Terrain Classification using Deep Neural Network

Himani Sharma (x22224815@student.ncirl.ie)

Divyansh Anand (x22240217@student.ncirl.ie)

Bhupinder Singh (x22197982@student.ncirl.ie)

***Abstract*— This research examines the implementation of the Convolutional neural networks (CNNs) invented for the terrain classification based on DeepSat (SAT-6) Airborne Dataset, which is taken from the National Agriculture Imagery Program. While ensuring both accuracy and efficiency, this study makes use of the Adam optimizer which possesses the ability to determine learning rate for each parameter without mentioning prior knowledge of learning rate. Our approach is aligned to the CRISP-DM methodology. CRISP-DM separates the process into the six stages namely business understanding, data understanding, data preparation, modeling, evaluation, and deployment. The CNN architecture in question was refined through intense research aimed at the perfect understanding of hyperparameters. Based on extensive studies, each layer of convolutional, pooling, and dense networks was purposely and efficiently implemented. The model's efficiency is thoroughly evaluated through the measure of the precision, recall, F1-score, and overall accuracy with the remarkable result of the accuracy of 98.63%. The implications illustrate the capability of deep learning in satellite image analysis for accurate terrain classification on a robust basis which is very important for urban planning, environmental monitoring, and sustainable resource management. This work offers a strong foundation that will support future studies aimed at improving CNN conformation for improved performance across various imaging datasets.**

Keywords—DeepSat (SAT-6) Airborne Dataset, CNNs, Adam optimizer, Hyper parameter Tunning

I. INTRODUCTION

Earth has various forms of terrains like hill, dessert, valley, river, forest and glacier which differs from location to location. To understand a specific type of terrain, one should understand the characteristics that defines the type of terrain. Some possible features that categorize different types of terrains can be elevation of the land relative to sea level, slope of the land surface, drainage patterns of water flow across the land, vegetation, soil type and so on. Terrains classification provides valuable insights that are crucial for planning cities, environmental and disaster analysis, infrastructure development and to understand landscape architecture.

Satellites rotates around the Earth's surface and collect images of different geographical locations which can be analysed by different algorithms to automatically classify terrain types. This research uses DeepSat (SAT-6) Airborne Dataset which has images originally extracted from the National Agriculture Imagery Program (NAIP) dataset. It has high resolution satellite pictures specifically designed for terrain classification task. It's a massive dataset with more than 3000 columns and Billions of records with size in few gigabytes. More details regarding the characteristics of the dataset will be discussed in methodology section of this research.

To analyse such huge and complex data, this research has used Deep Neural Networks to classify terrains efficiently. Convolutional Neural Network algorithm works best in finding the insights from complex pictures. CNN models can be easily trained to analyse various types of terrains such as forests, grasslands, water bodies and urban areas. This study will discuss about the inner working of CNNs, from extracting basic features from an image data to performing accurate terrain classifications. This research will discuss in depth about the Adam optimizer technique, which is a popularly used method for training Deep Neural Network algorithms. This research will explain how the Adam optimizer technique helps CNN to learn faster and more efficiently from the DeepSat dataset and how it affects accuracy in the image classification.

One problem of concern can be maintaining balance between accuracy and resource intensive computation while processing large scale satellite dataset. Complex models usually need powerful processing which can be impractical for real time scenarios. The proposed research, explores methods to achieve high accuracy without compromising with the computation cost.

By utilizing the efficient information that can be extracted from large DeepSat Satellite dataset and employing the power of Convolutional Neural Networks, the proposed research aims to gain deep understanding of accomplishing successful and fast land classification from satellite images.

Research Question: How efficiently land classification can be performed using satellite images and Convolution Neural Network methodology.

II. RELATED WORK

1-'State-of-the-Art CNN Optimizer for Brain Tumor Segmentation in Magnetic Resonance Images (2020)'

What this paper is about?

This research paper is related to a comparison which has been done for different CNN optimizers. This search focus on the efficiency of these optimizers for the Brain Tumor segmentation in MRI scans. BraTS2015 is the dataset which has been used in this studies, and different optimizers has been tested on this Dataset. Also this studies has the information regarding the impact of these optimizers on the CNN performance.

How this studies is relevant to our Project?

As this studies is comparing the performances of different optimizers for the CNN and have mainly discussed about the Adam optimizer, makes this study related to our project. As we have also used Adam optimizer in our project. Also this studies focus on different optimizer configuration which could affect the overall model accuracy and training efficiency, which is highly relevant to our project goals.

What information we have used from this paper in our project?

We have taken useful information from this paper which is related to setup and configuration of the Adam optimizer. Also about the results of this optimizer which has given us a clear picture of its advantages over other optimizer. This search was also useful to guide us about the adjustment which could be done in Adam optimizer setting to have better efficiency and better model training performance and outcomes.

2-‘ Optimized Deep Learning Model for Flood Detection Using Satellite Images (2023)’

What this paper is about?

This research paper is related to flood prediction with the help of the different satellite images. For this study purpose authors have used a deep hybrid model (DHMFP) which mainly uses a Unique combined Harris hawks shuffled shepherd optimizer algorithm(CHHSSO).In this study first they have used median filtering for the preprocessing of these satellite images. Then they have used a cubic chaotic map weighted K-means clustering algorithm to do the segmentation of these pre-processed images.

How this studies is relevant to our Project?

It has used the CNN for analysing the satellite images to predict the flood chances in a particular area. this approach of using the CNN is similar to our Project. The methodology which has been used in this research paper is very useful for our Project, because in this they have used different algorithms to optimize the CNNs to have better efficiency and accuracy.so this is something which we could use and implement in our search as well later on.

