CC BY

Comparing Linear Discriminant Analysis to AlexNet as a Novel Approach for Better Remote Sensing Image Segmentation and Classification with Improved Accuracy

K.Venkata Vinay Kumar Reddy[1], John Justin Thangaraj.S[2*]

[1]Research Scholar, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University Tamil Nadu, India, Pin:602 105.

[2*]Project Guide, Corresponding Author, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University Tamil Nadu, India, Pin:602 105.

ABSTRACT

Aim: Analyzing and categorizing individual items in images is part of image classification. Our major goal is to compare the performance of two different types of image segmentation classifiers which are used in the image segmentation process. The image segmentation is applied in many sectors, such as flood detection and evaluation, agricultural monitoring, environmental monitoring, defense, and so on. The classification and segmentation of small regions of interest from ground photographs is critical. One image of every location is randomly selected and changed into the bitmap formation to create the test type dataset consisting of 5 locations from the 400 different satellite images. Total 10 numbers of iterations were computed with400 images which were collected from 5 various locations. The images were collected at different views.**Materials and Methods:** The classifiers are making use to segment the remote sensor images using the AlexNet framework and LDA (Linear Discriminant Analysis). In this research work, The ORL kind image database is used for analysis, and the implementation is processed with the assistance of Python programming. **Results and Discussion:** The outcome of novel AlexNet compared with Linear Discriminant Analysis, which has an accuracy of 95.80%, the classifier accuracy confirmed with 93.70%. The two algorithms are statistically satisfied with the independent sample t-Test two tailed is 0.422 (α = 0.001) value ($p<0.05$) with a confidence level of 95%. **Conclusion:** Based on the outcomes, it is verified that the suggested novel AlexNet framework makes better outcomes in the image segmentation system than the Linear Discriminant Analysis classifier. The essential computational time takes place in a faster stage of 0.5 seconds.

Keywords: Image Segmentation, Remote Sensing, novel AlexNet, Linear Discriminant Analysis, Computational Time.

INTRODUCTION

Image classification is different from object prediction in that it works at the pixel state for determining the contours of the images over an object while doing satellite imagery. Those objects are like buildings, cars, trees, roads etc. (Camps-Valls et al. 2021). The applications of this method of Aerial imaging are widely spread from analyzing traffic to examining environmental differences occurring because of the global heat (Wang 2019).

In Last 5 years 2017-2021 the Google Scholar has published more than 196 articles and the IEEE published more than 200 articles about Remote sensing. Remote Sensing (RS) utilizes the energy of the electromagnet in the form of heat,

the waves of radio, and exposure of light for calculating and predicting the features of the final goal. The aerial and the satellite fields are employed in the RS (Khanna et al. 2020). Here in RS, the calculation occurs in the region of the microwave, open to light and infrared rays of the electromagnetic spectrum. The images from RS are utilized in the detection of coastal, geology, or formation of the classified maps, monitoring of ocean, agriculture cover land etc. (Sharma et al. 2021). The spectral and spatial features of the resolution of the picture offer the deepest information over the final target. Those pictures are mostly utilized in the sectors of habitat management, a cover of land mapping etc. (Prasad and Chanussot 2020). The spatial information in such an imaging method is limited by the number of pixels that are in the particular image. The order is utilized to bundle pixels present in a picture into one of the land cover classes (Chen 2007). The arrangement procedure is used to investigate the advanced picture and concentrate data from that picture contingent on the application. The most common way of creating topical guides with subjects like vegetation types, land use, and geography is called picture order. In remote detecting different quality pictures are delivered relying on a sort of sensor. Order exactness relies upon picture quality (Wu, Shen, and Sabuncu 2016).(Venu and Appavu 2021; Gudipaneni et al. 2020; Sivasamy, Venugopal, and Espinoza-González 2020; Sathish et al. 2020; Reddy et al. 2020; Sathish and Karthick 2020; Benin et al. 2020; Nalini, Selvaraj, and Kumar 2020)

