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Research Article

A Review of House Detection from High Resolution Satellite Images

[1]*Mariam Ismael Hassan*
dept.Remote Sensing
Univercity of Baghdad
Baghdad,Iraq
Mariam.ismael.ha98@gmail.com

[2]*Loay E.George*
Univercity of Information Technology and communication
Baghdad, Iraq
Loayedwar57@uoitc.edu.iq

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ABSTRACT

Detecting houses through high-resolution satellite images has received increasing attention in recent years and is considered a basic but difficult task in the field of remote sensing. Although, there are many methods that have been developed in this field, there is still a need for an in-depth review of recent articles about Extracting buildings and houses from high-resolution satellite images. This study aims to provide a comprehensive review of articles published in the scientific literature including developments that have occurred in recent years in this field. The topic of house detection is a popular, widespread and rapidly emerging research topic in domain of remote sensing. Because its importance in many fields, including drawing and updating urban maps, monitoring change, detecting damage resulting from environmental disasters, land use analysis, population estimation, and other applications. In addition to Availability of high-resolution images produced by the new generation to satellites. Topics of automatic detection of houses, object-based approaches, machine learning, and deep learning through high-resolution RGB images.

Keywords: Remote sensing, house detection, building extraction, machine learning, Deep learning

1. INTRODUCTION

Remote sensing is the scientific practice of gathering data about the Earth's surface without making direct physical touch. The system employs sensors to detect and record the energy released and reflected from the Earth. This data is subsequently analysed, processed, and utilised in several applications. The utilisation of remote sensing techniques has garnered growing interest as a result of the necessity to gather data on alterations in the environment.[1]

Automatic extraction and detection of buildings in the field of remote sensing is very important.

Especially in applications such as environmental monitoring and disaster prevention, and with the increasing availability of high-resolution satellite data from satellites such as WorldView, Quickbird, and IKONOS, remote sensing has become very vital.

Manual extraction of city objects and homes thru high-decision multispectral photos calls for revel in and top notch attempt, which requires a method for computerized extraction of buildings to store time.

The venture lies within the presence of massive version in spatial and spectral capabilities, which results in issue in class. In addition, there is cloud cover and sun radiation, which will increase the complexity of picture analysis.

To overcome these challenges, researchers have proposed diverse strategies that combine spectral and spatial capabilities into classification schemes. Moreover, machine getting to know algorithms have contributed substantially to the improvement of classification inside the discipline of far flung sensing, changing traditional methods.

The availability of high-resolution satellite images makes it possible to accurately detect buildings for applications such as urban mapping, change monitoring, damage detection, or population estimation and land use analysis.

With advances in remote sensing tools and object-based image analysis to obtain satellite images with high spatial resolution, it has become possible to detect buildings accurately.

In conclusion, remote sensing techniques play an essential role in detection by providing information about urban objects

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from high-resolution satellite data.
The integration of machine learning algorithms and object-based image analysis tools makes accurate building extraction possible for various life applications. [2][3][4][5]

1.1 Challenges of automatic building detection from satellite images

Automatic detection of buildings through satellite images faces many challenges and difficulties that must be overcome in order to achieve good and accurate results. Among these difficulties are:

1- There is a difference in the structures of residential buildings, which will show different textural and geometric characteristics.

2- High-resolution remote sensing images vary due to imaging conditions such as scope and spectral range.

3- Residential buildings tend to obscure each other visually.[2]

Moreover, because of background complexity, (for example, shadows, buildings and other artifacts objects), the differences of building colors, and the diversity in remote sensing image sources such as differences in spatial resolution and capture time.[3]

The presence of shadows is considered one of the main obstacles because it greatly affects the recognition of color and texture features in shaded areas, the absence of image features, and the decrease in clarity due to partial or complete blocking of light. It has a major impact on subsequent image processing, such as feature extraction and land cover classification.[4]

Addressing these challenges requires innovative methods to effectively deal with shadow compensation, contrast between buildings, small size of objects, problems of low resolution
and rotational invariance, limited data visibility, image size variations, and time differences that affect satellite images.[5]

2. Object – based approach for house detection:

2.1 Explanation of Object – based approach for house detection:

This approach to building detection through high-resolution RGB satellite images involves a segmentation process followed by object feature extraction and classification.

This method has gained increasing interest in recent years, as it relies on image segmentation using an algorithm that determines threshold watersheds and hierarchical merging, vegetation and shadows is removed from the divided areas.