What information we have used from this paper in our project?

First, The knowledge about using the CHHSSO algorithm to optimize the overall accuracy of the results in our Project. Also this project gave us information about using different neural network architectures to get a better prediction model, which again was very useful for our project to have better overall results. We have used the performance metrics which has given in this paper to compare our results with it to have better understanding of the results from our project.

3-‘ Investigating certain choices of CNN configurations for brain lesion segmentation (2022)’

What this paper is about?

In this studies the authors have mainly focused on CNN performance for different configuration of it for the medical Imaging. Mainly, They have discussed about the impact of using the different optimizer on the CNN architectures, like accuracy and efficiency of the different optimizers which they have used in this studies were Deep Medic and U-Net architectures has been used. And after implementation of these optimizers author have used Dice similarity Coefficient (DSC) performance metrics to determine which of these optimizers gets the best results.

How this studies is relevant to our Project?

As this Research mainly focus on how these choice of different optimizer changes the efficiency and accuracy of the results of CNNs, and mainly they have consider the Adam optimizer in these research which is similar to our Project. This Project is of great importance to us because it helps us to understand the impact of using different optimizer with different setting to have better results. Also one of the main point in this search is about how they have done the Parameter tuning to have better CNN configurations, which eventually gets better results and accuracy.

What information we have used from this paper in our project?

The knowledge about the performances of different optimizers when used to optimize the CNN models. Then the information about Adam optimizer to adapt its configuration related to our CNN model to have better classification of the land parts from the Dataset having satellite images. Also we have used the understanding of different CNN architectures which has been used in this paper to get the best CNN architectures which would suit our Dataset and give the best results. Also this search gave us the understanding of using different evaluation metrics like Dice Similarity Coefficient to understand the our results better.

4-‘ A systematic evaluation of learning rate policies in training CNNs for brain tumor segmentation (2021)’

What this studies is about?

This is the another studies which we have considered to use in our literature review. This studies is related to the Brain tumor segmentation which has been taken from MRI scans with the help of the CNNs. This studies has taken different learning polices and then have combined them with different optimizers and then have done there evaluation. For this study’s author have used a dataset which had brain tumor images form 534 different patients. They have used 2D slice based U-Net and 3D Deep Medicine CNN architectures for their study purpose.

How this studies is relevant to our Project?

In this paper as well they have trained the CNNs for the image classification, similarly to our Project, which makes its very much relevant to our project.as they have used different rate polices and then combined it with different optimizers to evaluate the performance of the CNN for this combination. This makes this paper very useful for our understanding of CNNs optimization. Also there methodology is very much useful to choose the best CNN architectures for the Project.

What information we have used from this paper in our project?

The paper has provided the information about using the learning rate polices with the optimizers and have shown great results. As they have showed polynomial decay is the best learning rate polices which works best with Adam optimizer, same approach could be taken by us to have better CNN model to have better result. Also we have understood the usage of different evaluation metrics like Hausdroff distance and dice similarity coefficient to evaluate our results better. Also we got the understanding of different statistical methods to

evaluate our results better which could help us to do the CNNs configuration better to have better results.

5-'Gaussian process regression-based learning rate optimization in convolutional neural networks for medical images classification (2021)'

What this paper is about?

This paper is related to medical image classification with the use of CNNs. In this paper the authors have improved the CNN efficiency with the help of learning rate optimization which is based on Gaussian Process Regression (GPR). In this basically the learning rate has been adjusted during the training of the CNN in such a way that it gives the best accuracy.so this paper has used this method for the classification of the images which are for human Brain tumors.

How this studies is relevant to our Project?

The methodology which they have used in this project is highly relevant to our project as they, are also using CNNs for the image classification like how we have used in our project for the satellite image classification. They have used a Novel approach of using Gaussian Process Regression based learning rate optimization(GLRO) to adjust the learning rates, which is very important for the CNN overall performance. This is very much relevant to our project as we are using the CNN as well for our Project and the kind of data they has used for their study is also very much similar to ours, so we could use these techniques as well in our project.

What information we have used from this paper in our project?

The paper has provided us the information about the usage of Gaussian Process Regression based learning rate optimization(GLRO) algorithm which improves the CNN Accuracy, we would be using this approach on our classification as well. Also we have understood the usage of statistical validations to evaluate the results better , we would be using these statistical methods to evaluate our results better which could help us to do the CNNs configuration better to have better results.

6-' Classification of Soil Fertility Level Based on Texture with Convolutional Neural Network (CNN) Algorithm (2023)'

What this paper is about?

This search paper is related to the classification of the soil fertility which is based on the texture analysis with the help of CNNs. this paper is very important as Agriculture yield is the main concern in today's world. In this studies the author have also focused on different parameters for the optimization purpose to have better results from CNNs. These parameters were mainly the Adam optimizer , learning rates and batch size. In this studies the author have used a dataset of 1120 images.

How this studies is relevant to our Project?

This studies have also worked on the same approach of image classification with the help of the CNN which is almost similar to our project. The methodology which has been used in this paper is very much useful in our project and there has been many optimization techniques which are directly having impact on the performance of the CNN has been used in this, which could be very useful for our project. This studies have used texture analysis which is almost similar to our project of satellite image classification ,this approach could help us to identify forest, water bodies and land area in our satellite image dataset.

What information we have used from this paper in our project?

