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REMOTE SENSING TECHNIQUES IN ENERGY SECTOR FOR BUILT FORMS EXTRACTION AND 3D MODEL DEVELOPMENT

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Abstract:
Urban areas are the major component of city growth. Urban Built forms information is essential for various GIS applications. In order to build and expand urban areas effectively, there is an active requirement of the existing built-up database. The information pertaining to urban built-up can be relevant to multiple agencies for predicting different criteria-based growths (low rise, high rise, etc.). Furthermore, accurate built-up information is crucial for analysis of urban application such as urban planning, transport related issues, energy demand and renewable energy sources for smart cities development. Earth observation satellite imagery is an encouraging source to extract these built-up areas. However, the automatic built-up extraction of a city from high-resolution satellite data is a familiar challenge in the remote sensing community across the globe. Various remote sensing techniques were analysed based on different high-resolution datasets. 3-D models have been reviewed based on different approaches and compared for implementing renewable energy sources. This study presents a review on various built forms detection and extraction techniques, development of 3D model and its application on energy sector for any city.
Keywords: Built-up Extraction, 3D City Model, Renewable Energy, Remote Sensing

1. Introduction

Over the past decades, urban areas in India have been enlarging at a revolutionary pace due to significant economic development. The major impact of urban development has resulted in the loss of valuable agricultural land, wetland and forest, as also an increase in energy consumption and environmental impact on the city (Zhang, et al., 2014). In order to appraise the urban issues occurring across the globe, researchers and planners require accurate information.

The Government of India is working on a design to make any megacity a sustainable and intelligent living- in megacity. The innovative megacity development plan also includes the installation of solar roof-top mongrel grid-connected and stand-alone systems, solar water heaters on Government services and places, revamping of a volley machine stand with a solar PV- grounded electrification system. (MoHUA, 2015)

The comfortable standard of living and quality of mortal life has become decreasingly dependent on energy. The only way to manage with similar growing dependence is to borrow energy conservation measures and use indispensable energy sources for power generation. To illustrate modern energy practices, the state capital accepted the Smart City Development action. A Clean-Up Action Plan to reduce the carbon footmark needed an intertwined action plan perpetration of sustainable energy technologies was charted. The Action Plan (AP) was grounded on the eventuality of demand-side measures and force-side addition through renewable energy technologies.

GIS technologies are being comprehensively used in the pursuit to develop and identify renewable energy sources. Which can lead to the identification of suitable sites and resource management. This approach not only changes the process of energy acquisition but the strategy of earth's and energy assets management. GIS can help in direct energy estimation like solar energy as well (Angelis-Dimakis, et al., 2011). It can rationale how solar energy resources can be optimized by arranging photovoltaic panels on rooftops around the city. The capital fund correlated with the development of energy resources are enormous, necessitating comprehensive assessment of site suitability before proceeding with renewable energy expenditure (Stambouli, et al., 2012). The role of GIS along with Remote Sensing (RS) techniques in reducing geographic constraints are immense as resources potential, area suitability, shadow analysis and local socio-political acceptance. GIS and RS technologies assists in mapping of renewable energy resources and are well suited for identifying potential zones and performance analysis (Mohammed & Ishak, 2017).

Remote Sensing images are a significant source for erected- birth in intelligent metropolises with different environmental conditions. Remote sensing technology provides a better comprehensive result and analysis of civic erected- up areas that are delicate to achieve through fieldwork. These datasets can also be used for historical studies for reviewing, monitoring, and preparing solution for urban problems, for example, to extract building (Song & Shan, 2008), automatic building extraction (Wang, et al., 2020), building outline extraction (Parthvi, et al., 2016), building height extraction (Li, et al., 2017). The development of 3D megacity models has constantly been one of the dominant factors which regulate the civic development and operations of 3D megacity models (Hu, et al., 2014). Over recent times, high-resolution satellite imagery capabilities have been used for studies on civic erected- birth and expansion, colourful civic parameters and planning for better serviceability (Wang, et al., 2020).

