Artificial Intelligence & Robotics Development Journal
Volume 4, Issue 1, pp 282-291, January 2024, https://doi.org/10.52098/airdj.20244110
ISSN: 2788-9696 Received: 19.2.2024 Revised: 17.3.2024 Accepted: 21.3.2024

Improving Digital Satellite Image for security purposes

Huda H. Ali*
Department of CET, Imam Al-Kadhum College, Baghdad, Iraq
* Corresponding author, Huda H. Ali
compeng.lecturer@alkadhum-col.edu.iq

Abstract

Satellite imagery is employed in many different fields of study. These pictures have serious quality problems. Image enhancement algorithms, however, can improve it in terms of contrast, brightness, feature elimination from noise contents, etc. These algorithms present and analyse the picture's properties by sharpening, focusing, or smoothing the image. Therefore, the specific application determines the goal of picture enhancement. This paper briefly overviews picture enhancement methods that produce optimal and progressive outcomes for satellite images used for secured remote sensing. To do this, various image enhancement techniques are used, which are widely used today to improve image quality across various image processing applications. Some commonly used image enhancement techniques include spatial filtering, contrast stretching, and histogram equalisation. These techniques aim to enhance the visual quality of satellite images by adjusting brightness and contrast and reducing noise. These methods can also improve the interpretability of the images for remote sensing purposes. The enhancement of satellite images finds use in several fields, particularly security. It is essential for security applications, including threat detection, border control, and surveillance. Security professionals may more effectively analyse and understand data to spot any dangers or questionable activity by boosting the visual details and general quality.

Keywords: Satellite image analysis; Image processing; mean filter; secured application; SVM; wavelet transformation

1. Introduction

A satellite is a model building that is orbiting the planets to investigate them for many different reasons, such as weather, climate, and changes in the earth's surface, network and broadcast monitoring, etc. Satellite imagery is utilized to provide an in-depth picture of events occurring worldwide, except for tropical waters where statistics are intermittently seen (Jensen, 1996).

Data can only be submerged in particular places throughout all areas worldwide. Nevertheless, without this information, predicting would be just as difficult as not having satellites. Our work's primary goal is to focus on satellite imagery image enhancement techniques, which highlight or improve picture elements such borders, boundaries, and contrasts to provide a visual presentation. This is more beneficial for displaying and analyzing picture characteristics. The improvement adds a dynamic scope to the selected features that can be easily investigated, rather than increasing the data's inherent content and capability. These strategies aim to do more than just improve the image in visual perception. To enhance anything is only to recognize what is genuine and what is unreal. Although these items may be seen in satellite images, shadows can occasionally make them invisible. Trees, buildings, mountains, and flying objects like clouds and aeroplanes cast these shadows (Masiha, R., 2022; Sarker, 2012). Some items are concealed by their shadows, and it is researcher job to find these objects in images. Satellite imagery is the application domain in which we use picture enhancement techniques in this research. Image-enhancing methods fall, Frequency-Domain Techniques; The Spatial Domain Approach; and Color Improving into three main categories. Only the first two enhancement techniques receive complete attention in a large number of research articles. Nevertheless, occasionally, we have to convert a grayscale image into an RGB image; finally, we also need to consider the images' color enhancement. The picture is first filtered pixel by pixel in the spatial domain. Next, it is transformed into a signal in the frequency domain and subjected to discrete transforms, such as wavelet, Laplacian, or Fournier transforms (Sonawane & Deshpande, 2014).

During the 1960s, digital image processing was developed by Bell Laboratories, the Jet Propulsion Laboratory, MIT, the University of Maryland, and a few other research centers, or digital picture processing, with applications including satellite imagery, wire-photo standards conversion, medical imaging, videophone, character recognition, and photograph enhancement. Initially, picture quality was the main goal of image processing. Proofread: Humans were to be able to perceive things more clearly. Image processing improves the quality of a low-quality image. The variables that determine which enhancement approaches to use include the specific task, the visual content, the characteristics of the observer, and the conditions surrounding the observation (Sarker, 2012; Shakkak & Al Mazruii, 2022).

