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Geospatial Techniques for Preparing the Requirements of 3D Modeling for Smart City Planning- Review paper

التقنيــات الجيومكانيـة لتهيئـة متطلبات النمذجـة الثلاثيـة الأبعاد لتخطيط المدن الذكيـة – مراجعـة

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KEYWORDS

Geospatial technique, 3D modelling, Smart city.

ABSTRACT

Developing smart city planning requires integrating various techniques, including geospatial techniques, building information models (BIM), information and communication technology (ICT), and artificial intelligence, for instance, three-dimensional (3D) building models, in enabling smart city applications. This study aims to comprehensively analyze the role and significance of geospatial techniques in smart city planning and implementation. The literature review encompasses (74) studies from diverse databases, examining relevant solutions and prototypes related to smart city planning. The focus highlights the requirements and preparation of geospatial techniques to support the transition to a smart city. The paper explores various aspects, such as the advantages and challenges of geospatial techniques, data collection and analysis methodologies, and case studies showcasing successful implementations of smart city initiatives. The research concludes that geospatial techniques are instrumental in driving the development of smart cities. By analyzing and synthesizing the outcomes of the reviewed articles, this study establishes the essential contribution of geospatial techniques in successfully realizing the vision of smart cities.

الكلمات المفتاحية

التقنيـات الجيومكانيـة، النمذجة، المدن الذكية.

الملخص

يتطلب تطوير تخطيط المدن الذكية تكاملاً مع التقنيات المختلفة، بما في ذلك التقنيات الجيومكانيـة ونمذجة معلومات البناء (BIM) وتكنولوجيا المعلومات والاتصالات (ICT) و وتقنايات الذكاء الاصطناعي. ومن بين هذه التقنيات، تلعب نماذج البناء ثلاثية الأبعاد دوراً مهماً في تمكين تطبيقات المدن الذكية. تهدف هذه الدراسة إلى تقديم تحليل شامل لدور وأهمية التقنيات الجيومكانيـة في تخطيط وتنفيذ المدن الذكية. تشمل مراجعة الأدبيات (74) دراسة من قواعد بيانات متنوعة، وتفحص الحلول والنماذج ذات الصلة المتعلقة بتخطيط المدن الذكية. وينصب التركيز على تهيئة المتطلبات وإعداد التقنيات الجيومكانية لدعم التحول إلى المدينة الذكية. وتستكشف الورقة جوانب مختلفة، مثل مزايا وتحديات التقنيات الجيومكانيـة، ومنهجيات جمع البيانات وتحليلها، ودراسات الحالة التي تعرض التطبيقات الناجحة لمبادرات المدن الذكية. ويخلص البحث إلى أن التقنيات الجيومكانيـة لها دور فعال في دعم عملية تطوير المدن الذكية. من خلال تحليل وتجميع نتائج الدراسات التي تمت مراجعتها، تحدد هذه الدراسة المساهمة الأساسية للتقنيات الجيومكانيـة في تحقيق رؤية واهداف المدن الذكية بنجاح.

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1. Introduction

Smart cities are emerging as a promising solution for urban development in the face of rapid urbanization and environmental challenges. A smart city can be defined as "a city well-performing in a forward-looking way in six characteristics areas: economy, people, governance, mobility, environment, and living". Smart technological innovations and (ICT)infrastructures, such as the Internet of Things (IoT), big data, and cloud computing, make these possible (Bibri, 2022; Wang et al., 2019). In other words, a smart city leverages (ICT)to enhance its residents, promote economic growth, and optimize the utilization of resources (Abella et al., 2017).

Smart cities are rapidly emerging as a key concept in urban development, and geospatial techniques are becoming increasingly important in supporting smart city planning. Geospatial techniques involve the usage of geographic information systems (GIS), remote sensing (RS), global positioning systems (GPS), and other related technologies (Nashait et al., 2020; Wattan and Al-Bakri, 2019). "Geospatial data and technologies play a crucial role in smart city governance, planning, and management.

Geospatial data can provide valuable insights into various aspects of urban development, such as land use (Jasim et al., 2019), transportation, energy consumption, and environmental quality (Goodchild, 2000), and support evidence-based decision-making. Geomatics data is used to build geodatabase and measure, monitor, and model urban processes and systems (Kitchin, 2014). Therefore, it is essential to explore the geospatial techniques for preparing the requirements of smart city planning. Reviewing and reviewing the existing literature on this approach, gain insights into the state-of-the-art methods, tools, and challenges in using geospatial techniques for smart city planning. The following sections review key literature on the topic and discuss their main findings and contributions.

