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An Efficient Comparative Analysis of CNN-based Image Classification in the Jupyter Tool Using Multi-Stage Techniques

Janarthanan.S[1], Dr. T. Ganesh Kumar[2], Dr. K. Uma[3], M.Arvindhan[4], Anandhan.K[5], C. Ramesh Kumar[6]
[1,2,4] School of Computing Science and Engineering, Galgotias University, Greater Noida, India
[1]jana.mkce@gmail.com, [2]tganeshphd@yahoo.com, [4]saroarvindmster@gmail.com, [5]anandhanpg13@gmail.com, [6]toramesh83@gmail.com
[3] School of Information Technology, VIT University,Vellore, India
[3]uma.kuppusamy@vit.aci.in
[5]Department of Computer Science and Engineering, GITAM University, Bengaluru
[6]School of Computing Science and Engineering, Galgotias University, Greater Noida, India

Abstract— The main process of this image classification with a convolution neural network using deep learning model was performed in the programming language Python code in the Jupyter tool, mainly using the data set of IRS P-6 LISS IV from an Indian remote sensing satellite with a high resolution multi-spectral camera with around 5.8m from an 817 km altitude Delhi image. To classify the areas within the cropped image required to apply enhancement techniques, the image size was 1000 mb. To view this image file required high-end software for opening. For that, initially, ERDAS imaging software viewer was used for cropping into correct resolution pixels. based on that cropped image used for image classification with preprocessing for applying filters for enhancement. And with the convolution neural network model, required to train the sample images of the same pixels, was collected from the group of objects that were cropped. Then we needed to use image sample areas to train the model with learning rate and epoch rate to improve object detection accuracy using the Jupyter notebook tool with tensorflow and machine learning model produce the accuracy rate of 90.78%.

Keywords- Image Enhancement; Edge Detection; Remote Sensing data; Jupyter tool; Classification

I. INTRODUCTION

The introduction proceeds with three categories in the access of the image source of this Jupyter software which are; (1) image enhancement, (2) Edge detection, (3) Image classification. The degree of picture categorization accuracy was then discussed.

A. *Image Enhancement*

Without a direct connection, image sensing is the collecting of diverse data, including images. It is a technology or method that combines numerous sensors with digital images to measure geographic things at a distance [1]. And it could differ from numerous sensors and satellites. And with photographs that have been received and have had various noise removal algorithms done to improve the image quality [2][3]. By using different enhancement algorithms to create a sharper and more contrasted brightness improvement procedure from noise components, these photographs primarily have quality concerns.

In this work, the following techniques were employed to enhance the image quality:

- Methods using the spatial and frequency domains

Image improvement

To enhance the image quality in the aforementioned areas, more filtering techniques are used. The evaluation-required average filter and 3 x 3 mask's performance must be improved, according to [4][5]. was implemented for n x n. The image features are improved in the image pre-processing programme [6][7]. for additional augmentation and pre-processing of digital photos. Similar photos with damaged pixels were chosen for brightness pixels. Additionally, [8]. the quality of the photos for remote sensing can be improved with typical brightness, contrast, and sharpening [9][10]. A finite collection of regions, X1, X2, X3, etc., are present in the image X after brightness thresholding and full segmentation.

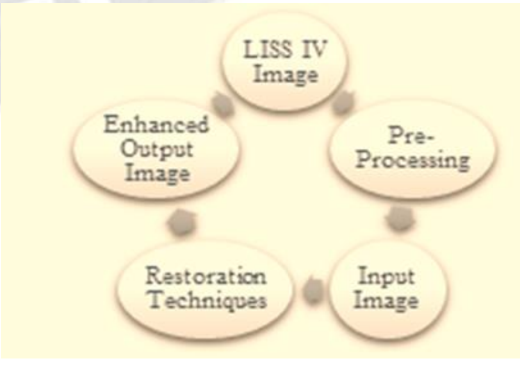

Figure 1. Image Enhancement Steps

B. *Edge Detection*

Edge detection for the majority of images is much more difficult than the typical edge detection process for images

