FUZZY INFERENCE SYSTEM BASED NOISE CANCELLATION FOR URBANIZATION USING SATELLITE IMAGES

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Abstract— Remote sensing plays a vital role in a wide range of fields including research. This paper proposes a method to improve the spectral resolution (SREM) of satellite images using a fuzzy inference system. Improving the image standard for better human perception is called image enhancement. Various image enhancement techniques are usually used to suppress impulse noise. When image enhancement technology is used, the standard of the first image is usually increased so that the machine or manual analysis can be better. Blurred image enhancement is one of the image enhancement methods. Symbolic logic deals with approximations, rather than firm and precise reasoning that studies possibility logic or various meaningful logics. Part of the true value is processed when the actual value may be between the completely wrong value or the true value that is taken into account due to the ambiguity of important application areas. Using triangular membership functions and fuzzy rules f The system increases the contrast of the first image due to fuzzy inference. First, apply the fuzzy rules to the first image, and then complete the defuzzification to control the enhanced image equivalently. Calculate the root mean square error (MSE) and peak signal-to-noise ratio (PSNR) of the enhanced image. The method was tested on three image data sets, so the improved spectrum was compared with visual interpretation and statistical analysis to measure performance. It has been shown that fuzzy inference produces good image data, which can greatly expand the range of satellite data.

Index Terms— Remote sensing, mean square error (MSE) and peak signal-to-noise ratio (PSNR), fuzzy inference system

I. INTRODUCTION

Remote sensing is playing an increasingly important role during a big variety of fields, like military target identification [1], precision agriculture [2], forest research [3], mineral exploration [4], natural science research [5], environmental monitoring [6] and mining [7]. Due to the difficulty of instrument design, the spectral and spatial characteristics of satellite images have a trade-off between signal noise (SNR) and data acquisition rate [8]. Therefore, satellite images have more bands, but the spatial resolution is lower and the bands are narrower. It becomes difficult to obtain extensive data coverage and high spatial resolution with better spectral resolution. In the past few decades, a large amount of satellite data has been used in military, civilian and research fields. Different types of research require spectral, spatial and temporal resolution data [9]. Applications such as mineral exploration, plant disease detection, land cover mapping, and vegetation research usually require satellite data with higher spatial resolution and wider coverage [10]. The amount of research in these fields is usually limited to a relatively small area, and better results can usually be obtained with higher spatial resolution. Satellite data is collected on a global scale. In order to transform the image to make it better suitable for human or machine analysis, or to improve the appearance of the image, many techniques are used in the field of image enhancement. Use image enhancement. Image blur enhancement involves linguistic variables, including sentence-based fuzzy rules for image processing and membership functions that convert the image from pixel level to membership level fuzzy. And leave the membership function [11]. Fuzzy image can be a data representation system that processes human knowledge within fuzzy rules, so fuzzy image processing is very effective in enhancing image contrast. It can also effectively manage blur and image anomalies. The blur in the measured image can be a function that increases as the sharpness of the image decreases. As the diffusion entropy. The gain parameter, diffusion and transition point are the three parameters to be considered. Using the method of minimizing contrast enhances a gradual image that shows bright objects on a dark background. Taking into account the relevant intersection points, in order to avoid fluctuations, the Shannon entropy is converted to diffuse entropy by the histogram, and the image parameters are also calculated. Then, by selecting the intersection point, the membership function is modified with reference to the intersection point, so the Gaussian membership function aims to modify the membership value used [12]. Initially, the maximum intensity pixel value of the input data is 1, and the minimum intensity pixel value is 1. The image should be assigned 0. Using the membership function, the intensity adjustment function indicates the blur or blur of the image with relatively low contrast. Intensity plane to blur plane, so pixels are grouped according to their intensity. Finally, with the help of defuzzification, the image is subordinated to the level conversion of the diffuse reflection level [13]. Different noises in different areas of the image are suppressed by different filters, and different filters are used for comparison purposes. This filter effectively suppresses various sounds and filters with different thresholds. During the original noise image, the value is applied to the noise image with a range of different noise levels. l Apply filters to make the applied filters have different window sizes. The size of the main window is limited to avoid excessive blurring of image details and high levels of noise. The filter removes any pixels equal to the minimum, maximum, or reasonable value during the window of use, and then calculates the remaining or four neighboring pixels as the average value of the pixels. Noisy pixels are replaced with typical filter pixel values, or the median value is used to replace damaged pixels. Increasing the contrast can improve the useful information about the image, thereby eliminating the noise in the image.Other membership functions usually convert the image from the pixel level to the post-processing level, and use symbolic logic to deal with the knowledge within the type of fuzzy if then rule. Fuzzification, defuzzification and diffusion rules are all included in the improvement process. The improved image is calculated after the image standard is improved.