The disadvantages of Remote detecting satellite pictures are considered as perhaps the main datum hotspots for land use/cover planning because of their broad geological inclusion at a proficient expense while giving indispensable data on the world's surface (Anandakumar, Arulmurugan, and Onn 2018). Land use/cover maps are generally delivered in light of remote detecting picture arrangement draws near. Nonetheless, the precision and handling season of land use/cover maps utilizing remote detecting pictures is as yet a test to the remote detecting local area (Major and Anderson 2019). To comprehend a characterization of satellite pictures, the initial step is to perceive the items and afterward perceive the classification of the scene (Rao, Rao, and Kubo 2018). The research gap is mainly due to the fact that remote sensing images are a fairly expensive method of analysis especially when measuring or analyzing smaller areas. Remote sensing requires a special kind of training to analyze the images. The aim of the study involves older cartographic techniques,mapping a satellite image is the simplest method, but the most significant effort is still analyzing specific targets in an image, such as trees or landmarks (Clark, Green, and Mumby 2000). There is an urgent need to know more about the recent news related to roadblocks and information that is the reason why machine learning and deep learning models have become widespread (Frappart and Bourrel 2018).

MATERIALS AND METHODS

This research work was performed at Deep Learning Laboratory, Saveetha School of Engineering, SIMATS (Saveetha Institute of Medical and Technical Sciences). The proposed work contains two groups such as group 1 is taken as AlexNet and group 2 as LDA. The AlexNet algorithm and LDA algorithm were assessed several times with

a sample size of 400. After collecting the dataset, unwanted contents were removed by pre-processing and data cleaning stages. Afterward, it opens the data sets, and the accuracy of both the AlexNet algorithm and LDA structure is evaluated. The results were calculated using G* power software and the minimum power of the analysis is fixed as 0.8 and the maximum accepted error is fixed as 0.5 with a threshold value of 0.05% and the Confidence Interval is 95%. Computational time for this method is less as it takes more pixels for calculation.

The ORL type database of satellite images is employed in this research task for analysis reasons. There are 10 iterations as shown in Table 2 and 400 images were collected from 5 various locations at different views. In order to attain 400 various photographs, a few remote sensing images change the descriptions alongside unstable illumination effects. In the PGM layout, the size of the image is set at 92 x 112 pixels. This research process uses Python programming for segmenting satellite images. It is one of the most commonly used computer-based programming languages for image segmentation. Its outstanding library functions and tools aid in the capable completion of image processing processes.

AlexNet:

AlexNet is a well-known design based on multiple-layer neural networks (deep neural networks) and is a point of reference for the application of neural networks in image processing. The authors illustrate the use of neural networks and a framework called DropBand to increase classification accuracy. Although Generative-Adversarial Networks were designed for picture synthesis, they can also be used to segment floods from UAV photos over tiny areas . The generator and discriminator are the two components of this new network, and a mask can be built across the region of interest (flood segmentation). AlexNet was the first convolutional network to employ the Graphics Processing Unit (GPU) to improve performance. AlexNet has five convolutional layers, three max-pooling layers, two normalization layers, two fully connected layers, and one softmax layer in its design. Convolutional filters and a nonlinear activation function ReLU are used in each convolutional layer. Max pooling is done using the pooling layers. Due to the presence of fully connected layers, the input size is fixed. The input size is most commonly stated as 224x224x3, however due to padding, it actually turns out to be 227x227x3.

The pseudocode for the novel AlexNet classifier :

Step 1 : Import the data from the required library.

Step 2 : Give directory of the dataset in the csv extension file.

Step 3 : Data as indexes with price prediction validation.

i . Price of the data.

ii . Data analysis as per the dataset.

iii . Plot the graph by using Matplot.

Step 4 : Import MLP models, Library Classification.

Step 5 : Now use model selection for importing, use train and test split, use AlexNet for the importing and Sequential models.

Step 6 : Give the sample size , the test size

and train size then fit the train and test.
Step 7 : Then print the accuracy score and end the program.

Linear Discriminant Analysis:

Linear Discriminant Analysis (LDA) is a well-known classification method that has been effectively used for a variety of statistical and pattern recognition issues. LDA's main goal is to divide samples from different groups. This is accomplished by changing the data into a new space that is ideal for class separation. The LDA method involves projecting all of the data points into a new space, usually one with fewer dimensions, in order to optimize between-class separability while reducing within-class variability. Finding two scatter matrices, referred to as "between class" and "within class" scatter matrices, is the first stage in describing LDA.

