SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF ENGINEERING
BIOMEDICAL DEPARTMENT

HYBIRD TECHNIQUES FOR SPCKLE NOISE REDUCTION IN ULTRASOUND IMAGES

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Outlines

- problem statement.
- objectives.
- what is ultrasound?
- Speckle noise.
- Comparative study.
- First proposed method (MHMF).
- Second proposed method (SRAD HMF).
- Conclusion.
- Future work

PROBLEM STATEMENT

The usefulness of ultrasound imaging is degrade by the presence of signal dependent noise known as **speckle**. This noise is **correlated multiplicative noise**, that different from other types of noise because it related to the signal and should be processed and removing without affecting important image features.

OBJECTIVES

GENARAL OBJECTIVE

- Give an overview about speckle noise, how to generate, its properties, and what the effectiveness of it on the ultrasound image.

SPECIFIC OBJECTIVE

- Learning about types of **speckle reduction techniques** in ultrasound imaging.
- To carry out a comparative evaluation of despeckling filtering based on image evaluation matrix.
- Proposed **new methods** as a despeckle filter based on hybrid techniques.

SPECKLE NOISE

- Speckle is a form of **locally correlated multiplicative noise** that corrupts medical ultrasound imaging making visual observation difficult ,Speckle in US B-scans is seen as a **granular structure** which is caused by the constructive and destructive coherent interference of back scattered echoes from the scatters that are typically much smaller than the spatial resolution of medical ultrasound system.

NEED FOR DESPECKLING

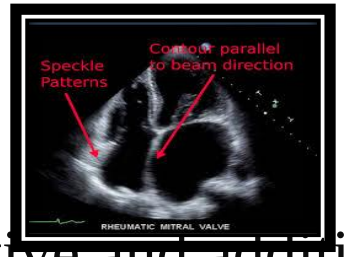
1. To improve the **human interpretation** of ultrasound images – speckle reduction makes an ultrasound image cleaner with clearer boundaries.

2. Despeckling is a preprocess step for many ultrasound image processing tasks such **as segmentation and registration** – speckle reduction improves the speed and accuracy of automatic and semiautomatic **segmentation & registration**.

Speckle Models

- A generalized model of the speckle imaging can be written as

$$g = fm + n$$



Let g denote the observed signal, m , n the multiplicative and additive components of noise respectively introduced by the acquisition process and f the original signal without noise.

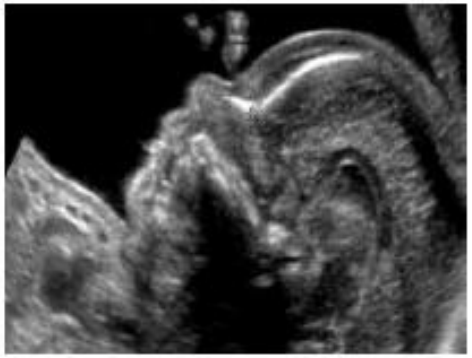
$$g \approx fm$$

- Generally the effect of additive noise is very small compared to multiplicative noise, So the simplified noise model

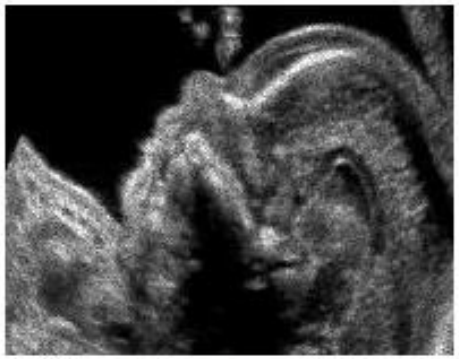
- The logarithmic compression transforms the model

$$\log g = \log f + \log m$$

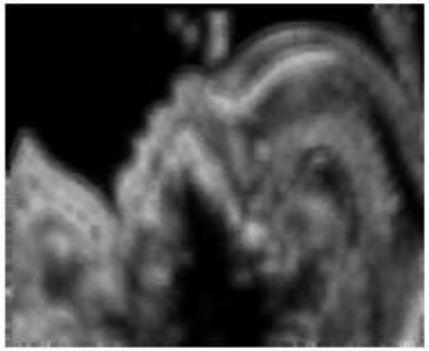
COMPARATIVE STUDY



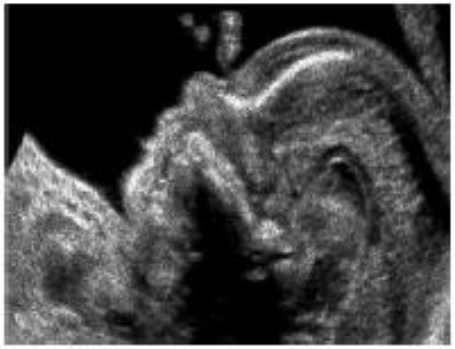
(a) Original image



(b) Noisy image

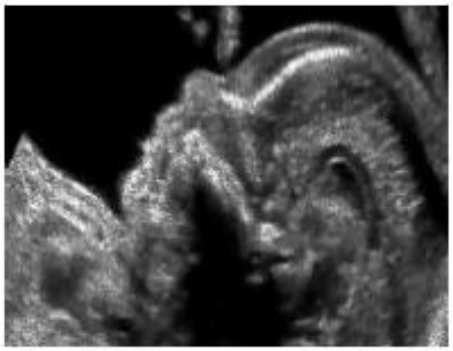


(c) Linear scaling gray level filter(DsFca)

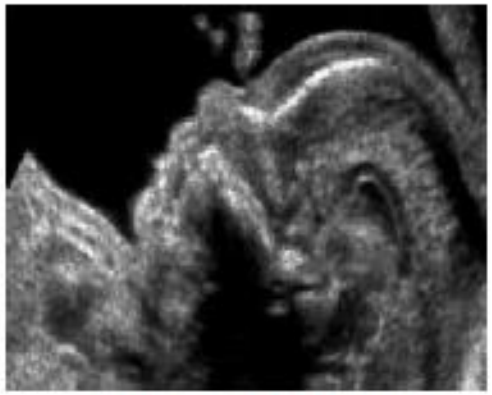


(d) Geometric filter (DsFgf4d)

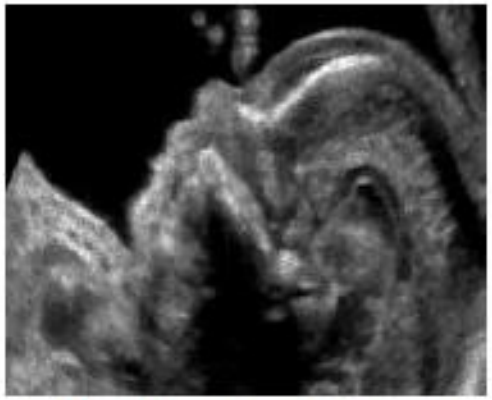
(e) Linear scaling filter(DsFls)



(f) Speckle reducing anisotropic diffusion filter



(g) Median filter (med)



(h) Hybrid median filter (hmf)

