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Methods for Reducing Mixed Noise in an Image

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ABSTRACT: Processing and analysis of digital images is important in various fields, especially in the automation of production processes. By processing the image, distortions in it are eliminated and its quality is increased. When the type of distortion in the image is known, it is possible to automate the process of image processing through an objective quality evaluation indicator. This requires a solution to the problem of developing an image processing rule based on the value of the quality evaluation criterion. An example of a common type of distortion in images is the noise that occurs during the recording and transmission processes and is accidentally added to the original clean image. In this article, the mixed case of Gaussian, salt-pepper, Poisson noises, which have been studied in detail in the literature, has been researched, and in their elimination, a series of existing filters suitable for each type of noise has been used, and hybrid filters suitable for a series of noises have been formed. The proposed approach to conducting computational experiments was evaluated by the well-known quality criterion BRISQUE, and an image processing rule was developed based on its values. Through the proposed rule, a significant increase in the accuracy of object recognition in the image using image processing methods has been achieved.

KEY WORDS: image, mixed noise, filter, index, sequence, BRISQUE, salt-pepper, Poisson, Gaussian, algorithm, local mean field, variance field.

I.INTRODUCTION

Digital images are used extensively in many areas of human endeavour today. In particular, image processing is becoming important in solving many practical problems in fields such as scientific research, internal affairs, agriculture, and medicine. The demand for digital image processing is especially high in enterprises that automate the production of technical products. Digital image processing is a technique for analyzing and manipulating digital images by computer [1]. Usually, the image captured by the imaging device is transmitted to the system for analysis. The system recognizes objects in the image by processing the image.

Digital image processing consists of a wide range of methods and algorithms designed for image enhancement, transformation or analysis [2-10]. In this case, image quality is increased by filtering, changing image brightness and contrast, increasing sharpness, and performing segmentation operations. By evaluating the quality of the processed image, it is determined whether the image meets the requirements. In some areas, quality testing is done by human vision, where a person observes the visual quality of an image. However, this is a subjective method that requires a lot of time and money. Therefore, it is necessary to use objective quality assessment indicators in the automation of the image processing process. The use of objective evaluation serves to increase the speed and accuracy of object recognition in images.

The criteria for evaluating the quality of the image without a benchmark are known to many as objective methods, and they are considered convenient for solving problems in the practical field. Because the image taken directly by the imaging tool will not have a reference image.

When evaluating image quality, knowing the type of distortion in an image is helpful in automating image processing. This means that the issue of developing an image processing rule based on the quality assessment value depending on the type of distortion is relevant. Noise is an example of a common type of distortion in images. In this research, a rule for automating the image processing process was developed based on the noise elimination approach. The famous BRISQUE criterion was used as an indicator of image quality. In this research, the mixed case of Gaussian [11], salt-pepper [12] and Poisson [13] noise types was studied. BRISQUE values were analyzed based on this mixed image denoising approach.

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II. LITERATURE REVIEW AND RELATED WORK