In order to capture the characteristics of houses, we proposed two types of edge regularity indicators (ERI) and shadow line indicators (SLI). These features showed good results by improving accuracy by 5.6% and recall by 11.2%.

In addition, machine learning techniques such as AdaBoost, Random Forest, and Support Vector Machine were used to identify house.[6]

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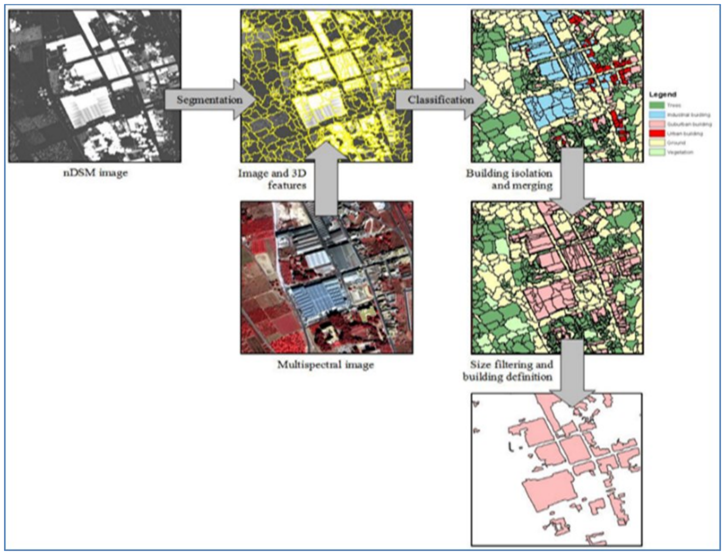

Figure .1. scheme of object-based classification building detection approach [7]

2.2 High-frequency image analysis techniques used for building traces:

Building detection through high-resolution satellite images relies heavily on high-frequency image analysis techniques. It is an essential method for identifying building features and overcoming difficulties related to resolution changes and color variations.

The integration of deep learning with convolutional neural networks (CNNs) has allowed accurate segmentation of high-resolution RGB aerial images.

Which facilitates the classification of individual pixels and the identification of specific objects within the image. It includes predicting the locations of objects as bounding boxes, providing a class label, and creating a mask to segment the objects detected within the bounding box.[8]

The proposed framework for extracting precise and dependable buildings from high-resolution panchromatic images incorporates directional morphological optimisation and multi-seed-based clustering by means of internal grey variation (IGV) extraction. It also involves shadow detection and false alarm reduction using positional information of building edges and shadows. Furthermore, there are segmentation approaches that rely on qualitative thresholding. The evaluation of this study was conducted utilising a diverse range of IKONOS and Quick Bird satellite pictures.[9]

3. Machine Learning Based-approach for house detection:

3.1 Introduction to Machine Learning Based-approach for house detection

Machine learning is a prominent field that creates algorithms to enable systems to learn and improve their performance by using data and learning it to improve various functions.[10]

Machine learning and remote sensing image processing methods are being used more and more to extract various types of data for urban planning, change detection, disaster assessment, and monitoring earthquake damage .[11]

The Red Cross has utilised machine learning methods, including multiple linear regression and artificial neural networks (ANN), to forecast and estimate the extent of building damage caused by typhoons in the Philippines.[12]

This method is gaining growing prominence in the domain of object detection. Machine learning typically involves two primary stages: the training phase, which entails the careful selection of samples and the extraction of features that greatly influence the accuracy of the outcomes. In the second stage, known as prediction, Classifier are trained Using training data and subsequently employed to recognise objects.[13]

4.Image segmentation using Edge Attribute

Image segmentation is an important part of identifying buildings through high-resolution satellite images Segmentation can be defined as dividing an image into many non-overlapping parts based on a set of specific criteria such as pixels and

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intrinsic properties such as texture, smoothness, color and contrast. Segmentation is generally considered useful in image processing applications such as object detection, object recognition and boundary detection and relies on techniques such as Thresholding, region expansion, edge detection, active contour models, clustering, histogram-based methods, and region growth, etc. Furthermore, the Full Lambda Table (FLS) algorithm carries out segmentation by utilising both spatial and spectral information. This algorithm initially considers each pixel as an individual region and subsequently combines neighbouring regions based on a defined set of spectral and spatial data.

