Babylonian Journal of Networking
Vol.2025, **pp**. 143–153
DOI: https://doi.org/10.58496/BJN/2025/013; ISSN: 3006-5372
https://mesopotamian.press/journals/index.php/BJN

Research Article

Optimizing 3D Model Visualization over Wireless Networks for Responsive Web Applications

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ARTICLEINFO

Article History

Received 20 Jul 2025
Revised 18 Aug 2025
Accepted 16 Sep 2025
Published 25 Oct 2025

Keywords
3D Visualization,
Wireless Networks,
Responsive Web,
Procedural Modeling,
CGA,
MATLAB,
CAD,
GIS.

ABSTRACT

In the era of interactive experience and immersive technology, rendering 3D model in responsive web applications must be made efficient, especially over wireless networks with varying bandwidth and latency restrictions. Older platforms, in particular, tend to have a hard time rendering high compression rate 3D polylines (such as point clouds and geometric meshes) that result from sophisticated processes such as LiDAR scanning, digital photogrammetry, and reverse engineering. Such models are getting larger and more detailed and can put heavy computing pressure on rendering engines and network transmissions. In this paper, we present a lightweight, low-cost 3D visualization framework for web-based application based on the procedural modeling. The Engine is based on MATLAB and makes use of rule-based algorithms for the generation of 3D structures, and an own CGA (Computer Generated Architecture) module, which allows dynamic geometry creation. Our approach efficiently preprocesses and streams 3D data, enhancing its rendering quality and user experience. In addition, it overcomes the restrictions in existing visualization pipelines through adaptive rendering according to client-side capabilities and network conditions. The developed system is a precursor to web-based GIS, CAD and remote visualization in low resource environments.

1. INTRODUCTION

The advancement of web technologies, virtual reality (VR) technologies, 3D graphics has changed the way users interact with spatial, and digital content. Today, interacting with these complex 3D spaces can be done in a web browser without need of expensive hardware or installation of specialized desktop software; all that is required is a modern browser and support for WebGL and HTML5 to support real-time 3D rendering and interaction over wireless networks [1-3]. By using 3D to explain social phenomena, it is being democratized, opening it up to a wider audience and broadening understanding in domains such as urban planning, architecture, cultural heritage preservation, and geographic information system (GIS). 3D models not only provide more immersive visualization, but also act as integrative platforms that enable cross-disciplinary cooperation. For example, physical heritage (using LiDAR, UAV photogrammetry, and laser scanning) can be converted into 3D models in which users can interact with for documentation, diagnostic, conservation, and disaster risk reduction. These models inherently integrate spatial, textual, and analytical data, fostering enhanced cross-disciplinary research and education [4]. The appeal of 3D visualizations is the intuitive geometry and relation to physical objects of interest, which makes complex data accessible for domain experts as well as non-experts. In view of the rapidly advancing research of 3DV based on GIS, especially the research for constructing smart cities, the sense of the reality for 3DV of the city plays a major role and the requirements for rendering a dynamic city online in real time are increasing. 3D Models in Web The global need for 3D building models—those defined with as a whole variety of data points such as outlines, texture, and semantics—is increasing. With 3D building models becoming the baseline datum in a host of industries and government departments, it is vital that agents can simulate new scenarios and proposals, with as real-like and accurate 3D models as possible [5]. It is possible to run analyses and simulations visually on proposed developments, drastically speeding up decision-making and identifying overlooked datasets and research holes. You could, for instance, drop a proposed structure into a 3D model of a city to measure its effect visually,

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how it aligns with existing infrastructure, and how benignly or disruptive it is in real time. Despite the benefits such representations afford, large-scale 3D model rendering is still computationally expensive, particularly in bandwidth constrained wireless networks. Hence, the main goal of this study is to enhance 3D model streaming on wireless networks using a web platform and to make navigation lightweight on the web [6]. This will involve the use of procedural/modelling generation tools (e.g., using the CGA module; implemented in MATLAB) to create models automatically, based on dynamic rule-based inputs. It is our goal to show that advanced 3D visualizations can be streamed interactively and efficiently to the web while at the same time maintaining a good level of user experience despite wireless network limitations.

2. RELATED WORK

Many analytical projects and works have focused on the design and enhancement of web-based 3D model visualizing tools. Important research work includes works that compared WebGL-based frameworks such as [1-4] concerning the quality of rendering, performance and integration with real-time physics engines and with interactive interfaces. Procedural modeling, photo-realistic texturing, and dynamic lighting have been studied in several academic theses with use of techniques to obtain screen space ambient occlusion (SSAO) and ray casting [2], [3]. For example, in a master's thesis at Uppsala University, web-based 3D gaming with realistic physics was investigated. Another study focused on ambient occlusion and procedural environments through SSAO, paying special attention to its real-time performance for depth estimation [2]. In the same way, to the best of our knowledge, there is only one bachelor's thesis carried out in South-Eastern Finland which focused on photorealistic texturing in real-time simulations where methods such as normal, light and reflection maps were applied to game scenarios [3]. 3D visualization is also used in commercial leagues. For instance, IKEA's web-based planning tool facilitates in the drag and drop interior design, which exhibits high usability but lags in mobile support owing to its dependence on plug-ins [4]. Open-source demos using in [5] and [6] offers interactive control of lighting and object properties with high-end rendering. Likewise, the framework [7] models enable complex models with physically-based rendering and reflection maps using the format. The literature in general emphasizes that a general trend has been the evolution towards lightweight 3D rendering, web-based platforms that reduce computation needs, without compromising interactivity. However, to the best of our knowledge, very few papers exist that addresses the optimization of 3D visualization across wireless networks, especially under some constraints such as bandwidth or delay - that was the motivation of this study. As present in the Table 1.

