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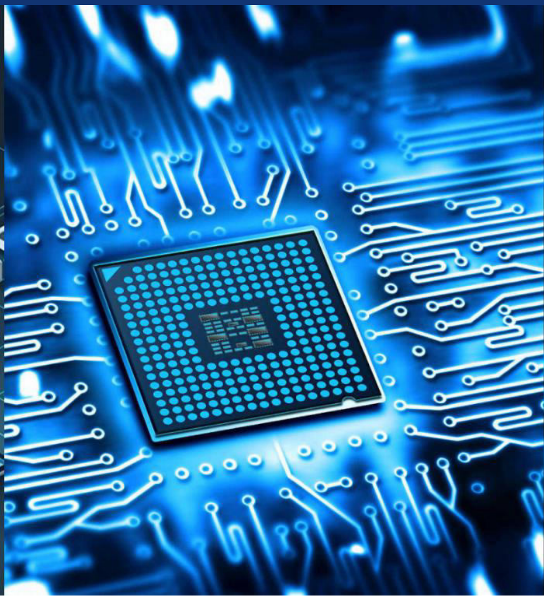


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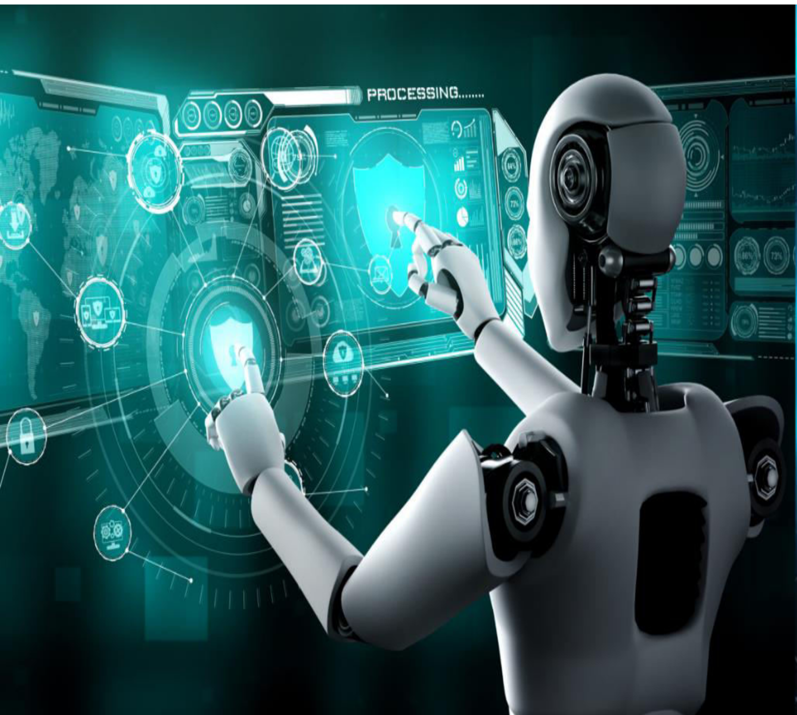

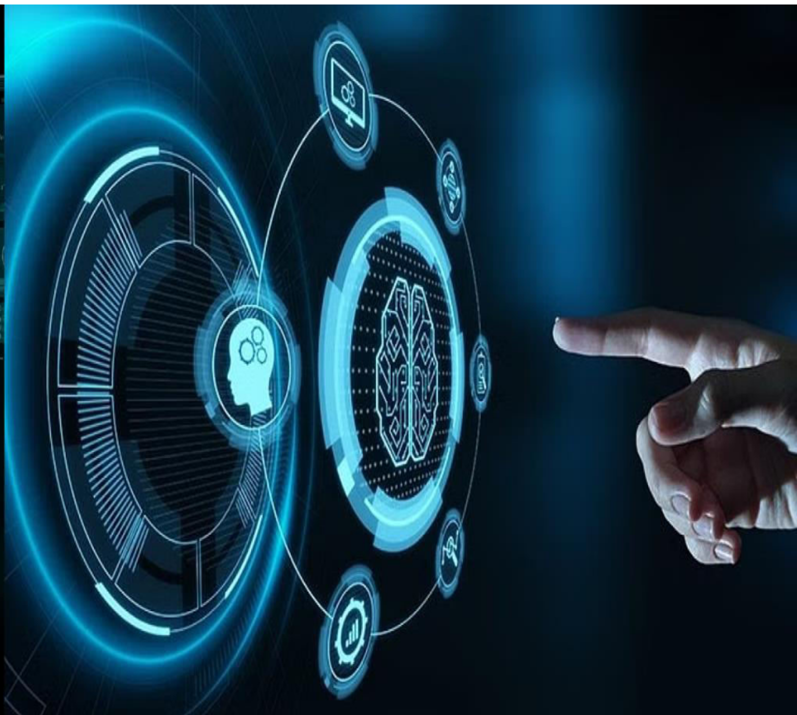

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Survey Paper for Industrial and Urban Vacant Land Identification