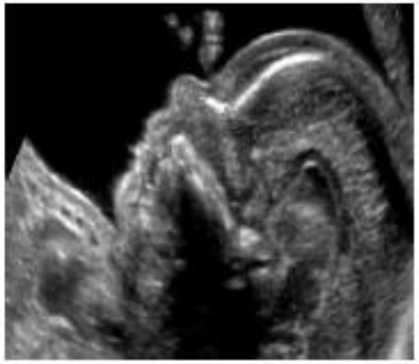
(i) Wavelet filter

(j) Total variation

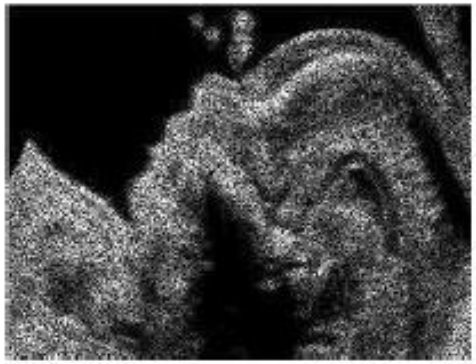
Results of fetal image despeckled by various filter on multiplication noise ($\sigma n=0.05$)

Table 1: Image quality evaluation metrics computed for the fetal (σn=0.05) at statistical measurement of PSNR, SNR and SSIM for different filter types .

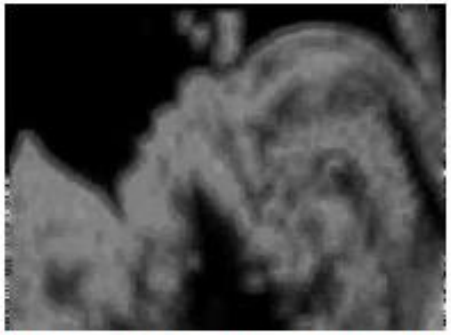
Filter type	SNR	PSNR	SSIM
DsFca filter	20.6551	45.1205	0.6166
DsFgf4d Filter	20.6543	43.9144	0.7875
DsFls Filter	20.6156	44.3001	0.5398
SRAD filter	20.6249	45.0864	0.6153
Med	20.5665	45.1205	0.7915
HMF	20.5603	45.0344	0.7381
Wavelet	20.6166	45.0864	0.8219
TV	21.5404	44.8482	0.7692



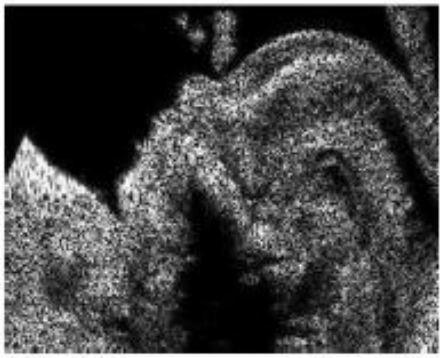
(a) Original image



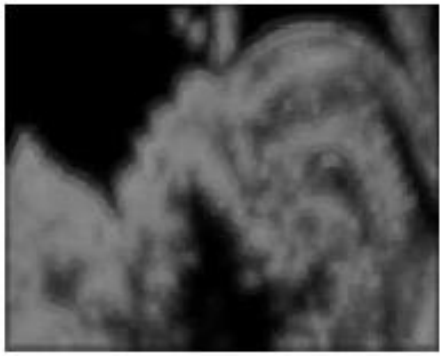
(b) Noisy image



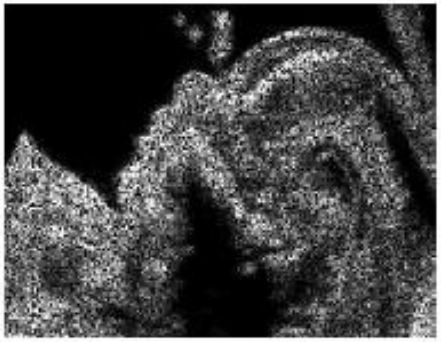
(c) Linear scaling gray level filter(DsFca)



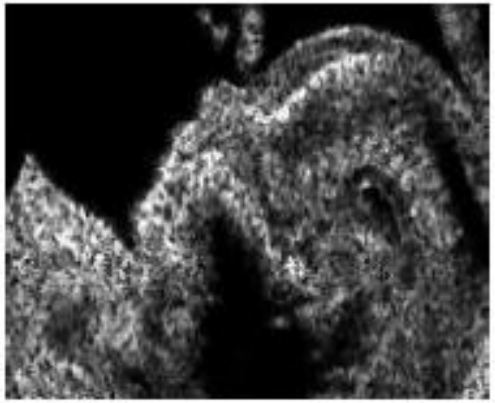
(d) Geometric filter (DsFgf4d)



(e) Linear scaling filter(DsFls)

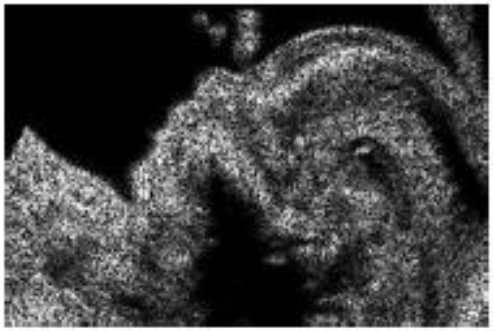


(f) Speckle reducing anisotropic diffusion filter

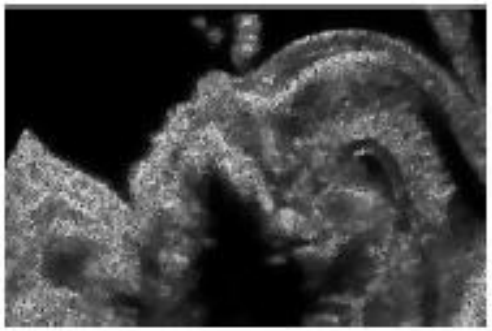


(g) Median filter (med)

(h) Hybrid median filter (hmf)



(i) Wavelet filter



(j) Total variation

Results of fetal image despeckled by various filter on multiplication noise (σn=0.5)

Table2: Image quality evaluation metrics computed for the fetal (σn=0.5) at statistical measurement of PSNR, SNR and SSIM for different filter types .

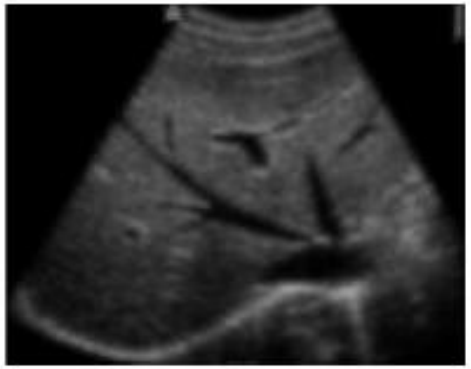
Filter type	SNR	PSNR	SSIM
DsFca filter	20.6325	44.2420	0.5416
DsFgf4d Filter	20.7903	45.1205	0.4853
DsFls Filter	20.6139	43.2688	0.4828
SRAD filter	20.7420	45.1205	0.4460
Med	20.6081	45.0864	0.4096
HMF	20.5071	44.7929	0.6562
Wavelet	20.6931	45.1205	0.4721
TV	20.5571	44.3921	0.6263