Urban planning, environmental simulations, navigation, disaster management, energy evaluation, and many more uses call for virtual 3D city models. Numerous application sectors for 3D city models and their requirements rely on information transcending 3D geometry and graphical features but require object categories, thematic attributes, and spatial and semantic relationships between objects (Yao et al., 2018). In this literature review, the focus will be on the utilization of geospatial techniques in the production of data modelling and data visualization, which are integral parts of planning a smart city, and planning professionals currently seek new methods for real-time simulations.

This study is an initial attempt to close the existing knowledge gap in the literature. The main objective of this research is to acquire a deeper knowledge to proceed with a comprehensive and up-to-date exploration of the utilization of geospatial techniques in preparing the requirements of smart city planning. The paper explores various geospatial technologies used in smart city planning, their applications in different domains such as transportation, environment, and disaster management, and the challenges and opportunities associated with using geospatial data in smart city planning. In particular, the following research question has been managed: Are the geospatial techniques basic or auxiliary techniques for smart city planning?

The remainder of the article follows: Section (2) presents the methodology with previous research. Section (3) details geospatial techniques in smart city planning. Section (4) discusses geographic data collection and analysis techniques. Geospatial techniques used in smart city planning are the subject of case studies in section (5). The paper presents results and conclusion in sections (6) and (7) and literature limitations argued in section (8).

2. The Methodology:

This study relied on a review of the relevant literature to identify trends and significant contributions made by geospatial approaches to the smart city. Figure (1) refers to the framework of methodology.

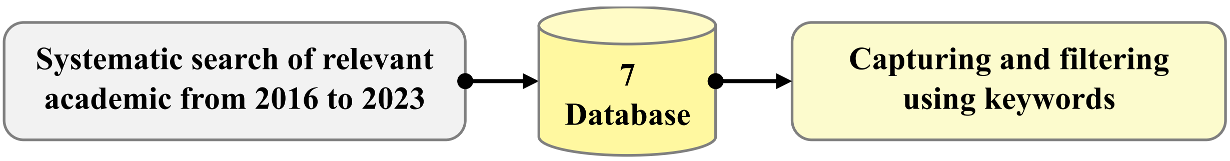

Figure 1. Framework of methodology (Source: Authors).

2.1. Academic Databases Elicitation:

This paper's methodology includes systematically searching relevant academic databases and journals, such as ScienceDirect (IEEE), SpringerLink (MDPI), and Tylor and Francis. The search terms included "geospatial techniques in the smart city," "3D modelling in smart city planning," "3D modelling accuracy in smart city planning," and "Stereo satellite images to produce 3D models." The search will be limited to articles published between (2016) and (2022) and subject to peer evaluation. The selected articles will have their main findings and recommendations summarized and synthesized based on their relevance to the topic and quality. The paper will conclude by discussing the major themes and trends identified in the literature and their implications for future research and practice in smart city planning.

2.2. Literature Collecting and Filtering:

The search entails gathering and filtering for each database because this survey focused mostly on studies that created specific procedures. The first review involved the Science Direct database from 2016 to 2023 using "smart cities" as a keyword that gives about 48420 articles discussing smart cities and their applications. Indeed, (2166) of these depend on geospatial techniques, which began increasing yearly, as shown in Figure (1). The second database adopted in this review was Springer Link data, and the findings were with the "smart cities" keyword about (2031) articles and (600) articles when using"geospatial technique and smart cities" as a keyword from 2016 to 2023، see Figure (2). Many other databases were also utilized, such as (IEEE), and (MDPI) with the same keywords, but almost all data were from Since Direct and SpringerLink databases