FLS segmentation is a step-by-step procedure through a series of algorithms. Accurate image segmentation is of great importance in detecting houses from satellite images, and is considered an essential step for subsequent processes such as identifying edge features, removing shadows, removing vegetated areas, and selecting candidate areas for identifying buildings.

In conclusion, image segmentation plays an essential role in determining the outlines of buildings and identifying them through high-resolution satellite images, and it fundamentally affects the effectiveness of subsequent steps for detecting houses.[17][18][19][57]

5.Removing shadow and Vegetation Area from segments

When it comes to detecting houses through high-resolution remote sensing images, it is necessary to remove shadows and vegetation areas from parts in order to achieve an accurate classification of buildings. Shadows is popular in high-resolution remote sensing images, as they are an important factor affecting the image data. Shadow detection in remote sensing image processing has gained increasing interest and become a prominent research topic, as algorithms have been classified into model-based approaches (requiring prior knowledge of environmental conditions to calculate shadow areas based on geometric features, sun angle, and related parameters) and nature-based approaches Shadow (which takes into account spectral and geometric properties and focuses on using the spectral approach with a wide range).[14]

One method of shadow removal involves using the Retinex algorithm in the HSV color gamut space. Shadows can be identified by their low brightness in the image. The algorithm transforms areas covered in shadow into high-quality areas, which effectively removes shadows without affecting other features. Taking into account that buildings in rural areas are usually gray in color, areas Shadows in remote sensing images will tend to blur between buildings with low gray value, and this will increase the error rate in identifying the target.[2]

color normalization Another vital aspect is color normalization of remote sensing images. This is done during different methods such as parametric methods, GAN-based style transfer algorithms, and methods based on reference images. The choice of method depends on factors such as computational time, color deviation, and generalization ability to build extraction models.[21][22]

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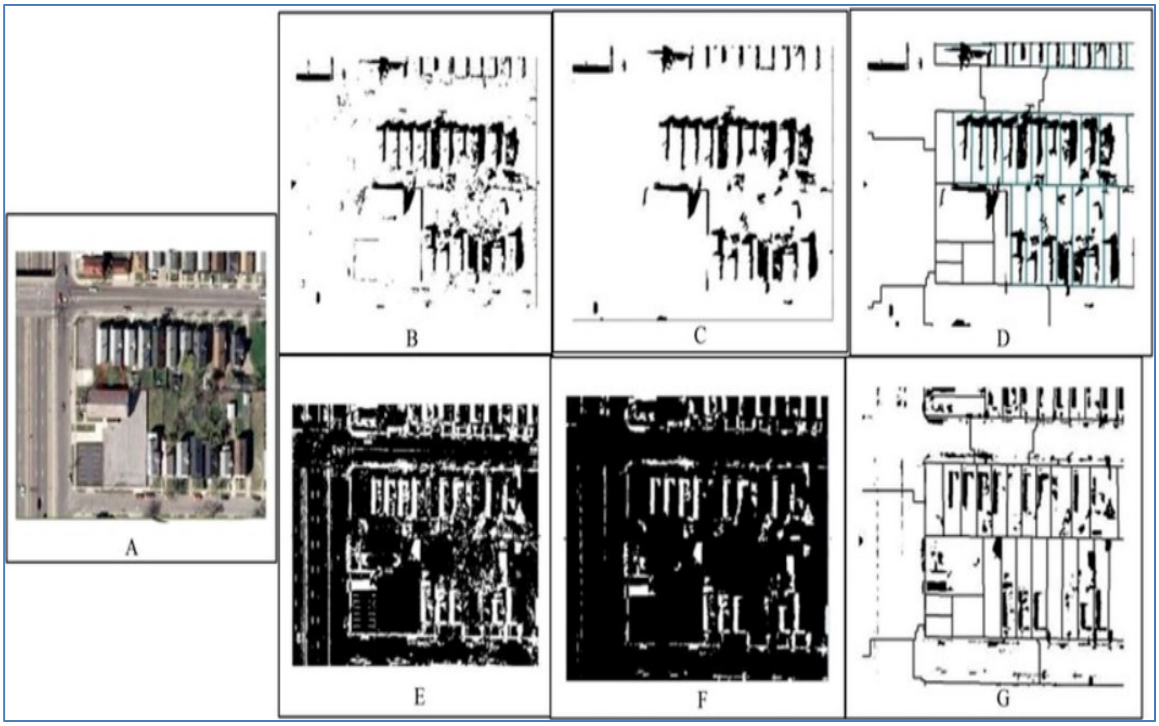

