WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Satellite Image Enhancement Techniques: An Overview

K. Anitha

Assistant Professor, Department of Electronics and Communication Engineering, Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya, Kanchipuram, Tamil Nadu, India

ABSTRACT :

In the realm of remote sensing, satellite image enhancement is essential because it is used in many different applications, such as military intelligence, urban planning, environmental monitoring, and disaster management. This paper provides a comprehensive overview of the methods that are currently being used to enhance satellite images. The four basic categories of enhancement methods include machine learning-based techniques, hybrid techniques, spatial domain techniques, and frequency domain techniques. While frequency domain techniques convert the image into the frequency space to enhance particular aspects, spatial domain techniques directly manipulate image pixels to boost contrast and sharpness. Since the development of artificial intelligence, deep learning-based machine learning approaches have demonstrated impressive results in improving the quality of satellite images by deciphering complex patterns.

Keywords: Satellite Image Processing, Image Enhancement

1. Introduction :

In numerous sectors including agriculture, urban planning, disaster relief, environmental monitoring, and military surveillance, imagery from satellites has become an essential tool. The ability to obtain high-resolution images of the Earth's surface in terms of spatial, spectral, and temporal aspects has completely changed the way we view and study our planet. However, noise, poor contrast, atmospheric distortions, and other degradations are frequently present in raw satellite images, which can seriously impair their usefulness and the accuracy of further analysis.

Through the use of image enhancement techniques, satellite images can look better and be better suited for study and interpretation. These methods can be roughly categorised as machine learning-based methods, hybrid approaches, spatial domain methods, and frequency domain methods. Every category includes a variety of algorithms created to address exact issues related to satellite imagery.

Frequency domain techniques use mathematical tools such as the Fourier transform to convert the image into the frequency space. This domain allows for the modification of the image's frequency components, such as the suppression of low-frequency components to lessen noise or the amplification of high-frequency components to strengthen edges. In this area, methods like the wavelet transform and the discrete cosine transform (DCT) are frequently employed.

With the development of artificial intelligence and machine learning, new techniques have surfaced that take advantage of deep learning models' ability to improve satellite pictures. These machine learning-based methods provide better results in tasks like noise reduction, super-resolution, and feature improvement because they can identify intricate patterns and features from big datasets. Among the most popular models in this field are generative adversarial networks (GANs) and convolutional neural networks (CNNs)

2. Satellite image pre-processing

Information from raw satellite data. This process involves several key steps, each essential for ensuring that the final images are accurate, clear, and useful for analysis. Below is an overview of the main steps involved in satellite image processing.

Image Acquisition

Sensor and Platform Selection: Selection of the appropriate satellite and sensor based on the application requirements (e.g., spatial resolution, spectral bands, revisit time). Data Retrieval: Collection of raw satellite data from the satellite's onboard sensors. This data is often transmitted to ground stations for further processing.

Radiometric and Geometric Correction

Radiometric Correction: Adjustment of the image data to correct for sensor noise and atmospheric effects, ensuring that the pixel values accurately represent the Earth's surface reflectance. Geometric Correction: Correction of geometric distortions due to the sensor’s perspective, Earth’s rotation, and terrain variations. This step involves aligning the image with a known coordinate system.

Image Enhancement

Noise Reduction: Application of filters or algorithms to reduce noise and improve image quality. Contrast Enhancement: Techniques such as histogram equalization or contrast stretching to improve the visibility of features. Edge Enhancement: Sharpening of image features to make edges more distinct and facilitate better interpretation.

3. Resolution Enhancement :

Resolution enhancement in satellite imagery refers to the process of improving the spatial, spectral, or temporal resolution of images to provide finer details and more accurate information. This is crucial for applications requiring high precision, such as urban planning, agriculture monitoring, and environmental assessment. The primary focus is on spatial resolution enhancement, but techniques can also apply to spectral and temporal resolutions.

3.1. Spatial Resolution Enhancement Techniques

Interpolation Methods are in different types, Nearest Neighbour Interpolation: Assigns the value of the nearest pixel to the new pixel location. Bilinear Interpolation: Uses the average of the four nearest pixels to estimate the new pixel value. Bicubic Interpolation: Uses the 16 nearest pixels to compute the new pixel value. Wavelet Transform-Based Methods: Wavelet Transform: Decomposes the image into different frequency components and enhances resolution by modifying these components. Pansharpening: Combines a high-resolution panchromatic (grayscale) image with a lower-resolution multispectral image to produce a high-resolution multispectral image.

3.2. Spectral Resolution Enhancement Techniques

Spectral Unmixing: Decomposes mixed pixels into their constituent spectral signatures to enhance the spectral resolution. Hyperspectral Imaging: Involves the capture and processing of information across a wide range of the electromagnetic spectrum.

3.3. Temporal Resolution Enhancement Techniques

Time Series Analysis: Enhances temporal resolution by analysing and combining data from multiple time points. Data Fusion: Combines data from different sensors or platforms to improve temporal. Resolution enhancement is a vital aspect of satellite image processing, significantly improving the utility of satellite data for various applications.

4. Contrast enhancement techniques :

Techniques for enhancing contrast in satellite images include the following: For better contrast, Global Histogram Equalisation (GHE) redistributes intensity values throughout the whole range; Contrast Limited AHE (CLAHE) lowers noise amplification by clipping histograms, whereas Adaptive Histogram Equalisation (AHE) increases local contrast by equalising histograms in tiny image regions. Both linear and non-linear histogram stretching enlarges intensity ranges to improve overall contrast. High-Pass Filtering highlights edges, whereas Homomorphic Filtering separates illumination and reflectance components. These are examples of frequency domain techniques. Low-contrast images are enhanced using fuzzy logic-based methods, which map intensity values using fuzzy principles. Pixel intensities are normalised via Retinex-Based Methods, like Multi-Scale Retinex (MSR) and Single-Scale Retinex (SSR), to improve contrast.