We got the information related to the different optimization techniques which could be used in our project to enhance the CNNs overall performance while image classification .As this studies have used a big dataset similar to our dataset, we could use the different Data handling techniques from this studies. This studies have used accuracy metrics to evaluate the results which has given a very high accuracy, which could be used by us to evaluate our results as well.

7-' Optimal Flame Detection of Fires in Videos Based on Deep Learning and the Use of Various Optimizers (2021)'

What this paper is about?

This studies is related to the flames detection from a video footage using CNN. But the main of the studies is to enhance the performance of the CNN model by using different optimizer. The optimizers which has been used in this study are Rmsprop, Adagrad, Adamax, Nadam, and also the Adam .In this studies they have also used different CNN architectures, these architectures have provided very good results when they have been used with these different optimizers. These architectures are VGG16 and VGG19. Also the author have mainly focused on finding the best learning rates and epochs to enhance the overall accuracy of this flame detection.

How this studies is relevant to our Project?

This research paper has also used the approach of utilizing the CNN for the image classification which is similar to our project. Author have used the different optimizers to enhance the overall performance of the CNNs. This understanding of making changes in the setting of these optimizer have given a good knowledge about how to fine tune the CNN to have much more better results in satellite image classification than the normal CNN settings. Also as they have used two different CNN architectures VGG16, VGG19 and have also explained about their performance and have compared the results as well. This gives a clear picture about which one is better among these two which could be used in our project.

What information we have used from this paper in our project?

This research provides a clear information about the use of the different optimizers and also there performance, which had provided us a valuable insights to select Adam optimizer for our Project. Also the methodology which they have used is very useful for our project which had given us information about changing the different parameters to get the better results. Also This studies have used accuracy metrics to evaluate the results which has given a very high accuracy, which could be used by us to evaluate our results as well.

8-'Detection of Areas of Deforestation in the Amazon Through Convolutional Neural Networks in the Period of 2020-2022'

What this paper is about?

This paper has also using CNNs for the satellite image classification. In this paper CNN has been used for the finding out the deforested areas in the amazon Rainforest. Mainly they have used different CNN architectures for this paper which are VGG16 and Mobile Net V2 and have got really good results after using these two architectures. This studies have also mainly focused on different optimizing techniques to get better results , these techniques are K-means clustering then use of Adam optimizer and also the fine tuning of the CNNs models. The dataset which has been used for this study is having 6760 images.

How this studies is relevant to our Project?

The findings of the deforested area in the amazon with the help of the CNN is almost similar to what we are doing in our Project. This makes this research very much relevant to our Project. Also as this studies have used different optimization techniques which has resulted in better accuracy and efficiency of this Project, makes this search very much useful for our Project .

What information we have used from this paper in our project?

This paper has provided very good information about the different aspects to have better results from the CNN model. This includes fine tuning of the CNN model and also the use of Adam optimizer with better settings, which had given us a clear understanding to set these parameters for our CNN model as well. Also this paper have provided us information about the effectiveness of different architectures of the CNN model as they have used VGG16 and MobileNetV2 in their studies. This had helped us while doing our Project and have provided very good results. Also there methodology was very useful because they have also used a very big Dataset like ours. Then have used statistical analysis for evaluating there results. This approach of analysis the results helped us to get better results with greater accuracy.

9-‘ Classification of Lung Chest X-Ray Images Using Deep Learning with Efficient Optimizers (2023)’

What this paper is about?

This paper is also related image classification using the CNN in the health care sector . In this paper author have mainly focused on the classification of the lung chest x-ray images with the help of the different CNN architectures and These CNN architectures are VGG16,VGG19,ResNet50 and Xception net. Also there has been usage of different optimizers in this study, these optimizers are SGD, RMSProp and Adam as well. The author have used different epochs for these different architectures as well to get the best output from it. These different epochs values are 5,10 and 15, but the learning rate is same for all which is 0.0001. The main aim to perform all these variation was to get the best configuration having the highest accuracy.As a result some of the configuration were giving 100% accuracy as well.

How this studies is relevant to our Project?

This study is also using the image classification using CNN which is similar to our Project and that's why this is highly relevant to our Project. This studies is mainly focused on finding the best possible CNN architectures to have better results, and this is what we have aimed for in our study, which makes the methodology of this paper highly relevant to our Project. Also this Project focus on doing different parameters tunning like having different Epoch variations and different learning rates , makes this more relevant to the approach of what we have taken in our Project.

What information we have used from this paper in our project?

This paper have provided us information about different optimization techniques and strategies to have better results. so we had used this information in our project where we had checked different CNN architectures and selected the best one out of these which gave us the best accuracy. Also this studies helped us to identify the best optimizer for our studies as we could get the best optimizer having best performance using this study results. Also the performance evaluation which has been done in this paper had given us a clear picture of how to evaluate the results of our Satellite image classification ,to get the highest accuracy and efficiency.

10-‘ Optimizing CNN Using Adaptive Moment Estimation for Image Recognition (2023)’

What this paper is about?

This is the another paper which we have considered in our literature review. This studies is also related to the image Recognition where the Author have used CNN . They have used Adaptive Moment Estimation (Adam) optimizer for the optimization of thee Convolutional Neural Networks (CNN). In this studies there has been a detailed information about how the CNN models has been constructed. Information like different layers configurations, usage of Adam optimizer and about the Activation functions, all this details has been discussed in detail. And then there has been a detailed discussion of how CNN has been tested for the image classification. The CNN model has been used for the classification of the image into two different categories. the first one is Lake and the second one is Aircraft.

How this studies is relevant to our Project?

