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EFFECTIVE PERFORMANCE OF DIFFERENT DEEP LEARNING MODELS FOR LAND USE LAND COVER CLASSIFICATION OF SATELLITE IMAGES

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Abstract— Land Use / Land Cover (LULC) generally refers to the categorization or classification of human activities and natural elements on the landscape within a specific time frame based on established scientific and statical methods of analysis of appropriate source materials. The rapid industrialization and urbanization of an area require quick preparation of actual land use/land cover (LU/LC) maps in order to detect and avoid overuse and damage of the landscape beyond sustainable development limits.This project focuses on leveraging deep learning techniques for land use/land cover (LULC) classification of satellite images to address the challenges posed by rapid industrialization and urbanization. It involves analyzing various deep learning models, selecting appropriate ones based on past research, and developing a hybrid model for improved accuracy. The performance of individual models and the hybrid approach will be compared to determine the most effective method for automatic image interpretation in LULC classification tasks.

Keywords— Dataset, Satellite Images, U-Net, DenseNet121, Image Segmentation, Hybrid Model

I. INTRODUCTION

The terms land use and land cover are often used interchangeably, but each term has its own unique meaning. Land cover refers to the surface cover on the ground like vegetation, urban infrastructure, water, bare soil, etc. Identification of land cover establishes the baseline information for activities like thematic mapping and change detection analysis. Land use refers to the purpose the land serves, for example, recreation, wildlife habitat, or agriculture. When used together with the phrase Land Use / Land Cover (LULC) generally refers to the categorization or classification of human activities and natural elements on the landscape within a specific time frame based on established scientific and statistical methods of analysis of appropriate source materials

A. Fundamentals

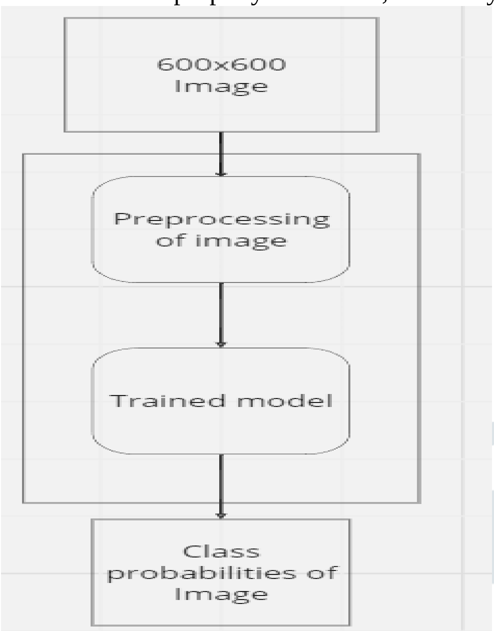
Land Use/Land Cover (LULC) classification involves categorizing human activities and natural features on the landscape using scientific methods, crucial for sustainable development planning. Rapid urbanization and industrialization necessitate timely mapping to prevent landscape degradation. Deep Learning (DL) techniques, increasingly applied to remote sensing data analysis, offer superior performance in LULC classification. This project aims to analyze various DL models for classifying satellite images into categories like urban, agriculture, forest, etc. A hybrid model combining the strengths of selected DL models will be developed and evaluated against individual models to determine its effectiveness in LULC classification.

B. Objectives

Land Use Land Cover (LULC) maps serve as crucial tools for comprehending the existing landscape characteristics of a region. By providing detailed information about the distribution of various land use types and natural features, these maps aid users in understanding the current state of the landscape. Furthermore, maintaining annual LULC data in national spatial databases facilitates the monitoring of temporal changes within agricultural ecosystems, forest cover, surface water bodies, and other landscape elements. This temporal analysis enables policymakers, researchers, and land managers to track trends, identify patterns of change, and formulate informed decisions for sustainable land management and resource conservation..