Several literatures list Rician, Gaussian, uniform, speckle, Poisson, Rayleigh, and salt-pepper noises as examples of different kinds of visual noise. Salt-pepper and Gaussian, Poisson noise types are the three most common types of noise observed in digital images [14]. The literature contains much information regarding different kinds of noise [15–16].
The problem of recovering the quality of the noisy image that results from the addition of Poisson and salt-pepper noise to a unique image has been addressed by a number of researchers. It has been discovered that the Gaussian Filter [17], Baes Shrink [18], total variation (TV), Non-local means (NLM) and Block matching 3D (BM3D) [19] techniques work well to remove Gaussian noise from images. Researchers have devised several methods to lessen the noise in images caused by salt and pepper. Weiner [20], median [21], adaptive median filter (AMF) [22] and weight median filter (WMF) are a few examples of techniques. In the [21] study, the objective image quality metrics, PSNR and MSE, were used to analyze the noise removal techniques for salt and pepper. The median filter is described as the best algorithm in many literatures for eliminating salt-pepper noise from the image.
It has been discovered that the BM3D [19], NLM [23], bilateral [24] and TV [25] approaches work well to remove Poisson noise. [26] examined the efficacy of six algorithms for mitigating Poisson noise in medical imaging and discovered that the TV algorithm, which was created for Gaussian noise, outperforms contemporary techniques in this regard.
According to the results of [27], which looked into the best noise reduction technique for images with Gaussian-Poisson noise, the TV method provided the best results in MSE, PSNR, SSIM image quality indicators and values of BRISQUE. The fast and efficient reduction of Poisson noise from the image was examined in [28], and the TV algorithm performed well according to the results of the computational experiments. The TV algorithm has been suggested as the most effective method for reducing Poisson noise by various researchers [29–31].
According to a review of the literature, numerous studies have looked at situations where one noise was added to the images separately or when two noises were combined. Nevertheless, most of the time the image is not damaged by one or two noises; instead, a variety of noises work together to lower the image's quality for a variety of reasons. Thus, three Poisson-Gaussian noises— salt and pepper have been examined in this study. A novel method was created to get rid of the resulting mixed noise, in which the best filter for every kind of noise was chosen by looking through the literature and applied to get rid of the mixed noise in all of its combined cases. These filters were chosen in light of the literature analysis, which concluded that the TV filter effectively removes Poisson noise, BM3D effectively removes Gaussian noise, and the median effectively removes salt and pepper noise.

III. METHODS

Initially, a mixed noise image is formed based on y_G – Gaussian, y_S – salt-pepper, y_P – Poisson noises. According to the order in which noise is added to the original clean image, noisy images are defined as follows:

$$\begin{aligned} M_{GPS} &= M_{org} + y_G + y_P + y_S \\ M_{GSP} &= M_{org} + y_G + y_S + y_P \\ M_{PGS} &= M_{org} + y_P + y_G + y_S \\ M_{PSG} &= M_{org} + y_P + y_S + y_G \\ M_{SGP} &= M_{org} + y_S + y_G + y_P \\ M_{SPG} &= M_{org} + y_S + y_P + y_G \end{aligned} \qquad (1)$$

As a mixed denoising approach, the filters that effectively reduce each type of noise were selected based on the literature review. In this case, BM3D filter Gaussian, median filter salt-pepper, TV filters were selected to remove Poisson noise. Possible combinations of the resulting filters are listed below, namely:
A_G : BM3D filter, A_P : TV filter, A_S : Median filter

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$$
\begin{aligned}
&A_{GPS}: A_S\left(A_P\left(A_G\left(M_{nosiy}\right)\right)\right)\\
&A_{GSP}: A_P\left(A_S\left(A_G\left(M_{nosiy}\right)\right)\right)\\
&A_{PGS}: A_S\left(A_G\left(A_P\left(M_{nosiy}\right)\right)\right)\\
&A_{PSG}: A_G\left(A_S\left(A_P\left(M_{nosiy}\right)\right)\right)\\
&A_{SGP}: A_P\left(A_G\left(A_S\left(M_{nosiy}\right)\right)\right)\\
&A_{SPG}: A_G\left(A_P\left(A_S\left(M_{nosiy}\right)\right)\right)
\end{aligned}
\tag{2}
$$

$\hat{M}$ is defined by the image resulting from successively applying filters to a noisy image in various combinations. Below is a sequence of filters applied to a mixed noise image:

$$A_{GPS}(M^j_{noisy}), A_{GSP}(M^j_{noisy}), A_{PGS}(M^j_{noisy}), A_{PSG}(M^j_{noisy}), A_{SGP}(M^j_{noisy}), A_{SPG}(M^j_{noisy}),\ \ j=\overline{1,6} \tag{3}$$

where $M^1_{noisy}=M_{GPS}, M^2_{noisy}=M_{GSP}, M^3_{noisy}=M_{PGS}, M^4_{noisy}=M_{PSG}, M^5_{noisy}=M_{SGP}, M^6_{noisy}=M_{SPG}$.