Linear Discriminant Analysis (LDA) is a dimensionality reduction technique for supervised classification problems. It's used to represent group differences, such as separating two or more classes. It is used to project higher-dimensional features onto a lower-dimensional space. The applications that are utilized in LDA are i) face recognition is a common application in the field of Computer Vision, in which each face is represented by a huge number of pixel values. Before the classification procedure, linear discriminant analysis (LDA) is performed to reduce the number of features to a more manageable quantity. Each of the new dimensions created is a template made up of a linear combination of pixel values. ii) fisher's faces are the linear combinations obtained using fisher's linear discriminant. iii) linear discriminant analysis is a technique used in medicine to classify a patient's disease status as mild, moderate, or severe depending on the patient's numerous parameters and the medical therapy he is receiving. This allows clinicians to speed up or slow down the pace of their treatment iv) to identify the types of clients who are most likely to buy a specific product in a shopping mall, which is known as customer identification. It is possible to acquire all of the characteristics of the clients by conducting a simple question-and-answer survey. In this case, a linear discriminant analysis will assist us in identifying and selecting the attributes that best represent the characteristics of the group of customers most likely to purchase that particular product in the shopping mall.

The pseudocode for the LDA classifier :

Step 1 : Import the data from the required library.
Step 2 : Give directory of the dataset in the csv extension file.
Step 3 : Data as indexes with price prediction validation.

i . Price of the data.

ii . Data analysis as per the dataset.

iii . Plot the graph by using Matplot.

Step 4 : Import MLP models, Library Classification.
Step 5 : Now use model selection for importing train and test split, and use Linear Discriminant Analysis (LDA) for the importing and Sequential models.
Step 6 : Give the sample size , the test size and train size then fit the train and test.
Step 7 : Then print the accuracy score and end the program.

Hardware setup references the details and

system resource settings selected for specific devices, the following are minimum hardware specifications to develop this model. Processor: Intel i5, RAM 8GB, 1 TB HDD storage. The required software specifications for this model are Windows OS, version 10, Python programming language version 3 or above, IDE PyCharm, Jupyter.

Statistical Analysis

Statistical software IBM SPSS with the standard version 26.0 to find the SD(Standard Deviation), mean deviation, significance level and also plot the graphs, etc. The SPSS software was used in this research work for statistical analysis. Group statistics and independent sample tests were executed on the experimental results and the graph was constructed for two graphs with two parameters under the concerned study. The independent variables are the pixel values and the dependent variables are image quality, and embedding capacity in the study, Image Steganography.

Training type dataset and test type datasets are assigned to the database (400 different images, photos of 5 locations). One image of every location is randomly selected and changed into the bitmap formation to create the test type dataset consisting of 5 locations from the 400 different satellite images. The training type dataset is created by removing the test type dataset images from the ORL type database, providing 400 image data as a whole. Entire images are converted to bitmap format once again.

RESULTS

Both the pseudocodes show how to perform the improved segmentation and classification of remote sensing images. For the given image datasets, the suggested algorithm novel AlexNet framework will offer more precise results than Linear Discriminant Analysis(LDA). The accuracy rate of AlexNet architecture and the LDA classifier are described in Table 1. AlexNet and LDA accuracy are 95.80 percent and 93.70 percent, respectively according to the data shown in Table 1. These are the datasets which were used for the searching of the project title. Accuracy of AlexNet and LDA are shown in Table 1. The AlexNet algorithm is 2.33% more accurate than the LDA algorithm shown in Table 2. Independent sample T-test is performed for the two groups for significance and standard error determination. Two Tailed Significance value is 0.0001 ($p<0.01$) and it is statistically significant shown in Table 3. TheBar graph analysis of AlexNet algorithm and LDA algorithm is shown in Figure 1. Graphical representation shows the mean accuracy of 95.05% and 92.72% for the proposed algorithm AlexNet and LDA respectively. X-axis : AlexNet vs LDA, Y-axis : Mean precision ± 2 SD.