Figure .2. (A)original high-spatial-resolution image (B)shadow extraction from red and green band (C) shadow refinement result (D)segmentation and shadow shifting result. (E)MBI threshold result (F) MBI refinement result. (G)MBI feature map segmentation result. MBI 14 morphological building index.[15]

6. Feature extraction for building classification

Feature extraction is a crucial process in image analysis and classification and improves the effectiveness and efficiency of analysis and classification by eliminating variability and redundancy in image data. It aims to determine a set of image characteristics and determine the spatial information necessary to identify the target.[16]

Identification of houses from high-resolution satellite images relies heavily on feature extraction. A range of methods are used such as colour, edge, corners, geometric indices, arsenic moments and more[6].

Usually, extracting features from satellite images begins with classifying images into two types: pixel-based and object-based. Pixel-based image classification uses spectral information to classify the images and cannot use synthetic spatial information. To solve this problem, object-based image analysis (OBIA) is used. For example, the image is divided into homogeneous groups based on spectral and spatial uniformity.[17]

The presence of various shapes and overlapping gadgets such as timber, roads, and shadows, in addition to the presence of man-made structures, pose demanding situations to function extraction. Accurate function extraction is vital for determining constructing obstacles and spatial characteristics in unique segmentation strategies. Meta-heuristic algorithms have been proposed to address the limitations of computerized clustering algorithms.[18]

Recent research has shown that machine learning-based methods such as U-net architecture has been shown promising results in building segmentation and feature extraction with high accuracy rates[19]

7. Candidate Region selection process

The method of testing areas to detect homes in satellite snap shots requires several steps to ensure accurate and reliable effects. One important aspect is putting off color and vegetated regions from parts, as this may cause fake results in building detection. Therefore, it's miles necessary to accurately detect and get rid of shadows to ensure accurate selection of the candidate region for building category.

When shadows are accurately detected and removed, the contextual relationships between buildings and their corresponding shadows can be used when selecting the candidate area. Taking into account the direction of the angle of incidence of sunlight in each image, buildings can be placed in their context based on whether there is shadow in that direction. This is a condition in the selection of the candidate area, ensuring that specific objects such as buildings without expected shadow in the direction of falling sunlight are excluded from consideration. In conclusion, the process of selecting candidate areas does not only include removing shadows and green areas, but taking advantage of the contextual relationships between buildings and their shadows to ensure obtaining more accurate and reliable results.[10][28]

8. Deep learning methods

Deep learning is a type of machine learning technology and its algorithms have shown excellent results in many disciplines, which are being expanded and improved.[20]

In latest years, the use of deep mastering generation has emerged, in particular convolutional neural networks (CNNs), which might be specifically suitable for the trouble of semantic segmentation to extract buildings from photographs, and CNN processes based totally on patching have advanced, such as Visual Geometry Group (VGG). In addition to deep residual networks (RestNet) and DenseNet, absolutely convolutional networks (FCNs) and accelerated networks inclusive of SegNet and Deconv Net.[21]

The remarkable achievements of deep convolutional neural networks (CNNs) in semantic segmentation has generated significant research enthusiasm in the remote sensing field. Consequently, object-based image analysis (OBIA) have replaced traditional segmentation techniques with conventional image segmentation approaches that employ semantic segmentation methods based on CNNs.).[31][32][33][34][35]

The emergence of deep learning has results significant interest in field of natural language processing (NLP), particularly in the advanced neural network known as Transformer. Towards the end of 2020, an enhanced version called Vision Transformer (ViT) was introduced, further enhancing its capabilities. The model exclusively utilizes the self-attention process to identify significant components of the input data, resembling the human brain's ability to prioritize relevant information for decision-making. This approach has yielded remarkable outcomes when compared to contemporary CNNs.[36][37][38][39]

However, Deep learning requires rich samples to participate in training model, which limits the usefulness of these methods in practical application.[22][58]

9. Non-Deep learning methods

Due to the frequently a finite number of the samples, the performance of the building detection process in deep learning is adversely affected. To address this issue, a set of algorithms has been presented that are not exclusive to deep learning and have gained widespread usage in building detection. A technique has been suggested to identify a point that is both of a specific size and unique. The classic morphological building index (MBI) is utilized to analyze the multi-scale textural qualities and orientations of the stacking area. Subsequently, the MBI feature images are subjected to threshold segmentation to produce the desired outcomes.[23]