C. Scope

Land Use Land Cover (LULC) provide information to help users to understand the current landscape. Various type of LULC elements is there like Urban or Built-up Land, Agricultural Land, Forest Land, and many more. LULC maps have their wide applications like Natural resource management, Baseline mapping for GIS input, Legal boundaries for tax and property evaluation, and many more..



II. LITERATURE SURVEY

Several researchers have approached to develop different methodologies for Land Use and Land Cover Classification using Satellite Images. The task of detecting the different uses of land bought about by humans and development on the environment. There is comparison of different methods used but the one that outshines are deep learning architectures. Input is also very important aspect in the development of models, so study on different datasets have also been done.

A. *Literature Review*

1. Guillaume Rousset, Marc Despinoy, Konrad Schindler and Morgan Mangeas , "Assessment of Deep Learning Techniques for Land Use Land Cover Classification in Southern New Caledonia" (2021),Guillaume Rousset, Marc Despinoy, Konrad Schindler and Morgan Mangeas describes LU detection task with RGBNIR as input on the training set gives ResNet gave 95.00 and DenseNet gave 96.00% and LC detection task with RGBNIR as input on the training set gives ResNet gave 99.00% and DenseNet gave 99.00%.

2. Laith Alzubaidi, Jinglan zhang, Amjad J. Humaidi, Ayad Al-Dujaili, Ye Duan, Omran Al-Shamma, J. Santamaría, Mohammed A. Fadhel , Muthana Al Amidie and Laith Farhan, "Review of deep learning: concepts, CNN architectures, challenges, applications, future directions" (2021), Describes different deep learning networks, CNN helps to detect significant features automatically, describes different layers in it, different activation functions and regularization of CNN.

3. Shraddha Marbhal, Minakshi Kumar, "Evaluation of Datasets for CNN based Image Classification",(2020).This paper showcases theoretical and experimental study of various large-scale, high resolution remote sensing datasets. An image retrieval dataset is used to perform image classification and promising results are found. Kshitiz Srivastava, Namrata Dhanda, Anurag Shrivastava, "An Analysis of Automated Essay Grading System" (Nov 2020) [4]. Automatic short answer scoring (ASAS) is a research subject of intelligent education, which is a hot field of natural language understanding.

4. Natya.S and Dr.Seema Singh, "Land use Land Cover Classification using Deep Learning Classifiers for Remote Sensed Images (2020), The residual network, inception network and fused/combined network and found that the fused/combined network approach has accuracy=98.2. Fused/combined network accuracy is much greater than that of independent network performances.

III. DENSEUNET – 3SI

A. *Overview*

There are some drawbacks in the existing system which is "Land Use Land Cover using Aerial Images". To overcome from these drawbacks, we are developing DenseUNet – 3SI as "Effective performance of different Deep Learning models for Land Use Land Cover Classification of Satellite Images". Land Use Land Cover (LULC) maps of an area provide information to help users to understand the current landscape. Annual LULC information on national spatial databases will enable the monitoring of temporal dynamics of agricultural ecosystems, forest conversions, surface water bodies, etc. on annual basis. This system is basically designed to perform all the tasks that previous existing system was able to perform but with advanced additional features. In this, the system will take any satellite image as the input and will give a segmented image as the output where we can get to identify the regions of different types by the color labels such as Industries, River, Crop, Residential, etc.