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ABSTRACT: Land Use and Land Cover (LULC) mapping as well as vacant site identification are important tasks for achieving balanced urban growth and management. This paper investigates the development possibilities for remote sensing along with deep learning methods that include Convolutional Neural Networks, Graph Convolutional Networks, and Vision Transformers in respect of their application in land feature determination on satellite images. The papers "Identifying Land Features from Satellite Images using Deep Learning It Seems and "DGCC-EB: Deep Global Context Construction with an Enabled Boundary for Land Use Mapping of CSMA" show how these methods and systems are developed to work far better than mere manual classification techniques which involve a lot of labor and time for detailed analysis.

Furthermore, the article focuses on the use of FOSS and GIS layers to identify and remediate underused and neglected urban and industrial sites by using citizen science. Case studies from Dongguan, Tangshan, and Germany provide examples of how land types are classified and major obstacles to urban redeployment and ecology equilibrium are handled. Although great strides have been achieved, issues such as locating broken-up parcels in intricate environments remain challenging. This paper does not contain any significant new information. Still, it synthesizes – and collates – findings that are meaningful for researchers and practitioners and provide bases for sustainable land use and management in the region.

KEYWORDS: Land Use and Land Cover (LULC) Mapping, Vacant Land Identification, Sustainable Urban Development, Land Management, Remote Sensing Technology, Deep Learning Techniques, Convolutional Neural Networks (CNNs), Graph Convolutional Networks (GCNs), Vision Transformers (ViTs), Satellite Imagery, GIS Layers, Citizen Science Data, Urban Regeneration, Ecological Balance.

I. INTRODUCTION

The post-industrial period has sparked significant changes in city environments, marked by a notable increase in industrial vacant land (IVL) and urban vacant land (UVL). These underused areas—comprising abandoned buildings, brownfields, and forsaken properties—arise as intricate urban issues stemming from economic changes, demographic transitions, and technological upheavals. Although often perceived as urban decay, these vacant spaces hold essential prospects for sustainable growth, ecological restoration, and strategic urban revitalization

The issues related to vacant land are complex and varied. Shifts in demographics, deindustrialization, changes in the job market, and new housing trends have led to the fragmentation of urban areas. These vacant zones frequently present adverse socio-economic effects, such as diminished community engagement, heightened crime risks, and falling property values. As a result, it has become crucial for urban planners, policymakers, and researchers to identify, comprehend, and thoughtfully repurpose these lands

In the past, pinpointing and classifying vacant land necessitated labor-intensive and expensive manual assessments. However, advancements in technology, including remote sensing, Geographic Information

Systems (GIS), and machine learning, have transformed this field.
New deep learning methods, such as Convolutional Neural Networks (CNNs), Graph Convolutional Networks (GCNs), and Vision Transformers (ViTs), provide exceptional abilities to analyze satellite images and discern subtle land use trends with impressive precision.

This survey paper seeks to thoroughly investigate the leading-edge techniques for identifying, mapping, and understanding urban and industrial vacant lands. By integrating recent studies and technological breakthroughs, we analyze how innovative computational methods are reshaping our approach to land use classification. Our inquiry centers on three vital aspects:

Technological Progression: Examining the shift from conventional manual classification to sophisticated machine learning algorithms
Methodological Perspectives: Assessing various computational strategies for detecting vacant land
Potential Effects: Emphasizing the transformative possibilities of these technologies for urban sustainability, ecological preservation, and strategic land management.
Through this systematic review, we highlight the pressing necessity for advanced, scalable solutions that can tackle the intricate challenges of identifying vacant land in ever-evolving urban settings

II. RELATED WORKS

A. Zhang et al.(2022) - DGCC-EB Framework Study
Technology: Deep Global Context-aware with Edge-preservation Bilateral (DGCCEB)
Methodology:
Combined CNNs, GCNs, and Vision Transformers, Implemented superpixel segmentation, Developed custom loss function for feature constraint fusion
Key Findings:
Achieved 89.06% overall accuracy in Shouzhou, 88.68% accuracy in Zezhou cities, Superior boundary preservation in irregular regions, Effective handling of non-Euclidean data