This paper has used the CNN as well for the Image classification as well, which is similar to our Project approach of using CNN for satellite image classification. This makes this paper very much relevant to our Project. Then they have used the Adam optimizer as well to improve the overall accuracy of the CNN , which is the same approach of what we have done in our Project.

What information we have used from this paper in our project?

This paper has provide a base for the use of the Adam optimizer , which has given us the knowledge for how to use it for our CNN model to get better performance of it in Satellite image classification. The methodology which has been used in this research was very useful for us, as it has provided us the information about The framework for the CNN model to have better efficiency. Also this methodology has given us the knowledge about the Performance metrics , which helped us for the result evaluation of our CNN to make sure that, these results were robust and efficient.

11-‘ Multiscale Satellite Image Classification Using Deep Learning Approach (2019)’

What this studies is about?

This paper also uses the CNN model for the image classification similar to our Project. For this studies purpose

and testing they have used different Dataset like WHU-RS, Brazilian Coffee and UCmerced Land use. The main aim of this studies is to optimize the CNN to have better accuracy in satellite image classification and for this purpose they have mainly focused on the selection of the suitable image scales. So because of this the authors were able to develop a method which could adapt to the different image scale prior to sending them to the CNN model for the image classification. This has given them a higher accuracy in the image classification process.

How this studies is relevant to our Project?

This Paper has also used the same CNN model for the image classification similar to our Project. As they have used the approach of making changes in the image scale to have better CNN performance, this is very much relevant to our Project as we are also doing the image classification in our Project. As mentioned above they have used different dataset for the testing purpose of the CNN model , which is almost similar to our approach where we have also used a big dataset similar to these dataset for our Project to test our CNN model for the image classification.

What information we have used from this paper in our project?

This paper has provided the information about selecting the image scale to have better CNN performance in image classification was very useful while doing our Image scale selection, This helped us for better satellite image classification. This methodology have provided us a performance matrix, which helped us to evaluate our results to make sure that these results were robust and efficient.

12-‘ Deep Learning Ensemble Method for Classification of Satellite Hyperspectral Images (2021)’

What this studies is about?

This paper is also related to the image classification using CNN . In this author have used 2D and 3D Convolutional Neural network (CNNs) for the classification of the images which are from Hyperspectral. They have used Inception inspired Architecture (IIA) in addition to what they already had, like HybridSN architectures and also the Inception ResNet V2. They have done this to have better performance for the image classification.

How this studies is relevant to our Project?

They have also used the CNN for the image classification which is similar to our Project of satellite image classification which makes this paper very much relevant to our project.

What information we have used from this paper in our project?

This paper has given us information about using the mix of different CNN models and this approach has given better results in the image classification. This was very useful information which gave us what approach we must take to have better results from our CNN models. Also this paper gave a understanding of using Inception blocks which captures more features from the images and gives better accuracy in classification of the images. There methodology was very useful to us as they have also used a dataset related to Hyperspectral images which is similar to our Dataset. Also this paper has given us information about the performance metrics, which helped us to evaluate our results to make sure that these results were robust and efficient.

13-‘ Classification and Object Detection on Satellite Images Using Custom CNN Architecture (2023)’

What this paper is about?

This paper is related to image classification using the CNN models. In this there has been a use of custom designed CNN model and this model has been used for the satellite image classification. The architecture is very unique to this study as the aim main of the project is to get object classification within the satellite images with more accuracy. This architecture of the CNN model is able to mitigate the challenges in image classification, these challenges are different backgrounds in the images and also the different size of the objects in these images.

How this studies is relevant to our Project?

They have also used the CNN for the image classification which is similar to our Project of satellite image classification which makes this paper very much relevant to our project. and the unique architecture which has been used in this paper is similar to what we have used in our Project which is unique as per our dataset.

What information we have used from this paper in our project?

This paper gave us a clear view of usage of different CNN architecture and also the kind of result they provide. With the help of this knowledge we were able to implement our CNN model on our dataset of satellite images which apparently gave us the high accuracy. Also there approach of identifying the background and the size of the object in the image also helped us to modify our tunning parameters while performing our classifications .Also this paper has given us information about the performance metrics, which helped us to evaluate our results to make sure that these results were robust and efficient.

14-‘Satellite Image Classification Using a Hierarchical Ensemble Learning and Correlation Coefficient-Based Gravitational Search Algorithm (2021)’

What this paper is about?

This paper is also related to the satellite image classification with the help of the CNN. In this study author have used different architectures of CNN for the image classification. These architecture are ResNet, LeNet, AlexNet. Also they have used a optimization technique for this paper which is known as Correlation coefficient Based Gravitational Search Algorithm (CCGSA) to get better accuracy in image classification. Author have used different Dataset for this studies, which are SAT-6 ,SAT-4 and also Eurosat. They have also used Muti Support Vector Machine(MSVM) for the image classification additional to above architecture to have better classification of the images.

How this studies is relevant to our Project?

This paper is related to image classification using the CNN models. In this there has been a use different CNN architectures to have better results in the image classification ,which is similar to our Project. They have also used Algorithm to get better accuracy in image classification. Also they have used big dataset for the image classifications which

are almost similar to the dataset what we have for our satellite image classification.

What information we have used from this paper in our project?

This paper gave a clear view of usage of different CNN architecture and also the kind of the result they provide. With the help of this knowledge we were able to implement our CNN model on our dataset of satellite images successfully which apparently gave us the high accuracy. There methodology was very useful to get the optimum results from our Dataset as they have too used big datasets which are similar to our dataset. Also this paper has given us information about the performance metrics, which helped us to evaluate our results to make sure that these results were robust and efficient.

