International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-3S, February 2019

A Probabilistic and Statistical Detection Based Median Filter for Salt and Pepper Noise Removal in Images

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Abstract:** a present day probabilistic and quantifiable recognizable proof based absolutely totally center channel (PSDBMF) is proposed for denoising the pix, which can be corrupted with the helpful guide of salt and pepper confusion (SPN) and unordinary regarded inspiration fuss (RVIN). The proposed computation fuses of levels: (I) character set up together making sense of if the photo is destroyed through SPN or RVIN, dependent upon the histogram of the uproarious photo and (ii) treatment set up doles out to the remainder of the pixels, a standard regard that relates to the chance of corruption by means of RVIN. in this computation, the yield pixel regard is equal to weighted quickly blend of the main acknowledgment pixel regard and center estimation of uncorrupted pixels inside the window, with the weight contingent upon its pennant. This computation additionally clears the joined confusion. intrigue outcomes exhibits that the proposed count plays better than the some unique figurings until date. what's more, the proposed count is direct and time skilled.

I. CREATION

Simple to advanced Conversion and unmarried piece or burst mistakes made in transmission, blessing a blend of customary regard and discretionary regarded main thrusts in pictures. The critical errand in picture denoising is to see accurately the pixels which might be animated through hullabaloo the utilization of a quantifiable and strong technique and to address them without affecting the image edges and unmistakable top notch nuances. until date no longer numerous figurings healthy for covering such blended uproar had been proposed recorded as a hard copy. absolutely, even those which empty mixed fuss are a triumph decent for little estimations of tumult densities.

1.1 Impulse Noise

Vitality noise modifications a pixel with circumstance p or keeping it perfect with a hazard (1-p). that is respected in Equation 1, wherein n(x,y) is indistinguishable from crazy powers zero or Z-1, if the uproar is a SPN. strain commotion limit of the time takes region because of transmission mistakes or air or human-made aggravations.

$$f'(x,y) = \begin{cases} \mathbf{n(x,y)\ with\ probability\ p} \\ \mathbf{f(x,y) with\ probability\ 1-p} \end{cases} \quad (1)$$

1.2 Related Work

SMF (across the board Median channel out) [3] is a non-direct channel regularly used to empty pressure tumult reasonably at little estimations of uproar densities. aside from on record that every pixel is adjusted it demonstrates over the top corruption and lack of photo nuances. In TSMF [13], the yield pixel regard is same to one of the three potential states, to be exact uncorrupted pixel regard (upheaval free pixels), the SMF yield or CWMF [8] yield. This technique is in like manner prepared for denoising in reality low thickness consolidated bustle. decision fundamentally based genuinely channels especially ACWMF [9] and - u . s . a . SD-ROM [10] can in like manner be connected in view of this with the burden of propelling the limits for each noise sorts. As of past due proposed approach BDND [11] is truly productive for SPN clearing and to remarkable upheaval is going which may be confined to the limits of the picture dynamic range. For previews polluted totally through the utilization of RVIN this count gives negative impacts. besides the genuine prevalence contraption ROLD [12] and the general Trilateral channel [14] yet empty RVIN in all regards solidly flop as a result of pollution through enduring regarded the utilization of powers. PSMF [15] beats the once in the past noted channels concerning quantitative estimations anyway the genuine drawback is it is an iterative computation and because of this dull.

II. PSDBMF

Each and every other estimation particularly Probabilistic and Statistical Detection based absolutely totally Median get out (PSDBMF), which effectively clears SPN as a lot as a bustle thickness of 90%, RVIN up to a racket thickness of half, and besides a blend of each. It utilizes a quantifiable area inspiration personality computation. the primary dimension utilizes the tumultuous photo histogram to capture pixels which is most likely undermined with the helpful asset of SPN in the meantime as the second dimension doles out to the unwinding of the pixels, a pennant regard that identifies with the opportunity of pollution through way of RVIN.

Manuscript published on 28 February 2019.
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The yield pixel regard is indistinguishable from the weighted direct blend of exact cognizance pixel regard and focus estimation of uncorrupted pixels in the window, with the weight depending on its flag. One major thing of the count is that it has phenomenally a dazzling arrangement tons less time multifaceted design and extraordinary detail ensuring potential. PSDBMF moreover clears picture debasements, for example, streaks, stripes, blotches, cross sections and scratches.