In low-resolution and noisy photos, in particular, the detection performance of small items in remote sensing images has not been as good as that of large objects. An extended super-resolution GAN (ESRGAN) model, which is based on generative adversarial networks (GANs), shown outstanding picture enhancing capabilities, yet high-frequency edge information, is typically lost in reconstructed images (Rabi et al., 2020; Alkishri et al, 2024). A framework is suggested that combines Generative Adversarial Networks (GANs) and Convolutional Neural Networks (CNNs) in an optimal manner, aiming to achieve high-accuracy ship recognition from low-resolution satellite photos (Khan, & Singh, 2023). This approach not only enhances image quality but also reduces training time, as outlined in reference (Pushkar et al., 2020). This system is validated using a numerical simulation analysis. Furthermore, a variety of security analysis techniques, including information entropy, correlation testing, histogram analysis, key space analysis, and other statistical analysis, were used to examine the stability and efficacy of the suggested chaotic encryption structure (B. Vaseghi et al., 2021; Alshar'e, M., 2023).

The system may scan through a lot of satellite footage for interesting things or infrastructure by combining evaluations with a detecting component. It could address the initial issues in this way (Sara et al., 2019; Al-Hatmi & Yousif, 2017). Jog Sayali et al,A study comparing various supervised classifiers found that The maximum likelihood classifier demonstrates superior performance in terms of accuracy and kappa coefficient when compared to the minimum distance and parallelepiped classifiers (Yousif M., 2023). All image types have overall accuracy better than 88%, except for Landsat MSS photos. SVM is more accurate overall for both kernels, with radial basis and sigmoid functions enhancing its accuracy (Hore et al., 2010; Alasadi & Chyad, 2021).

2. Methodology

This research study aims to assess the effectiveness of different image enhancement techniques in improving the quality of satellite imagery for secure remote sensing applications. The study will use quantitative research design to compare the performance of various enhancement methods and analyze their impact on image quality.

2.1 SVM Implementation

The pairwise coupling approach may be used to combine several binary classifiers to accomplish classification. First created for classification, support vector machines (SVMs) have been expanded to include regression and preference (or rank) learning. SVMs started as binary classifiers, with a trained function producing a positive or negative output. Multi-class Classifiers that distinguish between data points from two categories are called binary SVMs (Yousif, et al,.2022). A vector with n dimensions represents each data object, also known as a data point. Each of these data items might be assigned to two classifications. A hyperplane is used to divide them using a linear classifier. For instance, two data sets and dividing hyperplanes-lines in a two-dimensional space are displayed in Figure 1.

Numerous linear classifiers, such as L1, L2, and L3 in Figure 1, accurately identify (or split) the two categories of data. SVM selects the hyperplane with the most significant margin to get the greatest possible separation between the two classes. The margin is the total of the shortest paths between the closest data points in each category and the dividing hyperplane. A hyperplane with this kind of generalization will probably properly categorize "unseen" or test data points. SVMs help with nonlinear classification issues by mapping from input to feature space. This is made possible by the kernel technique, which permits the lack of precise mapping function formulation that may result in the curse of dimensionality (Chandra et al., 2021).

2.2 Wavelet Transformation

A wavelet is characterized as a wave-like oscillation with its amplitude initiating at zero, ascending, and subsequently descending. It is commonly visualized as a "brief oscillation," resembling the recordings seen on a seismograph or heart monitor. Wavelets are functions centered on a specific point in both time and frequency. The shortcomings of the Fourier approach are addressed by this transformation technique. The Fourier transform does not offer temporal information, while working with frequencies.