(a) Original image

(b) Noisy image

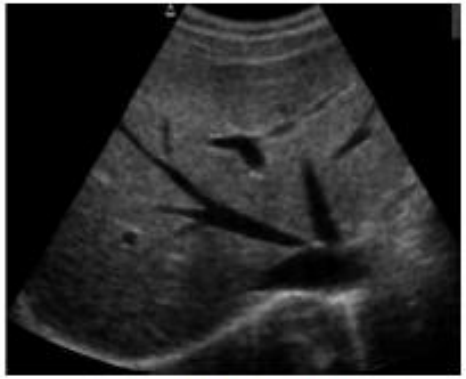
(c) Linear scaling gray level filter(DsFca)

(d) Geometric filter (DsFgf4d)

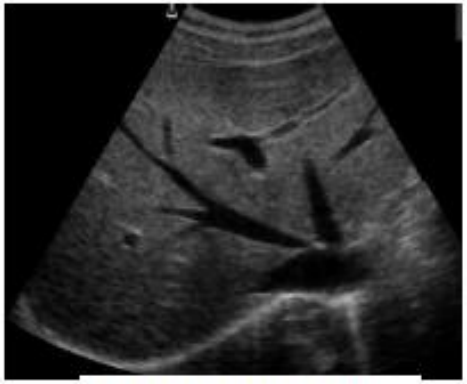


(e) Linear scaling filter(DsFls)

(f) Speckle reducing anisotropic diffusion filter

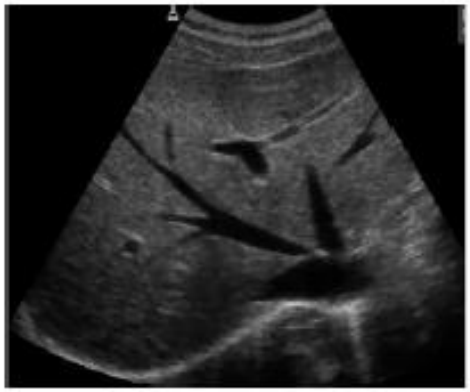


(g) Median filter (med)



(h) Hybrid median filter

(i) Wavelet filter

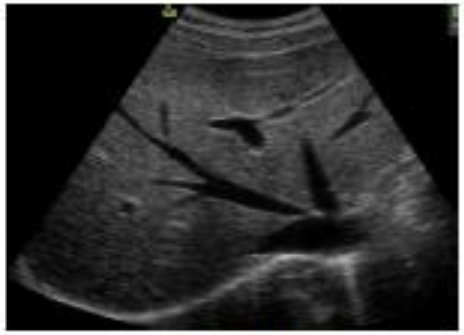


(j) Total variation

Results of liver image despeckled by various filter on multiplication noise ($\sigma n=0.05$)

Table3: Image quality evaluation metrics computed for the liver (σn=0.05) at statistical measurement of PSNR, SNR and SSIM for different filter types.

Filter type	SNR	PSNR	SSIM
DsFca filter	18.5023	44.0741	.6992
DsFgf4d Filter	18.5293	45.0013	.7334
DsFls Filter	18.5289	42.2283	.6493
SRAD filter	18.3719	44.3935	.6703
Med	18.3650	43.2634	.7840
HMF	18.3718	43.5002	.7940
Wavelet	18.5480	44.6616	.7510
TV	18.5006	44.1924	0.8327



(a) Original image

(b) Noisy image

(c) Linear scaling gray level filter(DsFca)

(d) Geometric filter (DsFgf4d)

(e) Linear scaling filter(DsFls)

(f) Speckle reducing anisotropic diffusion filter

(g) Median filter (med)

(h) Hybrid median filter

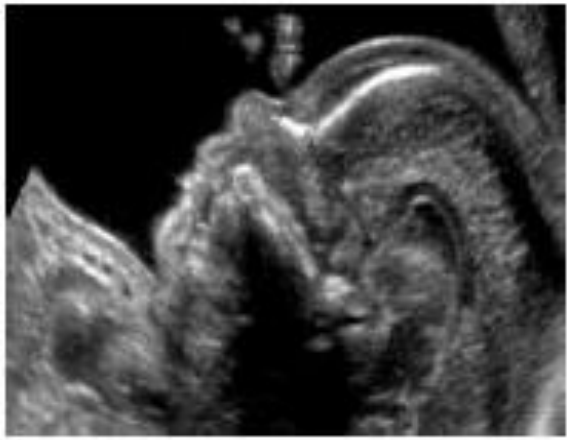
(i) Wavelet filter

(j) Total variation

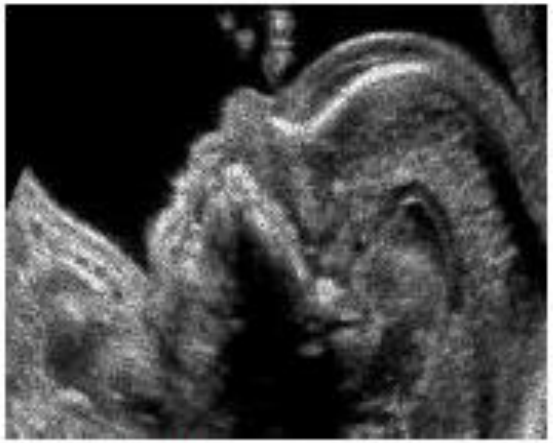
Results of liver image despeckled by various filter on multiplication noise ($\sigma n=0.5$)

Table 4: Image quality evaluation metrics computed for the liver (σn=0.5) at statistical measurement of PSNR, SNR and SSIM for different filter types .

Filter type	SNR	PSNR	SSIM
DsFca filter	18.8367	44.8471	0.6500
DsFgf4d Filter	18.8436	44.9843	0.4590
DsFls Filter	18.8035	42.1681	0.6356
SRAD filter	18.5798	44.8652	0.6392
Med	18.4127	44.3486	0.6412
HMF	18.4653	43.1833	0.6697
Wavelet	18.8328	44.5987	0.4934
TV	18.3942	43.9810	0.6858

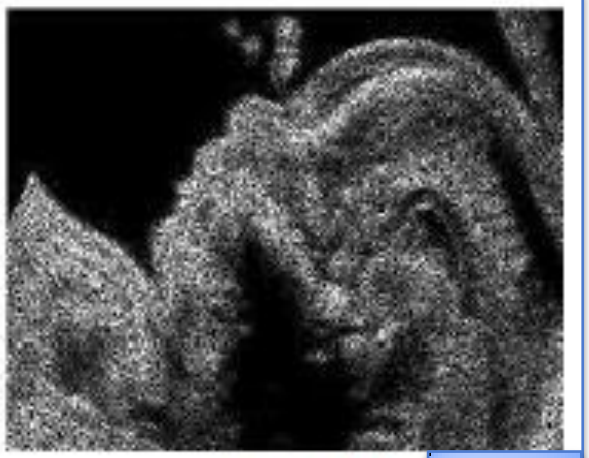


(a) Original image



(b) Noisy image (0.05)