2.1 NOISE model

Hullabaloo is anticipated as mix of SPN (wherein some aimlessly decided on pixels of an eight-piece monochrome photograph is likely spoiled with the asset of fixed incredible characteristics, 0 and 255), and RVIN (in which a couple of subjectively chosen pixels of a picture might be contaminated by methods for method for self-assertive capacities drawn from uniform scattering inside the interim [0, 255]). that is, inside the event that the photo is corrupted by means of SPN, at that factor, for each pixel at (i,j)th ($1 \le I \le M$, $1 \le j \le N$ for a M x N picture) region with power regard Oij, the estimation of the pixel inside the uproarious picture could be $\hat{X}_{ij}$ in which the probability density function (I) of $\hat{X}_{ij}$ is

$$f(\hat{x}) = \begin{cases} \rho_s / 2 & \text{for } \hat{x} = 0 \\ 1 - \rho_s & \text{for } \hat{x} = O_{ij} \\ \rho_s / 2 & \text{for } \hat{x} = 255 \end{cases} \quad (2)$$

where, ρ_s is SPN probability.

The SPN corrupted image is further degraded by adding RVIN to simulate the mixed impulse noise model. For each pixel at $(i,j)^{th}$ location, the value of the pixel in the final noisy image is X_{ij} in which the pdf of X_{ij} is

$$f(x) = \begin{cases} \rho_r & \text{for } x \in (0\ ,\ 255) \\ 1 - \rho_r & \text{for } x = \hat{X}_{ij} \end{cases} \quad (3)$$

where, ρ_r is RVIN probability.

2.2 ALGORITHM FOR PSDBMF

2.2.1 Detection algorithm

Let X_{ij} be the pixel to be processed currently. Let S_{ij} be the sliding window of size W x W centered at X_{ij}, where W = (2L+1) and L is a positive integer. S_{ij} comprises of pixels defined by the set $\{X_{i-u,\, j-v}\ ,\ -L \le u,v \le L\}$.

SPN detection:

1. Let X be the input noisy image of size M x N.
2. Set the window size W based on noise density ND as shown in tables 3.1 and 3.2.
3. Compute the histogram H of the noisy image X.
4. Assign the intensity values corresponding to the two maxima in H to thresholds T_{min} and T_{max}.
5. If Tmin = X_{min} (minimum value in the noisy image), T_{max} = X_{max} (maximum value in the noisy image) and H_{max} is very large, it indicates the presence of SPN.
6. For every pixel X_{ij} in the image,
   a. If $T_{min} < X_{ij} < T_{max}$ then the pixel X_{ij} is considered as uncorrupted and its flag status is set to '0' in the flag image SPF.
   b. Else X_{ij} is corrupted and its flag status is set to '1' in the flag image SPF.

RVIN detection:

1. Fix the thresholds T_1 and T_2 as specified in section 2.2.3.
2. Initialize the flag image F to SPF.
3. For every pixel X_{ij} in the image for which SPF_{ij} = 0 (i.e. not salt or pepper),
   a. Collect those pixels in S_{ij} whose flag value in SPF is '0' in a vector D_VEC.
   b. Sort the absolute difference of the centre pixel X_{ij} with all elements in D_VEC and store in a vector SV, i.e. SV = Sort {| X_{ij} – D_VEC |}.
   c. Find the sum of first four values in SV as a statistical measure SM to detect random noise.
   d. The probabilistic flag value is assigned as follows:

$$F_{ij} = \begin{cases} 0 & SM \le T_1 \\ \dfrac{SM - T_1}{T_2 - T_1} & T_1 < SM < T_2 \\ 1 & SM \ge T_2 \end{cases} \quad (4)$$

2.2.2 Correction algorithm

Let X_{ij} be the pixel to be processed currently and Y_{ij} be its restored value. Let S_{ij} be the sliding window of size W x W centered at X_{ij}, where W = (2L+1). S_{ij} comprises of pixels defined by the set $\{X_{i-u,\, j-v}\ ,\ -L \le u,v \le L\}$.

1. Get the noisy image X and the flag image F of size M x N as input from the detection stage.
2. For every corrupted pixel (i.e., flag value, $F_{ij} \neq 0$),
   a. Select those pixels in S_{ij} whose value in F is less than or equal to 0.5 in a vector C_VEC.
   b. If C_VEC is not null, assign the median of the vector elements to MED.
   c. If C_VEC is null, assign the median of S_{ij} to MED.
   d. The value of the restored pixel Y_{ij} is computed as follows:

$$Y_{ij} = (1 - F_{ij}) * X_{ij} + F_{ij} * MED \quad (5)$$

The detection and correction algorithm is iterated IC (Iteration Count) number of times with the restored image Y fed back as noisy image. The iteration count IC is defined based on the noise density ND.