II. METHODOLOGY

All three sets of satellite images are input into the system. The resulting image is in JPEG or PNG format, which is then processed to enhance the image.

A. Fuzzification

The concept of assigning the required membership function to the image in which the image is converted from the pixel plane to the diffuse reflection plane is called blurring. The feature function in the exact set is a fuzzy set with a unique scene membership function, and the feature function of the exact set is the only scene in the fuzzy set membership function. When the membership function is used, the obtained color image with gradual color gradient is converted into a membership function whose value varies between the interval of 0 to 1 and the interval of 0 to 1. Can have infinite values 1. The pixel level of the member. The triangular membership function is used in the first level. Use the membership function editor toolbar to configure the area of each membership function, and select three membership functions for the input and output of the three image intensities. When defining fuzzy rules for the system, the main consideration is the range of input and output membership functions. Drag the selected membership function into the toolbox to change the range of input and output membership functions.

B. Triangular Membership Function

Three triangular membership functions are used for input and output, respectively, mf1, mf2 and mf3, as shown in the figure. The dark area represents mf1, the gray area represents mf2, and the white area represents the mf3 image. It is 0-100, the range of mf2 is 25-225, and the range of mf3 is 150-250, respectively. As shown in the figure, add the fuzzy rule to the rule editor toolbox according to the parameters of the three membership degrees. In this case, the X-axis represents the intensity value of the pixel, and the Y-axis represents the degree to which the element assigned to the pixel changes relative to its intensity.

C. Membership Modification

The member value is calculated using fuzzy inference system FIS it is divided into i.Mamdani type FIS type and Sugeno FIS type. FIS is a MATLAB toolbox consisting of rule editor, FIS editor, rule viewer, surface viewer, membership function editor, and input and output variables. FIS consists of built-in member functions. Set the gray-level membership value of the image, which defines the difference between gray-level, maximum gray-level and minimum gray-level. The membership value is assigned to the pixel according to the change in the intensity level of the pixel, and a new membership value is determined for the pixel relative to its gray intensity value.

D. Fuzzy Rules

Fuzzy rules are represented by linguistic variables, and the values of these variables are sentences or words. Non-numeric variables, which can be compound or atomic, are usually used to express rules and facts. Language variables can be modified. Variables in mathematics usually take numerical values, and then are composed of fuzzy rules when they are fuzzy. Rules are defined for values. Use pixel intensity and fuzzy operator modification memberships when defining rules. Fuzzy rules are added using the fuzzy rule editor toolkit, which allows you to add or delete rules related to the selected member function and its display area.

E. Defuzzification

The main goal of the defuzzification process is to find a sharpening value that sums up the fuzzy set input by the inference system, which is an inverse fuzzification process. The image is converted from the diffuse reflection level back to the pixel level, and member values are set for the system during the deblurring process. The defuzzification method is initially selected from the toolbar of the fuzzy inference system during the fuzzy process, and the system uses the centroid defuzzification method.

F. MSE AND PSNR

First capture images of different sizes for the system, then enhance the image, and calculate the peak signal ratio (PSNR) and root mean square (MSE) of the enhanced image. Low MSE and high PSNR indicate effective image contrast improvement, and the calculated parameter values are listed for different images.

III. IMPLEMENTATION

A. Image Acquisition

The image acquisition system collected three satellite images of the Karnataka area and checked the images of different sizes.

B. Fuzzy Inference System

Images are processed using different fuzzy inference toolsets. Fuzzy logic can be used to perform the process of matching a given input with an output, which becomes the basic basis for decision-making or pattern recognition. The fuzzy inference system consists of the following parameters: display input variables, use fuzzy operators, add and hide rule outputs.