III. DATA MINING METHODOLOGY

Cross-industry Standard Process for Data Mining (CRISP-DM):

CRISP-DM Methodology is the most widely used framework that guides and helps to understand data mining and machine learning projects. It offers an organized approach to ensure comprehensive and accurate results of the models.
This approach has six major phases namely Business Understanding, Data Understanding, Data Preparation, Modeling, Evaluation and Deployment which is represented in below given figure 1.

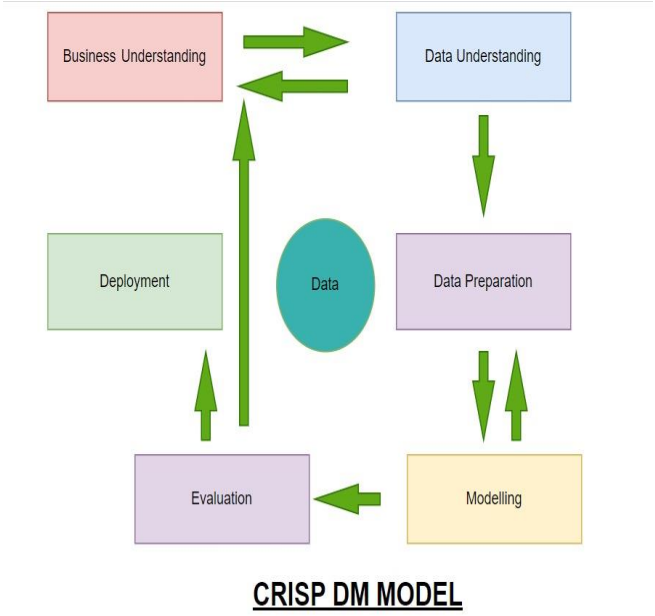

Figure 1. CRISP-DM Model

Business Understanding:

Terrain classification from DeepSAT Satellite Dataset has many applications in various sectors, influencing business choices and decisions.
For sustainable resource management, it is important to identify and keep an eye on different land terrains such as forests, grasslands, and water bodies. It is useful in monitoring deforestation, agriculture activities and optimizing water usage.
Land classification aids in urban area development by giving information about the land that can be used for construction, developing infrastructures, and managing green spaces.
It helps in planning and maintaining important projects like road construction, pipeline maintenance, electricity, and mobile tower constructions. It also allows for choosing the best routes with the reduction of possible environmental effects.

Terrain data is also useful for studying the impact of climate change on agriculture, wildlife, and natural resources.

Data Understanding:

The entire analysis of land classification has been performed on DeepSat (SAT-6) Airborne Dataset. Some of the key attributes of this dataset are listed below.
This dataset is sourced from National Agriculture Imagery Program (NAIP) which has high resolution aerial images of the whole United States continent. [1] DeepSat (SAT-6) Airborne Dataset (kaggle.com)
This dataset is huge with 405,000 image patches, with each patch having a resolution of 28 x 28 pixels which is extracted from larger NAIP images.
The dataset classifies the images into 6 major categories namely Trees, Roads, Buildings, Water bodies, Grassland and Barren land.
This research has explored the distribution of categories in the given dataset which is represented in figures 2 and 3.

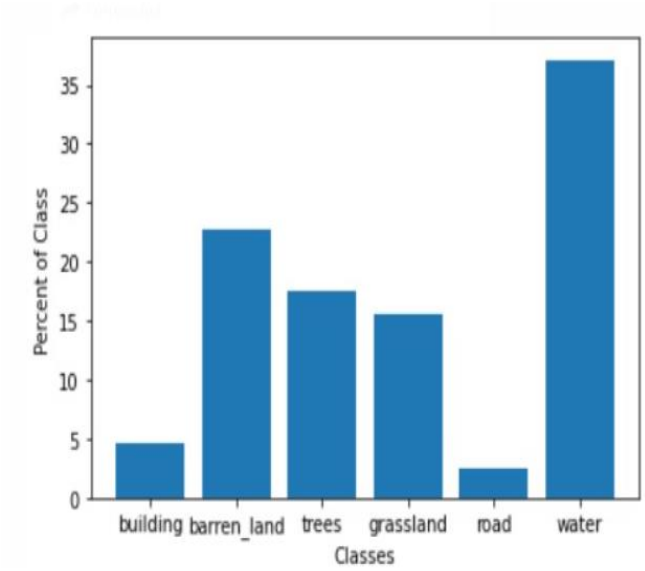

Figure 2. Distribution of the Classes

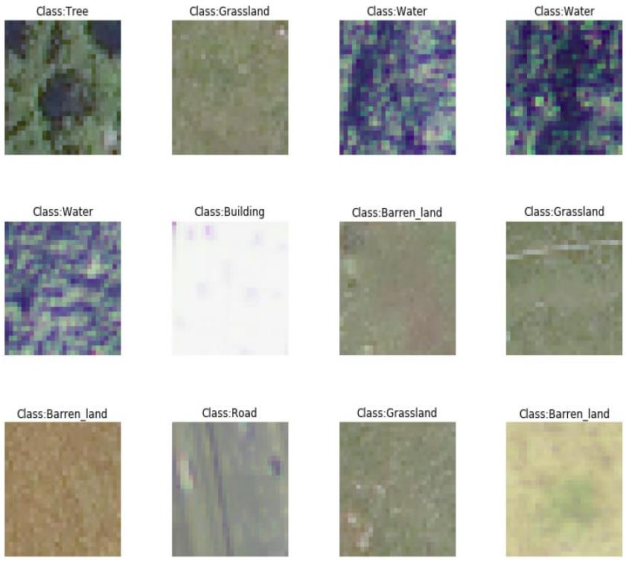

Figure 3. Sample Image Categories

Data Preparation:

Use of Panda libraries - After diving the given input file into training and testing data files, panda library has been used for reading the training and testing datasets.

