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Review on Semantic Segmentation of Satellite Images Using Deep Learning

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Abstract: Image segmentation for applications like scene understanding, medical image analysis, robotic vision, video tracking, improving reality, and image compression is a key subject of image processing and image evaluation. Semantic segmentation is an integral aspect of image comprehension and is essential for image processing tasks. Semantic segmentation is a complex process in computer vision applications. Many techniques have been developed, from self-sufficient cars, human interaction, robotics, medical science, agriculture, and so on, to tackle the issue.In a short period, satellite imagery will provide a lot of large-scale knowledge about the earth's surfaces, saving time. With the growth & development of satellite image sensors, the recorded object resolution was improved with advanced image processing techniques. Improving the performance of deep learning models in a broad range of vision applications, important work has recently been carried out to evaluate approaches for deep learning models in image segmentation.In this paper,a detailed overview provides onImage segmentation and describes its techniques likeregion, edge, feature, threshold, and model-based. Also, provide Semantic Segmentation, Satellite imageries, and Deep learning & its Techniques like-DNN, CNN, RNN, RBM, and so on.CNN is one of the efficient deep learning techniques among all of them that can be usedwith the U-net model in further work.
Keywords: Image segmentation (IS), Deep learning (DL), Satellite imageries (SI), Semantic Segmentation (SS).

I. INTRODUCTION

An image is a process of transmitting information, and it provides a wide range of valuable information. Recognizing the image then collecting information from the image to achieve certain tasks is a vital field of usage of digital image technology, and image segmentation is considered as the first step to recognize the image.In reality, it is frequently not involved in all areas of the image, but instead in those that share similar characteristics. Image segmentation is an active research area of image recognition and computer vision. It is a crucial requirement for image recognition.It divides an input image into a number of the same type of category based on a certain criterion to extract the region in that people are interested. It also serves as the foundation for image processing and the interpretation of image feature extraction and identification [1].

Semantic segmentation is an essential aspect of the identification of the image object. It is a pixel-level understanding of an image. Many semantic segmentation approaches require an image label for each pixel. It predicts each pixel. The prediction not only concerns the class but also the boundaries of each type of object. It is an architecture for pixel-basedsemantic segmentation as the applications that differentiate the presence and dividing lines of the objects inside the scene. The outcome also reflects the spatialrelationship among all objects, such as sky, land, and botany in a single image[2].

Satellite imagery is useful for various purposes, including surveillance, and it covers vast areas, almost every portion of the globe, even inaccessible locations that were historically too distant or risky to penetrate using traditional aerial imagery, e.g. dense forest, peat swamp forest, & mangrove forest. Researchers can gather data that is not affected by local air traffic restrictions by using satellites; they can also compare ground cover at various intervals, which is ideal for complex studies. Satellite-based research approaches save time and money while improving the ability to identify plants by spectral and texture studies. In other words, Ground measuring techniques are complex, costly, time-consuming, and labor-intensive [3-7].

Deep learning (DL) is the most efficient, supervised, time-consuming, and cost-effective form of machine learning. DL is not a specific way of learning, but it implements diverse methods and can be used for a varied variability of difficult issues. This technique is very stratified in terms of illustrative and different features. Deep learning approaches have made an important innovation in various applications of useful safety tools with great performance. It is considered the best choice for discovering complex architecture by using them for backpropagation algorithms in highly dimensional files. DL is an artificial intelligence sub-set of ML. Artificial intelligence is a process that makes it easy for a machine to mimic beings. Machine learning is a technique for data training, and ultimately, DL is a kind of ML inspired in deep learning by the structure of the human brain. This network structure is called an artificial neural network [8].

II. IMAGE SEGMENTATION

IS is early or front-level image compression processing. The segmentation method's efficiency is the speed, its good form & its best form connection. The segmentation involves the process by which surface & regions of digital image referring to structural units are identified and isolated. Also, segmentation can rely on diverse features that can be either color or texture contained in images [9].

A. *Classification Of Segmentation Techniques*

The following categories can be divided into.