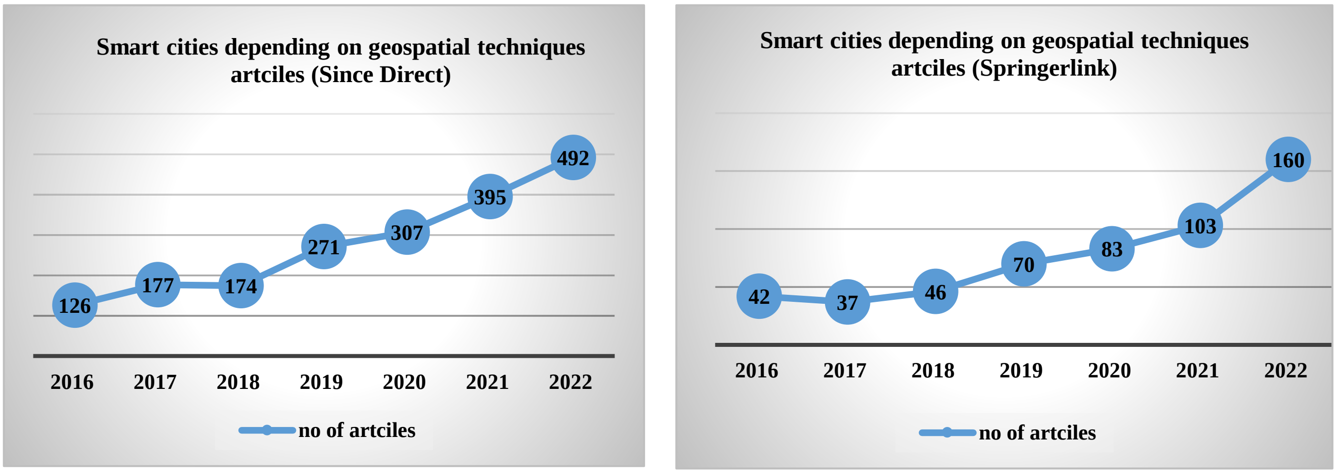

Figure 2. Articles numbers at Since Direct & SpringerLink between (2016-2022), (Source: Authors).

3. Geospatial Techniques in Smart City Planning:

Geospatial techniques use GIS, RS, global positioning systems (GPS), 3D modelling, and other related technologies for collecting, storing, analyzing, and visualizing spatial data (Aattan and Al-Bakri, 2020). These techniques are gaining importance in smart city planning because they can provide valuable insights into various aspects of urban development, including land use, transportation, energy consumption, and environmental quality.

In smart city planning, geospatial techniques can map, measure, monitor, and model urban processes and systems. For example, (GIS) can be used to map land use, zoning, and transportation networks, whereas RS can provide data on urban expansion, vegetation cover, and environmental conditions. The (GPS) can monitor and track traffic patterns, pedestrian movement, and fleet management. Another essential aspect of geospatial techniques in smart city planning is spatial analysis. It uses statistical and computational techniques to extract meaningful patterns and relationships from spatial data. This can be utilized to identify crime locations, predict traffic congestion, and model the spread of disease.

Overall, geospatial techniques have a wide range of applications in smart city planning, and their integration with other technologies, such as the Internet of Things (IoT) and artificial intelligence (AI), is expected to transform the way cities are planned, developed, and managed (Safari Bazargani et al., 2021).

3.1. Geospatial Techniques Roles in Smart City Applications:

The geospatial umbrella includes many sciences and tools, such as the GIS-BIM (Building Information Modeling). A GIS-BIM-based urban energy planning tool was suggested to assist in the design of smart cities. GIS can analyse the physical world by layering the information and integrating it with its position. It can give a detailed account of the community at multiple scales and dimensions of place and time. The 3D city model in GIS unifies research, the data of energy components, and related urban infrastructure (Yamamura et al., 2017). GIS technology stopped being restricted to the display of distinct forms of maps on fixed computers. Nowadays, it is a specific sector of the economy where different groupings of entities work together. The initial step is to use technological solutions, and the range of data sources that may be used in applying GIS technology in city administration can be identified according to their scope. These applications might be used to implement the idea of a "Smart City" in a specific city (Turek and Stępniak, 2021). To stay ahead of some of the advantages of GIS, varying amounts of data are supplied with The map of the designated region. The land use provides the colour codes assigned to the numerous plots. Building codes are tied to the appropriate plots in the case of developed and under-development facilities to make it simpler to integrate data on the GIS map with both the data from BIM models and the external database. (Marques-perez et al., 2020; Marzouk and Othman, 2020). Also, in RS data, which has long been used to simulate, plan, develop, and manage cities, different image contents are activated differently throughout the processing stage; many techniques can be used depending on the properties of the data itself then the feature map can be used to emphasize these differences (Li et al., 2020).

RS data is one example of traditional, authoritative information that big data typically complements. Big data may be voluntary, automated, or driven depending on the source, e.g., "passive" technological devices that can produce 2D or 3D (Mortaheb and Jankowski, 2023).