1) Existing System Architecture: The mapping of the land cover and land use has been done manually. With the help of photo interpretation, the human operator would manually classify the different classes under land cover and land use. This method requires a lot of time to analyze and mark the different classes on the images that are provided. To overcome the labor work, time waste and human error of existing manual system, we have a system that is land use/land cover using Aerial Images with the help of deep learning methods. With only an aerial image as input, the deep learning model analyzes and classifies the image and give the output automatically. The model has two main parts: The aerial images dataset and the ResNet50 Model. The Aerial Images Dataset (AID) consists of large number of different classes of 30 having airport, bare land, baseball field, beach, bridge, center, church, commercial, dense residential, desert, farmland, forest, industrial, meadow, medium residential, mountain, park, parking, playground, pond, port, railway station, resort, river, school, sparse residential, square, stadium, storage tanks and viaduct. But the classes that we selected are river, port, parking, mountain, industrial, forest, dense residential, commercial, bridge and airport.10 This dataset consists of sample images from Google Earth imagery, which have been post-processed using RGB rendering from original optical aerial images. This dataset consists of aerial images, which would have been taken from an aircraft using highly-accurate camera from the troposphere layer of the atmosphere (below the clouds). The dataset obtained is already a structured and labelled that has been analyzed and also cleaned. The input to the training model is a very crucial part for this system [5]. The ResNet50 is a deep learninG model which is used to classify and detect the different features of the image. This model is a pre-trained model and so transfer learning technique is used for training it according to the classes and dataset that we have. This model takes batchwise data and processes each batch during each epoch and give probabilities as output for each class. This model is a convolutional neural network which consist of 50 layers. It has a max pooling layer, 48 CNN layers and a SoftMax layer

2) Proposed System Architecture: Land use and land cover can be studied using satellite images, which can provide detailed and accurate information about the Earth's surface. From the existing models ResNet-50 and the DenseNet121 which individually performed better than the rest of the models, from research we also found out that the hybrid model DenseUNet-3SI System of U-Net and DenseNet-121will give the better accuracy than ResNet-50 and DenseNet-121. Semantic segmentation involves classifying and segmenting each pixel in an image into a specific class. The primary goal of semantic segmentation is to understand the image at the pixel level, enabling machines to comprehend the visual world in the same way humans do. By associating each pixel with a specific class (such as 'car,' 'tree,' 'person,' etc.), computers can gain a detailed understanding of the objects and their spatial layout within an image. Deep learning techniques, particularly convolutional neural networks (CNNs), have significantly improved the accuracy and efficiency of semantic segmentation tasks. The DenseUNet – 3SI model would be hybrid version of the two models, U- Net and DenseNet121 and comparison between the accuracies obtained by the three models is done. Overall, satellite images can provide a powerful tool for studying land use and land cover, and can be used in a variety of applications such as land management, environmental monitoring, and urban planning.

B. Implementation Details

In this system, satellite images are given as input to the system. The model has been trained with Satellite Images dataset. This dataset consists of satellite images that have been classified into different classes that Building, Land, Water, Vegetation, Road and unlabeled. This supervised data will be analyzed, cleaned and then classified [11]. This system would be hybrid version of two model, U-Net and DenseNet-121. Deep learning method is the core part for the implementation of this system. U-Net is a popular deep-learning architecture for semantic segmentation. In the encoding process of U-Net, higher dimensional features are extracted by processing local information layer by layer. DenseNet-121 is a convolutional neural network architecture that belongs to the family of Densely Connected Convolutional Networks. It is characterized by its densely connected layers, where each layer is connected to every other layer in a feed-forward fashion. This connectivity pattern has several advantages, including feature reuse, strengthening feature propagation, and encouraging the flow of gradients during training. Transfer learning has been used to modify a model according to our system and also classes. In transfer learning, the weights of the pre- trained model that have been learnt from training with ImageNet dataset is used and the input layer is changed according to our requirement and also the output layer. The hybrid version of the two models, U-Net and DenseNet121 and comparison between the accuracies obtained by the three models is done. We are utilizing pretrained models of DenseNet-121 as encoders and using feature of skip connections from U-Net as decoder. These models process the input data and extract high level features. Subsequently, we concatenate the extracted features from both models. The features that are extracted from the DenseNet-121 is given as the input through skip connections which gives the final output. Weights of the model remains same and untrainable but new layers can be added accordingly in which the weights are trained. The image after getting processed through the model classifies the input image and also detects the objects i the image and displays it by creating a box around it [11]. The DenseUNet – 3SI model would be hybrid version of the two models, U-Net and DenseNet121 and comparison between the accuracies obtained by the three models is done. Overall, satellite images can provide a powerful tool for studying land use and land cover, and can be used in a variety of applications such as land management, environmental monitoring, and urban planning.