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2.2.3 Parameter configuration

After extensive simulations for various images, the threshold values T_1 and T_2 used in the assignment of probabilistic flag value are fixed at 50 and 100 respectively. The window size, W used in the algorithm and the number of iterations, IC to be carried out are shown in Table 1. The iteration count IC depends only on the RVIN density whereas the window size W depends both on SP and RD noise density.

Table 1: Parameter specification for PSDBMF

Noise type	Noise range (%)	Iteration Count, IC	Window size, W
SP	≤ 40	1	3
	40 – 65	1	5
	65 – 75	1	7
	> 75	1	9
RD	< 20	1	3
	20 – 40	2	3
	> 40	3	3

III. SIMULATION RESULTS AND DISCUSSIONS

On this area, the proposed estimation is endeavored for different popular check previews explicitly Barbara.png, Bridge.tiff, Lena.jpg, Elaine.tiff, Zelda.bmp, Boat.tiff and Peppers.bmp of period 512 x 512, eight bits/pixel. every single one of the photographs are undermined with regards to the predefined hullabaloo model, with various racket densities and the proposed channel is mounted on the tainted pics for denoising. all the front line day channels are appeared differently in relation to reverence with PSNR. The propagations are done on a PC (1.86 GHz and 1 GB RAM) outfitted with MATLAB 7.zero.1 and the estimation occasions of all counts are in addition investigated.

three.1 SPN

The emotional and quantitative introduction of the proposed channel is differentiated and the forefront channels, as an occasion, SMF, WMF, CWMF, ACWMF, AMF, PSMF, FIDT, BDND and DBA. decide 3.1 presentation the seen impacts of forefront techniques and the proposed PSDBMF on SPN demolished 'Peppers' photo of disturbance thickness 80%. Tables 2 and 3 shows the presentation of the proposed figuring and indistinguishable old channels from far as PSNR and count time for a boisterous 'Bridge.tiff' picture at uncommon inspiration bustle thickness ranges.

The seen results conveyed demonstrate that PSDBMF obviously beat all the looked at frameworks in any regard fuss densities. From the quantitative appraisals appeared work area 2, execution of SMF, WMF, CWMF and FIDT spoils prominently as upheaval thickness augments as they might be not decision based absolutely totally. besides, it's far determined that anyway AMF recommends further excellent PSNR at low confusion densities, its introduction degrades basically at higher clatter extends because of the reality the window time frame is ventured forward if center regard is contaminated along the ones lines obviously debasing photo noteworthy. frameworks like ACWMF, PSMF and BDND have the genuine burden of being monotonous as put from table 3. The proposed estimation offers built up execution in removing SPN with capture to PSNR and count time than each unmarried standard system recorded as a hard copy.

Table 2: PSNR (in dB) of various filters for Bridge image at different SP noise densities

Noise density (%)	SMF	WMF	CWMF	ACWMF	AMF	PSMF	FIDT	BDND	DBA	Proposed PSDBMF
10	25.92	27.37	27.43	29.03	34.36	29.06	31.88	32.27	29.33	34.32
20	24.11	24.44	23.35	26.68	30.50	26.48	28.64	29.74	28.24	31.46
30	21.28	23.64	19.15	24.37	28.07	24.63	26.60	28.14	26.58	29.16
40	17.97	22.39	15.44	22.24	26.06	23.35	24.87	26.40	25.60	26.74
50	14.62	21.28	12.66	20.14	24.16	22.32	22.49	24.87	24.33	25.53
60	11.88	19.55	10.54	17.88	22.48	21.17	18.82	23.44	23.15	24.56
70	9.72	15.98	8.78	15.00	20.60	18.60	14.62	22.46	22.00	22.98
80	7.90	11.70	7.37	12.01	18.76	13.06	10.81	21.65	20.63	21.75
90	6.42	7.93	6.20	8.45	16.32	7.62	7.73	20.37	18.58	20.60