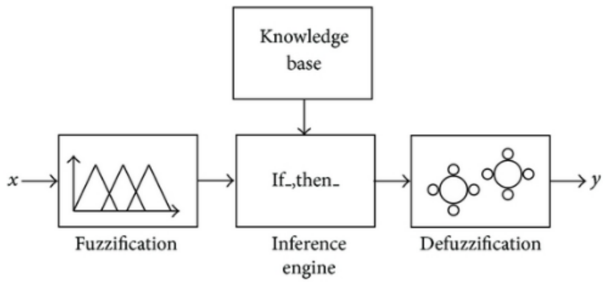

Fig -1: Block Diagram of Fuzzy Inference System

Figure 1 shows the block diagram of the fuzzy inference system. The fuzzy inference system editor displays information about FIS, and the FIS editor tool allows you to define the highest-level attributes of the fuzzy inference system and the number of inputs and outputs. variable. Various other editors that work with the fuzzy inference system, the FIS editor provides easy access to all other editors and emphasizes the maximum flexibility of fuzzy system communication.

C. FIS Editor

The basic structure of FIS is shown in Figure 2. The output variable is on the right side of FIS, and the input variable is on the left side of the FIS editor. As shown in the figure above, the field display function and membership function are represented by symbols and do not represent the membership function. In this editor, select fuzzy operators, namely AND and OR, select the range of the system and the method of defuzzification. Each time you select an inference system for the system, you can access the membership function editor for input and output system variables by double-clicking the pixel icon. The FIS editor tool has changed the important characteristics of the fuzzy inference system, that is, the type of membership function, the range of the membership function, the number of outputs and the required input variables, and the defuzzification method. The FIS editor provides advanced rendering for any fuzzy logic inference system, but also because of other changes made in FIS. Their scope is given in this toolbox.

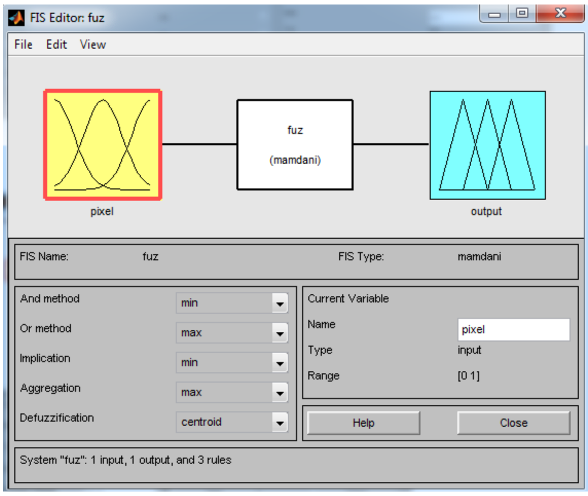

Fig -2: FIS editor tool box

D. *Membership Function Editor*

The types, names, and other variables of all member functions have been changed. A built-in membership function is provided in the toolbox, and the display area and membership function are selected in the toolbox. For input and output, select the membership function and its parameters from the toolbar to convert the image from pixel level to blur level. The X axis represents the pixel area, and the Y axis represents the pixel corresponding to the degree of membership.

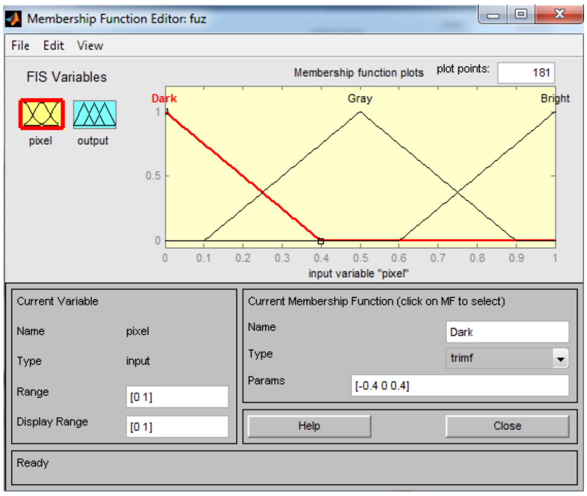

Fig -3: Membership Function Editor

Figure 3 shows the tools used to edit the membership functions of the input variables and output variables used in the entire fuzzy inference system. Member functions are integrated in the toolbox. are you free. Select the corresponding pixel or triangular membership function for the system.

E. *Fuzzifying The Input Variables*

The main process is to convert the exact value into the membership degree of the fuzzy language variable. Determine the membership value to change the intensity of each pixel, and use the fuzzy inference toolbox to determine the membership function[5].