[11][12]. While aerial view images were able to identify objects and computer vision camera captures of those objects were able to detect edges, remote sensing images had a wide variety of edges with selected areas, making edge detection for those images much more difficult [13][14][15]. Techniques for edge detection are typically used to locate the points in an image where there are discontinuities. Applying filters will give remote sensing images, such as road areas, river floating, and building positions in grayscale, smoothing, equalized, threshold, and binary with OTSU conversion, an edge. In order to determine the best filter for edge detection, it was suggested that the sample image be examined Using Sobel, Prewitt, Laplacian, and Canny edge detection methods [16][17][18]. The best results are produced by those filters based on the value they receive.

Why is edge detection necessary? To identify the object in the image, edge boundaries of two regions were first segmented and the original information from the image was revoked. Identify the image categories that will enable more accurate object detection, such as smooth and sharp images [19][20]. Sharp photos can only be produced in this way if you want the best outcome. Images must be viewed as arrays containing samples of continuous functions of intensity in order to identify the edges in which there is a noticeable shift in intensity due to discontinuity [21]. In this article, we use a sample photograph.

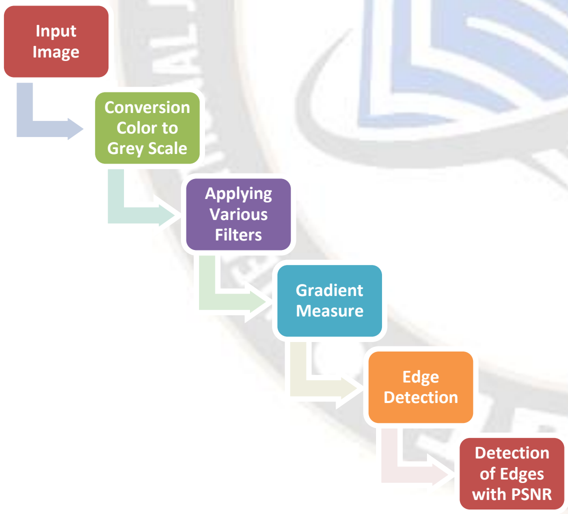

FIGURE 2. Edge detection process flow

In this study, the proposed methods were used to the image to discover the edges in the remote sensing data, and the PSNR rate value was used to determine which PSNR rate value was optimum for the IRS P6 satellite image. [9] Enhancing the edge extraction of quantum images with the Sobel operator to keep the key characteristics. With this filter, the difficulty in terms of time and space to calculate the grey gradient with greater accuracy increases. using threshold operation to improve the edge. [10] The edge detection method for remote sensing images has been improved in this study employing genetic algorithms (GAs) for the best Robert operator for 2D gradient measurement in images with high spatial resolution.

C. Image Classification

The high dimensionality of this data has recently been demonstrated to make it challenging to pre-process them in a variety of ways. One of the most important tactics to overcome this issue is to use a diversity of learning techniques. according to recent studies. But if the data gets more complicated, existing techniques can no longer handle it. The recommended approach illustrates that the maximum likelihood classifier may greatly reduce overfitting and obtain high classification accuracy by combining a variety of recent models along with Adam and other optimization process [22][23][24]. By recommending VGG16 and Inception v3, classification accuracy is increased and results at 96.08%.

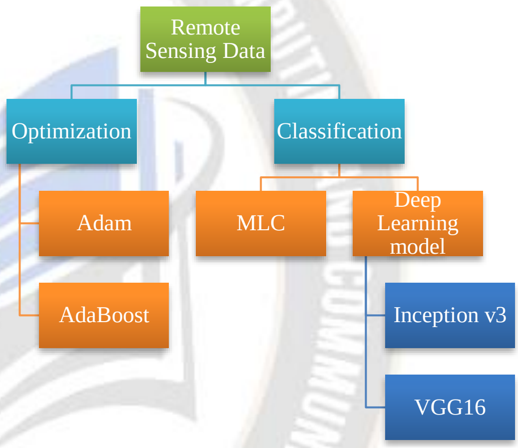

FIGURE 3. Workflow of Optimization and Classification.