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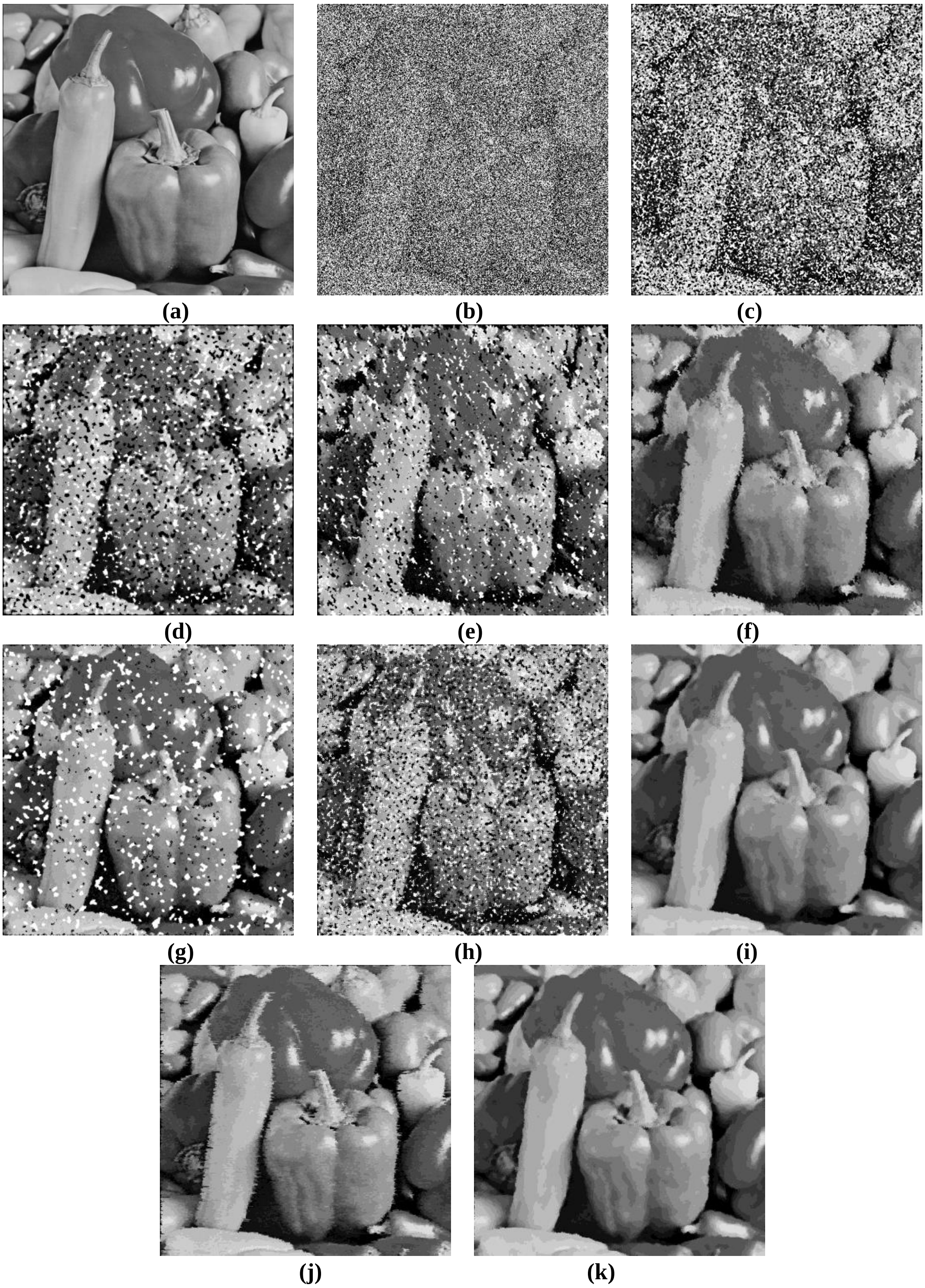

Figure 3.1: (a) Original Peppers image (b) Noisy image (SP=80%). Restoration results of (c)SMF (d) WMF (e) ACWMF (f) AMF (g) PSMF (h) FIDT (i) BDND (j) DBA (k) Proposed PSDBMF

Table 3: Computation time (in Seconds) of various filters for Bridge image at different SP noise densities

Noise density (%)	SMF	WMF	CWMF	ACWMF	AMF	PSMF	FIDT	BDND	DBA	Proposed PSDBMF
10	0.09	14.86	8.79	30.45	1.45	57.24	7.58	34.41	9.67	1.69
20	0.06	31.79	8.71	30.63	2.10	57.76	7.80	36.03	9.58	2.55