The following equation forms the membership function (2) P (i, j) = (1 + (X max x 11 (i, j) / Fe)) ^ Fd),

where P (i, j) = i row and j column . Image result pixel

x11 (i, j) = i row j column image pixel

x max = maximum grayscale

F. *Rule Editor*

Use the rule editor in the FIS editor to modify the fuzzy rules. When using fuzzy inference, the applied rules are reviewed and edited, and the rule editor allows you to add rules for all input and output variables. You can use this toolbox to change, create, and delete [11]. The process of increasing the contrast of a grayscale image is determined by the fuzzy rules: if the pixel is gray, then turn it into gray: if the pixel is bright, then make it bright: if the pixel is dark, then make it dark . Fuzzy input data is processed by fuzzy rules before the antecedents. If the obtained fuzzy rules have multiple antecedents, a fuzzy operator (AND or OR) is used to get a number, which is the result of evaluating the antecedents [12], fuzzy OR The operator is used to calculate the disjunctive precursor of the rule.

$$\mu_A(Z) \cup \mu_B(Z) = \max[\ \mu_A(Z), \mu_B(Z)] \qquad (5)$$

Where $\mu_A(Z) \cup \mu_B(Z)$ is union of two fuzzy sets A and B

$\mu_A(Z)$ is degree of membership of subset A

$\mu_B(Z)$ is degree of membership of subset B

To evaluate the conjunction of the rule antecedents AND fuzzy operators are used.

$$\mu_A(Z) \cap \mu_B(Z) = \min[\ \mu_A(Z), \mu_B(Z)] \qquad (6)$$

is intersection of fuzzy sets A and B

$\mu_A(Z)$ is degree of membership of subset A

$\mu_B(Z)$ is degree of membership of subset B

The output of the rule is aggregated to describe the union of the output of each rule by taking the membership functions of all the results of the rule and combining them into a fuzzy set. The input data for the aggregation process is a list of member functions. For all output variables, this is the input and output of the aggregation process.

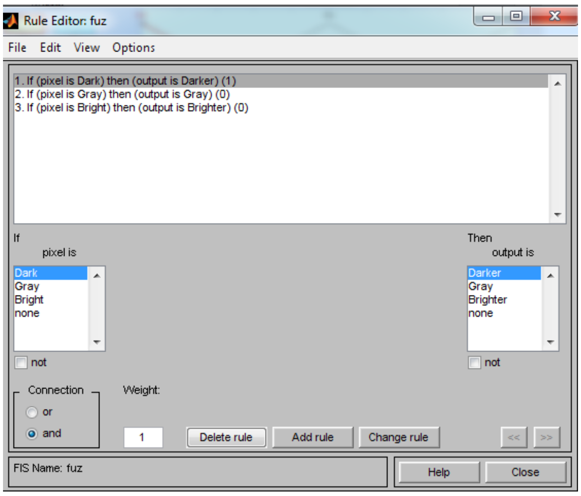

Fig -4: Rule Editor

The tools that can be used to change the FIS structure rules are shown in Figure 4. This toolkit is used to check the rules that FIS uses for the system. This editor uses the range and type of membership functions, and adds rules for each other based on input and output.

G. Rule Viewer

The rule viewer describes the fuzzy output graph of FIS. Use the rule viewer to monitor the entire supply process from start to finish. Browse the linear index corresponding to the input, then observe the system reconfiguration and recalculation tool. The tool used to inspect the FIS output surface of any number of inputs is called the Surface Viewer, which is a read-only editor. Because it will never change the fuzzy system or related FIS structure. You can select two input variables for the two input axes (X and Y); you can also use the drop-down menu to assign the output variable to the output axis (or Z). Smoother graphics, they are graded in the input and output areas. The rule viewer describes the fuzzy output map of FIS in Figure 5, and the surface viewer is shown in Figure 6, which is used to check the total number of tickets in the FIS output interface. It is a read-only editor and will not change the fuzzy system or related FIS structure at any cost.