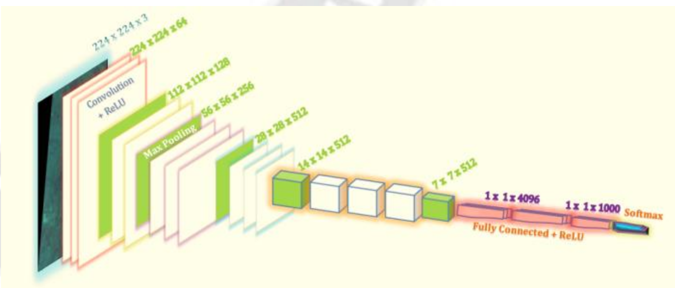

FIGURE 4. CNN model Process flow

II. DATA AND TECHNIQUES USED

A. Image data selection

The remote sensing image dataset of IRS P6 LISS IV utilized; for more information, go to https://shorturl.at/cpLR8. In Table I, which also includes the combined RGB bands from Figure 8, the LISS IV data set that were used in our research are briefly explained. Only the Delhi region of India is the topic of the study.

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FIGURE 5. Combined 3 band tiff image.

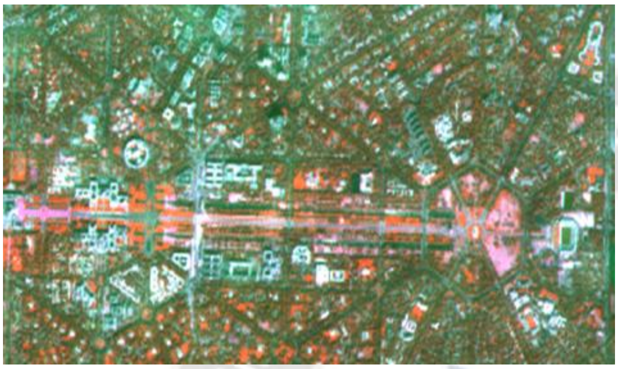

FIGURE 6. Combined 3 band image building area.

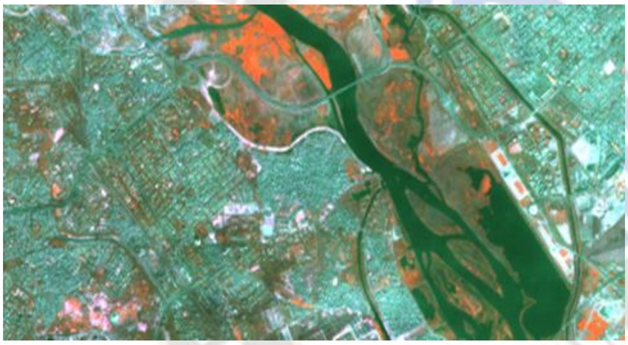

FIGURE 7. Combined 3 band image river and vegetation area.

TABLE I. IRS P6 DESCRIPTION

Parameter	Description
Location	Delhi area
No.of. Bands	Three bands
Format for Analysis	Geo Tiff format
Resolution around	5.8 M

There is a detailed description of the data set in table 1.

III. METHODOLOGY AND RESULTS

A. *Gaussian filter*

Gaussian filter approaches using the frequency method for contrast enhancement Instead of using nonlinear mapping techniques, linear filtering is used. Most often, brightness is normalized in order to improvise contrast for the image. Applying filters to reduce noise is homomorphic. when applying a Gaussian filter to a picture, the size of the kernel or matrix that will be used to demean the image is first determined [25][26]. Since the sizes are typically odd numbers, it is possible to compute the total results on the central pixel. The Kernels also have the same number of rows and columns because they are symmetric. The Gaussian function, which computes the values inside the kernel, is as follows:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (1)$$

Where, x, y are coordinate values, constant PI value, σ Standard deviation.