Use of chunk size function- Due to large size of training and testing datasets, chunk size function has been utilized to break down the data into manageable small chunks for making the file reading process easy.

Reshaping input data- Deep learning models require input data in a specific format. In this research, the model expects each image patch to be a four channel (red, green, blue, NIR) array with a shape of (28, 28, 4). Below figures 4 & 5 respectively which represents training and testing data frames.

```
In [9]: x_train=x_train_values.reshape(-1,28,28,4)
        x_train.shape

Out[9]: (324000, 28, 28, 4)
```

Figure 4. Reshaping of Train Dataset

```
In [13]: x_test=x_test_values.reshape(-1,28,28,4)
         x_test.shape

Out[13]: (81000, 28, 28, 4)
```

Figure 5. Reshaping of Test Dataset

Use of np.argmax function- Our input file contains target values in one-hot encoding format, one-hot encoding represents array of zeroes with a value 1 at the index corresponding to the class label. To convert them back to original string values np.argmax function is used.

By using panda libraries and methods like chunksize, reshape and np.argmax this research effectively prepares the data for training the CNN model.

Modelling:

A. Keras Library and TensorFlow Backend:

In the proposed research, Convolutional Neural Network (CNN) architecture was built using the Keras library with the TensorFlow backend. Keras library is a high-level neural network API (Application Programming Interface) which offers user-friendly interface for building a CNN model. TensorFlow serves as a backend for Keras which manages mathematical computation part.

B. Model Architecture (Sequential or Functional)

There are two model architecture choices namely Sequential or Functional which depends upon the complexity of the architecture. A Sequential model is suitable for simpler, linear stacking of layers, whereas a Functional model offers more flexibility for branching or merging paths in the network. In the proposed research, Sequential model has been used which allows linear stacking of layers in the CNN architecture.

C. Convolutional Neural Network Layers

The proposed CNN model consists of five layers, use of each and every layer has been explained below.

1. Convolutional layers (Conv2D): These methods carry out extraction of basic features from input pictures. They take advantage of learning a set of filters which are trainable and use them to highlight spatial and temporal dependencies in the information.

2. Pooling layers (MaxPool2D): These layers are designed for pooling widely-used feature maps from the previous convolutional layers. They help in reducing the dimensionality of the feature maps in order to introduce rotation invariance and thus reduce the computational complexity.

3. Dense layers (fully connected layers): These layers are responsible for integrating the features that have been learned in the previous convolutional and pooling layers respectively. They perform the final object classification or regression task according to the extracted features.

4. Dropout layers: These layers are used for regularization purposes. They randomly throw away a fraction of the neurons in the network during training phase, this helps the network to avoid overfitting and improve generalization.

5. Flatten layer: This layer is responsible to transform the multi-dimensional output from convolutional and pooling layers (typically in 3- Dimensions) into 1-Dimensional vector suitable for feeding the Dense layers.

D. Rectified Linear Unit

ReLU activation function is a popular choice for CNNs as it introduces non-linearity which allows the model to learn complex relationship between features. The proposed research has used ReLU function in the convolutional and dense layers.

E. Adam Optimizer

Adam Optimizer is an efficient optimization algorithm used to adjust the weights and biases withing the CNN model. This research employed this technique for training the CNN model for faster convergence and better performance.

F. Loss function used for training the CNN model

The choice of loss function depends on the format of the target variable. If the input target labels are class labels, an integer representing land categories then sparse_ categorical_ cross

entropy loss is appropriate. For one-hot encoded target variables, the categorical_crossentropy loss function is used.

G. Additional hyperparameters used for training the CNN model

Learning rate: regulative the magnitude of weight adjustments to the model during training.

Learning rate decay: Impose the decaying learning rate during a training process.

Number of epochs: The number of times the entire training dataset is traversed in a step for training. This research uses 10 epochs value for training the dataset.

Batch size: It gives the number of samples used in each update during the training phase.

Evaluation:

Evaluating a model's performance in important to understand its effectiveness in terrain classification. Below are the potential metrics, validation strategies and training parameters used in this proposed research.

Evaluation metrics :

Overall accuracy: This measure is expressed as the ratio of the number of correctly classified to total number of instances.

Precision: This measure is a rate of the number of true positives among the objects that the system estimates as positives.

Recall: This metric shows the percentage of true positive examples found by model, which were classified correctly.

F1-score: This metric is the harmonic mean of precision and recall, measuring the model's performance with a balanced arrangement.

Confusion matrix: This performance matrix shows how the model performs with respect to the number of correctly and not correctly classified examples for each class.

Validation Strategies :

The method of validation was applied to measure the model performance during the training process and to make the correction related to hyperparameters. Moreover, this research has used a validation split of 0.2 was used which means 20% of the data was used to validate as opposed to the training set, which accounted for 80% of the overall data.

Training Parameters (Batch Size and Epochs) :

The CNN model was trained using batch size of 128, which implies that updates to the model weights took place on completion of processing 128 instances from the training set. The utilization of this method boosts the model's performance and its ability to generalize.

The model was trained for 10 epochs, each epoch denotes one pass through the whole dataset for training. Increasing the number of epochs enhances the model's performance but it may lead to overfitting if not properly regularized.