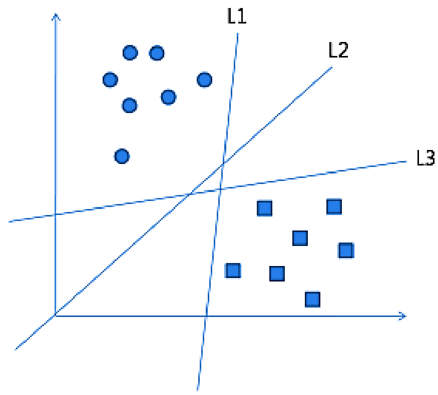

Figure 1. Linear classifiers (hyperplane) in two-dimensional spaces

The Uncertainty Principle formulated by Heisenberg asserts that we can opt for either a low temporal resolution with outstanding frequency resolution, or vice versa. Wavelet transform is most effective when applied to non-stationary signals as shown in Figure 2. High temporal resolution for high-frequency components and decent frequency resolution for components with low frequencies are obtained with this transformation. The initial step in this process involves a mother wavelet, such as Haar, Morlet, Daubechies, etc. Subsequently, the signal undergoes transformation into scaled and shifted versions of the mother wavelet. This results in approximations and details (sub-signals), two distinct components of the information available on a picture (signals), are separated using wavelet analysis (Stefan et al., 2007).

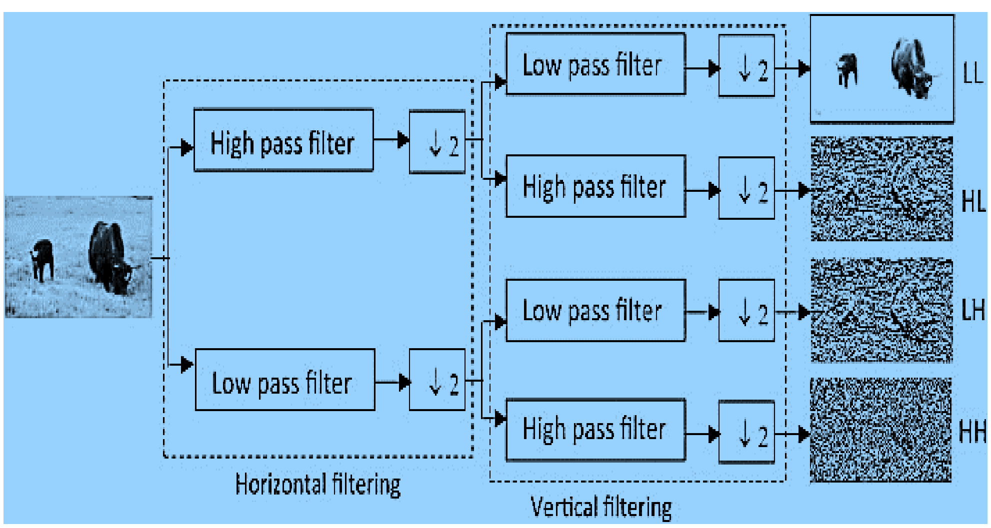

Figure 2. Decomposition of an image 2-D discrete wavelet transform (Parida, & Bhoi, 2017).

The signal undergoes the application of high-pass and low-pass filters. Following this, the image is partitioned into low-frequency (approximation) and high-frequency (details) components. At each level, there are four sub-signals representing the estimate, including the general pixel value pattern and specifics in the form of diagonal, vertical, and horizontal elements. If these features can be considered negligible without causing a noticeable impact on the image, filtering and enlargement can be achieved.

2.3 Mean Filter

The mean filter is a simple spatial filter that involves a sliding window. Instead of the center value, it replaces the central pixel value with the average (mean) of all the pixel values within the window. The window, commonly referred to as the kernel, is usually square but can be arranged in various configurations. An example of mean filtering is illustrated using a single 3x3 value window (Jayaraman et al., 2009).

3. Design and Implementation

To make the result clearer for any user, a graphical interphase has been designed and implemented to show the result of algorithms implementation as shown in Figure 3.