Remotely sensed imagery from upstanding and space-borne detectors assists as a source to identify the civic erected forms using colourful bracket algorithms fleetly. Advanced bracket algorithms have been enlarged in the last decade to amplify the efficacity and delicacy of image classification (Schowengerdt, 2006). The automatic inception of erected forms from remote sensing data capitulates rapid-fire results and is, therefore, salutary for energy-related civic operations in an intelligent megacity. Still, automatically relating and rooting erected forms from high-resolution remote sensing data is a familiar challenge in the remote sensing community (Ball, et al., 2017). Many experimenters have made extraordinary charity in this direction.

Coarse-resolution imagery similar as moderate- resolution imaging spectroradiometer, medium-resolution satellite imagery (like Landsat and Sentinel- 2, and high-resolution satellite imagery similar to Quick Bird and WorldView) have been extensively used for built-form extraction (Huang, et al., 2018). Landsat imagery has been used constantly to extract built-up areas in urban sprawl studies. Its effective content, suitable spatial resolution (30 m) and free access have proved that Landsat imagery is helpful in built-up mapping areas. The image classification techniques, which have been considerably established, are grounded on pixel-grounded and object-acquainted classification methods (Meneguzzo, et al., 2013).

2. Built Forms Detection and Extraction

Built Form Detection and Extraction Identify and isolate architectural structures and features in digital images or maps. This is often achieved through computer vision techniques and algorithms that analyze satellite images or aerial photographs and extract relevant information about structures, such as their location, size, shape and type. This information can be used for a variety of purposes, including urban planning and management, building and evaluating inventories, and responding to disasters. The goal of detecting and extracting built form is to provide a reliable, automated way to gather information about the built environment, which can support decision-making and improve our understanding of urban areas. Integrated mold detection and extraction methods are continually improving. Recent advances in machine learning and deep learning have enabled the detection and extraction of building structures with increased precision and accuracy.

Exact built forms extraction and detection from remote sensing techniques is one of the stimulating concerns in both remote sensing community and computer vision. Due to the complication of different factors, different angles of satellites, shadows of different objects, image noise and other factors; It is actually a rigid and strenuous to detect and extract exact built forms from high resolution remote sensing datasets (Ulch & E.G, 1995)

Number of books, conference proceedings, papers and journal special issues have also been published on extraction using remote sensing techniques. (Lin & Nevatia, 1998) has presented a system for detecting structures from a single-intensity image though it can also integrate results from several similar images. In this system, for illustration, simply pointing to a structure or correcting a corner can fully recover a missed or incorrect structure (Lin & Nevatia, 1998). Morphological segmentation by the outgrowth of the morphological profile was proposed by (Benedikt, et al., 2002). The debit of the proposed system concerns the necessity of looking at a range of adding, opening, and ending reconstruction operations. The proposed formula by the author for the morphological specific assumes a "simple" gets of the morphological profile where each structure is supposed to have only one significant derivative maximum (Benedikt, et al., 2002).

The author can use the classification-guided approach for the parcels of both multispectral and panchromatic images. (D. Scott, et al., 2002) Also, using unsupervised bracket/ clustering to segment building class from its background and surroundings can avoid the difficulty in determining the threshold in classical binary image segmentation (D. Scott, et al., 2002). On the other hand, the author proposed model-based building extraction from upstanding images performs well and exhibits birth in acquiring 3D data of buildings. The trial results demonstrate the trustability of the proposed system. (Tseng & Wang, 2003).

Wu, et al., 2004 put forward a texture analysis- grounded tree crown discovery and delineation algorithm, which can fete trees in complicated scenes similar to the megacity. Wu, et al., 2004 developed an algorithm which can handle a wide range of remote sensing images, and it works best when the pixel distance is lower than 10 cm, and the tree's periphery exceeds two measures (Wu, et al., 2004). Boyer, et al., 2005 introduced a modified KMC algorithm to prize a double member representing possible houses, road networks, seminaries, promenades and parking lots (Boyer, et al., 2005).