B. Sun et al. (2023) - Industrial Vacant Land Study
Technology: HRNet, ResNet-UNet, VGG16-UNet
Methodology: Created training datasets from Chinese cities, Implemented multi-source data integration, Compared multiple deep learning architectures, Applied semantic segmentation techniques
Key Findings: Achieved 97.84% accuracy with HRNet, Successfully automated large-scale IVL mapping, Demonstrated global scalability potential

C. Moser et al. (2015) - URBIS Project
Technology: Support Vector Machines (SVMs), Markov Random Fields (MRFs)
Methodology: Utilized high-resolution multispectral imagery, Implemented temporal change detection, Conducted pilot studies in three European cities
Key Findings: Successful classification of various vacant land types, Effective monitoring of temporal land use changes, Integration with EU policy initiatives

D. Kiran Arakalgudu Nagaraju et al. (2023)
Technology**:** Parameterized multi-filter CNN
Methodology**:** Applied CNN-based classification on Euro SAT dataset, Implemented preprocessing techniques: Data scaling, Augmentation, PCA feature extraction
Key Findings**:** Improved feature extraction capabilities, Enhanced processing of low-resolution images, Reduced computational complexity

E. Newman et al. (2016)
Developed an inventory of vacant urban land in America
Proposed a chronological typology of vacant areas
Categorized vacant spaces from dead space to urban wasteland

F. Kim et al. (2018)
Expanded typology of vacant areas
Identified types including post-industrial, abandoned, overgrown, natural, and transportation-related spaces
Emphasized that vacant areas may have natural surfaces

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G. Image Classification Studies

Smith et al. (2017): Focused on identifying vacant lots for potential greening and agriculture
Volpe et al. (2008): Used geospatial techniques to identify abandoned railroad areas
Su et al. (2008): Applied textural and local spatial statistics for urban area classification

H. Quantifying Land Use and Urban Expansion in Dongguan, China

Technology: To study urbanization trends in Dongguan (1987–2020) using remote sensing and GIS methods.
Methodology: **Remote Sensing and GIS Integration-** Landsat imagery and Google Earth Engine, Landsat imagery provided data for land use and land cover (LULC) classification, and GIS-based spatial analysis identified urbanization trends over time. **Temporal Analysis-** Urbanization trends were examined for the period 1987–2020, Spatial patterns such as urban sprawl and phase transition (diffusion-coalescence) were analyzed. **Statistical Data Analysis-** Socioeconomic data from the Dongguan Bureau of Statistics were used to correlate urban expansion with economic growth and population increase.
Key Findings: Significant urban expansion marked by a shift from scattered to consolidated development, Key drivers: Economic growth and population increase

I. Large-Scale Automatic Identification of Industrial Vacant Land

Technology Used: Using Deep Learning Models and Sentinel-2A satellite imagery with a 10-meter resolution
Methodology: Semantic Segmentation Using Deep Learning Models: UNet (or similar deep learning models for semantic segmentation). Multi-Source Data Fusion: Integrated surface temperature data from Landsat 8, Used population density data from Baidu heat maps for contextual analysis.
Key Findings: Framework effectively identifies IVL in Tangshan City and combines population density and temperature data for precision.

III. DATASETS

The table summarizes various research projects focused on urban land use categorization, identification of unoccupied land, and mapping of industrial areas. Each project utilizes different core technologies and datasets, such as high-resolution satellite images, to analyze urban environments and land coverage changes. The techniques employed enhance the precision of distinguishing land types and demonstrate advancements in feature extraction and boundary maintenance. Overall, these studies highlight the importance of remote sensing, machine learning.

Study	Primary Technology	Dataset Used	Accuracy	Key Innovation	Applications
Zhang et al.	DGCC-EB Framework	Shouzhou, Zezhou city data	89.06%/88.68%	Boundary preservation in irregular regions	| Urban mapping, CMSA analysis
Sun et al.	HR Net	Chinese industrial zones	97.84%	Multi-source data integration	IVL identification
Moser et al.	SVMs	European urban zone	Not specified	Multi-temporal analysis	Urban vacancy mapping
Nagaraju et al.	Multi-filter CNN	EuroSAT	Not specified	Enhanced feature extraction	LULC classification
Automatic Detection of Urban Vacant Land	Data Fusion Framework	Urban Atlas (UA), Imperviousness layers, CORINE Land Cover (CLC), OpenStreetMap (OSM), Citizen Science	96.3% (Unattended areas) 96% (Transport) 86.9% (Natural sites) 69.2%	Integration of open-source spatial data and citizen science for cost-effective urban land mapping	Nationwide mapping of vacant land to support urban sustainability goals, including housing,

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			(Brownfield)		green infrastructure, and biodiversity conservation
automatically identifying vacant area in the current urban environment based on open source data	Remote sensing classification, Geoprocessing techniques	Phoenix metropolitan area, Claro, Brazil, Urban imagery	Not specified	Chronological vacant area classification, Expanded classification including	

IV. DISCUSSION AND FUTURE WORK

Although considerable advancements have been achieved in identifying and mapping vacant urban land, numerous challenges persist that should inform future endeavors in this area. These challenges encompass technological, data-related, and contextual factors that impact the efficiency and scalability of urban land mapping techniques.