1) Use case Diagram/ Activity Diagram

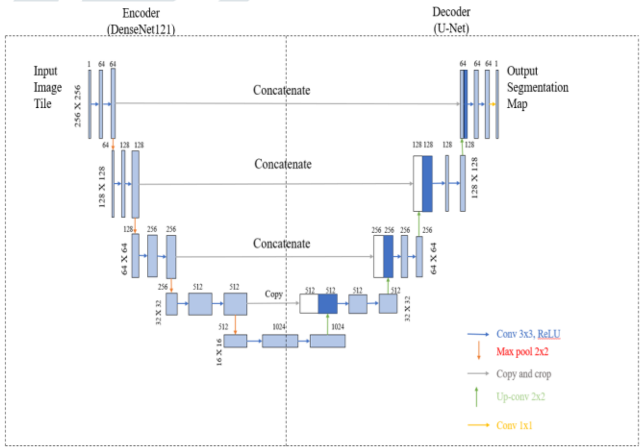


Fig 3.1: Architecture of DenseUNet – 3SI

2) Identification of Input, Output and Dataset

In this System we have used Dataset for the satellite Images of Dubai as input. The dataset consists of aerial imagery of Dubai obtained by MBRSC satellites and annotated with pixel-wise semantic segmentation in 6 classes. We present a novel dataset based on Sentinel-2 satellite images covering13 3 spectral bands and consisting out of 6 classes with in total 72 images. The new dataset is made up of the following classes: Building, Land, Road, Vegetation, Water, Unlabeled. In all, dataset has a number of 72 images within classes and each image is of size 256x256. It is shown below in Table 3.1

Dataset	Class	Images per Class	Images	Image Size	Type
Dubai Images Dataset	6	9 - 10	72	256 x 256	Images

Table 3.1: Dataset Used for Experiment

3) Hardware and Software Specifications

The experiment setup is carried out on a computer system which has the different hardware and software specifications as given below

Hardware Details:

- GPU GTX 1650

Processor:

- Intel i7 9th Gen 9750H

Software Details:

- Windows Version 11
- Python 3.8
- Anaconda
- For Environment Setup

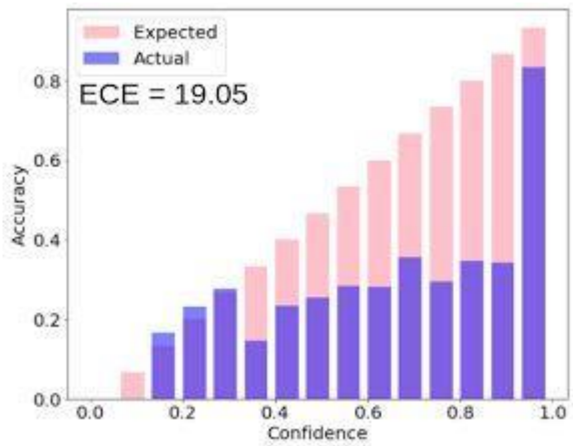
IV. RESULT AND DISCUSSION

In the DenseUNet – 3SI, after applying transfer learning by using DenseNet121 and U-Net to our model. With that, we got a training accuracy of 91.62% and validation accuracy of 80%. There is an 11.32% difference between the training and validation accuracy which is not very large and so is acceptable, with a prediction accuracy of 80%. The DenseUNet – 3SI is trained fast and the accuracy level achieved is also high.