The BRISQUE indicator is defined as the Br operator when evaluating the image quality resulting from filtering.
The efficiency of the hybrid filter in (2) is checked by the following condition.

$$Br\left(A\left(M_{noisy}\right)\right) < Br\left(M_{org}\right) \tag{4}$$

Determining the most suitable among the filters is done as follows.

$$\min\left\{A_{GPT}\left(M_{noisy}\right), A_{GTP}\left(M_{noisy}\right), A_{PGT}\left(M_{noisy}\right), A_{PTG}\left(M_{noisy}\right), A_{TGP}\left(M_{noisy}\right), A_{TPG}\left(M_{noisy}\right)\right\} \tag{5}$$

Image Quality Assessment Criterion

BRISQUE (Blind/No-reference image quality assessment) is one of the popular criteria for evaluating image quality without reference. This criterion is considered to be capable of predicting quality close to human perception of quality. There are few benchmark-free evaluation methods that can predict image quality without any knowledge of the type of distortion affecting the image. In [32], the algorithm for calculating the value of the BRISQUE indicator is presented as follows:

a) Creating a natural statistical scene (NSS) model of an image for a distorted image.

The distorted image is denoted by M_{noisy}. Each pixel intensity of this image is changed $M_{noisy}(i,j)$ to $\tilde{M}(i,j)$ ($i=1,...,N_1;\ j=1,...,N_2;\ N_1,N_2-$ image size). Mean separated contrast normalization (MSCN) coefficients are calculated as follows:

$$\tilde{M}(i,j)=\frac{M_{noisy}(i,j)-\rho(i,j)}{\zeta(i,j)+C} \tag{7}$$

where $C=1-$ is a constant magnitude;

$$\rho(i,j)=\sum_{p=-P}^{P}\sum_{q=-Q}^{Q}\omega_{pq}M_{noisy}(i+p,j+q), \tag{8}$$

$$\zeta(i,j)=\sqrt{\sum_{p=-P}^{P}\sum_{q=-Q}^{Q}\omega_{pq}\left(M_{noisy}(i+p,j+q)-\rho(i,j)\right)^2}, \tag{9}$$

$\omega=\left\{\omega_{pq}\mid p=-P,...,P, q=-Q,...Q\right\}-$ 2D circularly symmetric Gaussian weight function, $P=Q=3$, $\rho(i,j)-$ local mean field, $\zeta(i,j)-$ local variance field. The intensity value is 0 if $i+p$ $[1,N_1]$ is outside the interval or $j+q$ $[1,N_2]$ is outside the interval.

b) Extracting some statistical features from the NSS model.

According to [32], the generalized Gaussian distribution is calculated as follows.
Pairwise multiplications of adjacent MSCN coefficients along four directions - horizontal (H), vertical (V), main diagonal (D1), additional diagonal (D2) are modeled using the following distribution:

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$$
\begin{aligned}
H(i,j) &= \tilde{M}(i,j)\tilde{M}(i,j+1) \\
V(i,j) &= \tilde{M}(i,j)\tilde{M}(i+1,j) \\
D1(i,j) &= \tilde{M}(i,j)\tilde{M}(i+1,j+1) \\
D2(i,j) &= \tilde{M}(i,j)\tilde{M}(i+1,j-1)
\end{aligned} \tag{10}
$$

where $i \in 1,2...N_1,\ j \in 1,2...N_2$.

The asymmetric generalized Gaussian distribution is calculated as in [20]. There will be 4 parameters for each direction, a total of 16 parameters, with an additional 18 parameters estimated by GGD and AGGD by matching MSCN coefficients. Since the distortions affect the image structure along the scale, the image size is taken in a state where the size is reduced by a factor of 2.

c) Calculates the quality score using the regression algorithm for the 36 generated characters. SVM (Support Vector Machine) was used as the regression algorithm.

IV. COMPUTING EXPERIENCE

In this research work, 120 image samples were taken from the human chest X-ray image database [33] for computational experiments. Sample images from the addition of three noise combinations to each image in the base are shown in Figure 1 along with BRISQUE values.