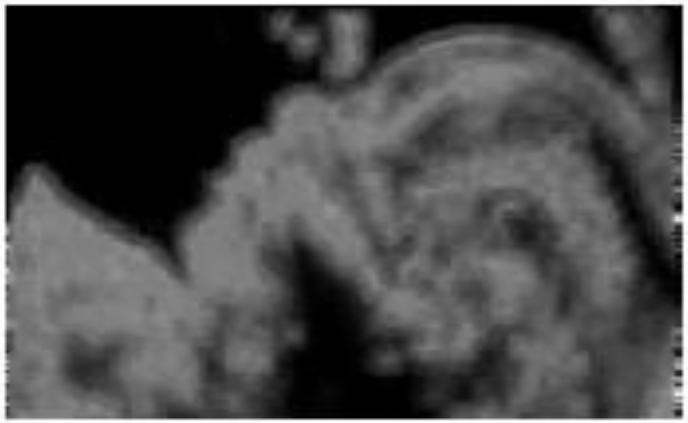
Original image **(a)** noisy image **(b)** with (σn= 0.05 and 0.5)



(b) Noisy image (0.5)

(c) Linear scaling gray level filter(DsFca)

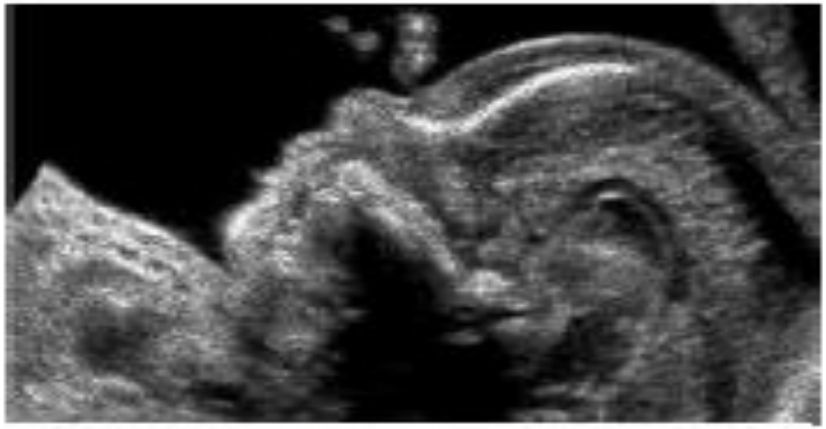
(0.05)



(c) Linear scaling gray level filter(DsFca)

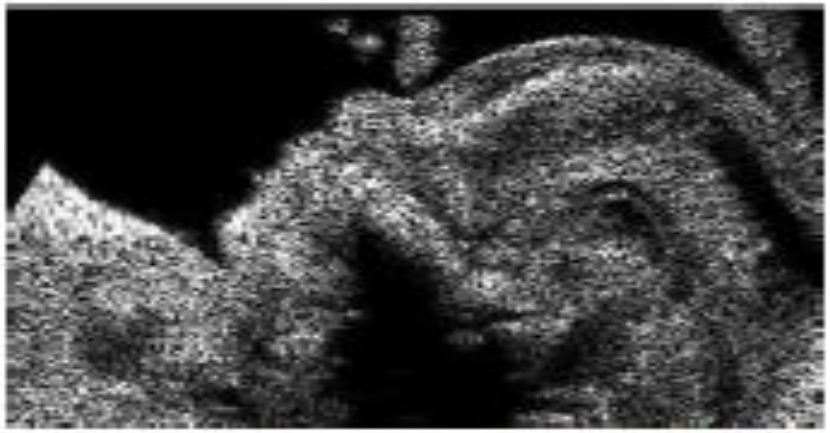
(0.5)

In **(c)** we can see that, the linear scaling gray level filter**(dsfca)** has high degree of blurring and was affect on gray level, because it is compute the mean of all pixels whose difference in the gray level with the intensity(the middle pixel in the moving window) is lower than or equal to a given threshold



(d) Geometric filter (DsFgf4d)

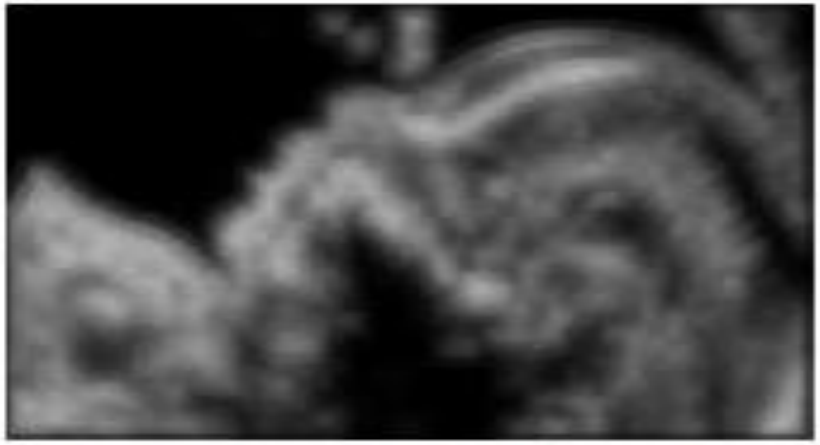
(0.05)



(d) Geometric filter (DsFgf4d)

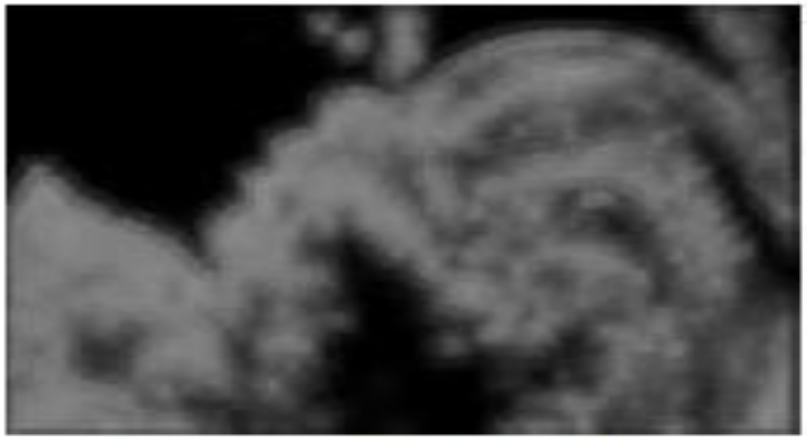
(0.5)

(d) although the result obtained by geometric despeckle filter **(DsFgf4d)** given poor performance for removing the speckle noise from the ultrasound image, it is lead to increasing the contrast significantly of the image.