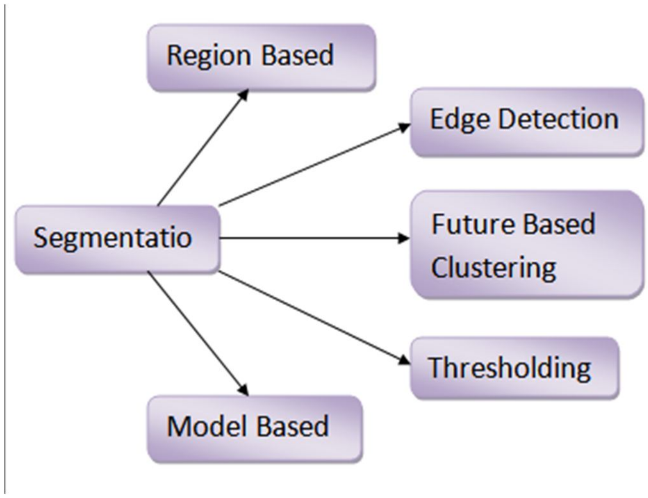

Figure 1. Segmentation Techniques

1) *Segmentation by Edge Detection:* Edge detection [9] is importantphase in method of segmentation of images. picture splits into object & its context. Distribute image on edge detection phase by analyzing the intensity shifts or pixels of image. Two key identification methods contained in segmentation are found in Gray histogram & Gradient. As 1^{ST}-order derivatives operatives&2^{ND}-order derivatives operators split into two groups. A second-order derivative operator is the canny edge detector. Second-order operators provide reliable outcomes.
2) *Segmentation by Thresholding:* Image Segmentation [11] easiest method for an image is dependent on intensity thresholds & is referred to as threshold. Both globally and locally thresholding can be used. global threshold splits object &contextual pixels by adding them to selected threshold value. Often known as adaptive thresholds are local thresholdingstrategies.Threshold Adaptive technique: threshold value varies as per local characteristics of the sub-separated areas in the image. Histogram thresholds are applied to segment provided image; for threshold segmentation certain preprocessing & processing methods are essential.
3) *Segmentation by Region-based:* Pixels associated with a similar object are classified by segmentation in this method [9]. With region-based segmentation, the thresholding technique is safe. The segmentation region observed should be closed. Also, region-based Segmentation is primarily called Segmentation of Similarities. Since edges are missing, the most dependent segmentation of edges is known for segmentation throughout this area. The sting flow is regenerated into vector after distinctive shift in color & texture takes place. The sides for more segmentation are found from this.
4) *Segmentation by Feature:* Based Clustering [9] supported the collective's attributes by a way of organizing the team. a cluster typically coversacluster of identical pixels from a given field & entirely afteranother area. Terms such as cluster analysis, automated classification, numerical taxonomy, metrology, and category analysis. Based on the content, images may be grouped. Clump paths are often categorized into hierarchical algorithms.The grouping of the content is mainly based on the clump and the genetic features of the pixels such as the shape, the color, etc. Many clump methods are used, mainly the K-Mean algorithm rule and the FCM algorithm rule are used.

Based on K Means Clustering[12]method of segmentation applied here is k indicates the algorithmic clump software. In this initial procedure, the image is read and shown scanning mistreatment. Afterward, color transformation is finished as ofunique image for testing the image. bunch techniques are often broken up into gradient algorithms and partial algorithms. In the bunch-based material, the grouping is carried out by built heritage of pixels including form, texture, etc. images can be clustered according.

Image segmentation is compared and its advantages are mentioned in Table I with limitations [31] and tabulated..

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Table I. Comparison between Image Segmentation Techniques