The MMFBI was introduced as a solution to address the limitations of the MBI by employing a multi-channel multiscale filter. This index is efficient for extracting limited spectrum information from HRRS images, but it necessitates proper sampling for accurate findings and is consistently constrained to the thresholding procedure. Numerous scholars have extensively researched the implementation of MAP in the identification of buildings.[24]

A new adaptive morphological feature profile was proposed within the object boundary method (AMAP-OBC). This method created the correlations between (AMAP-OBC) and landmark features in HRRS images in comparison with the building index. The MAP method adopts multi-scale and Multi-class features in building detection and can obtain Get more dependable results.[25]

10. New Research Trend

- A method has been proposed for automatic detection of buildings through high-resolution satellite images. This method uses the morphological building index (MBI) and includes discovering local features and improving them through the use of the salience index, and also calculating the voting matrix based on the improved feature points, and finally detecting buildings using the MBI algorithm. The experiments conducted confirmed the effectiveness and accuracy of this proposed method in detecting buildings in complex environments.[26]

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- A method was suggested to mechanically extract buildings, with the goal of addressing difficulties encountered and highlighting small-scale structures. The method is called Deep Automatic Building Extraction Network (DABE-Net). The method employed excitation and compression processes (SE) in combination with a residual recurrent convolutional neural network (RRCNN). Moreover, the attention mechanism is integrated into the network to improve the precision of segmentation. The trial results revealed the effectiveness of this technology in extracting structures, outperforming many comparable technologies.[27]

- A novel encoder and decoder framework has been supplied for the automatic extraction of homes from satellite pics. The encoding thing employs a compact network composed of dense convolutional and transition blocks to effectively seize facts at numerous scales. The deciphering segment employs a chain of deconvolution layers to repair the absent spatial information and reap dense segmentation. In this segmentation, white pixels correspond to buildings, whilst black pixels correspond to the backdrop and different gadgets. By engaging in experiments, this method proven notable overall performance when applied to a tough dataset.[28]

- A method of combining old techniques for processing digital images and convolutional neural networks was proposed. The pre-processing stage involved selecting a set of training data using threshold segmentation and eliminating shadows. Subsequently, the image is enhanced by introducing noise and flipping to optimise the image and augment the training data's dimensions. The deep learning data was subsequently employed to identify buildings utilising the R-CNN model, as well as the SegNet and U-Net models. In addition, a fully convolutional network (FCN) was employed to recreate the extracted features. This approach effectively enhanced detection precision and decreased calculation time.[2]

- A new deep learning algorithm for accurate building detection from high-resolution satellite images called SP-VAE-CNN has been suggested. The proposal includes segmenting the image into super-homogeneous pixels and using Variable Automatic Encoder (VAE) to extract features, after which classification was done using a convolutional neural network (CNN). Comparison was made with the Res2-Unet and SLIC-CNN algorithms in order to evaluate the effectiveness and efficiency of the proposed approach, The results showed superior accuracy. It can be relied upon for urban monitoring and city planning quickly and accurately.[29]

- The importance of semantic segmentation turned into emphasized with the aid of using deep gaining knowledge of networks to extract items from high-resolution satellite photographs. A have a look at added a method that leverages the improved talents of vision transformer networks, and in comparison it to conventional convolutional neural networks (CNNs). The look at additionally investigated the impact of numerous hyperparameters, including photo corrections, linear embedding, and multi-head self-attention (MHSA), on the accuracy of transformer-primarily based fashions for extracting building footprints from high-decision images.The findings imply that utilizing smaller picture patches and using better dimensional embeddings yield advanced accuracy. The consequences yielded beneficial insights on the way to enhance land cover accuracy the usage of VHR photos thru the implementation of a configuration transformer-based totally community.[30].
- In this research, a new vision transformer called Build Former was proposed to extract buildings with high accuracy from remote sensing images. Build Former includes a two-pass structure to capture global context and spatial details simultaneously. Experiments on a group of complex buildings showed superior performance of this method compared to the latest methods.[31]
- The progress made by deep learning methods has been highlighted as researchers have discovered the possibility of using transformers, in particular the dual-path transformer architecture, to improve the accuracy of building extraction by learning long-range dependencies in both channel and spatial dimensions. This approach, called Sparse Symbol Transformer (STT), represents The buildings are used as discrete vectors and reduce the computational time significantly. The results showed the effectiveness and efficiency of this proposed model and its superiority over traditional transformers in terms of accuracy and computational complexity.[32]