Deployment:

Some potential deployment considerations and techniques to optimize the model's performance and computational efficiency for deployment are given below.

Potential deployment considerations:

1- Adequate computational power should be ensured through GPUs or cloud computing models so that the inference and the processing of big scale satellite imagery can be done more efficiently and immediately.

2- The CNN model needs to be integrated with ongoing geospatial information systems, data pipelines and decision support systems which require carefully defining data formats, APIs and interoperability.

3- Techniques need to be designed to update the CNN model in certain period with new satellite images or ground truth data to maintain the accuracy of the model and to adapt the dynamic changes in the environmental factors or land cover patterns.

Techniques to optimize the model's performance:

1- Reducing the precision of the model's weights and activations from 32-bit floating-point to lower-precision formats for example 8-bit or 16-bit integers can result in smaller model sizes and faster computations without significant loss in accuracy.

2- Removing redundant or less important connections (weights) from the CNN model can effectively reduce its size and computational requirements while maintaining acceptable performance levels.

3- Deploying the CNN model using optimized inference libraries like TensorFlow Lite, ONNX Runtime, or PyTorch Mobile can significantly improve inference performance and reduce computational overhead.

IV. EVALUTION AND RESULTS

As discussed above In our Project we have used Convolutional Neural Network (CNN) for the satellite Image classification on the Dataset 'DeepSat(SAT-6)'. After successful Implementing of CNN on our Dataset we got an accuracy of 98.63%, which shows the Proposed model has performed well in analyzing satellite dataset and hence answered our research question. Below is Figure 6 which is for the Confusion matrix, and we have discussed this Confusion matrix in detail.

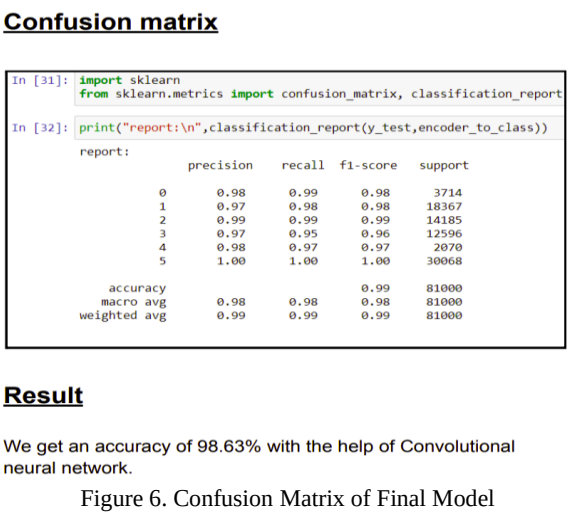

Figure 6. Confusion Matrix of Final Model

Precision and Recall:
The CNN model which we have used has got very high Precision and Recall value in almost all the categories. Both the metrics have got more than 0.97 value in almost each category. By seeing this value in each category, we can conclude that there is a very high degree of reliability in our CNN model prediction.

F1 Score:
The F1 score is also very high in all the categories, which indicates that the findings and model performance of our CNN model is very Robust. As we have seen in our Confusion matrix Category 5 has a very good score of 1, in all three, Precision, recall, and F1 score. which tells us that our model has really performed well in this category.

Support:
The support value for each category in the confusion matrix tells us about the true instances in each category. And by seeing this value for each category we can tell that there are enough records in our Dataset which has been used for training the model effectively under each category.

So, the high accuracy of our CNN model in satellite image classification proves that these deep learning techniques are very efficient in image classifications from the big datasets. and this is what we have seen in each paper which we have reviewed in our literature review section.

Model optimization:
So, the results and the accuracy which we have got in our image classification tells us about how important it is to select the correct optimizer and learning rate to get the best results from the CNN model. As we have discussed in detail in our literature review section that selection of these parameters has a huge impact on the results. And our choice of selecting the Adam optimizer and learning rate of 0.01 ensured that we get high efficiency and accuracy in our results.

Contribution for the future studies:
As we have used The CNN model for the satellite image classification and have got very good results from it. This parameter optimization and Fine-tuning setting of CNN model could be used for image classification of other sectors and very useful insights could be obtained from this. The high accuracy and overall effectiveness of our CNN model could be used as a base for the upcoming research to get more robust models for the CNNs.

V. CONCLUSION AND FUTURE WORK

CONCLUSION:

This study revealed the potential of Convolutional Neural Networks (CNNs) in terrain classification based on the DeepSat Airborne Dataset. The proposed CNN model achieved high classification accuracy of 98.63% with the help of Adam optimizer and fine-tuning of hyperparameters. The huge dataset of satellite was successfully interpreted and processed with the application of CRISP-DM and its data preparation approaches. This guaranteed a structured analytical approach covering the business and data understanding, data preparation, modeling, assessment, and deployment phases. The result has been evaluated using various metrics precision, recall, F1-score, and confusion matrix to assist in thorough examination of how the model performed in different terrain. The results indicate that CNNs can perform complex image classification tasks and especially to handle some of the satellite images that we use to study surface characteristics. Additionally, it further reveals that the CNN approach is undoubtedly the best to perform image analysis and classification of satellite images for various landscapes. It can be an important contributor to the field of urban planning, environment conservation and better resource management. This study gives a theoretical background to the usage of deep learning approach in geospatial analysis.