Figure 8. Gaussian filter image enhancement result

B. *The canny edge detection process*

This process detect the edged by applying canny, to recognizes various edges in images using a multi-stage methodology. Canny edge detection employs linear filtering with a Gaussian kernel to determine the edge intensity and direction for each pixel in the noise-smoothed image [27][28]. It is possible to discover potential edge pixels by looking at the pixels that go through the non-maximal suppression thinning procedure.

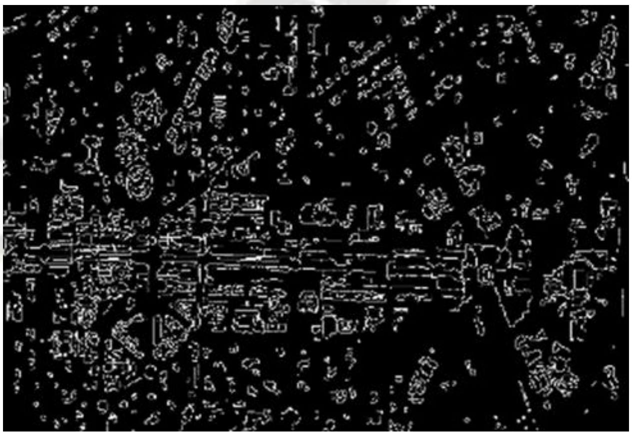

FIGURE 9. Canny edge detection Result for building area

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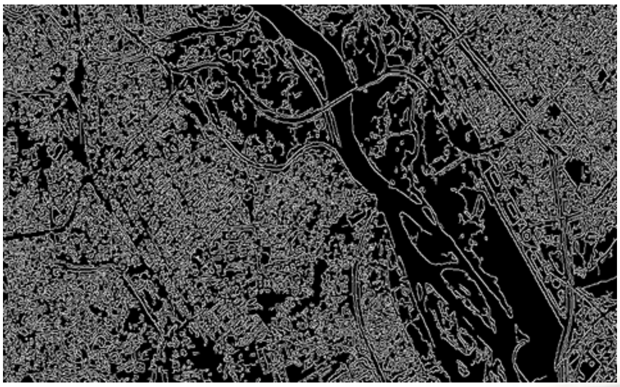


FIGURE 10. Combined 3 band edge detection vegetations and river zone

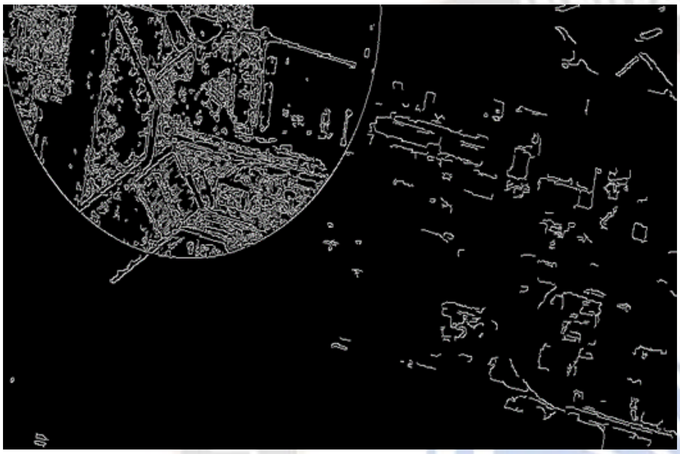


FIGURE 11. Combined 3 band edge detection result for enhanced data set

C. Performance metrics

$$PSNR = 10 \log 10 \frac{(2^n - 1)^2}{MSE} \quad (2)$$

$$MSE = \frac{\sum M,N \; [I1(m,n) - I2(m,n)]2}{M * N} \quad (3)$$

Where,' n' the number of bits in the grayscale image in PSNR (Eq. 1) and I is the intensity of the satellite picture, which in MSE (Eq.3) is zero, and rows(M) and columns(N). A good high-quality image offers a greater PSNR value, where I1 denotes the original, free image's intensity noise and I2 denotes a noisy image. Significant value predicted by PSNR.