DISCUSSION

LDA classifier is used in the existing research work, with a mean value for accuracy rate of 92.72 percent. AlexNet is recommended, which has a mean accuracy value of 95.05 percent.CNN is one of the familiar models that produce a better ranking of attributes. Jonathan Long et al., 2014 say that CNN is trained based on pixel-level in semantic image segmentation. Their research work aims to design a fully CNN that accepts various inputs and generates equivalent size outcomes with effective learning and inference. Here the authors define and elaborate the importance of CNN, its

application, and make the associations to the existing models (Eugenio and Marcello 2019). Fully connected CNN produces 20% associative improvement to 62.2% average value in 2012. The limitationof the above article depends on the image information by the number of pixels that are present in the particular image.

Combination of these two different types of neural networks are used in the suggested method for patch (small cropped image) categorization. The first is a deep CNN architecture designed for remote images (spatial and aerial), AlexNet (Bhatta 2010), and the second is a perceptron architecture with a set of efficient features as input (Skidmore 2017). AlexNet is the proposed classifier. The architecture and settings, which have been customized for our application, are shown in. It has eight layers: seven convolutional layers that operate as filters on the image, extracting the most important information, and a fully connected layer (Kumar et al. 2018). The classification of two methods like AlexNet and LDA which are used to find or capture the images from the space about the land covers to know the whole data about RS images (Gomarasca 2009). Computational time for this method is very less as it takes more pixels for calculation. The similar findings of the AlexNet algorithm had achieved better performance than the other algorithms. The opposite findings of the study proposed that the novel AlexNet gains more percentage in accuracy than the Linear Discriminant Analysis.

The disadvantage of the LDA is because topics are soft-clusters, there is no objective metric to indicate the best choice of hyperparameters. For example, you could have a model with a low level of perplexity yet uninformative themes. The future scope of this technique can be improved in the upcoming times by providing another classifier to increase the accuracy rate. The feature removal process can produce the use of a variety of newly created techniques. The accurate values of the extracted features are more, hence the effectiveness of the system improves.

CONCLUSION

In summary, as compared to LDA, the suggested AlexNet system creates a better outcome with an accuracy value rate of 95.80%. The essential computational time takes place in a faster stage of 0.5 seconds. The segmentation and classification of remote sensing images makes each and every location to be captured. Based on the outcomes, it is verified that the suggested novel AlexNet framework makes better outcomes in the image segmentation system than the Linear Discriminant Analysis classifier.

DECLARATION

Conflicts of Interests

No conflict of interest

Authors Contribution

Author KVVKR was involved in data collection, data analysis, manuscript writing. Author CMV was involved in the Action process, Data verification and validation, and Critical review of the manuscript.

Acknowledgement

The authors are grateful to Saveetha School of Engineering and Saveetha Institute of Medical and Technical Sciences (formerly known as Saveetha University) for providing the required infrastructure for this research to be

completed successfully.

Funding

We thank the following organizations for providing financial support that enabled us to complete the study.

1. Sun Microsystems Technologies
2. Saveetha University
3. Saveetha Institute of Medical and Technical Sciences
4. Saveetha School of Engineering.