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30	0.08	31.71	8.73	30.58	2.83	57.80	8.11	37.85	9.59	3.47
40	0.06	31.60	8.74	30.64	3.54	57.67	8.41	40.01	9.59	4.64
50	0.06	60.97	8.73	31.06	4.30	57.68	8.71	43.61	9.59	5.58
60	0.06	60.58	8.73	30.75	5.07	57.88	9.02	48.01	9.61	6.47
70	0.06	60.43	8.70	30.48	5.85	58.66	9.28	51.54	9.60	7.94
80	0.06	60.25	8.70	30.75	6.73	60.01	9.57	53.94	9.61	9.20
90	0.06	59.83	8.71	30.70	7.66	62.61	9.83	56.09	9.58	9.83

3.2 RVIN

The subjective and quantitative presentation of the proposed channel is contrasted and the present day channels, for example, SMF, ACWMF, TSMF, PSMF, 2 state SD-ROM, Trilateral channel, BDND and ROLD-PRMF. determine 3.2 showcase the visible aftereffects of current strategies and the proposed PSDBMF on RVIN adulterated 'Lena' photo of clamor thickness half of. Tables 4 and five show the presentation of the proposed calculation and the standard channels as some distance as PSNR and calculation time for a boisterous 'Boat.tiff' picture at special motivation commotion thickness degrees.

Seen effects appeared in figure three.2 honestly show that numerous structures show missing clamor concealment at arbitrary commotion densities extra prominent than 30%. in spite of the truth that ROLD-PRMF gives in addition ="hide">extremely good="tipsBox"> 7339ff1fc90882f8f31ca1efdd2ac191 at such immoderate commotion densities, a portion of the great subtleties of the picture are obscured. From desk 4, virtually 2 state SD-ROM and ROLD-PRMF supply nearly same effects to the proposed structures. BDND bombs in evacuating RVIN all matters considered, whilst a few channels like SMF, PSMF, TSMF, ACWMF, and so forth carry out really at low commotion densities. From table five, the calculation time for ROLD-PRMF increments considerably due to the fact the clamor thickness changes from 20% to 30% as the window length is changed from 3 x three to 5 x 5. Likewise, it is the most tedious of all, because of its iterative nature, at the same time as the time multifaceted nature of PSDBMF is less. The sporadic range in time of the proposed manner is a cease result of the growth in cycle include with ascend in arbitrary clamor thickness.

Table 4: PSNR (in dB) of various filters for Boat image at different RD noise densities

Noise density (%)	SMF	ACWMF	TSMF	PSMF	2 state SD-ROM	Trilateral filter	BDND	ROLD-PRMF	Proposed PSDBMF
10	29.86	30.76	31.80	29.04	32.23	25.30	23.18	31.49	30.64
20	28.31	28.84	29.47	26.57	29.86	24.88	20.07	29.31	29.26
30	26.16	26.93	26.91	25.13	27.70	24.31	18.46	26.49	27.67
40	23.46	24.97	24.13	24.01	25.72	23.53	17.08	25.45	26.46
50	20.92	22.85	21.39	23.02	23.53	22.27	16.04	24.82	25.11
60	18.57	20.72	18.95	21.30	21.05	20.38	15.15	24.06	23.20

Table 5: Computation time (in Seconds) of various filters for Boat image at different RD noise densities

Noise density (%)	SMF	ACWMF	TSMF	PSMF	2 state SD-ROM	Trilateral filter	BDND	ROLD-PRMF	Proposed PSDBMF
10	0.09	30.83	11.66	59.84	14.01	18.85	34.88	66.38	6.06
20	0.08	30.53	11.53	57.37	13.87	19.02	35.77	67.71	6.85

30	0.08	30.56	11.56	57.11	13.91	19.07	36.94	110.52	12.46
40	0.08	30.53	11.53	57.57	13.96	18.92	38.13	111.00	13.68
50	0.06	30.50	11.63	57.53	13.96	18.99	38.80	111.63	19.84
60	0.06	30.51	11.58	57.54	13.91	18.79	39.91	113.26	21.71