Algorithm	Details	Benefits	Limitations
Segmentation through Clustering	Pixel grouping with similar properties and defines cluster values based on visible intensities.	Currently, this works well on small datasets and creates appreciable clusters.	The calculation time is too long and expensive. k-means is an algorithm based on distance. Often it's not suitable.
Segmentation through edgeDetection	End to end division is created to identify boundaries by segmentation.	Contrast good imagery helps preserve the grey colour on the margins.	The low contrast pictures are a hitch. If the edges are many, this is not suited.
Segmentation through Fuzzy Logic	The Fuzzy Logic Algorithm can be conveniently made for opacity and manipulation in datasets.	Better than K-means is Fuzzy and Unsupervised. Put together well.	Determination of membership is not straightforward. It's expensive to calculate.
Segmentation through Neural Network	Nodes for use in NN.	Training data set are used to easily detect errors and difficult problems.	Training of data sets takes longer so sometime overtraining is required.
Segmentation through Region Based	Separates the artifacts from the morphologic operations into different regions.	The operations are fast and the calculation is simple so it works well in high contrast images.	It is often difficult to overlap pixel grayscale values. It's fine with Marker's implementation.
Segmentation through Thresholding	An image depends on histogram and the threshold.	There is a simple outlooks to adopt without previous knowledge of image.	Computational expensive. Not suitable for real-time applications

III. SEMANTIC SEGMENTATION

Semantic segmentation requires the assigning of a label of class to each pixel of an image. It is a high-level task that leads to a complete understanding of the scene. Semantic segmentation is procedure of grouping together parts of images of same class of objects. [13,14].

The wildest new fields are semantic segmentation in computer vision &ML.availability of images&systems has significantly improved interest in further considerate meaning and segmentation of images is one of the key components of this process.

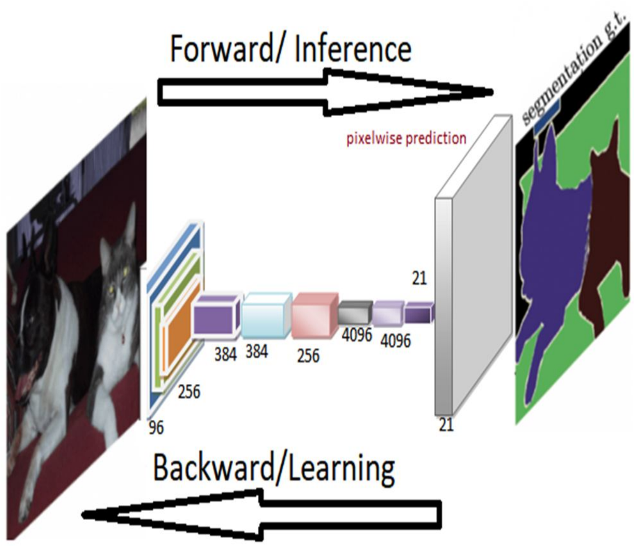

Figure 2. Semantic Segmentation

The following stages of understanding are sought when an image is analyzed:
1) The most prominent object in an image is a description, e.g.
2) localization Classification, i.e. expanding the previous approach by an object bounding box.
3) Detection of objects that classifies and detects several objects of various types.
4) Semantic segmentation, which classifies and locates every pixel in the image.
5) Segmentation,for instance, andelayforSSwhere multiple things of a similar kind are viewed as separate objects.
6) Panoptic segmentation integrating semantic &example segmentation, which assigns a class mark to all pixels and uniquely segmented all object instances.

In several applications, semantic segmentation plays an important role:
a) Diagnosis of medical image
b) Independent driving
c) Processing of satellite image
d) Analysis of the environment.
e) Growth of agriculture
f) Search engines for images.

A. DLMethods to Semantic IS
1) *Fully Convolutional Networks (FCNs):* CNs were initially applied to classify (GoogleNet,VGG, AlexNet,).The networks were used for the first time to process the input image with many coevolutionary layers and reduced filters vectorized by the new CN. Preceded by FC layers, the vectorized features learn how groups with the softmax output layer are spread.
2) *Encoder-Decoder Architecture:* In DeconvNet, writers note that owing to a lack of true devolution and a small feature map, the solution has been lost. The trained network uses FC-CRF to get customized segmentation, which is joint in the lastSS. [15].

IV. SATELLITE IMAGES

Satellite images in various spatial resolutions are available from low to high. In the case of applications e.g. environmental assessment, mapping, forestry, disaster evaluation, & urban monitoring, pixel images over 10m in the low resolution are of benefit.In comparison, images with high-resolution data in pixel format below 5m offer accurate information about the surface of small items, like buildings, streets, rivers& trees, which are helpful for transport network maps, emergency planning, and farming.