(e) Linear scaling filter(DsFls)

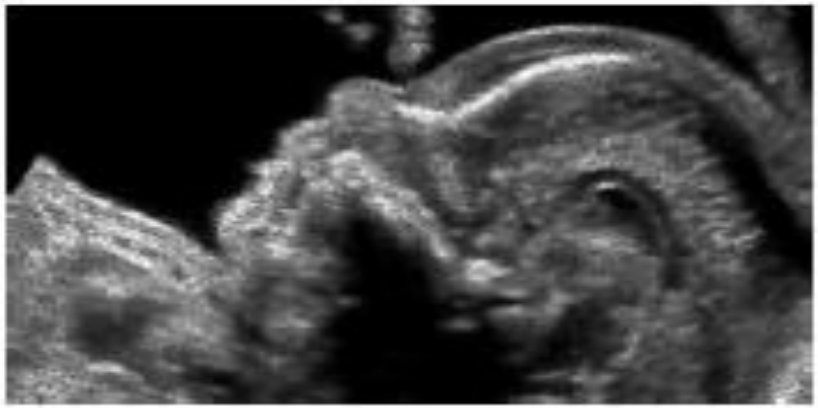
(0.05)



(e) Linear scaling filter(DsFls)

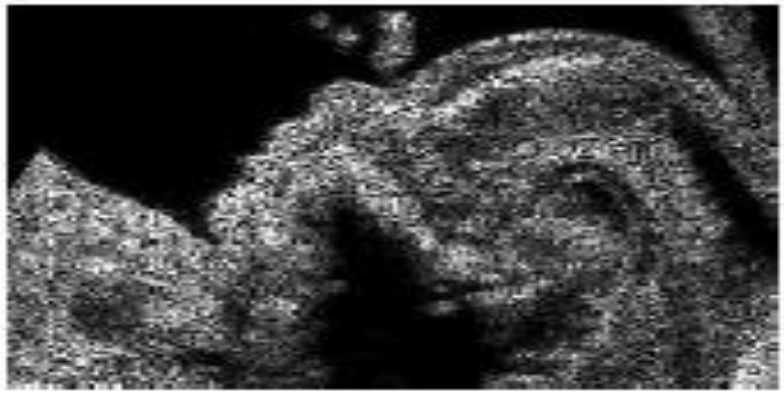
(0.5)

(e) Show the result obtained by liner scaling **(DsFls)** filter scales the pixel intensities by finding the maximum and the minimum gray-level values in every moving window, and then replaces the middle pixel with the average of them also give blurred image.



(f) Speckle reducing anisotropic diffusion filter

(0.05)



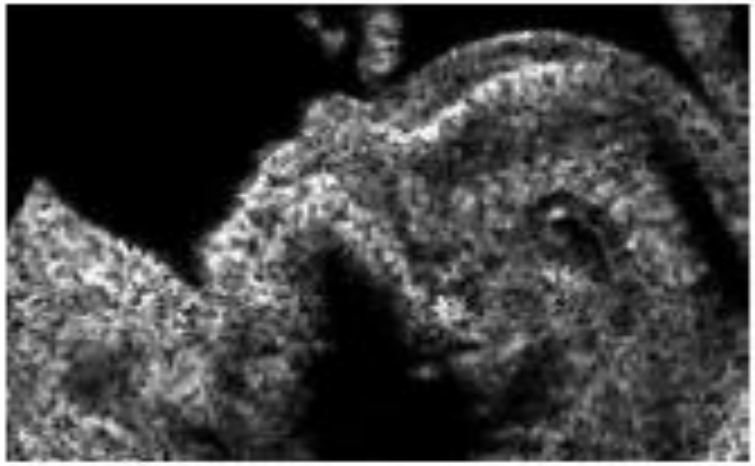
(f) Speckle reducing anisotropic diffusion filter

(0.5)

(f) show the result of speckle reducing anisotropic diffusion filtering (**srad**), it is better for preserves the edges as a comparison with the other despeckle filtering techniques and subjectively has good result, and referred to evaluated metrics, it was also given bad results.

(g) Median filter (med)

(0.05)



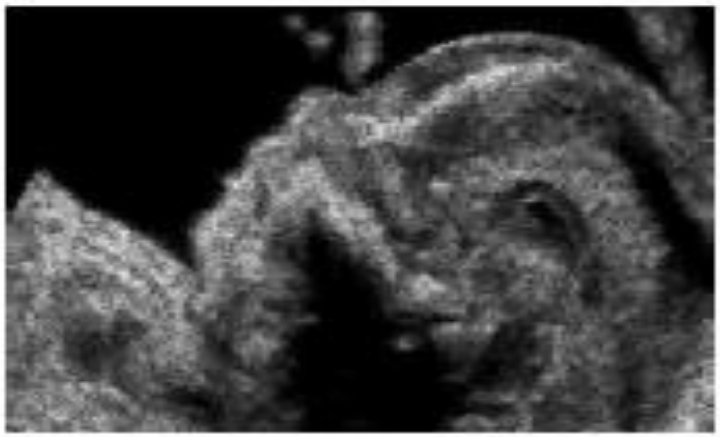
(g) Median filter (med)

(0.5)

(g) show the result obtained by **median despeckle filter**, which don't able to remove the speckle and produced blurred edges in the filtered image .

(h) Hybrid median filter (hmf)

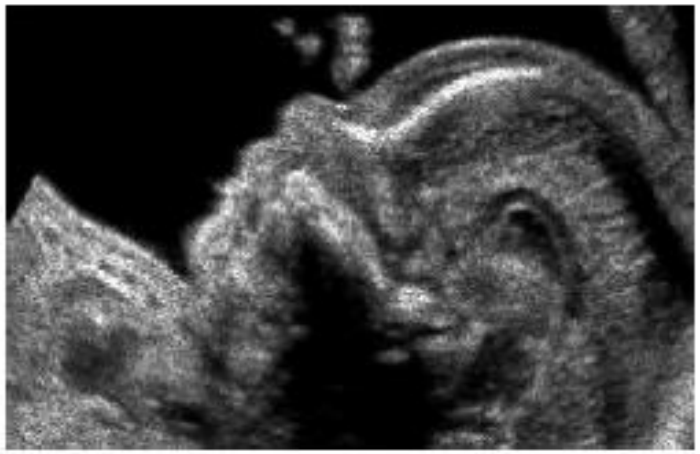
(0.05)



(h) Hybrid median filter (hmf)

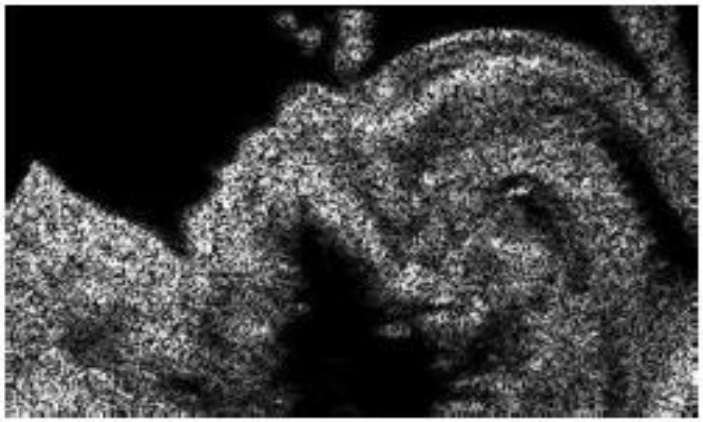
(0.5)

Figure **(h)** show The result of hybrid median filter**(hmf)** that given better edge preserving characteristics than normal median filter,and hybrid method is faster than the conventional median.