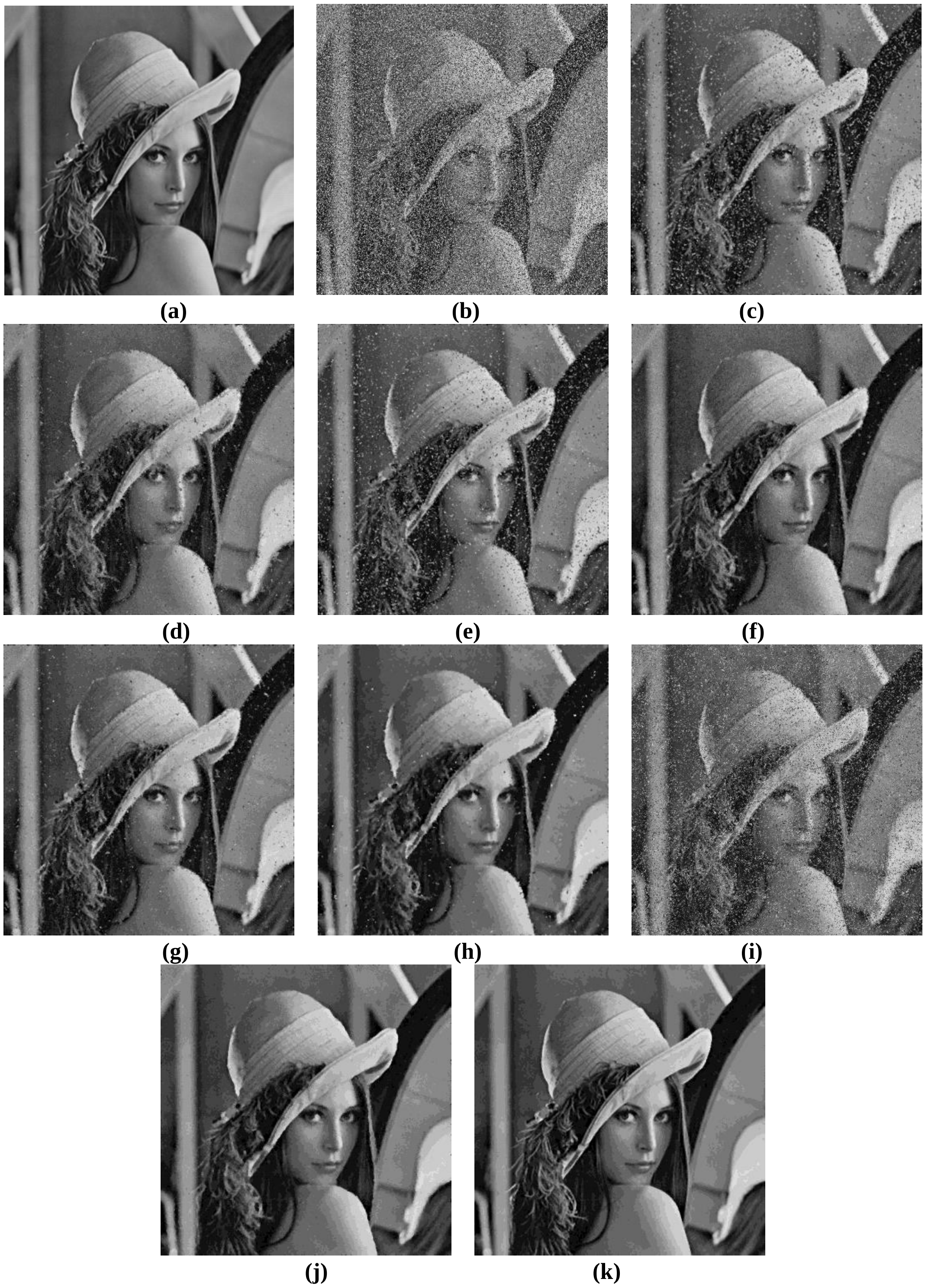

Figure 3.2: (a) Original Lena image (b) Noisy image (RD=50%). Restoration results of (c) SMF (d) ACWMF (e) TSMF (f) PSMF (g) 2 state SD-ROM (h) Trilateral filter (i) BDND (j) ROLD-PRMF (k) Proposed PSDBMF

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IV. CONCLUSION

Probabilistic and Statistical Detection based definitely virtually Median channel out (PSDBMF), a actually one in every of a kind method to de-clamor SPN, RVIN and their combination is alluded to. Its version that uses a versatile window is also referenced. not numerous methods in writing are equipped for putting off unreasonable thickness mixture of the fixed esteemed and atypical esteemed using forces. This inconvenience has been triumph over inside the proposed systems with the aid of utilizing a inexperienced degree discovery approach. the primary function of this technique is its straightforwardness and time execution making its system utilization possible. also the strategies are effective in mild of the fact that the overall in widespread execution remains unaffected with the determination of limits and the debasement is smooth, for any image.

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