A. CHALLENGES

Data Access and Quality: The existing dependence on open-source and remote sensing data brings forth issues regarding data quality, particularly in areas with restricted access to high-resolution datasets. While satellite imagery and citizen-contributed data offer valuable perspectives, their quality can fluctuate, compromising the accuracy of land classification. - The variability in data access across different locales complicates the application of methodologies universally, especially in regions lacking infrastructure for remote sensing or volunteer-based mapping efforts.

Complicated Land-Use Classifications: Areas with mixed uses, low-density industrial districts, and informal settlements present notable challenges for classification. The heterogeneous nature of urban land, featuring overlapping elements like greenery, abandoned structures, and industrial sites, complicates the accurate categorization of land into distinct types. - The identification of boundaries in intricate urban environments, particularly in rapidly developing areas or regions with complex land- misclassification.

Technological and Computational Limitations: The demand for significant computational resources to analyze large datasets and conduct advanced assessments, such as those based on machine learning or deep learning approaches, may pose challenges in technologically underserved areas. Furthermore, the implementation of real-time processing and data integration in resource-constrained settings could impede the broader adoption of these technologies.

Environmental and Socioeconomic Factors: Urban land utilization is shaped by various influences beyond mere physical and spatial attributes. Socioeconomic data (including population density, economic activity, and housing patterns) is vital for a more nuanced understanding of land-use trends. Future studies should aim to incorporate these elements for improved prediction and classification. - The environmental impacts of urban growth, such as urban heat islands, deterioration of air quality, and effects on local ecosystems, must also be investigated to promote sustainable urban development.

B. Future Research Directions

Expansion of Data Sources:

Subsequent studies should aim to broaden the datasets utilized for land classification by integrating socioeconomic and environmental information. By including factors such as population growth patterns, economic activities, and

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infrastructure advancements, urban land classification models can achieve greater robustness and precision. Additionally, the incorporation of temporal data will facilitate the monitoring of vacant land changes over time, yielding valuable insights into urbanization trends and opportunities for land repurposing.

Utilization of Machine Learning and Artificial Intelligence:
The application of machine learning and artificial intelligence methodologies has the potential to significantly improve the precision of land-use classification and boundary identification. These advanced techniques can more effectively categorize complex land types, particularly in areas characterized by mixed-use and low density. Furthermore, the creation of lightweight, machine learning-driven models will be essential for regions with limited computational resources, thereby enhancing accessibility for municipalities with constrained budgets.

Real-time and Ongoing Monitoring:
Future initiatives should prioritize the processing of real-time data and the establishment of automated systems for the continuous observation of vacant land. This approach will enable cities and municipalities to identify vacant properties more efficiently and address urban planning issues promptly. Additionally, the investigation of cutting-edge remote sensing technologies, such as hyperspectral and thermal imaging, could yield more accurate data for land classification, especially in identifying brownfield sites and areas with nuanced land-use differences.

V. CONCLUSION

This research introduces an innovative, open-source framework designed for the automatic identification and categorization of vacant urban land, utilizing remote sensing, GIS data, and contributions from citizen science. By establishing a comprehensive typology for vacant land, the study fills a significant void in urban planning and land management, especially in regions with constrained financial resources. The methodology proposed has been validated across various urban and rural areas in Germany, showcasing high levels of accuracy and the potential for broad application in promoting sustainable urban development.

Nonetheless, several challenges persist, particularly in maintaining data consistency, accurately classifying intricate land-use types, and incorporating environmental and socioeconomic factors into the land detection framework. Future investigations should prioritize the enhancement of data fusion techniques, the inclusion of temporal and real-time data, and the application of machine Learning models to boost classification precision. Furthermore, integrating environmental and socioeconomic indicators will yield a more comprehensive understanding of urban land dynamics, facilitating more informed decision-making in sustainable urban planning. In summary, the progress outlined in this study establishes a robust basis for more accessible, efficient, and equitable urban land mapping. With ongoing advancements and the incorporation of diverse datasets and cutting-edge technologies, this approach holds significant potential for cities globally in tackling the challenges associated with urbanization, land reuse, and sustainable development.

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