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- The researchers presented the new Feature Aggregation Network (FANet), which is an innovative method that addresses difficulties such as differences in building shape and size, and complex ground surface conditions that hinder precise definition of building boundaries. The Pyramid Vision Transformer encoder method was used to capture multi-scale dependencies and enrich features through feature aggregation and removal modules. Differences, receptive field block and dual attention for comprehensive understanding of image data and precise image segmentation by using Fusion decoder.[33]
- PolyBuliding, an advanced end-to-end polygon transformer model, was used to extract buildings from remote sensing images. It uses an encoder-decoder architecture to predict vector instances of buildings such as bounding boxes and polygons. This model includes context information and relationships between polygons, performs angle classification, and applies optimization operations to obtain polygons. Regular shapes and low complexity. This model outperformed other methods based on the pixel level and accuracy of representation and geometric properties, and achieved superior performance and good accuracy in detecting buildings.[34]
- The researcher suggested a categorization approach that falls under non-deep learning methods, primarily because of the challenges associated with deep learning. The morphological building index (MBI) and the Multi-Channel Multi-Scale Filtering Building Index (MMFBI) were employed of accurately depict the attributes of the buildings. The researchers investigated the utilisation of)MAP) morphological attribute profile and the combination of strategies such as alternating sequential filters) NASFs(and Adaptive Morphological attribute Profiles (AMAP-OBC), in order to establish a correlation between them for the purpose of enhancing and integrating automatic building detection from high-resolution remote sensing images. The findings demonstrated the efficacy and precision of the approach in comparison to contemporary techniques in HRRS images across diverse areas and sensors.[35]
- A multi-media fusion network (CMGFNet) was developed to extract multi-level features from RGB and DSM data through the use of encoders. The network also incorporates approaches to merge multi-media and multi-level features in order to extracting building footprints from Very High-Resolution (VHR) remote sensing photos and DSM data. The results demonstrated the exceptional efficacy of this approach.[36]
- An enhanced convolutional neural network (CNN) architecture, known as SegNet, was suggested and utilised for the multi-objective semantic segmentation of remote sensing images. An analysis was conducted to examine the benefits and drawbacks of each model. A CNN architecture called Encoder-Decoder was developed using SegNet as a basis. This architecture was designed to enhance the recovery of image information during sampling, resulting in successful segmentation outcomes. Furthermore, a novel integrated model approach was introduced to merge the outcomes of semantic segmentation from the two distinct CNN models. The results demonstrated an enhancement in the segmentation process, and via comparison with prior research, we deduce that the suggested integrated algorithm exhibited superior outcomes.[37]

11. Conclusion

While growing and comparing residence detection fashions from high-decision satellite photographs, many key overall performance signs had been considered. Accuracy, Intersection over Union (IoU), F1 rating, precision, recall, and Dice score had been used to degree the performance of different fashions on a validation dataset.

The U-Net model, which is predicated on VGG because the backbone, had the highest accuracy of 92.5% and IoU of 77.Four%. This suggests the effectiveness of appropriately detecting house functions from satellite images. [38]

The U-Net with VGG continued to outperform other models on the test data set, achieving an accuracy of 89.28% and an IoU score of 74.7%. The results show the power of this model in detecting buildings through high-resolution satellite images.[39]

Moreover, the accuracy of different network structures for extracting buildings was examined, such as: DMU-Net, DMU-Net (FPN), SMU-Net, DU-Net, and IEU-Net. Among these models, DMU-Net emerged as the most accurate model. Overall (OA) is 96.16% and IoU is 84.49% . [40] [38]

Informal settlements are big in many nations, and the automatic extraction of homes in city environments has lengthy been a mission because of the complicated environment and various constructing shapes. With advances in deep mastering algorithms and photograph segmentation techniques, it has turn out to be feasible to attain powerful building extraction.

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An critical component of destiny studies is to in addition explore the restrictions, taking into account the variety in the accuracy of far off sensing information, choosing high-resolution models, as well as enhancing example segmentation models to higher phase homes, in particular in areas with high populace density.

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