Song & Shan, 2008 delineated the boundary of a structure by an active figure algorithm grounded on the position set system developed by the author (Song & Shan, 2008). While Ok, 2014 proposed an approach to prize above-ground indirect structures from near-nadir VHR satellite images. Although artificial objects substantially belong to civic surroundings, the author's approach may inaptly descry objects as storage structures(Ok, 2014).

Kadhim, etal., 2015 concluded that using the VHR image from advanced satellites, similar to WorldView- 3, illustrates strong support for object discovery and birth within civic areas (Kadhim, et al., 2015). Chen, et al., 2016 has concluded the problem of detecting and reconstructing vestiges of the gable-encamped structure in single VHR airborne SAR images (Chen, et al., 2016).

The use of SAR imagery became prominent during the periods. Likewise, Parthvi, et. a. 2016's system can be generalized to colourful types of structures, and it is robust against complications of erecting structures similar to the actuality of inner yards and multiple primary exposures (Parthvi, et al., 2016). While Lisini, etal., 2018 presented the rearmost release of the SAR-grounded UEXT algorithm. Results have been validated and compared with datasets at several scales from added-up fiefdom positions for the entire China (Lisini, et al., 2018). likewise, other studies also handed critical deeper operations in this birth using SAR, like inferring an indicator using binary polarimetric parcels of HH and HV polarizations of ALOS PALSAR data (Sinha, et al., 2018). Alternately, furnishing an upstanding and satellite structure data set is anticipated to contribute to developing and accessing dataset, which is anticipated to contribute to developing and accessing new styles similar to as pixel-wise segmentation, multisource transfer literacy, case segmentation and change discovery (Ji, et al., 2018). In the environment of complex conditions, (Abdikan, etal., 2019) had delved into exploring the birth of civic areas. The author used ALOS-2 data acquired for civic birth (Abdikan, etal., 2019). The author proposed an adequate and effective model called ENRU-Net for rooting structures from high-resolution upstanding imagery. ENRU-Net adopts aU-shape encoder-decoder structure as the backbone to adequately use the detailed information to ameliorate the recognition of small structures (Wang, etal., 2020).

They proposed a workflow to estimate building heights from a single SAR image using building footprints from GIS data (Sun et al., 2017). By comparing building height information in overlaid aerial images with building height information in lidar data, the authors found that building height information is highly correlated (Li, et al., 2017).

Besides using SAR, segmentation is another way to create shape extraction. How, Komodakis, et al., 2018 present a new technique for structured semantic segmentation of high-resolution satellite imagery. Next, the authors' method imposes structure when predicting more regulated building footprints (Komodakis et al., 2018). However, Tan et al., 2018 built a graphical model based on deep features, extracted built-up areas and verified them through multiple comparative experiments (Tan, et al., 2018).

Alternatively, with the development of machine and deep learning (DL), various methods can be used for mining, such as the application of DL in non-constructive SAR mining (Shahzad, et al., 2019). Additionally, the author adopted bungalow mining and then combined single-point bungalow mining with human-computer interaction (Ma, et al., 2019).

Over the past decade, it has been suggested that automatic construction techniques of shape extraction have evolved [(Ok, et al., 2013), (C., et al., 2003), (Anupama Mishra, 2016)]. This analysis is the basis for the integrated shape mining achievable with remote sensing and how it can be applied to energy demands and photovoltaic systems in smart cities. Each development period is divided into four stages. The duration of each stage is about fifty years. The most common data sources for embedded shape mining are aerial and high-resolution satellite datasets.

Image segmentation and classification methods are standard methods for extracting and tracking accurate building footprints from high-resolution satellite images [(Wang, et al., 2001), (bin, et al., 2002), (Chen & Wang, 2004), (Zhengjun, et al., 2008). Segmentation is the first step in image analysis, followed by classification. Classification methods are automatic and semi-automatic means of identifying signature categories. Table 1 describes the narrative in stages, and Table 2 provides details based on the trend timeline.