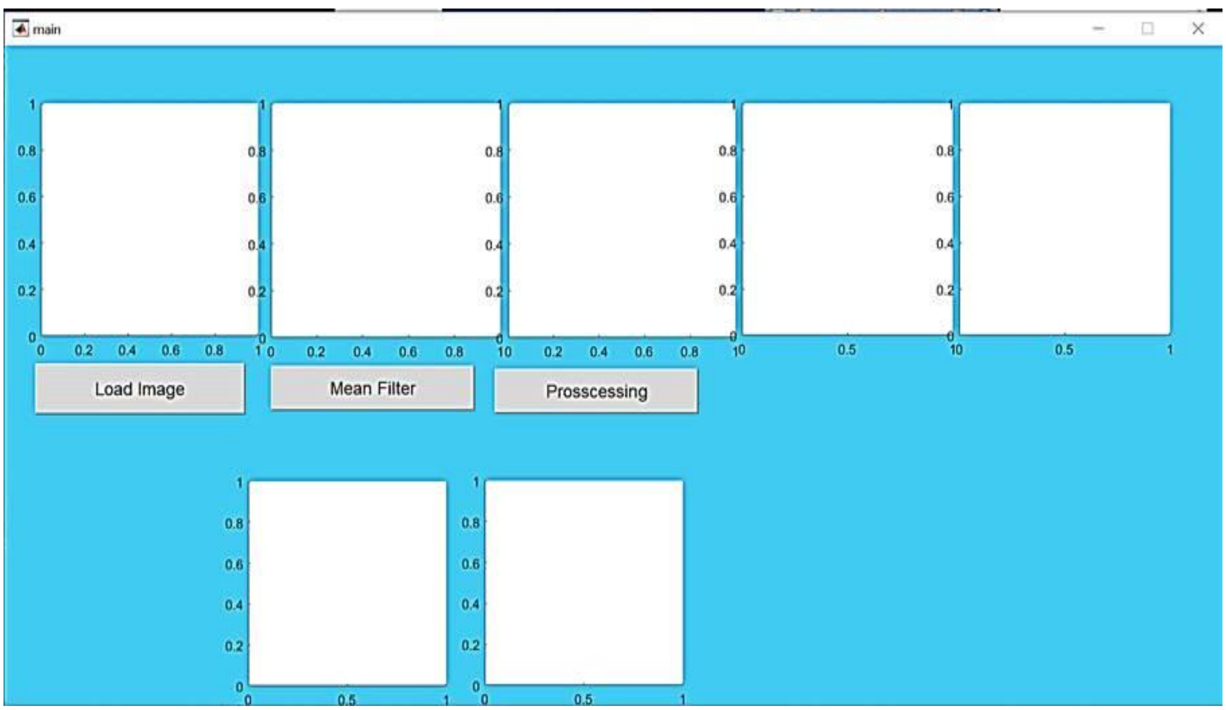

Figure 3. Main interface of the program

Figure 4 shows the main screen to add an image and then, the following interface appears:

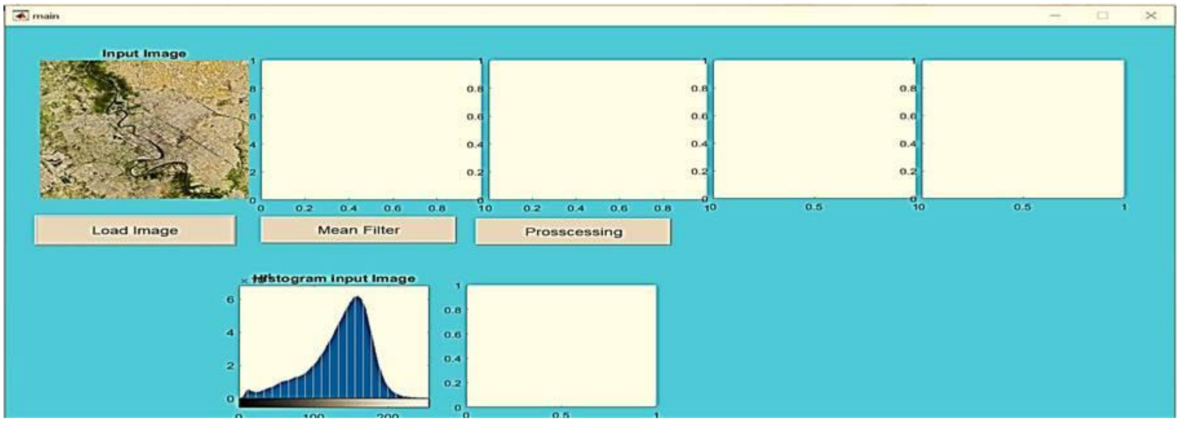

Figure 4. Loading an image

The application includes different filters to be implemented. The user can execute the needed filter, for example the Mean filter, and the result will be as in Figure 5.

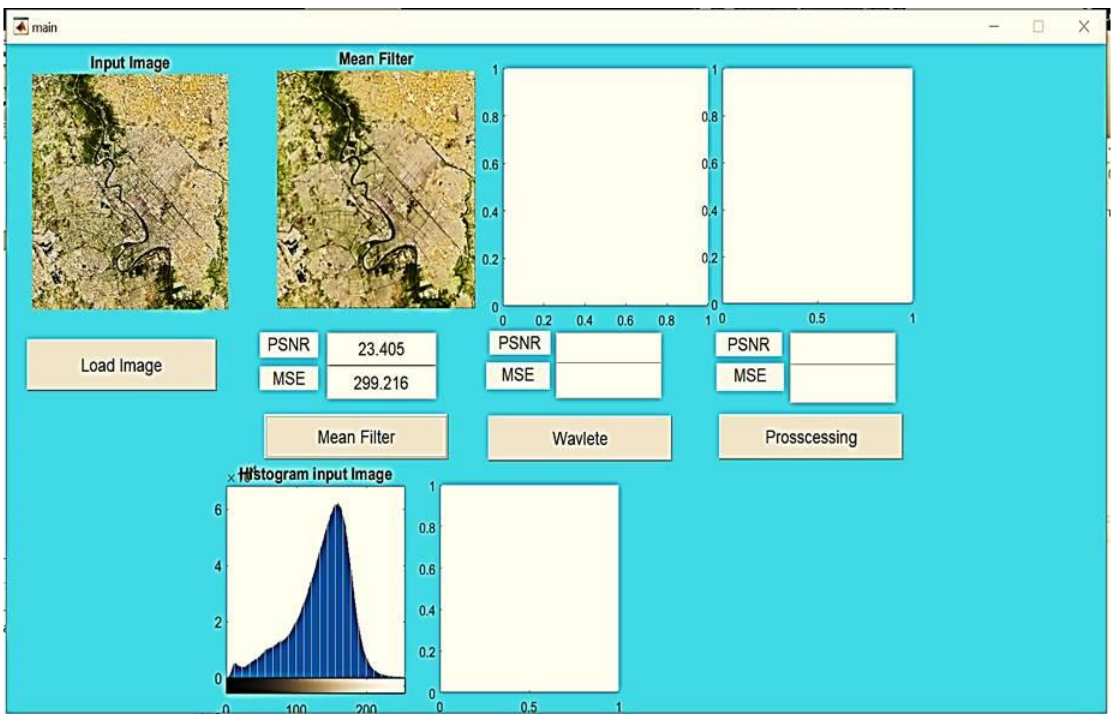

Figure 5. Mean Filter execution

Selecting the "Execute" button for the wavelet initiates the process, yielding the outcome depicted in Figure 6:

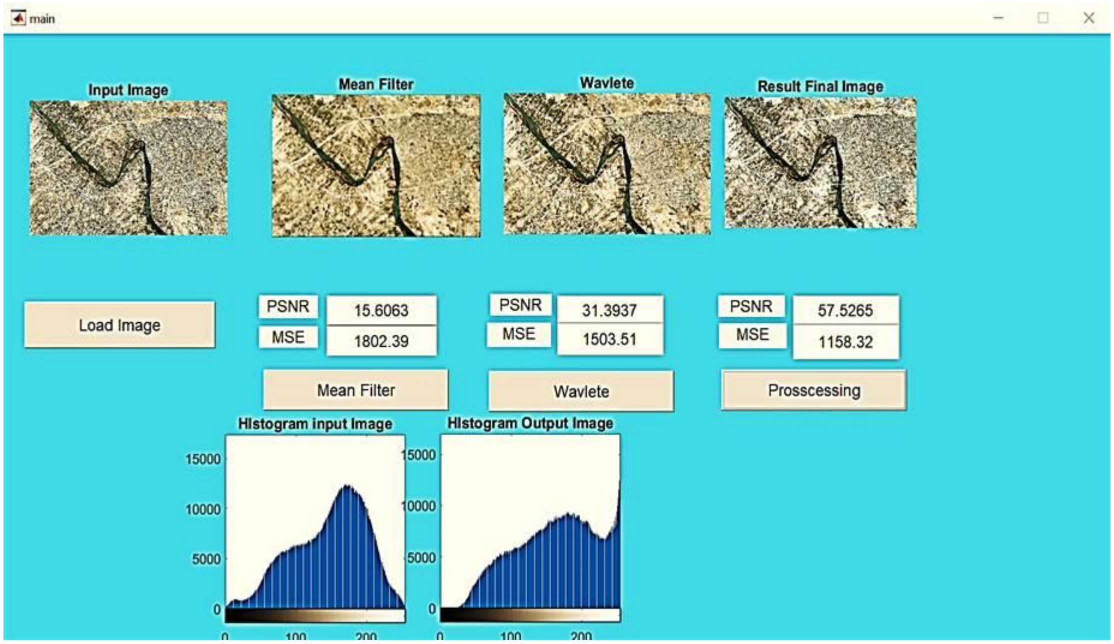

Figure 6. Result of wavelet and final processing

4. Results and discussion

The project pertaining to programming the mean filter is implemented, and after being treated with filters to remove noise, the outcome will be displayed in Table Number (1), through the results that appeared using the criteria for image accuracy under Mean filter**,** the following table shows the varying results as presented in Table 1.

Table 1. Remove Noise using mean Filter

image	**PSNR**	**MSE**	**SSIM**	**FSIM**
1.jpg	74.2472	0.0025	0.8520	0.9932
2.jpg	69.8475	0.0068	0.4319	0.9634
3.jpg	72.7253	0.0035	0.8487	0.9915

Through the results that appeared using the criteria for image accuracy under SVM and Wavelet, the following table shows the varying results as shown in Table 2.

The image comparison performance index is analysed based on quantitative accuracy criteria. The signal to noise ratio (SNR), Equation 1 and peak signal to noise ratio (PSNR), Equation 2, measure distortion more qualitatively and objectively. A fixed amount is used to compare noise instead of an unstable signal, as in SNR. SNR is used to compare the performance of replicated images, which is defined as in Equations 1 & 2.

$$SNR = 10 \times log_{10}\left[\frac{\frac{1}{M\times N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} f(m,n)^2}{\frac{1}{M\times N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}(f(m,n)-g*m,n))^2}\right]\ldots.(1)$$

$$PSNR = 10 \times \log_{10}\left[\frac{(2^b-1)^2}{\frac{1}{M\times N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}(f(m,n)-g*m,n))^2}\right] \ldots. (2)$$

Table 2. Remove Noise by SVM and Wavelet Filter

image	**PSNR**	**MSE**	**SSIM**	**FSIM**
1.jpg	65.9155	0.0168	0.3232	0.9566
2.jpg	66.0527	0.0163	0.3790	0.9835
3.jpg	66.5310	0.0146	0.5117	0.9876

From the Figures 5-6 and Tables 1-2, it's clear that the effect of the using the proposed algorithm is efficient for image enhancement so the result for images can used for security purpose where high accuracy image is needed for recognizing the attended state or objects.