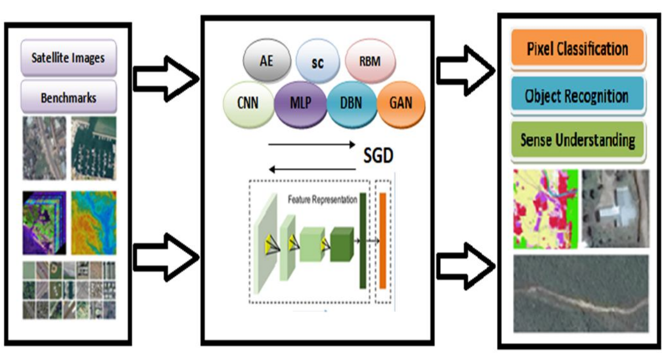

Figure 3: General Framework of Satellite Image Classification Using Deep Learning

The elevation and the topographic characteristics of a given land can also be calculated with satellite images. Furthermore, it is beneficial to see agricultural fields where farmers can track their crops' health. Researchers or scientists may examine environmental trends in future weather forecasts or natural disasters. In the meantime, city planners should plan for communities to build new residential areas. For transportation, traffic tests with satellite data can be carried out, and plan new road networks can be facilitated. Satellite images may be used at earthquakes or fire events for the planning of evacuation routes. Satellite images, forest distribution, booth density, forest extension, operational surveillance, and discrimination organisms on the dryland and wetland are the last things to provide detailed information in the Forestry sector [16].

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A. Satellite Image Processing

IPdenotes techniques & operations used to derive useful information from an image and its characteristics. These operations aim to boost or change the image's properties so that after classification there are improved outcomes. Several algorithms are applied to a mathematical way to execute image operations for knowledge extraction. ISisthemost common technique of IP.

B. Satellite Image Classification

For satellite image classification, there are many methods and techniques. During the processing/analysis section, various methods were followed for the extraction and learning of the images. The classification of images can be subdivided into two main categories, based on the approach which takes account of the spatial resolution: -

1) *Pixel-based Classification:* Several algorithms were used for classification in pixel-based classification over the past. The key goal of these classification methods is to understand the characteristics of the images and to predict them. Often, they have the samples they can use to train classification models and instead estimate the characteristics of the samples. In other cases, the size (in this case image) of the data should be learned by an analytic and various clustering and grouping techniques. [17].
2) *Object-Based Classification:* Object-based classification isasubstitute for object-oriented high-resolution image classification based on pixels. Most object-oriented section classification is called object-oriented classification of the satellite image in the object. For segmented objects such as agency, volume, type, and scale, etc., the object-oriented classification offers a very exact classified outcome of the high-resolution image of satellites. [18].

C. Satellite Sensors

Satellites include images that are widely used today for remote sensing. The satellite's special properties make it especially useful for remote earth surface sensing.

1) *Thermal Sensors:* Thermal sensors that sense reflected radiation from the target object are used to measure the surface of the target user on the ground as well as its thermal properties.
2) *Irborne& Space-borne Sensors:* One-time activities are airborne remote sensing. The sensors on the aircraft, however, cover less land, are mounted here, and provide a picture with a high spatial resolution. Remote space-borne sensing allows for continuous earth surface monitoring. Here, space shuttles or satellites contain the sensors. The surface is larger and less spatially resolute. [19].

V. DEEP LEARNING

DL is an artificial neural network sub-set of ML that deals with algorithms inspired by the structure & function of the human brain. In another way, it shows our brains exactly how they function. DL algorithms are like how each neuron connects to and transmits information. Deep learning algorithms run in layers and there are no fewer than three layers of a significant model. The information and data from the previous layer are recognized by each layer and then sent to the next. Deep learning models tend to do well with a great deal of data while traditional models do not change after a doused time.