5. Intensity Transformation :

In satellite image processing, modifications of intensity, hue, and saturation are crucial methods for improving image quality and deriving significant information. Using techniques like linear stretching to boost contrast, logarithmic and exponential transformations to enhance dark and bright areas, and power-law (gamma) transformation to accommodate different lighting conditions, intensity transformation modifies the brightness of an image by altering its pixel values. Hue transformation, which includes hue correction and rotation to remedy colour imbalances and colour matching to align with reference images, modifies the colour property without changing brightness or saturation. Colour vibrancy is changed by saturation transformation, which uses saturation clipping to avoid oversaturation and linear and non-linear changes to increase saturation either consistently or selectively. These transformations collectively enhance the visual quality and interpretability of satellite imagery, facilitating accurate analysis and applications.

6. Enhancement of Edge :

In satellite image processing, edge enhancement techniques make edges and tiny features easier to see, which makes interpretation and analysis easier. These strategies include spatial filtering techniques that highlight areas of fast intensity change, such as the Laplacian, Sobel, and Prewitt filters. Sharp transitions and details are highlighted by high-pass filtering, which sharpens high-frequency components. On the other hand, unsharp masking sharpens edges by removing a blurry version from the original image. To improve edges, the wavelet transform breaks the image down into distinct frequency components. Accurately detecting genuine edges is possible with gradient-based techniques like the Roberts Cross and Canny edge detector. Edges and small details are further enhanced using frequency domain techniques, such as using a high-pass filter in the Fourier transform domain. Together, these methods enhance the satellite images' clarity and detail for a variety of applications.

All authors are required to complete the Procedia exclusive license transfer agreement before the article can be published, which they can do online. This transfer agreement enables Elsevier to protect the copyrighted material for the authors, but does not relinquish the authors' proprietary rights. The copyright transfer covers the exclusive rights to reproduce and distribute the article, including reprints, photographic reproductions, microfilm or any other reproductions of similar nature and translations. Authors are responsible for obtaining from the copyright holder, the permission to reproduce any figures for which copyright exists.

7. Conclusion :

In satellite image processing, various techniques are employed to enhance different aspects of imagery, making it more suitable for detailed analysis and interpretation. Contrast enhancement methods, such as global and adaptive histogram equalization, histogram stretching, and frequency domain techniques, improve the visual distinction between features. Resolution enhancement techniques, including interpolation, super-resolution, wavelet transform, and pansharpening, increase the level of detail in images. Intensity, hue, and saturation transformations adjust brightness, color attributes, and color vividness, respectively, enhancing image quality. Edge enhancement methods, including spatial filtering, high-pass filtering, unsharp masking, wavelet transform, gradient-based methods, and frequency domain methods, sharpen edges and fine details. Each of these enhancement techniques addresses specific challenges, and their application depends on the requirements of the task, the quality of the input data, and available computational resources.

REFERENCES :

1. Pizer, S. M., Amburn, E. P., Austin, J. D., Cromartie, R., Geselowitz, A., Greer, T.& Zuiderveld, K. (1987). Adaptive Histogram Equalization and Its Variations. Computer Vision, Graphics, and Image Processing, 39(3), 355-368.
2. Stark, J. A. (2000). Adaptive Image Contrast Enhancement Using Generalizations of Histogram Equalization. IEEE Transactions on Image Processing, 9(5), 889-896.
3. Yang, C.-Y., Ma, C., & Yang, M.-H. (2014). Single-Image Super-Resolution: A Benchmark. Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 1946
4. Park, S. C., Park, M. K., & Kang, M. G. (2003). Super-Resolution Image Reconstruction: A Technical Overview. IEEE Signal Processing Magazine, 20(3), 21-36.
5. Glasner, D., Bagon, S., & Irani, M. (2009). Super-Resolution from a Single Image. IEEE International Conference on Computer Vision (ICCV), 349-356.
6. Canny, J. (1986). A Computational Approach to Edge Detection. IEEE Transactions on Pattern Analysis and Machine Intelligence, PAMI-8(6), 679-698.
7. (CLAHE) for Real-Time Image Enhancement. Journal of VLSI Signal Processing Systems for Signal, Image and Video Technology, 38(1), 35-44.
8. Peli, E. (1990). Contrast in Complex Images. Journal of the Optical Society of America A, 7(10), 2032-2040.
9. Farsiu, S., Robinson, M. D., Elad, M., & Milanfar, P. (2004). Fast and Robust Multiframe Super Resolution. IEEE Transactions on Image Processing, 13(10), 1327-1344.
10. Li, S., Kang, X., & Fang, L. (2017). Pixel-Level Image Fusion: A Survey of the State of the Art. Information Fusion, 33, 100-112.
11. Gonzalez, R. C., Woods, R. E., & Eddins, S. L. (2004). Digital Image Processing Using MATLAB. Prentice Hall.
12. Stokes, M., Anderson, M., Chandrasekar, S., & Motta, R. (1996). A Standard Default Color Space for the Internet - sRGB. Color and Imaging Conference, 1996(1), 238-245.
13. Parker, J. R. (2010). Algorithms for Image Processing and Computer Vision (2nd ed.). Wiley.
14. Zhou, J., & Lam, K. M. (2004). A Modified Gabor Filter Design for Fingerprint Image Enhacement. Pattern Recognition Letters, 25(11), 1273-1288.