Smart cities connect local resources, governments, businesses, citizens, and tourists through smart environments and devices, which are crucial for data collection from resources and stakeholders and the delivery of a variety of smart services to stakeholders, such as smart energy, smart transportation, and smart health services. The services allow the parties involved to communicate with one another, and cooperation produces value (Lim and Maglio, 2018). Table (1) lists some of the studies on applications for smart cities and details how geomatics was adopted in each study. As demonstrated, studies have argued the utility of different geomatics techniques for creating smart city applications like GIS, RS, and others (Aina, 2017).

Table 1. Literature papers utilized geospatial techniques for smart city applications (Source: Authors).

ID	References	Smart City application	Geospatial technique		
			GIS	RS	GPS
1	(Khazael et al., 2023)	Smart environment		✓	✓
2	(Al-Habaibeh et al., 2023)	Smart Transportation		✓	
3	(Nefros et al., 2022)	Smart environment	✓	✓	✓
4	(Hilal et al., 2022)	Smart device			✓
5	(Dasari et al., 2016)	Smart building		✓	
6	(Yang et al., 2022)	Smart device		✓	✓
7	(Hashem et al., 2016)	Smart health, Smart Transportation, Smart governance	✓		
8	(Pluta and Mitka, 2019)	Smart environment, smart building	✓	✓	✓
9	(Johansson et al., 2016)	Smart environment, smart urban planning	✓		
10	(Zhu et al., 2022)	Smart urban planning	✓	✓	✓
11	(Lella et al., 2017)	Smart environment	✓	✓	✓
12	(Degbelo et al., 2016)	Smart urban planning	✓		✓
13	(Degbelo et al., 2016)	Smart urban planning			

3.2. Advantages and Challenges of Using Geospatial Techniques in Smart City Planning:

Improving geographic information delivery techniques can be considered one of the most important challenges for smart city development using geospatial techniques. Common objectives of big data use cases (e.g., district and building) are the analysis of data and delivery of designated information by geographic unit. Effective information visualization and delivery through GIS is a crucial success factor in utilizing big data in smart cities. Indeed, to increase information acceptance by residents, visitors, and employees, visualizations of information content in data-based smart city development projects should be clear and substantial (Hashem et al., 2016).

The citizen-related issues consider crucial challenges that impact the vision of the smart city. In this context, six challenges can be identified: the creation of convincing user interfaces, the need for open standards, the improvement of citizen data literacy, the pairing of quantitative and qualitative data, and the involvement of citizens. Hence, GIS applications help to address these issues. (Degbelo et al., 2016).

A smart, powerful, and efficient urban surveillance system is necessary for addressing prospective urban issues. The smart city approach, which employs sensor technology, IoT, and Cloud computing for surveillance and captures data in real-time on urban issues, is one solution easily applied, which will take a while and be relatively expensive to install sensors and IoT throughout the city (Supangkat et al., 2023).

Integrating BIM in settings like GIS is one of the most significant difficulties facing the urban spatial information community facing the urban spatial information community. One of the numerous challenges in properly realizing this kind of integration is geo-referencing data from the BIM domain, which is very important for the GIS industry. As a remnant from computer-assisted design (CAD), the latter usually used local coordinate systems, which provide models with no or inaccurate information about their actual geographic position (Diakite and Zlatanova, 2020).

Another key issue is the accuracy of 3D modelling, which is greatly impacted by the shadow of the buildings. Generally, GIS models can be used to do shadow calculations and other geographical studies (Park et al., 2021). These models have proven to be the most effective way to estimate solar potential (Machete et al., 2018). To cover the topic in detail, Table (2) summarizes some of the previous research, which involves the model used in fulfilling the 3D modelling and the accuracy of this model.

Table 2. Literature papers of smart cities to create 3D modelling method with accuracy (Source: Authors).