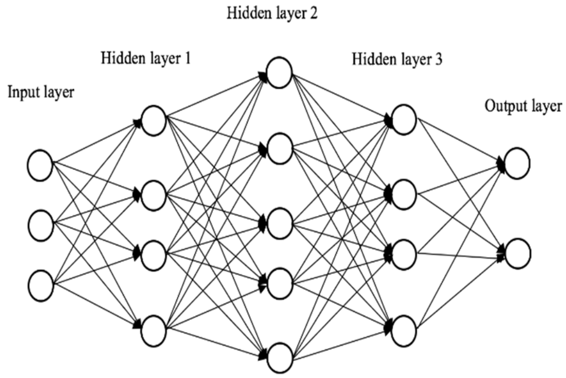

Figure 4. A Deep Learning Model

DL is known as DNN. It is one of the learning approaches based on the representation of learning results. The learning can be supervised, semi-supervised, or unsupervised. Four models are used in deep learning methods: stacked autoencoder, DBN, CNN, or RNN.

A. Deep Learning Techniques

1) *Deep Neural Networks:* DL is a perceptron, which is a single neuron in a NN, the basic building block. If a set of m inputs is finished (e.g., m words or m-pixel), each input is increased by weight (that 1 to theta m), we sum up the weighted input mix, apply distortion and finish by a non-linear function of activation.
2) *Convolutional Neural Networks:* CNN's are very much the same as common NNs, they comprise neurons with learning weights and preconditions. Both neurons obtain these inputs, produce a dot product, and can optionally be accompanied by non-linearity. The network now provides one single differential score feature from raw pixels on one end to class score on the other. The later (completely connected) stage still has a missing purpose and we still apply all the tips and tricks we have learned to learn standard NNs. CNN uses the fact that the feedback consists of pictures to more sensitively limit the architecture.
3) *Recurrent Neural Networks:* RNN is the basic algorithm for more popular and robust sequential data. Even Siri Apple uses profoundly slow RNN to process speech. RNN has a clear memory that recalls the memory input. This segment consists of the RNN principles and Process. RNN works, which are more common because of the super memory it remembers and forecasts future events. In time-series data, speech data, and other uses, RNN is commonly used.
4) *An Autoencoder:* A feedforward neural network is historically an autoencoder to learn a compact or distributed data set representation. A 3-layer neural network is a self-encoder, that is learned to construct its inputs by with them as output. It has to learn features that capture data variation to duplicate it. If a linear activation function is only used to minimize dimensionality, it can be shown to be equal to PCA. The triggering of the secret layer is used as the trained features during training and the first layer can be disabled.
5) *RBM:* RBM is an undirected, visible layer and hidden layer, two-layer NN. Within-layer there are no links, but the links are concealed to clear. It is learned to optimize the expected data log opportunity. Binary vectors are the inputs since each input receives Bernoulli distributions. In the same way, as in a normal NN, the activation function is determined & the logistic function commonly used is from 0 to1. every neuron is activated if activation is higher than the random variable and is viewed as a chance.

Table II. Study on DL Techniques

Techniques	Working principle	Pros	Cons
DNN	DL is a perceptron, which is a single neuron in a NN, the basic building block.	meaningful representations, no need for additional annotations	No different models for the very high-resolution datasets
CNN	CNN's are specifically designed to lower data parameters used by sparse connections, exchange of parameters, and equal representation, which minimizes layer-to-layer connection to amounts less than ANNs.	highly competitive and robust scalability data security	the resource-constrained system in support of on-board safety system
RNN	RNNs integrate data sets into the temporal layer, then learn multi-faceted differences with a hidden cell unit.	Excellent efficiency possible IoT security	gradients are finished or destructive.
AE	An AE has a hidden layer h, that has an input code. input is obtained by the encoder and transformed into a language abstraction. The decoder then acquires the built-in code, first generated to signify input to reconstruct original input.	Significant, minimizing dimensionality without existing information	Calculation time high, complicate learning
RBM	RBMs are deep generative structures for unsupervised learning. They are undirected models without any relation among the same layer of two nodes.	extract several critical features	resource-restricted IoT devices is difficult in support of onboard protective devices

B. Challenges of DL

DL has many problems:

1) DL large-scale analytics
2) DL methods scalability
3) Capability to produce data that is necessary if the information is not accessible to a device for learning (particularly for vision tasks such as inverse graphics).
4) Special purpose computer energy-saving technology, with mobile intelligence, FPGAs Multi-task, multi-module learning, and transition. This involves studying from multiple fields or models together.
5) Causalities in the learning process [20,23].