4.1 Comparison With Previous Study

As shown previously there are several research focused on improving satellite image to increase its accuracy and clarity to use it for different application, in this paper the aim of improving image is to use it for security purpose as it cleared before. To show the features of this work, the results are compared with other nearest studies as shown in Table 3.

Table 3. Result Comparison with other studies

Papers	**Aim of Image Improving**	**Method**	**Results**
Rabbi et al., 2020	Detecting small object	GAN (EEGAN) and ESRGAN	Have a good result but need for more dataset and more training
Pushkar et al., 2020	Ship detection for sea security	GANs and CNNs	Have a good result, but there is problem with cloudy and tidal wave
B. Vaseghi et al., 2021	remove all of the appearances of the original satellite image during the transmission with keep image resolution	chaotic keys+ encryption method chaotic masking of QAM symbols	Need to increase the protection of the wireless OFDM. T
This work	To make the images suitable for security purposes	Mean filter +svm+wavelate	It's given a good result especially with the use of wavelet. Need to try another filters type

Table 3 shows that the new method depends on Machin learning and deep learning algorithm which need long time for training and testing and need for big data set for training purpose times. It's clear that the result of this work is good compared with other new methods and all that is tied with quality of the original image and the state of weather and also the environments.

5. Conclusion

The resolution of the images is one of many issues with a satellite image enhancement programmer for security purposes. Similar geographical problems, weather, clouds, fog, and sunshine, also affect us. They create a shadow or a dark area that gradually changes in appearance depending on the atmosphere and the passage of time. This is why we discovered quite different yet comparable images. Ultimately, according to the image analyses particular requirements, we must visualise and analyse the characteristics. The true aim of image improvement is to distinguish between the real and virtual objects in the image. Our study creates a vision to identify the efficient method for advanced executions, such as classification and segmentation. We included the majority of methods for improving the features and quality of the images. Using a high pass filter, we can recognise the picture's edges, which are utilised to designate objects in the image, such as vegetation or elevation areas. Future assignments: Using the same technique, additional filters, such as Prewitt and Roberts, can be applied to the existing image, utilising the existing technique for photo litigation in the remote sensing domain. In addition, video applications may need to be updated or clarified.

The main limitations of this work include:

1. Low image resolution can limit the effectiveness of enhancement techniques and object recognition, especially for security applications requiring high detail.
2. Geographical and environmental factors, such as weather, clouds, and lighting conditions, can affect image quality and introduce inconsistencies that hamper enhancement methods.
3. Variability in the appearance of satellite images of the same area over time due to environmental changes makes comparing and analysing images reliably challenging.
4. The complexity of accurately identifying and interpreting objects within enhanced images remains a significant challenge, particularly for security applications demanding precise object recognition.
5. The study may only cover some possible image enhancement techniques or address some aspects of quality improvement, leaving room for further research.
6. Implementing suggested future enhancements like additional filtering may require additional resources and evaluation of their effectiveness.

Acknowledgment

The research leading to these results has received no Research Grant Funding.

Author contribution: All authors have contributed, read, and agreed to the published version of the manuscript results.

Conflict of interest: The authors declare no conflict of interest.

References

[1]. Alasadi, A. H. H., & Chyad, D. A. (2021) Human–Ear Recognition Using Scale Invariant Feature Transform. Artificial Intelligence & Robotics Development Journal 1 (1), 1-12. https://doi.org/10.52098/airdj.20217

[2]. Al-Hatmi, M. O., & Yousif, J. H. (2017). A review of Image Enhancement Systems and a case study of Salt &pepper noise removing. International Journal of Computation and Applied Sciences (IJOCAAS), 2(3), 171-176.