(i) Wavelet filter

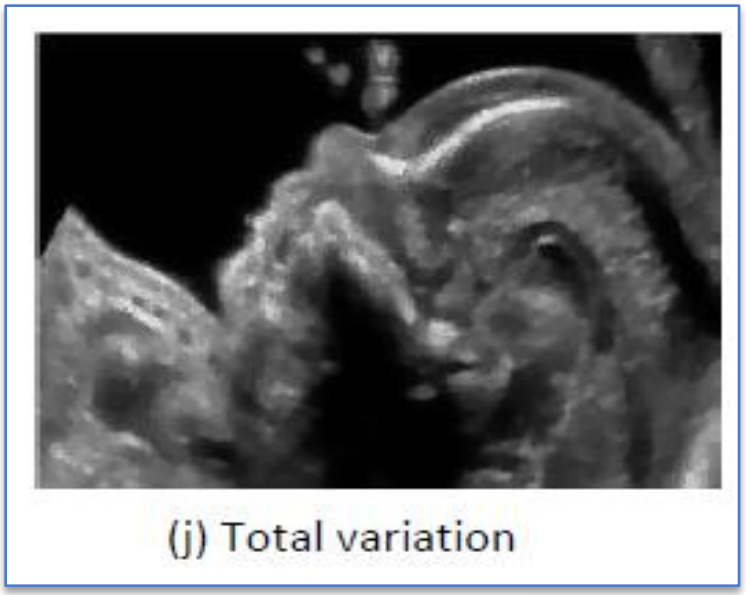
(0.05)



(i) Wavelet filter

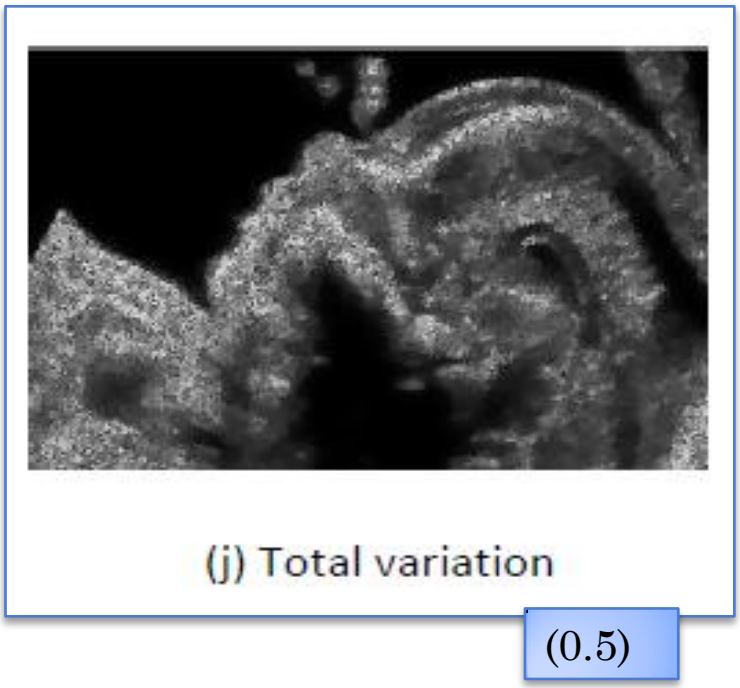
(0.5)

(i)the result through **wavelet** despeckle filtering perceived that it's moderate in order of variance decreasing but execute to decrease the contrast.



(j) Total variation

(0.05)



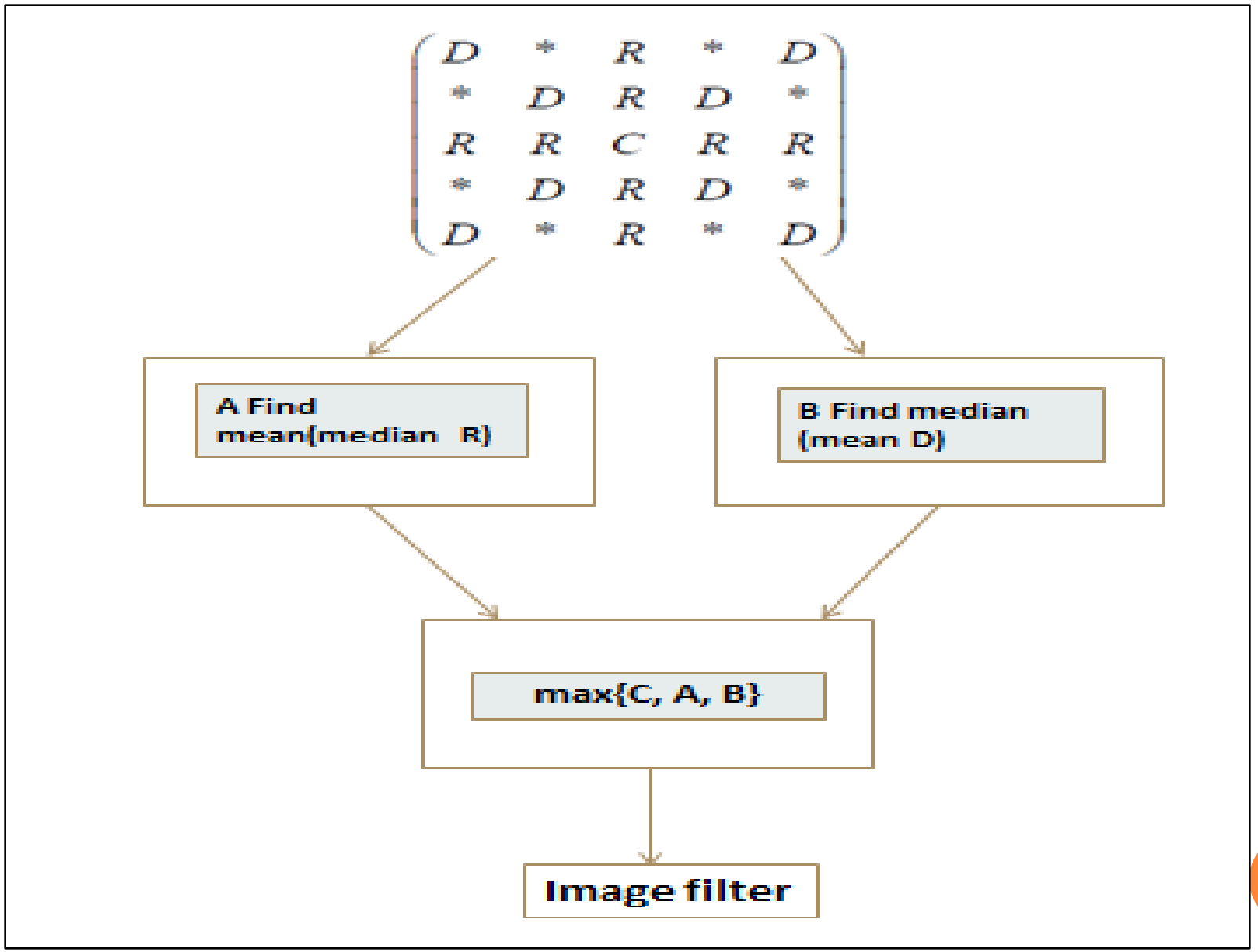
(j) Total variation

(0.5)

(J) show the result obtained by total variation despeckle filter(**TV**)methods. We see that most of the unwanted details haven't been removed efficiently, whilst preserving important details such as edges.