VI. LITERATURE REVIEW

S. Chantharaj et al. (2018)To be compared between semantic segmentation models FCN, SegNet, & GSN with medium resolution Landsat-8 images. They also recommend an updated SegNet model to be implemented for catalogs obtained from remote sensing. Results show that SegNet is the RGB aerial image band with the highest accuracy model. For Short-Wave Infrared (SWIR) & Near Infrared (NIR) bands, a cumulative best model enhances.The findings showed that all basics in terms of mean F1 values are outperformed in our proposal (using anadaptedSegNet model, RGB-IR-IDX-MSN technique) [24].

D. Hordiiuk et al. (2019)This paper introduces the core algorithm/instrument for the identification of ships with varying Spatial Resolution, based on the CNN. The issue has been divided into steps to obtain the highest performance and efficiency of intermediate output has been tracked. The proposed solution consists of 2measures: (1) a classification system based on XCéption; (2) a model based on U-net with an exact Resnet18 segment encoder, which allows us to achieve more than 84% accuracy.[25].

M. Papadomanolaki et al. (2019)Proposed a modern paradigm focused on deep neural networks, which enables semantic segmentation and image reconstruction to be solved at the end of the training. The reconstruction of the image is a regularisation, which essentially constrains the solution in the whole image region, according to the suggested terminology. In particular, for a limited number of annotations, this self-controlled aspect greatly contributes to the simplification of a network for SS. Experimental findings of the ISPRS (WGIII/4) dataset and quantitative analyses are proof of the high potential of the method developed [26].

H. Im& H. Yang (2019)evaluated and refine the semantic segmentation network (U-Net) based on the CNN. U-Net is recognized to be the newest in semantic segmentation but because of its high memory use and computational constraints, it is problematic to extend U-Net specifically to resources-constrained systems. they use the filter cutting approach for optimizing the network to overcome this drawback. Experimental results show memory use decreased by 0.26 times &the rate of inference improved by 0.57 times by filter pruning of 75%. Furthermore, the IOU & F1 score, reflecting the precision of semántic segmentation, also was decreased by 4.7 or 4.5%, as associated to original U-net in both.[27].

R. DavariMajd et al. (2019) Suggested a VHR image system for new object-based deep CNN (OCNN). The datasets for research included aerial images of Vaihingen as well as satellite imagery of Tunis Worldview 2 (WV2). Text findings demonstrate that their architecture is extendable to multiple picture styles byasimilar sensor or sensor (such as WV2) until done tuning.In the size, color, material, spectral highway, & complex histories, their system extracts various types of buildings. QE showed that the scheme proposed could produce positive outcomes at the object level (quality 0.82, F-score 0.90, overall accuracy 0.95, and Kappa coefficient 0.90,average precision 0.88 and recall 0.92). Relativetest findings suggest that the traditional method for building extraction is much better than our OCNN suggested [28].

A. A. Tiurin et al. (2020)proposed an important semantic segmentation algorithm based on neural U-Net architecture for satellite image segmentation. The algorithm creates raster masks for single class items. Although the size of U-Net input data is small, this algorithm requires a consistent outcome without stitches in infinite satellite images. This is done by observing the processing procedure. This article examines the specifics and implementation of the evolved algorithm using models for rural, forest, and urban segmentation [29].

M. Y. Saifi et al. (2020) design and implementing the automated model to extract semantical maps of buildings for waterway, road & satellite imagery to track urban growth. An experimentally tested DNN is used since it is an ML issue. SpaceNet's data package provides such data to implement Semantic segmentation from urban areas of satellite imagery.The data that have been selected for this study are from the city of Khartoum (capital of Sudan). This will help to control resources, like agriculture, natural power, and resource, monitor & respond to natural disasters, like floods, earthquakes, and environmental tsunamis, for example, deforestation, urban development monitoring [30].