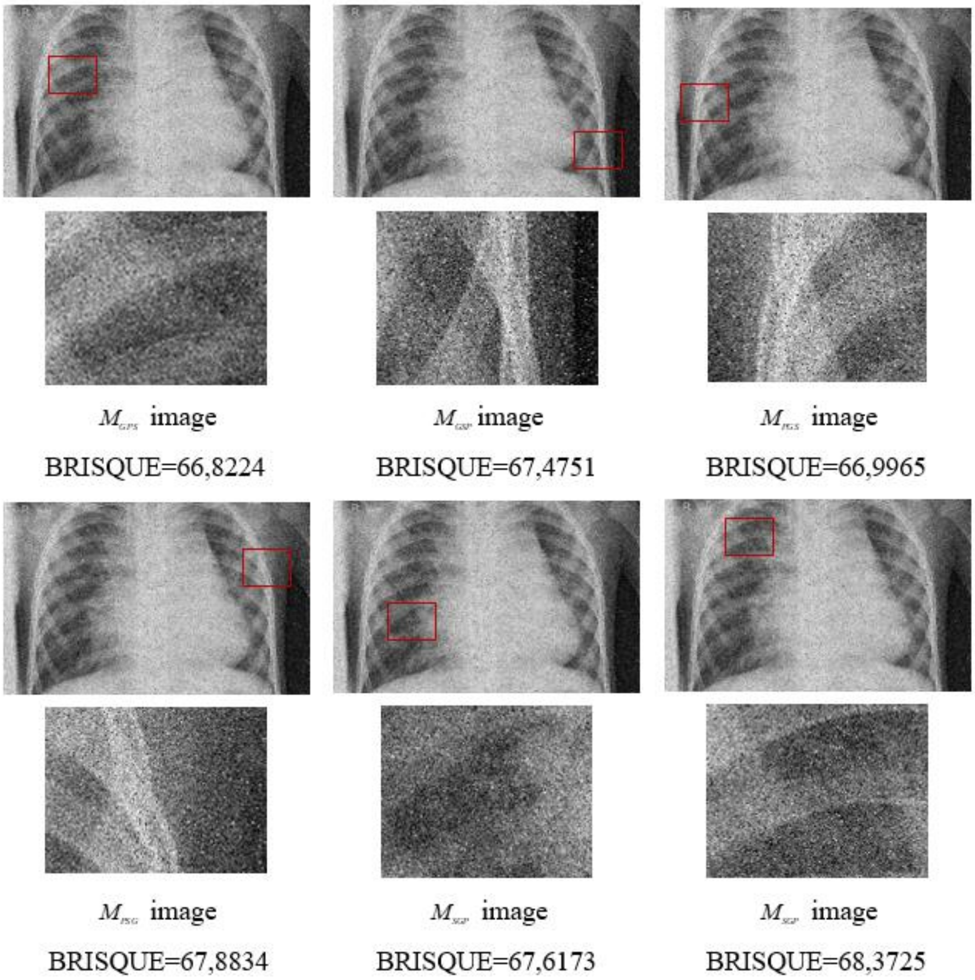

Fig 1: Examples of mixed noisy images

Figure 2 shows an example of the result of sequentially applying filters to each of the 6 hybrid filters.