FUTURE WORK:

1-This model could be used for the real time analysis, as this could help in Decision making in situations like Natural calamities and while planning of Urban cities Maps.
2-As most of the studies have used satellite image for the classification purpose by using these deep learning models, other categories image such as Multispectral and hyperspectral, could be used to get more useful insights about the type of terrain or may be Humidity levels or Soil conditions and agricultural yield production.
3-Dataset with more parameters and which are more complex as compared to what has been used in the project could be used to get more accurate results about the terrains with much more accuracy. This type of data could be collected with the help of Drones or some other Aerial surveys rather than only satellite images.
4-By using integrated deep learning models could help increase the accuracy and performance of the overall model to handle diverse datasets.
5-Latest and advanced model optimization methods like automatic machine learning can be used to increase the efficiency of the model.
6-More opportunities for further research in this area that can analyze socio-economic consequences of land ownership, conservation efforts as well as agricultural policies.

By overcoming these limitations, future models have the potential to develop both the technical proficiency of the terrain categorization model and its practical application to the environment and society.

REFERENCES

1-M. Yaqub *et al.*, “State-of-the-Art CNN Optimizer for brain tumor segmentation in magnetic resonance images,” *Brain Sciences*, vol. 10, no. 7, p. 427, Jul. 2020, doi: 10.3390/brainsci10070427.
2-A. Stateczny, H. D. Praveena, R. H. Krishnappa, K. R. Chythanya, and B. B. Babysarojam, “Optimized deep

learning model for flood detection using satellite images," *Remote Sensing*, vol. 15, no. 20, p. 5037, Oct. 2023, doi: 10.3390/rs15205037.
3-M. Rahimpour, A. G. Radwan, H. Vandermeulen, S. Sunaert, K. Goffin, and M. Koole, "Investigating certain choices of CNN configurations for brain lesion segmentation," *arXiv (Cornell University)*, Jan. 2022, doi: 10.48550/arxiv.2212.01235.
4-S. T. Bukhari and H. Mohy-Ud-Din, "A systematic evaluation of learning rate policies in training CNNs for brain tumor segmentation," *Physics in Medicine & Biology/Physics in Medicine and Biology*, vol. 66, no. 10, p. 105004, May 2021, doi: 10.1088/1361-6560/abe3d3.
5-Y. Li, Q. Zhang, and S. W. Yoon, "Gaussian process regression-based learning rate optimization in convolutional neural networks for medical images classification," *Expert Systems With Applications*, vol. 184, p. 115357, Dec. 2021, doi: 10.1016/j.eswa.2021.115357.
6-M. S. Natsir, E. Palantei, I. Nurtanio and A. Suyuti, "Classification of Soil Fertility Level Based on Texture with Convolutional Neural Network (CNN) Algorithm," 2023 5th International Conference on Cybernetics and Intelligent System (ICORIS), Pangkalpinang, Indonesia, 2023, pp. 1-6, doi: 10.1109/ICORIS60118.2023.10352265
7-T. Fofana, S. Ouattara, and A. Clément, "Optimal flame detection of fires in videos based on deep learning and the use of various optimizers," *Open Journal of Applied Sciences*, vol. 11, no. 11, pp. 1240–1255, Jan. 2021, doi: 10.4236/ojapps.2021.1111094.
8-A. Gamarra-Moreno, L. Aroni-Ordoñez, E. Ambrosio-Carrasco, S. Arias-Rafael, J. Huamán-Guizgueta and Y. Baldeón-Huaccho, "Detection of Areas of Deforestation in the Amazon Through Convolutional Neural Networks in the Period of 2020-2022," 2023 XLIX Latin American Computer Conference (CLEI), La Paz, Bolivia, 2023, pp. 1-10, doi: 10.1109/CLEI60451.2023.10346180
9-A. Asaithambi and V. Thamilarasi, "Classification of Lung Chest X-Ray Images Using Deep Learning with Efficient Optimizers," 2023 IEEE 13th Annual Computing and Communication Workshop and Conference (CCWC), Las Vegas, NV, USA, 2023, pp. 0465-0469, doi: 10.1109/CCWC57344.2023.10099228
10-Z. Liu, X. Xu, D. Fang and D. Gan, "Optimizing CNN Using Adaptive Moment Estimation for Image Recognition," 2023 IEEE International Conference on Control, Electronics and Computer Technology (ICCECT), Jilin, China, 2023, pp. 454-463, doi: 10.1109/ICCECT57938.2023.10140526.
11-N. Laban, B. Abdellatif, H. M. Ebied, H. A. Shedeed, and M. F. Tolba, "Multiscale satellite image classification using deep learning approach," in Studies in computational intelligence, 2019, pp. 165–186. doi: 10.1007/978-3-030-20212-5_9.
12-P. Iyer, A. Sriram, and S. Lal, "Deep learning ensemble method for classification of satellite hyperspectral images," Remote Sensing Applications, vol. 23, p. 100580, Aug. 2021, doi: 10.1016/j.rsase.2021.100580.
13-S. Deepthi, S. Kumar, and L. P. Suresh, "Detection and Classification of Objects in Satellite Images using Custom CNN," International Journal of Engineering Research and Technology, vol. 10, no. 6, Jun. 2021, [Online]. Available: https://www.ijert.org/research/detection-and-classification-of-objects-in-satellite-images-using-custom-cnn-IJERTV10IS060287.pdf
14-K. Thiagarajan, M. Anandan, A. Stateczny, P. B. Divakarachari, and H. K. Lingappa, "Satellite image classification using a hierarchical ensemble learning and correlation Coefficient-Based gravitational Search algorithm," Remote Sensing, vol. 13, no. 21, p. 4351, Oct. 2021, doi: 10.3390/rs13214351.