REFERENCES

1. Anandakumar, H., R. Arulmurugan, and Chow Chee Onn. 2018. *Computational Intelligence and Sustainable Systems: Intelligence and Sustainable Computing*. Springer.
2. Benin, S. R., S. Kannan, Renjin J. Bright, and A. Jacob Moses. 2020. "A Review on Mechanical Characterization of Polymer Matrix Composites & Its Effects Reinforced with Various Natural Fibres." *Materials Today: Proceedings* 33 (January): 798–805.
3. Bhatta, Basudeb. 2010. *Analysis of Urban Growth and Sprawl from Remote Sensing Data*. Springer Science & Business Media.
4. Camps-Valls, Gustau, Devis Tuia, Xiao Xiang Zhu, and Markus Reichstein. 2021. *Deep Learning for the Earth Sciences: A Comprehensive Approach to Remote Sensing, Climate Science and Geosciences*. John Wiley & Sons.
5. Chen, C. H. 2007. *Image Processing for Remote Sensing*. CRC Press.
6. Clark, Christopher D., Edmund Peter Green, and Peter J. Mumby. 2000. *Remote Sensing Handbook for Tropical Coastal Management*. Unesco.
7. Eugenio, Francisco, and Javier Marcello. 2019. *Very High Resolution (VHR) Satellite Imagery*. MDPI.
8. Frappart, Frédéric, and Luc Bourrel. 2018. *The Use of Remote Sensing in Hydrology*. MDPI.
9. Gomarasca, Mario A. 2009. *Basics of Geomatics*. Springer Science & Business Media.
10. Gudipaneni, Ravi Kumar, Mohammad Khursheed Alam, Santosh R. Patil, and Mohmed Isaqali Karobari. 2020. "Measurement of the Maximum Occlusal Bite Force and Its Relation to the Caries Spectrum of First Permanent Molars in Early Permanent Dentition." *The Journal of Clinical Pediatric Dentistry* 44 (6): 423–28.
11. Khanna, Ashish, Deepak Gupta, Zdzisław Pólkowski, Siddhartha Bhattacharyya, and Oscar Castillo. 2020. *Data Analytics and Management: Proceedings of ICDAM*. Springer Nature.
12. Kumar, Pavan, Meenu Rani, Prem Chandra Pandey, Haroon Sajjad, and Bhagwan Singh Chaudhary. 2018. *Applications and Challenges of Geospatial Technology: Potential and Future Trends*. Springer.
13. Major, Nancy M., and Mark W. Anderson. 2019. *Musculoskeletal MRI E-Book*. Elsevier Health Sciences.
14. Nalini, Devarajan, Jayaraman Selvaraj, and Ganesan Senthil Kumar. 2020. "Herbal Nutraceuticals: Safe and Potent Therapeutics to Battle Tumor Hypoxia." *Journal of Cancer Research and Clinical Oncology* 146 (1): 1–18.
15. Prasad, Saurabh, and Jocelyn Chanussot. 2020. *Hyperspectral Image Analysis: Advances in Machine Learning and Signal Processing*. Springer Nature.
16. Rao, Peddada Jagadeeswara, Kakani Nageswara Rao, and Sumiko Kubo. 2018. *Proceedings of International Conference on Remote Sensing for*

Disaster Management: Issues and Challenges in Disaster Management. Springer.

17. Reddy, Poornima, Jogikalmat Krithikadatta, Valarmathi Srinivasan, Sandhya Raghu, and Natanasabapathy Velumurugan. 2020. "Dental Caries Profile and Associated Risk Factors Among Adolescent School Children in an Urban South-Indian City." *Oral Health & Preventive Dentistry* 18 (1): 379–86.
18. Sathish, T., and S. Karthick. 2020. "Gravity Die Casting Based Analysis of Aluminum Alloy with AC4B Nano-Composite." *Materials Today: Proceedings* 33 (January): 2555–58.
19. Sathish, T., D. Bala Subramanian, R. Saravanan, and V. Dhinakaran. 2020. "Experimental Investigation of Temperature Variation on Flat Plate Collector by Using Silicon Carbide as a Nanofluid." In *PROCEEDINGS OF INTERNATIONAL CONFERENCE ON RECENT TRENDS IN MECHANICAL AND MATERIALS ENGINEERING: ICRTMME 2019*. AIP Publishing. https://doi.org/10.1063/5.0024965.
20. Sharma, Harish, Mukesh Saraswat, Anupam Yadav, Joong Hoon Kim, and Jagdish Chand Bansal. 2021. *Congress on Intelligent Systems: Proceedings of CIS 2020, Volume 1*. Springer Nature.
21. Sivasamy, Ramesh, Potu Venugopal, and Rodrigo Espinoza-González. 2020. "Structure, Electronic Structure, Optical and Magnetic Studies of Double Perovskite Gd2MnFeO6 Nanoparticles: First Principle and Experimental Studies." *Materials Today Communications* 25 (December): 101603.
22. Skidmore, Andrew. 2017. *Environmental Modelling with GIS and Remote Sensing*. CRC Press.
23. Venu, Harish, and Prabhu Appavu. 2021. "Experimental Studies on the Influence of Zirconium Nanoparticle on Biodiesel–diesel Fuel Blend in CI Engine." *International Journal of Ambient Energy* 42 (14): 1588–94.
24. Wang, Qi. 2019. *Learning to Understand Remote Sensing Images*. MDPI.
25. Wu, Guorong, Dinggang Shen, and Mert Sabuncu. 2016. *Machine Learning and Medical Imaging*. Academic Press.