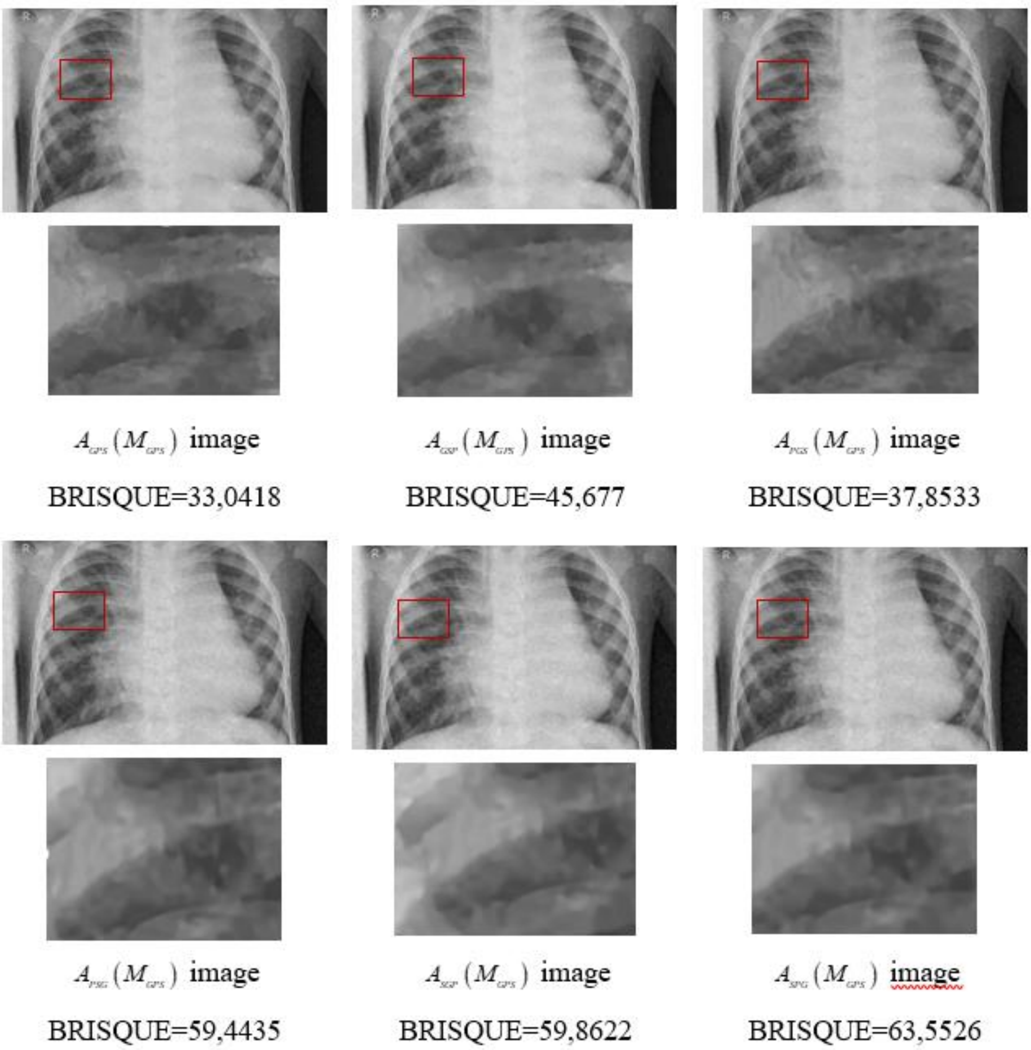

Fig 2: Examples of images resulting from the application of a hybrid filter to an M_{GPS} image

6 hybrid filters under condition (4) were tested on each image and their performance was determined (Table 1).

Table 1. Condition (4) is satisfied for M_{GPS} , M_{GSP} , M_{PGS} , M_{PSG} , M_{SGP} , M_{SPG} mixed noisy images

Image type	**Filter type**					
	A_{GPS}	A_{GSP}	A_{PGS}	A_{PSG}	A_{SGP}	A_{SPG}
M_{GPS}	37	8	26	6	6	6
M_{GSP}	38	8	25	6	6	6
M_{PGS}	40	9	22	6	6	6
M_{PSG}	28	8	26	6	6	6
M_{SGP}	28	6	24	6	6	6
M_{SPG}	31	8	23	6	6	6
$\sum$	202	47	146	36	36	36

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To determine the optimal hybrid filter suitable for a sequence of noises, the filter that satisfies (5) at most is obtained (Figure 3).