[3]. Alkishri, W., Widyarto, S., & Yousif, J. H. (2024). Evaluating the Effectiveness of a Gan Fingerprint Removal Approach in Fooling Deepfake Face Detection, Journal of Internet Services and Information Security (JISIS) 14 (1), 85-103. DOI: 10.58346/JISIS.2024.I1.006

[4]. Alshar'e, M. (2023). Cyber security framework selection: Comparision of NIST and ISO27001. Applied computing Journal, 245-255.

[5]. B. Vaseghi, S. S. Hashemi, S. Mobayen and A. Fekih , (2021), "Finite Time Chaos Synchronization in Time-Delay Channel and Its Application to Satellite Image Encryption in OFDM Communication Systems," in IEEE Access, vol. 9, pp. 21332-21344,.

[6]. Chandra, M. A., & Bedi, S. S. (2021). Survey on SVM and their application in image classification. International Journal of Information Technology, 13, 1-11.

[7]. Hore, A., & Ziou, D. (2010, August). Image quality metrics: PSNR vs. SSIM. In 2010 20th international conference on pattern recognition (pp. 2366-2369). IEEE.

[8]. Jayaraman, S., Esakkirajan, S., & Veerakumar, T. (2009). Digital image processing (Vol. 7014). New Delhi: Tata McGraw Hill Education.

[9]. Jensen, J. R. (1996). Introductory digital image processing: a remote sensing perspective. Jenson,3rd Edition, prentice -Hall,

[10]. Khan, M. J., & Singh, P. P. (2023). Advanced road extraction using CNN-based U-Net model and satellite imagery. e-Prime-Advances in Electrical Engineering, Electronics and Energy, 5, 100244.

[11]. Masiha, R. Y. (2022). Terminologies and Techniques based Image Encryption A Survey. Artificial Intelligence & Robotics Development Journal, 187-200.

[12]. Parida, P., & Bhoi, N. (2017). Wavelet based transition region extraction for image segmentation. Future Computing and Informatics Journal, 2(2), 65-78.

[13]. Pushkar, P., Aggarwal, L., Saad, M., Maheshwari, A., Awasthi, H., & Nagrath, P. (2020). Object Identification in Satellite Imagery and Enhancement Using Generative Adversarial Networks.

[14]. Rabbi, J., Ray, N., Schubert, M., Chowdhury, S., & Chao, D. (2020). Small-object detection in remote sensing images with end-to-end edge-enhanced GAN and object detector network. Remote Sensing, 12(9), 1432.

[15]. Sarker, S., Chowdhury, S., Laha, S., & Dey, D. (2012). Use of non-local means filter to denoise image corrupted by salt and pepper noise. Signal & Image Processing: An International Journal (SIPIJ), 3(2), 223-235.

[16]. Sara, U., Akter, M., & Uddin, M. S. (2019). Image quality assessment through FSIM, SSIM, MSE and PSNR—a comparative study. Journal of Computer and Communications, 7(3), 8-18.

[17]. Schulte, S., De Witte, V., & Kerre, E. E. (2007). A fuzzy noise reduction method for color images. IEEE Transactions on image Processing, 16(5), 1425-1436.

[18]. Shakkak, B. I. M., & AL MAZRUII, S. A. K. (2022). Face Recognition based on Convoluted Neural Networks: Technical Review. Applied computing Journal, 193-212.

[19]. Sonawane, S., & Deshpande, A. M. (2014). Image quality assessment techniques: An overview. International Journal of Engineering Research, 3(4).

[20]. Yousif, J. H., Zia, K., & Srivastava, D. (2022). Solutions Using Machine Learning for Diabetes. Healthcare Solutions Using Machine Learning and Informatics, 39-59.

[21]. Yousif, M. J. (2023). Enhancing The Accuracy of Image Classification Using Deep Learning and Preprocessing Methods. Artificial Intelligence & Robotics Development Journal