TABLES AND FIGURES

Table 1: Accuracy of AlexNet and LDA. The AlexNet algorithm is 2.33% more accurate than the LDA algorithm.The essential computational time takes place in a faster stage of 0.5 seconds.

ITERATION NO.	AlexNet (%)	LDA (%)
1	95.80	93.70
2	95.67	93.44
3	95.52	93.32
4	95.36	93.17
5	95.22	92.96
6	95.15	92.83
7	94.88	92.51
8	94.59	92.23
9	94.32	91.65
10	93.98	91.42

Table 2: Group Statistics of AlexNet and LDA algorithm with the mean value of 95.05% and 92.72%.

GROUP	N	Mean(%)	Std.Deviation	Std.Error Mean
AlexNet	10	95.0490	.59825	.18918
LDA	10	92.7230	.76231	.24106

Table 3: Independent sample T-test is performed for the two groups for significance and standard error determination. Two Tailed Significance value is 0.0001 ($p<0.01$) and it is statistically significant.

		Levene's Test for Equality of Variance		T-test for Equality of Means						
	Equal Variances	F	Sig	t	df	Sig(2-tailed)	Mean Diff- - rence	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Accuracy	**Equal variances Assumed**	.674	.422	7.591	18	.0001	2.32600	.30643	1.68221	2.96979
	Equal variances			7.591	17.037	.0001	2.32600	.30643	1.67959	2.97241

	Not Assumed									

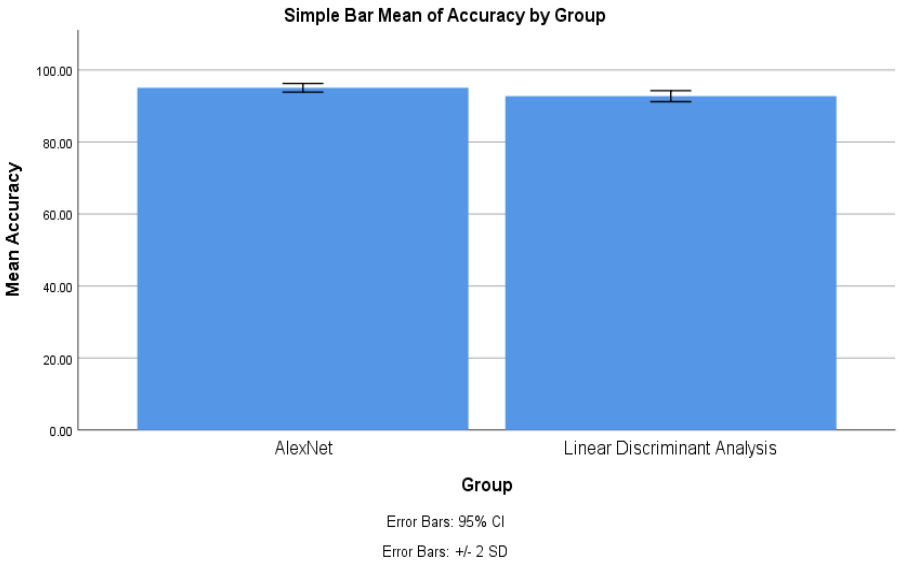

Fig 1. Bar graph analysis of AlexNet algorithm and LDA algorithm. TheBar graph analysis of AlexNet algorithm and LDA algorithm is shown in Fig 1. Graphical representation shows the mean accuracy of 95.05% and 92.72% for the proposed algorithm AlexNet and LDA respectively. X-axis: AlexNet vs LDA, Y-axis : Mean precision ± 2 SD.