TABLE 2. Performance metrics result PSNR Rate

Filters	Image Source Figure No	Figure 9	Figure 10	Figure 11
Canny	PSNR rate	32.669	32.273	34.781

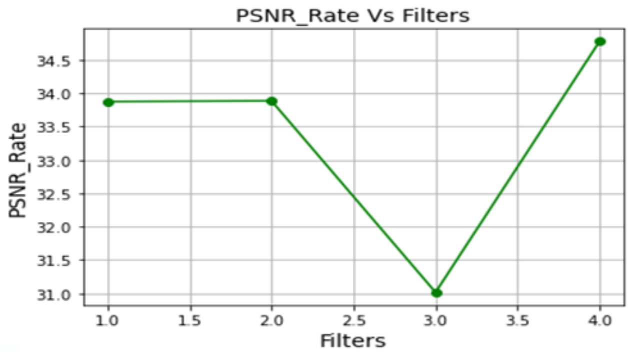


Figure 12. Performance graph for canny result metrics value

IV. IMAGE CLASSIFICATION ALGORITHM TECHNIQUES - SVM CLASSIFICATION

Although Support Vector Machines (SVM) is typically thought of as a classification tool, it can also be used to solve regression problems. Multiple continuous and categorical variables can be handled with ease [29]. To divide various classes, SVM creates a hyperplane in multidimensional space.

A. k-means clustering

In machine learning algorithm with unsupervised K-means clustering is used to combine n observations with k similarity clusters, with each observation being a part of the cluster with the nearest centroid [30].

Table 3. Class of vegetation areas sample detail

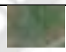
Number of class	Actual Finding	Data Sample Used	Details of Data
1	Agri area 1		Harvests
2	Deep forest area		Forest
3	Crops and yields		Yields
4	Land area		Residential source
5	Water body		River zone color

Table 4. Accuracy level of proposed model.

Class Name/ Type	Total No. of classes	Correct classes	Producer level accuracy %	User Level Accuracy %
1	91	85	90.78	96.7
2	282	255	97.67	90.66
3	756	635	94.2	83.05
4	330	320	92.68	97.41
5	250	240	98.6	97.21
Totals	1709	1535		

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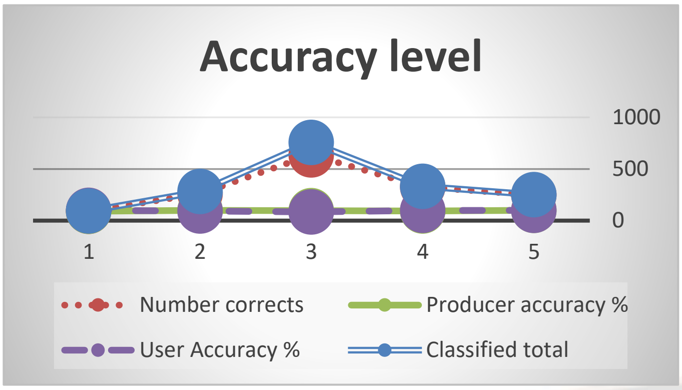

Figure 13. image classification accuracy level of proposed model

V. CONCLUSION

The primary goal of this research endeavor, analyses multi-stage techniques applied to IRS p6 LISS IV remote sensing data. In general, improvise the image clarity by requiring enhancement techniques to be applied to the image data set, then preprocessing it, and finally resizing image. required to apply the noise and denoise to improve the image quality for restoration of the image from distortion. After this process, a better image was taken for the edge detection process with the canny filter, which produced a better image accuracy level compared to the traditional filtering techniques. and for the image classification stage, analyzed only the support vector machine and k-means clustering techniques. Unsupervised image classification with producer level accuracy and user level accuracy received from the Python Jupyter Notebook produces an output result of 90.78% in the type 1 class regions. Type 5 produces higher accuracy levels and user level accuracy increased compared to the producer level accuracy. The future study and analyses required for testing and training using VGG16 and Inception v3 with Adam optimization produced the betterment test result.

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