ID	References	Area of Interest	Publication Date	3D modelling method	Accuracy
1	(Jiang et al., 2022)	Beijing, China	2023	3D laser scanning point cloud data	99.5%
2	(Lowphansirikul et al., 2019)	Mahidol, Thailand	2019	Deep learning architectures: PointNet PointCNN SPGraph	 83% 72.7% 83.4%
3	(Ma et al., 2021)	Paris and Lille, France	2021	MS-PCNN model	97.2%
4	(Zhong et al., 2017)	Indian Pines	2017	spectral-spatial residual network (SSRN). Convolutional neural networks (CNNs)	99.61% 97.08%
5	(Liu et al., 2023)	Zhangzhou, China	2023	Multi-Source 3D Data Quality Evaluation Network (MS3DQE-Net)	88.7%
6	(Münzinger et al., 2022a)	Dresden, Germany	2022	Object-based image analysis (OBIA)	95.5%
7	(Viana-Fons et al., 2020)	Valencia, Spain	2022	3D vector-based city model. Analytical shadow model	98%
8	(Cao et al., 2020)	Brooklyn, New York City, USA	2022	Multi-scale 3D building (MS3DB)	92%
9	(Münzinger et al., 2022b)	Dresden, Germany	2022	Object-based image analysis (OBIA)	95 %

Utilizing geospatial technology in smart cities is a potential case for integrating other IoT tools and systems. The range of data visualization options and the potential for community building around joint ventures consider guidelines for controlling the city's logistical systems (Turek and Stępniak, 2021). Developing geospatial big data and integrating it with ICT is crucial for developing smart city applications (Bibri and Krogstie, 2017).

GIS tools can enable the simultaneous integration and display of pertinent information. For instance, details on the municipality's local map, such as the location of the rescue teams, field hospitals, and mobile medical facilities, and the spatial distribution of emergencies. Also, other helpful data may be contributed to the map, such as reports of people who went missing during the natural catastrophe and the corresponding images. The government can use these maps in operation centres to efficiently manage the disaster response teams or make them available to the public via portals. As a result, the stakeholders can better address the natural disaster while the citizens gain direct access to crucial and reliable information (Nefros et al., 2022).

Utilizing citizen reviews submitted via mobile devices, Mobile crowd-sensing (MCS) is a technique used to retrieve and collect information in urban areas (Zhang and Yang, 2016). Since all data and information are gathered from community members or citizens, MCS implementation in data collection from the field is relatively quick and inexpensive (Vahidnia et al., 2020). Using the Digital Geo-based platform, The collected data and information from the community are combined and visualized. The ability to depict and reproduce actual urban conditions in the real world in a 3D virtual environment is a benefit of Digital techniques. This contrasts with other platforms primarily based on text and GIS in 2D. The quality of planning and policymaking for stakeholders is also anticipated to improve using the Digital Geo-based platform (Saad et al., 2023).

4. Geospatial Data Collection and Analysis Techniques:

The acquisition and analysis of geospatial data are essential for smart city planning. It involves collecting and analyzing tangible and built environment data, such as the location, size, shape of structures, infrastructure, and natural features. This information is then used to inform decision-makers regarding the safe and efficient design and management of urban environments.

4.1. Techniques for collecting geospatial data.

The term geospatial information refers to geospatial data that has been processed to make it possible to use it for supporting planning, decision-making, and a variety of relevant location-related tasks. Geospatial data are usually acquired from various sources using various techniques over different periods, at various levels of detail, and based on various models concerning geometry and semantics. As a result, users struggle with data heterogeneity (Gröger and Plümer, 2012). Several geospatial data techniques, including land survey, photogrammetry, and RS employing very high-resolution satellite imaging, LiDAR (Light Detection and Ranging) mapping (Zakariya Jasim, 2019), Geo-IOT data acquisition, field surveying and crowdsensing participants, and UAV photography, can be used to create usable geospatial information (Zhang et al., 2021). Each of these approaches has its advantages and disadvantages. For instance, a terrestrial survey yields high-precision results at a time and cost expense.

Geo-IOT data was gathered to facilitate the seamless fusion of high-precision spatial data, real-time location data, sensor data, and social media data into various Geo-IoT application services for smartphones, IoT devices, and 5G wireless communication technologies. Geo-IOT application development for Smart City and LBS application services has been active until now. Smart city services that integrate, visualize, and analyze sensor data, location data, and spatial data collected from the environment, infrastructures, water resources, traffic, and electrical grids and regulate them in real-time have received a lot of research (Kim, 2018). Currently, the most dependable method for mapping vast areas with accurate 3D data combines LiDAR with photogrammetry. Due to their portability and simplicity of use, UAV photographs also receive much attention (Sutanta et al., 2016). However, 2D centre axis data, satellite photography, and elevation data are combined to automatically create a realistic 3D model (Wang et al., 2021). On the other hand, the same data source has different properties depending on its resolution. For example, infrared cameras can estimate the density of individuals with low resolution or quantity with high resolution, which could be useful in designing security systems for managing and monitoring crowds in smart cities (Al-Habaibeh et al., 2023). Despite the advantages and disadvantages of each data collection technique, the availability of geographic information is crucial, regardless of the technology used to produce it.