Table 1: Photogrammetric Technique for Features Extraction

Phase	Technique	Comments
I	Plane table photogrammetry phase	Plane table photogrammetry is an established method in photogrammetry, and many scientists have proposed how to improve the accuracy and efficiency of the measurement process. Level tables are used for level table photogrammetry. The Frenchman Chevallier developed it in 1858. (IBIS, 2020)
II	Analog photogrammetry phase	Analog photogrammetry has been a widely used method in photogrammetry for many years and has been the subject of considerable research and discussion among scientists in the field. During this time, aerial imagery was used for cartographic purposes. (G., 2003)
III	Analytical photogrammetry phase	Analytical photogrammetry is an effective method in photogrammetry, and many scientists have proposed how to improve the accuracy and efficiency of the measurement process. Presents the first implementation of aerial triangulation, DEM generation, and feature extraction. (Madani, 2001)
IV	Digital photogrammetry phase	Digital photogrammetry is a widely used method in photogrammetry that has grown to include a range of new technologies and processes. This phase contrasts with the other phases in terms of the data used in this phase, with increased productivity thanks to the power of satellite imagery, photogrammetric cameras, GPS, scanners and RADAR technology. (Mishra, et al., 2016)

Table 2: Comparison of Building Detection and Extraction, 3D development, Height Detection, PV System, and Shadow Analysis Techniques Reviewed

The detection and extraction of buildings is an important and complex task in the field of remote sensing and computer vision. The purpose of this process is to identify and extract information about buildings and other man-made structures from digital images, maps or aerial photographs. This information can then be used in a variety of applications, including city planning, building inventory, disaster response, and more. There are two main approaches to detecting and extracting buildings: traditional computer vision techniques and machine learning algorithms. Both methods have advantages and disadvantages, and the choice of method depends on the specific requirements of the task at hand.

Traditional detection and extraction techniques use homemade algorithms to identify architectural structures based on their shape, size and texture. These algorithms are usually based on low-level image processing and feature extraction techniques such as edge detection, thresholding and segmentation. One of the main advantages of these methods is that they are computationally efficient and can be easily integrated into existing systems. However, they are often limited in their ability to handle complex and varied building structures, and their results can depend heavily on the quality of the input data.

On the other hand, machine learning algorithms use statistical models and neural networks to automatically learn how to detect and extract architectural structures from images. These algorithms can take into account a wide range of features and contextual information, such as color, texture, and topography, and can handle complex and varied building structures with greater precision and accuracy. Additionally, machine learning algorithms can be trained on large datasets, allowing them to learn from previous experience with detection and extraction tasks. However, one of the main challenges of these methods is that they are computationally intensive and difficult to implement, especially for those with limited knowledge of machine learning. Ultimately, the choice between traditional computer vision techniques and machine learning algorithms for building detection and extraction depends on the specific requirements of the task at hand. Both approaches have advantages and disadvantages, and the best approach depends on factors such as the quality of the input data, the computational requirements, and the experience and expertise of the user. However, with the rapid development of machine learning and deep learning, machine learning algorithms are likely to become increasingly important for creating detection and mining tasks in the future.

3D development refers to the process of creating and representing a three-dimensional virtual environment that represents real-world objects and landscapes. This technology has gained significant attention in recent years, with applications in fields such as architecture, gaming, film, and civil engineering. Remote sensing is a technique that uses remotely placed sensors to collect data about the earth's surface. This data can be used to produce images and maps that provide information about the physical and cultural features of the earth. Remote sensing techniques are often used in conjunction with 3D development to provide accurate representations of the earth's surface. One important application of remote sensing in 3D development is height detection. Height detection refers to the process of determining the elevation of the earth's surface. This information is crucial for various applications, such as creating topographic maps, monitoring land use and land cover changes, and studying the effects of natural disasters.