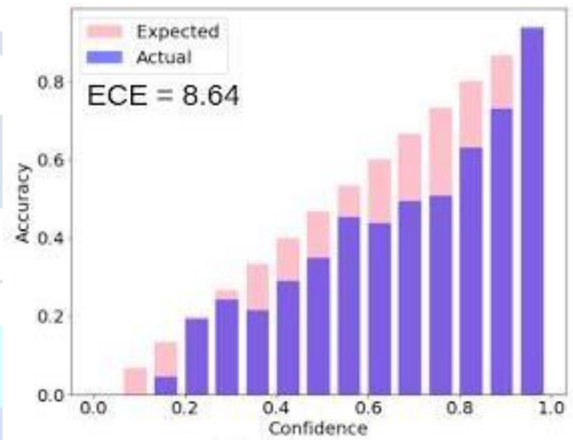
A. *Performance Metrics:*

- **Loss Function:**

A loss function is a mathematical function that quantifies the difference between predicted and actual values in a machine learning model. It measures the model's performance and guides the optimization process by providing feedback on how well it fits the data. A Focal Loss function addresses class imbalance during training in tasks like object detection.



4.3.: Accuracy with Normal loss Function



4.4: Accuracy with Focal Loss Function

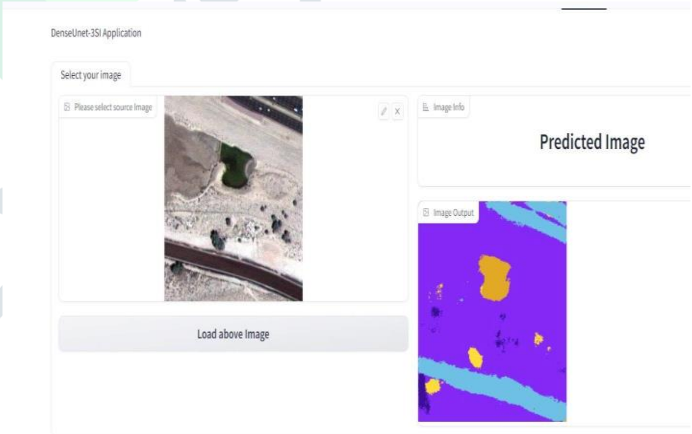


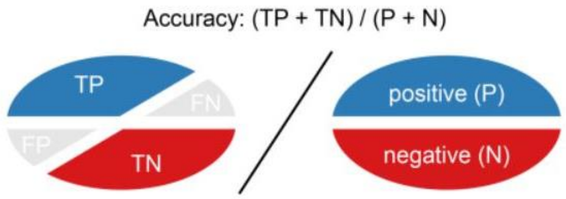
Fig 4.1.: Predicted output of the test image

Name	R	G	B	Color
Building	60	16	152	
Land	132	41	246	
Road	110	193	228	
Vegetation	254	221	58	
Water	226	169	41	
Unlabeled	155	155	155	

4.2.: Color for each class

- **Accuracy:**

Accuracy (ACC) is calculated as the number of all correct predictions divided by the total number of the dataset. The best accuracy is 1.0, whereas the worst is 0.0. It can also be calculated by 1 – ERR.



4.5.: Accuracy Formulae

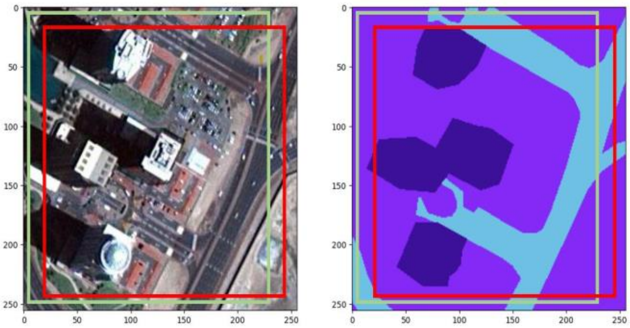
Accuracy is calculated as the total number of two correct predictions (TP + TN) divided by the totalnumber of a dataset (P + N).