4.2. Geospatial Data Analysis Techniques for Smart City Planning

The world's knowledge has improved due to the rapid rise of the geospatial data industry over the past few decades (Akylbekov et al., 2022). Geospatial data-derived insights and technologies address many complicated issues, from improving fuel economy by tracking logistical networks to creating cities prioritising sustainability (Wu and Biljecki, 2023).

Data analysis techniques can be used to identify patterns and trends in data, make predictions about future events, and inform the development of policies and strategies (Biljecki et al., 2016), (Barzegar et al., 2021). RS data can be considered one of the best and most useful ways to track how land cover changes as cities grow. However, making significant spatial and temporal changes is important to get up-to-date and correct information on urban land cover changes. This can happen depending on two main methods: classification and analysis (Chai and Li, 2023).

GIS is an important geospatial data analysis technique for smart city planning and analysis. It is a computer-based tool for representing, storing, analyzing, and managing geospatial data at multilevel, including city and rural (Khan et al., 2023). Collaborative between BIM and GIS can assist in obtaining an accurate analysis. In many studies, GIS refers to the macro details, while BIM refers to the micro details. The BIM/GIS integration can help different fields of analysis for smart cities and solve real-world problems. Three ways can be adopted to convert and integrate data from GIS to BIM and from BIM and GIS to a third system (Xu et al., 2020; Zhu et al., 2022). Nevertheless, using free and open-source GIS tools together with 2D and 3D tools that integrate effectively will assist in getting a high-resolution spatial analysis (Guillemot et al., 2023).

Machine learning is an AI that uses algorithms to analyze and interpret data. This technique can be used to identify patterns and trends in large datasets, make predictions about future events, and develop models that can be used to inform decision-making (Tuia et al., 2021),(Nsubuga et al., 2021).In smart city planning, machine learning can analyze traffic patterns, energy consumption, and other aspects of urban life (Bill et al., 2022). Geospatial information processing combines the knowledge and information outputs of several scientific disciplines, including photogrammetry, RS, cartography, engineering geodesy, and spatial observations in geography and environmental sciences, to produce structured information, maps, and other tools for human communication. Computational geometry, artificial intelligence, machine learning, and semantic technologies are some of the areas of computer science that have been modified and improved in an engineering-focused approach, in addition to software and technique development. (Xiong et al., 2021).

5. Case Studies of Geospatial Techniques Preparation in Smart City Planning:

The 3D geographic data set, models, and descriptions of their associated information serve as the reference and must be updated under the criteria. Based on needs and requests, more 3D spatial data must be provided. Extreme caution must be exercised while describing 3D spatial data and the related models. Decision-making processes can only be facilitated in this way. The case studies of several cities that used geospatial data and methods in smart cities are compiled in Table (3). All these studies demonstrated the importance of geospatial data, which can be collected using many sources, to create and build 3D modelling to offer a clear sight of urban land development and related changes.

Table 3. Case studies of smart cities utilized geospatial techniques (Source: Authors).

ID	References.	Area of Interest AOI	Description
1	(Themistocleous et al., 2021)	Choirokoitia, Cyprus	The case study demonstrates how to detect and analyze geohazard-induced ground deformation using SAR ground motion data and field survey methodologies for cultural heritage applications. Satellite location and conventional surveying techniques were used to measure micromovements in SAR data, whereas UAV and photogrammetry were utilized for documentation and 3D modelling comparisons. As the PSI analysis and GNSS control network of the Choirokoitia site exhibited comparable levels of displacement, there is a correlation between geodetic techniques and SAR images, indicating that longer-term site surveillance is necessary to assess the severity of the issue. Also, the movement of geohazards at impacted cultural heritage sites

