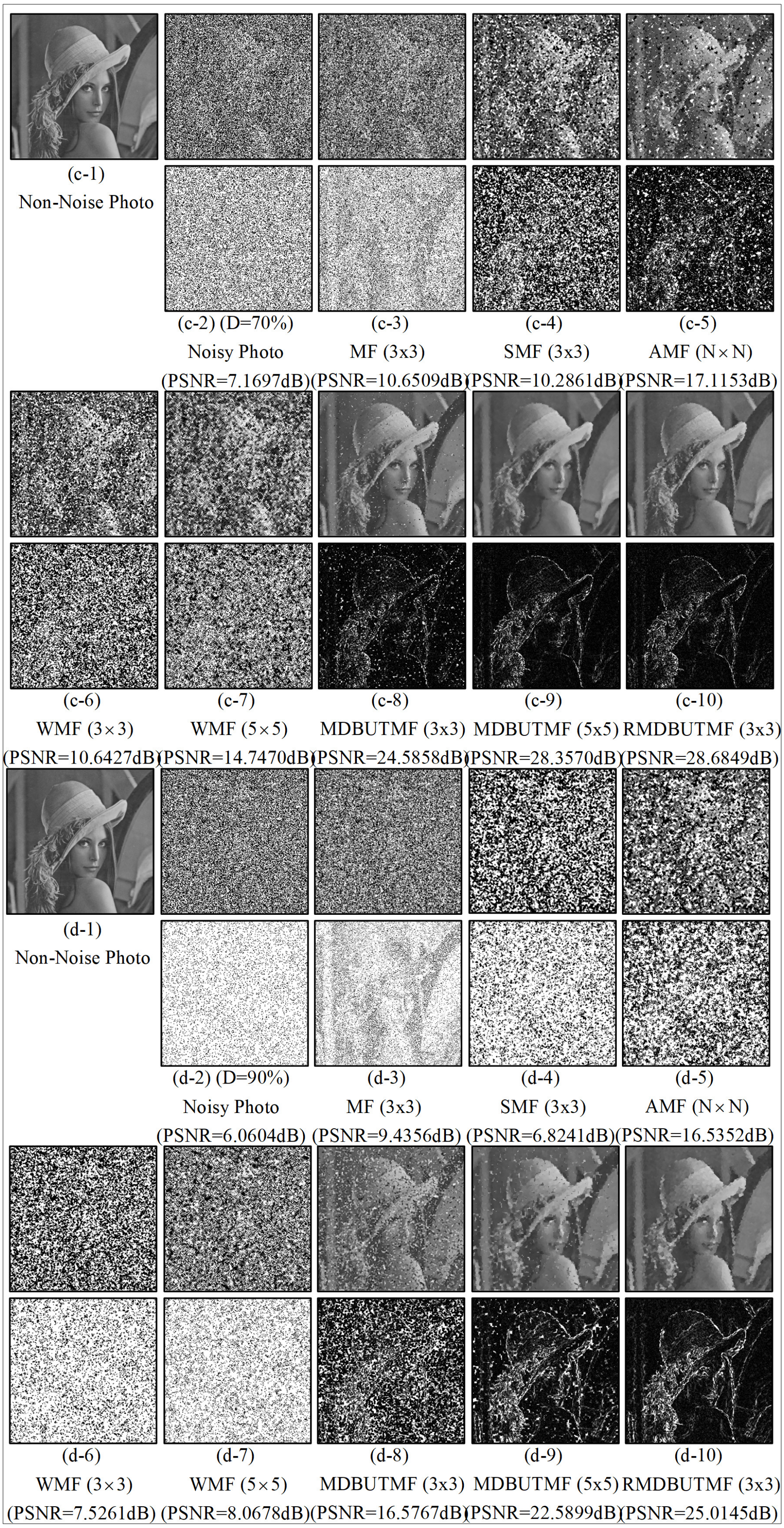

Fig.10: *Noise Removal Result in Graphical Quality (Lena) (Cont.)*

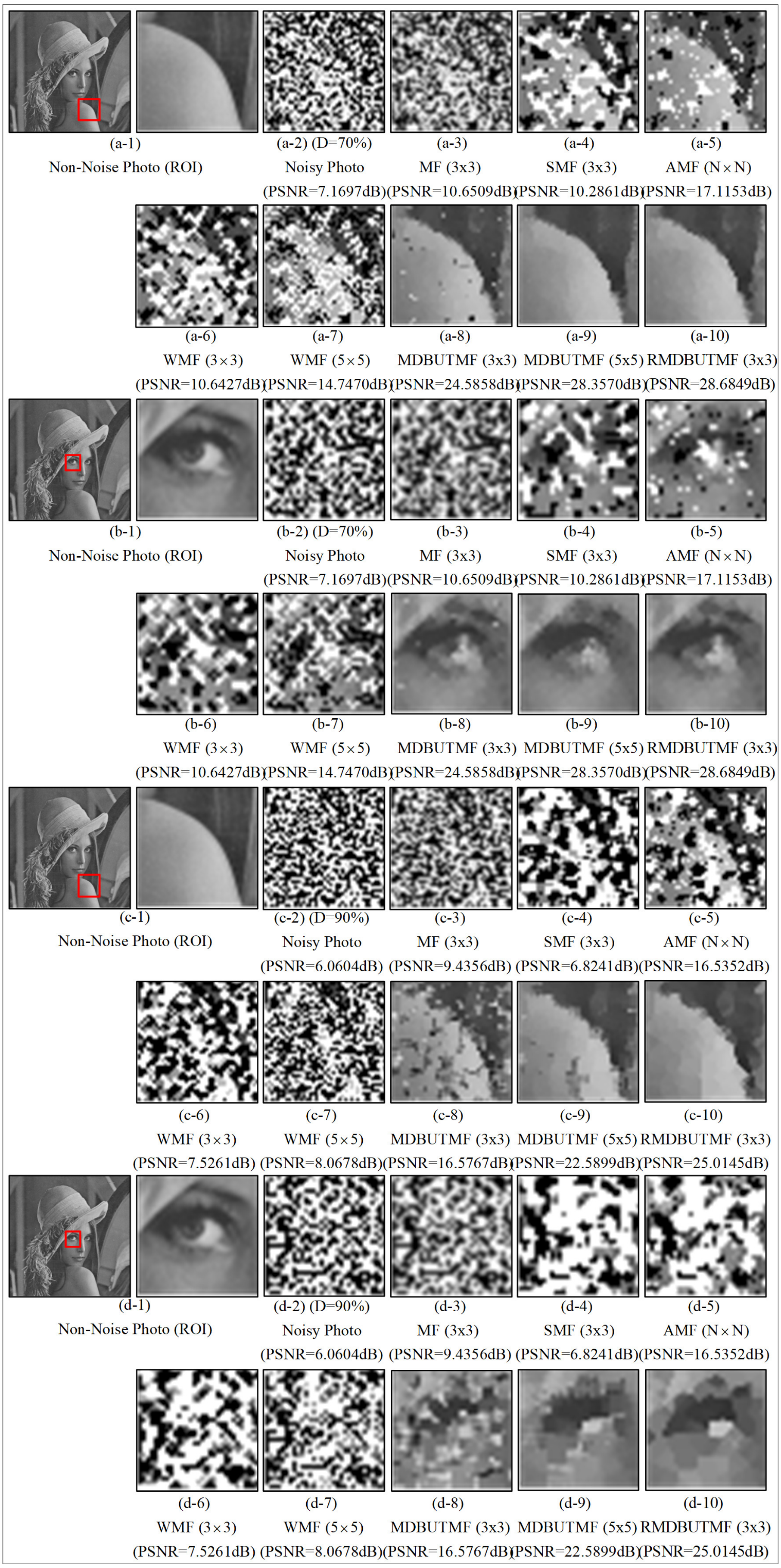

Fig.11: *Noise Removal Result (ROI) in Graphical Quality (Lena).*

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