FIRST PROPOSED METHOD MODIFIED HYBRID MEDIAN FILTER (MHMF)

METHODOLOGY



Algorithm of modified Hybrid Median Filter

ALGORITHM

- Step1: Find the **median** for the pixels marked as ***R*** then applied **mean** on the resulted pixels in the 5x5 window (A).
- step2: : Find the **mean** for the pixels marked as ***D*** then applied **median** on the resulted pixels in the 5x5 window (B).
- step3: Finally compute M_1
- M_1 = ***max*** (C, *A*, *B*).
- Step4: filter value $y_{i,j}=M_1$

RESULTS

a

b

Figure. (a),(b) images filtered by hybrid median filter and modified hybrid median filter, respectively from speckled **fetal image with variance (σn=0.05).**

a

b

Figure. (a),(b)images filtered by hybrid median filter and modified hybrid median filter, respectively from speckled **liver image with variance(σn=0.5).**

Table 4 Image quality evaluation metrics computed for the **fetal (σn =0.05)** at statistical measurement of PSNR, SNR and SSIM for different filter types and for **MHMF**.

Filter type	SNR	PSNR	SSIM
Hybrid Median Filter	20.5603	45.0344	0.7381
Modified Hybrid Median Filter	**20.7966**	**45.1035**	**0.8035**

Table 5 Image quality evaluation metrics computed for the **liver (σn=0.5)** at statistical measurement of PSNR, SNR and SSIM for different filter types and for **MHMF**

Filter type	SNR	PSNR	SSIM
Hybrid Median Filter	18.4653	43.1833	0.6697
Modified Hybrid Median Filter	**19.0237**	**44.8653**	**0.6727**

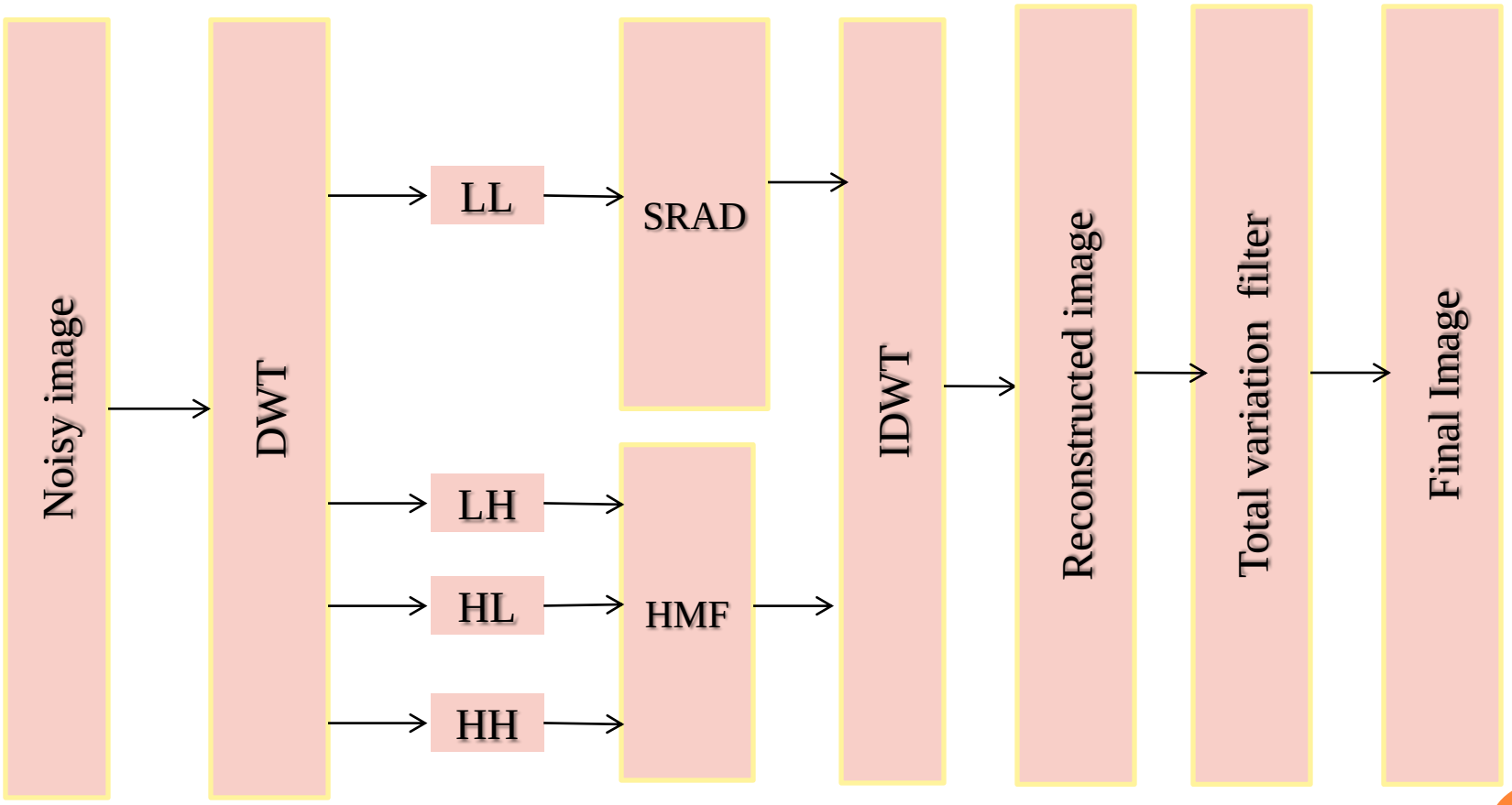
DESCUTION

The result of (MHMF) show that , by **modify the hybrid median filter** , this **give better edge preserving** characteristics than hybrid median filter, and **give less blurred image** , and **increase the brightness** of image by taking the **max** value.

as shown in the image quality metrics the result is better than normal hybrid median .