$$ACC = \frac{TP + TN}{TP + TN + FN + FP} = \frac{TP + TN}{P + N}$$

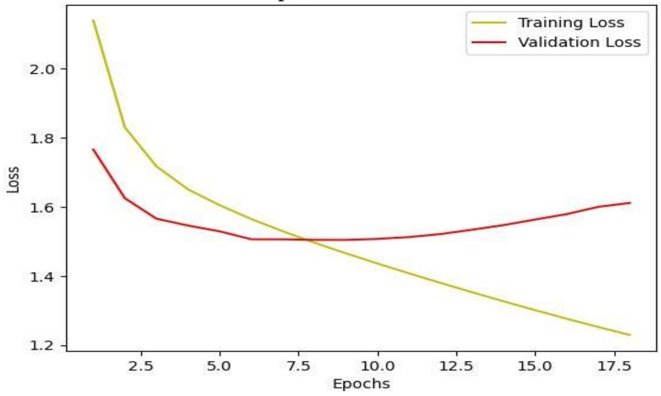
- **IoU:**

  Intersection over Union (IoU) is a widely used evaluation metric for image segmentation models. It measures the overlap between the predicted segmentation mask and the ground truth mask. IoU is an important metric for evaluating segmentation models because it measures how well the model can separate objects from their background in an image.

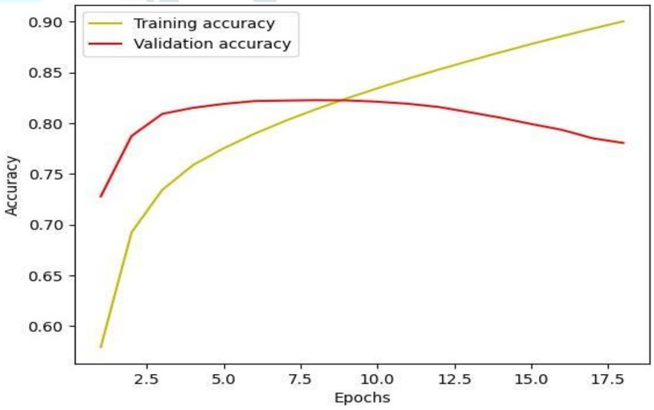
IoU = TP / (TP + FP + FN)



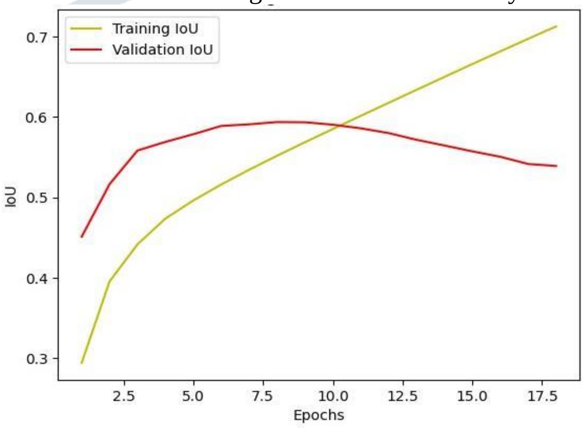
4.6.: Example Intersection over Union



4.7.: Training vs Validation Loss



4.8.: Training vs Validation Accuracy



4.9.: Training vs Validation IoU

V. CONCLUSION

In this report, the study of different domain techniques is presented. Land Use / Land Cover (LULC) generally refers to the categorization or classification of human activities and natural elements on the landscape within a specific time frame based on established scientific and statistical methods of analysis of appropriate source materials. It has various methods of classification. Various type of LULC elements is there like Urban or Built-up Land, Agricultural Land, Forest Land, and many more. LULC maps have their wide applications like Natural resource management, Baseline mapping for GIS input, Legal boundaries for tax and property evaluation, and many more. LULC mapping is not possible without the help of other geospatial datasets. The results of this study reveal the patterns and reasons behind changes in LULC in the past, present and future and provide an appropriate perspective for planners when managing land use. These results can be applied to assess the effects of development, evaluate the cumulative effects of projects, and identify vulnerable zones and aid in their reclamation. The employment of LULC change detection methods using satellite imagery and the analytical functions of distance and size in the GIS environment can help determine the process and pattern of significance changes in LULC. A good example of this is deforestation and the conversion of agricultural land to build-up areas. The identifications of changes in the supervision and management of urban development should play a major role in the determination of principle for future land.

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