Remote sensing techniques used for height detection include Light Detection and Ranging (LiDAR), Synthetic Aperture Radar (SAR), and Interferometric Synthetic Aperture Radar (InSAR). LiDAR is a laser-based technology that measures the time it takes for laser light to travel from the sensor to the ground and back. SAR uses microwave radiation to produce images of the earth's surface, and InSAR uses radar signals to measure changes in the earth's surface over time. Each of these remote sensing techniques has its own strengths and weaknesses, and the choice of technique depends on the specific application and the desired level of accuracy. For example, LiDAR is suitable for generating highly accurate elevation data, but it is limited by the density of the laser points it can collect. SAR and InSAR are capable of generating data in areas with limited ground access, but they are limited by the availability of satellite data.

In conclusion, remote sensing techniques are crucial for height detection in 3D development. By combining remote sensing data with other data sources, it is possible to produce highly accurate representations of the earth's surface, which can be used for a wide range of applications.

A photovoltaic system refers to a photovoltaic system, which is a system that uses solar panels to convert sunlight into electrical energy. These systems consist of various components such as solar panels, inverters, charge controllers, batteries (for off-grid systems) and mounting systems. The overall efficiency and performance of a photovoltaic system is affected by a variety of factors, including the location and orientation of the solar panels, weather conditions, shading from nearby structures, and the quality of components used.

Shading analysis is an important aspect of photovoltaic system design and performance evaluation. Shading from nearby buildings, trees, and other objects can significantly impact the amount of sunlight reaching the solar panels, affecting overall system performance. There are several techniques for analyzing shadows, including:

Sun Path Diagram: This technique involves creating a diagram showing the path of the sun across the sky and the location of shadows at different times of the day.

Sun Angle: This technique involves measuring the angle of the sun at different times of the day and using this information to predict the amount of shade that will occur.

3D Modelling: This technique involves the use of 3D modelling software to create a virtual representation of a proposed photovoltaic system and surrounding environment. This allows for accurate analysis of shadowing patterns and the impact of shadowing on system performance.

Site Survey: This technique involves physically visiting a proposed site and using tools such as sun angle calculators or umbrella poles to measure the amount of shading that occurs.

Each of these techniques has its own advantages and disadvantages, and the choice of which technique to use will depend on the specific project requirements and available resources. A Key highlights the latest extraction techniques published in the 21st century. Integrated shape extraction relies heavily on the classification base of satellite imagery. Urban distribution and land use patterns define techniques that can be applied to images for further analysis. The extraction of early architectural forms was based on human perception, including form, spatial layout lighting, and shadows or reflections at the feature extraction stage. Many urban applications have been constructed using semi-automatic techniques to extract architectural forms from different objects (Vosselman, 1998). Some methods have been used in regional road mining (Li, et al., 1995), (Sowmya, et al., 2007), (Wang, et al., 2016), (Hormese & Saravanan, 2016). Some scans improve the ability to identify the location of objects, and computers perform specific functions to detect accumulated fingerprints, such as seed growth algorithms. In this algorithm, the growth is defined by the pixel values.

The timeline compresses the knowledge extracted by the construct in various fields. These methods vary widely and highlight the need for better standardization. Due to the complexity of satellite imagery, high-resolution datasets from various sources (LIDAR, SAR, etc.) are required to extract architectural forms correctly.

3. Conclusion

This study reviews the different possibilities of techniques for the extraction of architectural forms, the development of 3D urban models and their use in the energy sector. Various techniques for detecting and extracting the shape of buildings using remote sensing images are discussed in the study. An important persistence is to build appropriate algorithms to detect architectural forms. Developing suitable algorithms is a major challenge facing the remote sensing community. This is beneficial for urban applications and the future sustainable development of smart cities.

This study provides an overview of various building shape algorithms and techniques, the development of 3D models and their application to smart city tasks in the energy sector. This helps identify issues for developing a sustainable future for built form mining using remote sensing.

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