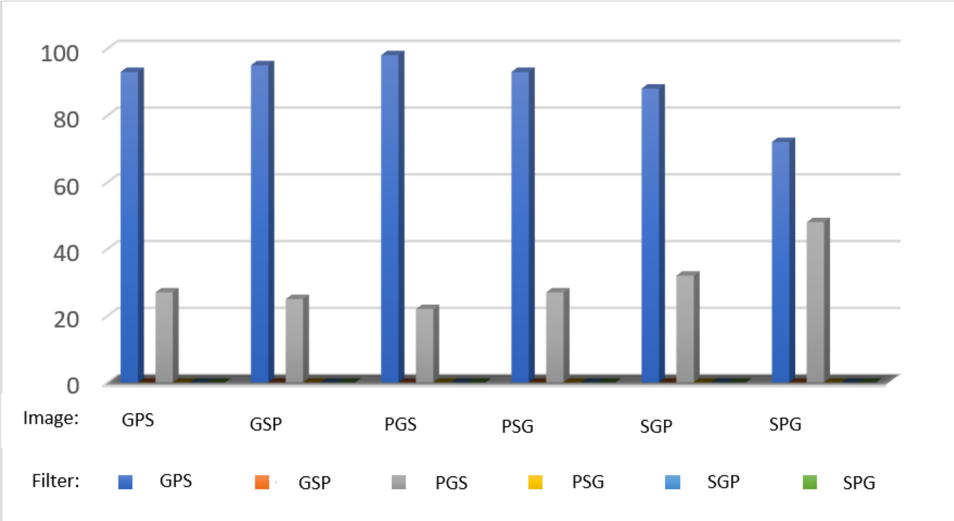

Fig 3: Optimal hybrid filters for each noise sequence

The result in Figure 3 shows that the optimal hybrid filter is A_{GPS} for all cases of noise order. The table below lists the BRISQUE criterion values of this hybrid filter.

Table 2. Values of BRISQUE criterion for noisy images M_{org}, M_{PGS} and images $A_{GPS}(M_{PGS})$, $A_{GPS}(M_{org})$

Image name	**BRISQUE criterion values**			
	$Br(M_{org})$	$Br(M_{PGS})$	$Br(A_{GPS}(M_{PGS}))$	$Br(A_{GPS}(M_{org}))$
Image4	11,6581	68,6144	39,3172	83,9408
Image16	16,0516	65,0691	34,5901	69,462
Image50	28,9757	67,3175	37,7611	66,604
Image70	32,9082	66,6811	32,3868	70,5609
Image62	37,7559	68,9005	40,8945	74,3872
Image94	49,8315	68,4135	36,4633	79,5618
Image108	60,6931	72,501	18,3901	72,886
Image111	68,3598	76,938	37,7138	23,9218
Image110	69,4122	76,5525	35,4234	30,0015
Image116	95,127	72,1969	19,3034	68,7414

V. CONCLUSION

In this research work, images with mixed noise were studied in the automation of the image processing process. 6 hybrid filters are used to eliminate the mixed noise, consisting of a combination of Gaussian, salt-pepper, and Poisson noises in the image. As a result of the above calculation experiment, the following conclusions were obtained:
- according to the research results, the $A_{GPS}(M_{noisy})$ hybrid filter was identified as the most optimal filter for eliminating mixed noise;
- based on the BRISQUE criterion values for a total of 120 images, a rule of the following form was developed to automate the image processing process:

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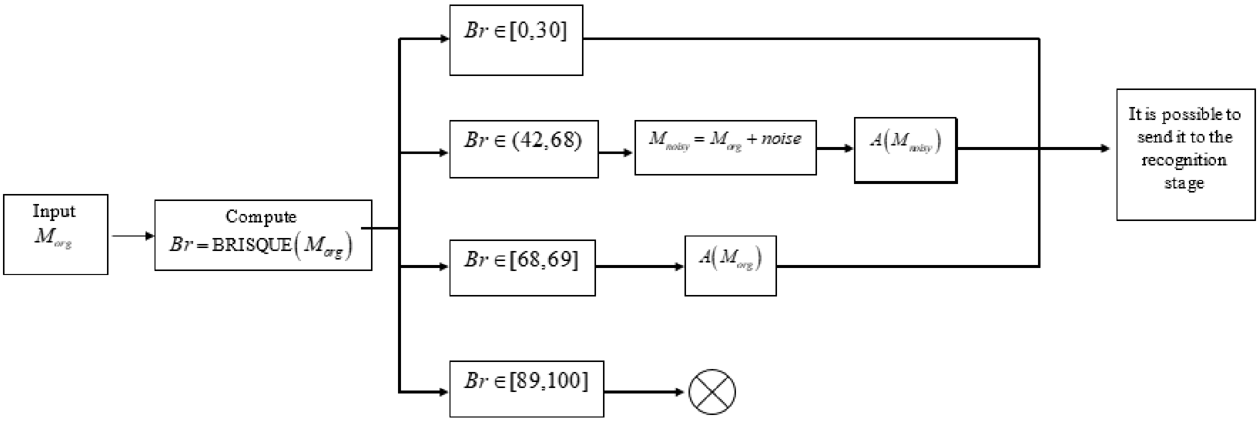