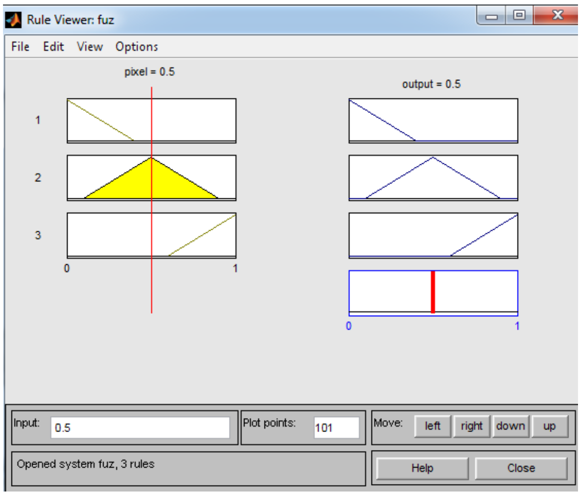

Fig -5: Rule Viewer

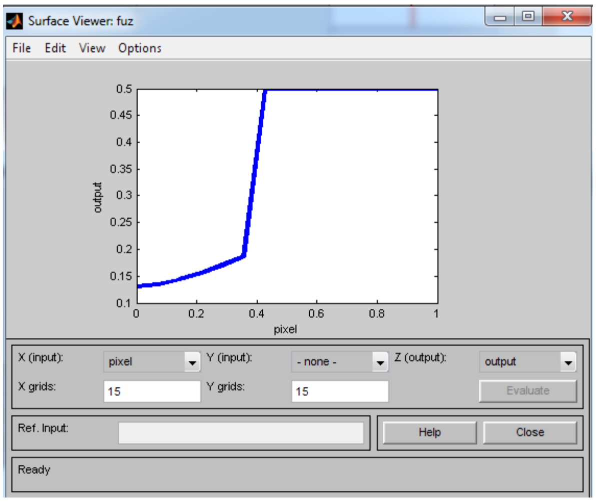

Fig -6: Surface Viewer

H. Defuzzifying

In a fuzzy inference system, this is the final stage. Obfuscation is used to evaluate the rules used, and the output of the fuzzy system is always a precise number. Added fuzzy set output, the output is the only sharp number in the defuzzification process [10]. The point representing the center of gravity of the fuzzy set is in the process of defuzzifying the center of gravity. Mathematically, the focus is expressed as follows:

$$COG = \frac{\int_a^b \mu_A(Z)Zdz}{\int_a^b \mu_A(Z)dz} \quad (7)$$

Where COG is Centre of gravity
Z is a fuzzy set
A is a subset of Z
$\mu_A(Z)$ is degree of membership of subset A

Enhanced Image Use a diffusion system. The contrast of the degraded input image will increase, and the process of changing the image properties creates a new image that is more suitable for any particular application. get.

$$I(i,j) = X_{max} - Fe * ((1/P(i,j))\wedge(1/Fd) - 1)$$
(8)

Where,
X_{max}= maximum gray level
Fe= Exponential Fuzzifier
Fd= Denomination Fuzzifier

I. MSE AND PSNR

Comparing between the evaluator and the score, MSE measures the average of the "errors":

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - k(i,j)]^2 \quad (9)$$

Among them, m and n indicate the size of the row and column, and i and j indicate the row and column number of the current pixel. PSNR is the difference between the maximum image intensity and noise distortion, which affects the accuracy of the image. PSNR is always expressed in logarithmic decibels, that is

The larger PSNR usually shows i. The restored image quality is the best:

$$PSNR = 10log_{10}\frac{MAX_i}{MSE} \quad (10)$$

MAXi is the maximum pixel intensity that can be achieved in the image. The pixel is represented by 8 bits, so MAXi is 255.

IV. RESULTS

We use three remote sensing data sets to test image enhancement using fuzzy inference. The images in the dataset cover the same area but were taken at different times. The image shows city sites with different types of city factors. This is a free Google Earth program that contains the basic data needed for evaluation. The study area for the three data sets is located in Karntaka (see Figure 3). From 2020, collect data sets in the study area, and evaluate the results based on visual interpretation, statistical characteristics, and classification effects.

(a) (b)

Fig -7: Sarakki lake, Karnataka study area. (a) Noisy Image (b) noise cancelled Image

Fig -8: Mangaluru Urban, Karnataka study area. (a) Noisy Image (b) noise cancelled Image

Fig -9: Bantwal Park, Karnataka study area. (a) Noisy Image (b) noise cancelled Image

Table -1: Test results of proposed Fuzzy Inference System MSE and PSNR calculation.

Data Set	PSNR	MSE
Sarakki lake, Karnataka study area	12.58	3673.84
Mangaluru Urban, Karnataka study area	15.32	1859.03
Bantwal Park, Karnataka study area	13.29	3028.45
Average Value	13.73	2853.77

V. CONCLUSIONS

The focus of the article is to improve the contrast of the image through diffuse reflection image enhancement technology. The system records images with different contrasts and size changes. Fuzzy rules and fuzzy membership functions are applicable to knowledge and fuzzy rules based on transforming an image from a pixel plane to a fuzzy plane. The triangular membership function is used and applied after the fuzzy inference system changes the membership value. It can overcome the deficiencies of histogram equalization, frequency domain, spatial domain, and threshold technology. While improving image contrast, it uses diffuse reflection technology to effectively improve low-contrast images.