			can be tracked using the local scale monitoring methodology to find the best method for mitigating and preserving these sites.
2	(Schrotter and Hürzeler, 2020)	Zurich, Switzerland	This study applies the City of Zurich's digital twin to processing significant geographical data. Buildings, bridges, vegetation, and other city-related topics are transformed into the digital domain using 3D spatial data and their models. With the addition of 3D spatial data and associated models, the existing spatial data infrastructure is enhanced and explained, and the construction and tracking processes are described holistically. The 3D geographic data will serve as the standard for more spatial data and data, and because they are interconnected, the virtual world becomes more and more like the real one. Communication is crucial, and to encourage distribution and the development of new applications, spatial data must be presented appealingly and effectively for various interest groups. Data access and ordering must be automated, and data processing and search must be easy and appealing.
3	(Morosini and Zucaro, 2019)	Gozo	This paper seeks to further the discussion of urban and land management, considering that urban built-up regions will occupy 700,000 km2 of the planet's surface by 2030; methods, techniques, and tools must be created to make sure anthropogenic changes are consistent with the natural properties of the soil resource to assist local decision-makers in enhancing land management. The proposed 3D GIS-based methodology has identified the most optimal areas for urban transformation based on the presence of residents, tourists, and services, as well as public transportation accessibility. When used to analyze the entire island of Gozo, the suggested methodology can, in theory, produce a preliminary visualization of the built-up areas that are most receptive to change, highlighting the high degree of transformability for both their physical and functional qualities. Healthcare facilities could be found in "transformable" developed areas in all three cities under consideration (Xlendi, Marsalforn, and Victoria), and local market presence may be strengthened, especially in Xlendi and Marsalforn.
4	(Judge and Harrie, 2020)	Stenkrossen and Råbykungen in Lund, Sweden	The project aimed to increase public participation in urban planning by creating detailed development plans (DDP) visualization. Developing cartographic standards, evaluating a technique for mapping uncertainty in the DDP, and discussing the advantages of interactive web-based 3D DDP visualizations for public involvement comprised the three components. The case study's conclusions are supported by semi-structured interviews with four GIS and urban planning specialists. There is proof that 3D visualizations improve layperson communication, which is one strategy to increase public engagement. The importance of developing 3D renderings of DDPs has grown as various aspects of Sweden's construction industry have been improved through standardization and new technologies. The study's map principles offer a solid framework for developing 3D DDP in Sweden.
5	(Qiao et al., 2019)	Nanjing City, China	To carry out qualitative and quantitative studies of the multi-dimensional expansion of urban space, this study first creates multi-temporal, three-dimensional urban models utilizing RS and GIS technology. Then, it uses plot ratio change maps and the MEUS quantitative index for built-up regions (MEUS). With a focus on volume growth contribution rate, this article examines the features of MEUS at various phases. The approaches used in this paper are educational and relevant to MEUS research, and they broaden the research perspective on urban spatial expansion. The results of this study will also help with empirical decision-making for land use management and urban planning, as well as improve comprehension of MEUS legislation.

6. Results:

The reviewed papers used geospatial techniques and information about smart city planning and producing 3D models. To highlight how researchers have used these techniques and their role in smart cities, three domains as a portion of systematic analysis were explained and discussed in detail. Firstly, the review highlighted 13 studies in our sample that fell within the role of geospatial techniques in smart city planning, listed and classified according to smart city application. The use of geospatial techniques and subsequent paragraphs include the advantages and challenges of utilizing geospatial techniques. List nine studies focusing on the 3D modelling type and its accuracy to highlight the challenges of using geospatial techniques. Secondly, the review included geospatial data collection and analysis methods with citations to the latest studies. Lastly, the paper highlighted five case studies of smart cities with descriptions and findings of this research.

7. Conclusions:

The main contribution of this literature review study is the development of knowledge and frameworks for geospatial techniques used in smart city planning, as well as the answer to the question of the role of geomatics as a base or auxiliary technique for smart city planning implementation. In comparison with many articles in the literature review argue smart cities from the viewpoint of AI development, IOT, cloud storage, monitoring, planning, decision-making, etc., this review focuses on the requirement of building 3D modelling of smart city planning, which highlights the first steps of smart city creation and the importance of geospatial data. An empirical approach was used to identify such findings by analyzing the existing use of vast geomatics techniques for smart cities and demonstrating that: (1) Geomatics techniques can aid in creating intelligent cities.; (2) Additionally, geomatics techniques can support smart cities by significantly enhancing the digital city dimension, particularly the urban information infrastructure.; and (3) The governance aspect of smart cities can profit from big geomatics techniques. However, the great role provided by geospatial techniques remains insufficient to transition to smart cities, which requires merging and integrating other basic elements such as BIM, ICT, and AI.

8. Limitations:

The limitation of this study was the difficulty of extracting the methods and type of geodata used to build and create the 3D modelling, which is the most articles that demonstrate the smart cities application.

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