Table III. Literature Survey

S. No.	Method (title)	Year	Features	Accuracy	Published
1	ModifiedSegNet model [24] (Semantic Segmentation on Medium-Resolution Satellite Images using Deep Convolutional Networks with Remote Sensing Derived Indices)	2018	RGB-IR-IDX-MSN	80%	15th International Joint Conference on Computer Science and Software Engineering (JCSSE)
2	CNN, XCeption-based classification system, U-net model with Resnet18[25] (Semantic Segmentation for Ships Detection from Satellite Imagery)	2019	data augmentation, upsampling	85%	IEEE 39th International Conference on Electronics and Nanotechnology (ELNANO)
3	deep neural networks[26] (A Multi-Task Deep Learning Framework Coupling Semantic Segmentation and Image Reconstruction for Very High-Resolution Imagery)	2019	U-REC, batch-normalization, rectified linear unit (ReLU) activation	90%	IEEE International Geoscience and Remote Sensing Symposium
4	U-Net based on the CNN[27] (Analysis and Optimization of CNN-based Semantic Segmentation of Satellite Images)	2019	filter pruning	75%	International Conference on Information and Communication Technology Convergence (ICTC)
5	object-based deep CNN[28] (Transferable Object-Based Framework Based on Deep Convolutional Neural Networks for Building Extraction)	2019	OBIA	95%	IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing
6	neural U-Net architecture[29] (An Effective Algorithm for Analysis and Processing of Satellite Images for Semantic Segmentation)	2020	post-processing	89%	IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus)
7	FCN with U-Net[30] (Deep Learning-based Framework for Semantic Segmentation of Satellite Images)	2020	Down-sampling, Up-sampling, Bottleneck	91%	Fourth International Conference on Computing Methodologies and Communication (ICCMC)

Table IV.Strength& Weakness comparison of different techniques

S. No.	Techniques	Dataset	Strength	Weakness
i	ModifiedSegNet model	Landsat-8 satellite	RGB is the best performance on the band, improve the overall accuracy	Need to optimise technologies to get the best semantin segmentation DCNN platform for medium resolution satellite images
ii	U-Net CNNwith Resnet18	Airbus Ships Detection Challenge	Needs to perform in both time and accuracy of identification.	Need to boost segmentation with NIR data
iii	DNNs	ISPRS (WGIII/4) dataset	Create more meaningful representations, No specific annotations are needed for the reconstruction task	No separate models for the high-resolution pixel-wise semantic data segmentation
iv	U-Net CNN, filter pruning method	Deep Globe Road Extraction Challenge data set	For the redevelopment project no special annotations are required. no significant distortion	The IoU value and the F1 score is lowered when the filter pruning is added to the initial U-Net at its highest degree.
v	object-based deep CNN	Vaihingen (Germany) aerial images & Tunis Worldview-2 (WV2) satellite imagery	Outperforms for building extraction	Discriminative features extraction
vi	U-Net CNN	satellite images	Creates raster masks of items of a single class	Size of the U-Net input data is small
vii	U-NetFCN	SpaceNet	A considerable amount of characteristic maps for the upgrade, symmetric shape	The number of parameters and calculation time was greatly affected

VII. CONCLUSION

Image segmentation is one of the most essential Image processing method. Image segmentation is the method of separating or splitting an image into small part known as segments. It is most suitable for applications such as image encoding or object detection, where processing the whole image will be inefficient. Semantic Segmentation is a computer vision task that predicts pixel labels relating to a region's belongs region or even the area containing by the region. In brief, the use of satellite imagery for mangrove forest conservation is critical in gathering data. Satellite imagery data have significant benefits in mangrove analyses and seem to be valuable for monitoring mangrove habitats. Recent deep learning experiments concerned with semantic segmentation have been greatly enhanced by the use of neural networks.This paper has provided a study on image segmentation and its classification techniques. Such techniques are categorized based on region, edge,feature, threshold, and model. Next, the concept of semantic segmentation has been described with deep learning techniques. Satellite image data are classified onPixel-based and Object-based classification for spatial resolution. Many deep learning techniques have used for image data classification are described in detail. Since various researchers have work on the same problem using different techniques represented in tabular form.This review is beneficial in upcoming research.

In the future work, wewill try to use two algorithms namely the U-net based CNN to perform segmentation for satellite images and modified Pyramid Scene Parsing Network to resolve the issue of satellite image classification.

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