REFERENCES

[1] A. Tripathi, S. Khan and S. Singh, "Secure and Success Rate of Packet for WSN using Leach Cluster Head Fuzzy Logic," *2020 IEEE International Students' Conference on Electrical,Electronics and Computer Science (SCEECS)*, 2020, pp. 1-4, doi: 10.1109/SCEECS48394.2020.199.

[2] F. Wu, C. Wang, B. Zhang, H. Zhang and L. Gong, "Discrimination of Collapsed Buildings from Remote Sensing Imagery Using Deep Neural Networks," *IGARSS 2019 - 2019 IEEE International Geoscience and Remote Sensing Symposium*, 2019, pp. 2646-2649, doi: 10.1109/IGARSS.2019.8898183.

[3] X. Wang, Y. Ban, H. Guo and L. Hong, "Deep Learning Model for Target Detection in Remote Sensing Images Fusing Multilevel Features," *IGARSS 2019 - 2019 IEEE International Geoscience and Remote Sensing Symposium*, 2019, pp. 250-253, doi: 10.1109/IGARSS.2019.8898759.

[4] J Y. Liu, Y. Kong, B. Zhang, X. Peng and H. Leung, "A Novel Deep Transfer Learning Method for Airborne Remote Sensing Semantic Segmentation Based on Fully Convolutional Network," *2020 4th International Conference on Imaging, Signal Processing and Communications (ICISPC)*, 2020, pp. 13-19, doi: 10.1109/ICISPC51671.2020.00010.

[5] J. H. Uhl and S. Leyk, "A framework for radiometric sensitivity evaluation of medium resolution remote sensing time series data to built-up land cover change," *2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, 2017, pp. 1908-1911, doi: 10.1109/IGARSS.2017.8127351.

[6] S. Liu, J. Tian, S. Wang, D. Wang, T. Chi and Y. Zhang, "Crop Drought Area Extraction Based On Remote Sensing Time Series Spatial-Temporal Fusion Vegetation Index," *IGARSS 2019 - 2019 IEEE International Geoscience and Remote Sensing Symposium*, 2019, pp. 6271-6274, doi: 10.1109/IGARSS.2019.8899853.

[7] Z. Huang *et al*., "Joint Analysis and Weighted Synthesis Sparsity Priors for Simultaneous Denoising and Destriping Optical Remote Sensing Images," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 58, no. 10, pp. 6958-6982, Oct. 2020, doi: 10.1109/TGRS.2020.2978276.

[8] C. Yang, Y. Li, B. Peng, Y. Cheng and L. Tong, "Road Material Information Extraction Based on Multi-Feature Fusion of Remote Sensing Image," *IGARSS 2019 - 2019 IEEE International Geoscience and Remote Sensing Symposium*, 2019, pp. 3943-3946, doi: 10.1109/IGARSS.2019.8899029.

[9] W. Huang, Q. Wang and X. Li, "Denoising-Based Multiscale Feature Fusion for Remote Sensing Image Captioning," in *IEEE Geoscience and Remote Sensing Letters*, vol. 18, no. 3, pp. 436-440, March 2021, doi: 10.1109/LGRS.2020.2980933.

[10] W. Huang, Q. Wang and X. Li, "Denoising-Based Multiscale Feature Fusion for Remote Sensing Image Captioning," in *IEEE Geoscience and Remote Sensing Letters*, vol. 18, no. 3, pp. 436-440, March 2021, doi: 10.1109/LGRS.2020.2980933.

[11] R. Gomathi and S. Selvakumaran, "A New Bivariate Shrinkage Denoising of Remotely Sensed Images with Discrete Shearlet Transform (DST)," *2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS)*, 2018, pp. 173-175, doi: 10.1109/ICCONS.2018.8663233.

[12] F. Huang *et al*., "A Parallel Nonlocal Means Algorithm for Remote Sensing Image Denoising on an Intel Xeon Phi Platform," in *IEEE Access*, vol. 5, pp. 8559-8567, 2017, doi: 10.1109/ACCESS.2017.2696362.

[13] Z. Huang, Y. Zhang, Q. Li, T. Zhang, N. Sang and H. Hong, "Progressive Dual-Domain Filter for Enhancing and Denoising Optical Remote-Sensing Images," in *IEEE Geoscience and Remote Sensing Letters*, vol. 15, no. 5, pp. 759-763, May 2018, doi: 10.1109/LGRS.2018.2796604.