REFERENCES

[1] Gonzales, R.C. and R.E Woods, 2008. Digital Image Processing. Prentice Hall, Harlow, pp: 954, ISBN: 013168728X.
[2] M. Narzillo, A. Bakhtiyor, K. Shukrullo, O. Bakhodirjon and A. Gulbahor, "Peculiarities of face detection and recognition," 2021 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan, 2021, pp. 1-5, doi: 10.1109/ICISCT52966.2021.9670086.
[3] N. S. Mamatov, B. A. Abdukadirov, A. N. Samijonov and B. N. Samijonov, "Method for false attack detection in face identification system," 2021 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan, 2021, pp. 1-4, doi: 10.1109/ICISCT52966.2021.9670153.
[4] Narzillo, M., Abdurashid, S., Nilufar, N., Musokhon, D., & Erkin, R. (2020). Definition of line formula on images. Journal of Physics: Conference Series, 1441(1), 012150. https://doi.org/10.1088/1742-6596/1441/1/012150
[5] Niyozmatova, N. A., Mamatov, N., Samijonov, A., Abdukadirov, B., & Abdullayeva, B. M. (2020). Algorithm for determining the coefficients of the interpolation polynomial of Newton with separated differences. IOP Conference Series: Materials Science and Engineering, 862(4), 042019. https://doi.org/10.1088/1757-899X/862/4/042019
[6] N.S. Mamatov, G. G. Pulatov, M.M. Jalelova. Image contrast enhancement method and contrast evaluation criteria optimal pair. Digital Transformation and Artificial Intelligence **1**(2). (2023)
[7] N.S. Mamatov, A.N. Samijonov, Y. Yuldoshev, R. Khusan. Selection the Informative Features on the Basis of Interrelationship of Features. In: Springer, Cham. (2020)
[8] N. A. Niyozmatova, N. S. Mamatov, B. I. Otaxonova, A. N. Samijonov and K. K. Erejepov, "Classification Based On Decision Trees and Neural Networks," 2021 International Conference on Information Science and Communications Technologies (ICISCT), Tashkent, Uzbekistan, 2021, pp. 01-04, doi: 10.1109/ICISCT52966.2021.9670345
[9] Mamatov N. et al. The choice of informative features based on heterogeneous functionals //IOP Conference Series: Materials Science and Engineering. – IOP Publishing, 2020. – T. 919. – №. 4. – C. 042009.
[10] Mamatov, N. S., Niyozmatova, N. A., Jalelova, M. M., Samijonov, A. N., and Tojiboyeva, Sh. X., "Methods for improving contrast of agricultural images," E3S Web Conf., vol. 401, p. 4020, 2023. DOI: 10.1051/e3sconf/202340104020
[11] Bharati, Subrato & Khan, Tanvir & Podder, Prajoy & Hung, Nguyen. (2020). A Comparative Analysis of Image Denoising Problem: Noise Models, Denoising Filters and Applications. 10.1007/978-3-030-55833-8_3.
[12] Priyanka Kamboj and Varsha Rani, "A Brief Study of Various Noise Model and filtering Techniques," Journal of Global Research in Computer Science, Volume 4, No 4, pp.166-171, April 2013.
[13] Thanh, Dang & Prasath, Surya & Le Minh, Hieu. (2019). A Review on CT and X-Ray Images Denoising Methods. Informatica. 43. 151-159. 10.31449/inf. v43i2.2179.
[14] V.C.Sakhare, S.V.Kamble, J.A.Alase. Noise Models in Digital Image Processing. International Advanced Research Journal in Science, Engineering and Technology. Vol. 7, Issue 12. 10.17148/IARJSET.2020.71204
[15] Goyal et al.," A Survey on the Image Denoising to Enhance Medical Images", Biosci., Biotech. Res. Asia, Vol.15(3), 501-507 (2018)
[16] Nik, M.M.Pura & Se, S.V.Hal. (2018). A Review Paper: Study of Various Types of Noises in Digital Images. International Journal of Engineering Trends and Technology. 57. 40-43. 10.14445/22315381/IJETT-V57P208.
[17] Kaur, Gurjinder & Garg, Meenu & Gupta, Sheifali & Gupta, Rupesh. (2021). Denoising of images using Thresholding Based on Wavelet Transform Technique. IOP Conference Series: Materials Science and Engineering. 1022. 012031. 10.1088/1757-899X/1022/1/012031.
[18] Perumal, B., Sindhiya, R., y Pallikonda, M. (2021). Extermination methods of image noises: a review. 3C Tecnología. Glosas de innovación aplicadas a la pyme, Edición Especial, (noviembre, 2021), 243-259. https://doi.org/10.17993/3ctecno.2021.specialissue8.243-259
[19] Ikhsan, Mohammad. (2021). Comparative Analysis of Different Algorithms for Image Denoising. 10.13140/RG.2.2.29939.14883.
[20] Maity, Alenrex & Chatterjee, Rishav. (2018). Impulsive Noise in Images: A Brief Review. Computer Vision Graphics and Image Processing. Vol 4. 6-15. 10.19101/TIPCV.2017.39025.
[21] Jasim, Muna. (2019). Image Noise Removal Techniques: A Comparative Analysis. International Journal of Science and Applied Information Technology. 8. 24-29. 10.30534/ijsait/2019/01862019.