SECOND PROPOSED METHOD WAVELET DECOMPOSITION BASED SPECKLE REDUCTION METHOD FOR ULTRASOUND IMAGES BY SRAD HMF

METHODOLOGY



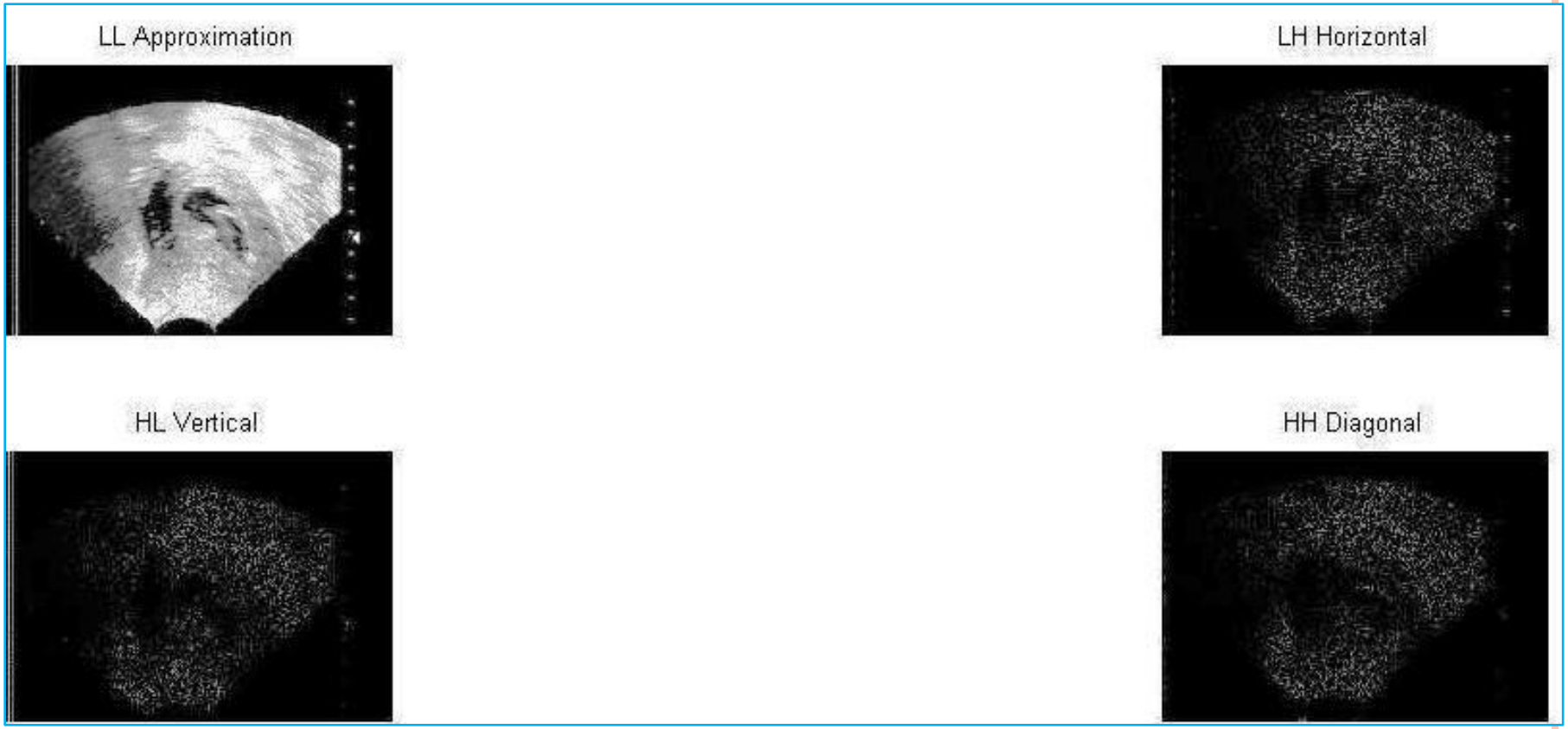
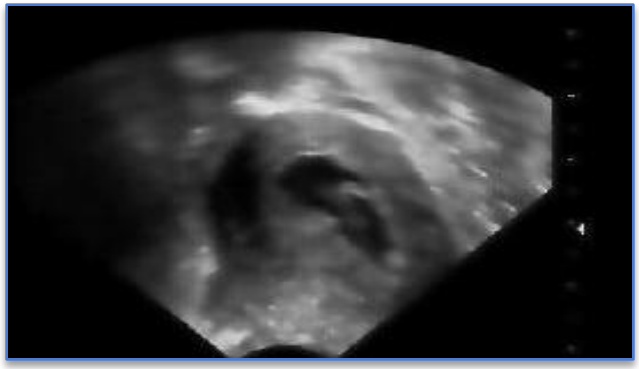


Figure :Wavelet decomposition of the vagina image noise =0.05 and 0.5, respectively

a



b

c

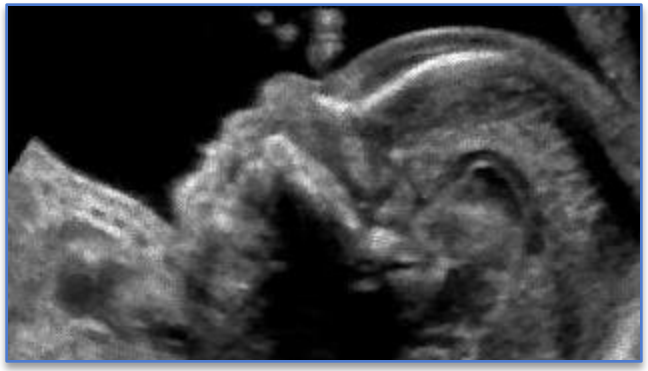
RESULT

Figure (a),(b),(c) images filtered by **hybrid median filter** and **SRAD** and **SRAD hybrid median filter** respectively from speckled vagina image with variance ($\sigma n=0.05$).

Table 6: Image quality evaluation metrics computed for the **vagina (σn =0.05)** at statistical measurement of RMSE, PSNR ,SNR and SSIM for different filter types and for **SRAD HMF**

Filter type	RMSE	SNR	PSNR	SSIM
SRAD filter	16.0393	19.7652	44.1712	0.7290
Hybrid Median Filter	16.6171	19.7508	44.5044	**0.8711**
SRAD HMF Filter	**13.0861**	**20.4837**	**45.0522**	**0.7865**

Figure :Wavelet decomposition of the fetal image noise σ_n=0.05



a

b

c

Figure (a),(b),(c) images filtered by **hybrid median filter** and **SRAD** and **SRAD hybrid median filter** respectively from speckled fetal image with variance (σ_n=0.05).

Table 7: Image quality evaluation metrics computed for the **fetal (σn =0. 5)**at statistical measurement of RMSE, PSNR ,SNR and SSIM for different filter types and for **SRAD HMF.**

Filter type	RMSE	SNR	PSNR	SSIM
SRAD filter	21.1283	20.6249	45.0864	0.6153
Hybrid Median Filter	10.6843	20.5603	45.0344	0.7381
SRAD HMF Filter	**10.5559**	**20.6644**	**45.1205**	**0.8192**

DESCUTION

- the proposed method can significantly reduce speckle in both of the low and high intensity regions, as well as preserve edges.
- In Comparing figures, we realized that our proposed method successfully improved the speckle reduction ,edge preservation and have more features and good contrast.
- In the table we realized that our proposed method is better than other filters in SNR and PSNR value’s.

CONCLUSION

- This study was started with comparative between several filters using quality metrics .

- Here there is two proposed method for speckle noise reduction in ultrasound image, first proposed method is (modified hybrid median filter) we modify the hybrid median filter to get best result than the normal one.

- The optimization of second proposed method "SRAD hybrid median technique" is obtained (SRAD new) algorithm. With the join SRAD, with hybrid median technique have demonstrated more robust estimation and more flexibility over other filters.

- In this project. The both proposed method (MHMF) and (SRAD HMF) takes full advantage of combine and modify filters to reduce speckle noise .
- Experimental results show this techniques are capable to get a good result referred to quality evaluation metric. while, subjectively, can be used in diagnostic and therapeutic terms.

Future Work

1- Use edge detection methods on SRAD hybrid median filter, to detect and measure the ability of this filter to preserve image edges.

2- Use Edge Preservation Factor (EPF) as on of image quality evaluation metrics to evaluate ability of the filter edge preservation.

THANK YOU