[22] Soni, Hetvi & Sankhe, Darshana & Student. (2019). Image Restoration using Adaptive Median Filtering. International Research Journal of Engineering IT & Scientific Research. 2395-0056.
[23] Thakur, Kirti & Damodare, Omkar & Sapkal, Ashok. (2016). Poisson Noise Reducing Bilateral Filter. Procedia Computer Science. 79. 861-865. 10.1016/j.procs.2016.03.087.
[24] Deledalle, Charles-Alban, Florence Tupin and Loïc Denis. "Poisson NL means: Unsupervised non local means for Poisson noise." 2010 IEEE International Conference on Image Processing (2010): 801-804.
[25] Rodrigues, Isabel & Sanches, João & Bioucas-Dias, Jose. (2008). Denoising of medical images corrupted by Poisson noise. 1756 - 1759. 10.1109/ICIP.2008.4712115.
[26] Thanh, Dang & Dvoenko, S. (2016). A method of total variation to remove the mixed Poisson-Gaussian noise. Pattern Recognition and Image Analysis. 26. 285-293. 10.1134/S1054661816020231.
[27] Wang, Wei & He, Chuanjiang. (2016). A fast and effective method for a Poisson denoising model with total variation. IEEE Signal Processing Letters. PP. 10.1109/LSP.2017.2654480.
[28] Rémy Abergel, Cécile Louchet, Lionel Moisan, Tieyong Zeng. Total Variation Restoration of Images Corrupted by Poisson Noise with Iterated Conditional Expectations. SSVM 2015, 5th International Conference on Scale Space and Variational Methods in Computer Vision, May 2015, Lège Cap Ferret, France. pp.178-190, ff10.1007/978-3-319-18461-6_15.
[29] Chan, Raymond H. and Ke Chen. "Multilevel algorithm for a Poisson noise removal model with total-variation regularization." International Journal of Computer Mathematics 84 (2007): 1183 - 1198.
[30] Sawatzky, Alex & Brune, Christoph & Müller, Jahn & Burger, Martin. (2009). Total Variation Processing of Images with Poisson Statistics. 533-540. 10.1007/978-3-642-03767-2_65.
[31] Lebrun, Marc. (2012). An Analysis and Implementation of the BM3D Image Denoising Method. Image Processing On Line. 2. 175-213. 10.5201/ipol.2012.l-bm3d.
[32] Mittal, Anish & Moorthy, Anush & Bovik, Alan. (2012). No-Reference Image Quality Assessment in the Spatial Domain. IEEE transactions on image processing: a publication of the IEEE Signal Processing Society. 21. 10.1109/TIP.2012.2214050.
[33] https://www.kaggle.com/datasets/tolgadincer/labeled-chest-xray-images