TABLE I. SUMMARY OF RELATED WORK IN 3D WEB VISUALIZATION

No.	Study / Project	Focus / Contribution
[1]	Uppsala University Master's Thesis	Compared WebGL libraries (Three.js, Physi.js) with game physics integration.
[2]	Linköpings University Thesis	Examined ambient occlusion & procedural settings (SSAO, ray casting).
[3]	South-Eastern Finland Bachelor's Thesis	Explored photorealistic texturing in real-time game rendering.
[4]	IKEA Web Planner Tool	Interactive drag-and-drop 3D space planner (limited by plug-in support on mobile).
[5]	Three.js Lighting Demo	Showcased GUI lighting controls, realistic textures, and 3D interactions.
[6]	Babylon.js 3D Scene	Used physical-based rendering; demonstrated stability and flexibility.
[7]	Xeogl.js Helmet Model	Visualized complex geometry using reflection maps and glTF standards.

3. COMPUTER GRAPHICS AND GIS

Computer graphics is a fundamental building block in digital modeling and representation, especially in the context of domains such as architecture and GIS [6]. The design process often consists of two main steps: modeling (constructing digital models of the spatial elements), and rendering (presenting models for analysis and decision making) [7]. When designing landscapes and buildings, including 3D model can also improve comprehension of the spatial, aesthetic, and functional aspects of proposed developments. Contrary to the standard 2D (e.g., maps and plans) images, 3D visualization allows for immersive way of presentation of data and information, notably through inclusion of web technologies [8]. This is vital for sharing Machina spec designs and rapidly iterating on designs in real-time with architects, urban designers, and stakeholders. CG integrated GIS environments support accurate modelling, visualization and presentation of geographic phenomena. For example, 3D GIS combines attributes and geometry to model realistic environments in planning and visual control [9]. Thanks to WebGL and technologies, the visualization is consistent and runs across Web browsers, providing good accessibility via wireless nets [10]. Additionally, these representations are useful for conveying design intent and enabling stakeholders to remotely review, annotate and propose changes. Through the application of immersive 3D models, projects become transparent and inclusively participative at each stage of its realization. Table 2 Summary of key concepts in computer graphics and GIS.

TABLE II. SUMMARY OF KEY CONCEPTS IN COMPUTER GRAPHICS AND GIS

No.	Concept	Description
1	**Modeling**	Digital construction of spatial objects for GIS or architectural projects.
2	**Rendering (Representation)**	Graphical visualization of models using lighting, materials, and textures.
3	**2D vs. 3D Graphics**	2D maps are common; 3D adds realism and interaction capabilities.
4	**GIS Integration**	Combining spatial attributes with 3D models for urban and landscape analysis.
5	**Web Visualization**	Real-time 3D display using WebGL and glTF formats across browsers.
6	**Collaboration & Feedback**	Enables remote evaluation and cooperative design decisions.

4. THREE-DIMENSIONAL COMPUTER GRAPHICS

Three-dimensional (3D) computer graphics are an essential part of today's architectural, GIS, and web-based visualization scenarios. Computer-based modeling and representation including manual ones (such as physical models or hand-drawn perspectives) [11] are the scope of this research. 3D modeling mainly starts with blueprints or CAD data, which are used to build geometric models in computer. In modeling operations, the object geometry is created by specifying its location in space in the X, Y, and Z dimensions and its corresponding dimensions in height, width and depth [12]. The result will usually be a wireframe or mesh of vertices, edges, and faces that will be joined to create solid surfaces as a representation of the volume of the object. After modeling stage is done, it represents -or render- this data into such a form that can be seen and interpreted. Although 3D, these visualizations are typically observed on 2D screens. But these allow for improved spatial insight through virtual tours, animations, or interactive web viewers [13]. Following is a compilation of methods including those of photo-montage, position of a virtual camera and generation of a scene that are used to produce realistic scenes. Perspective types like linear, cavalier, and natural views assist in depicting depth and spatial relations properly [14]. In the real estate and architectural space these tools are crucial for client presentations, spatial validation and stakeholder interaction. Additionally, materials, textures, and lighting need to accurately represent their real-world properties to ensure that what is expected in the digital world is consistent with what would be expected from reality. This comprises placing the model in realistic dimensions, in life scale and context-specific (e.g., vegetation, furniture or façades) [15]. Table 3 Key concepts in 3d computer graphics for web-based visualization.

TABLE III. KEY CONCEPTS IN 3D COMPUTER GRAPHICS FOR WEB-BASED VISUALIZATION

No.	Concept	Description
1	3D Modeling	Digital construction of object geometry using X, Y, Z axes.
2	Mesh/Wireframe	Structure composed of vertices, edges, and faces.
3	Rendering (Representation)	Visual transformation of 3D models using textures and lighting.
4	Perspective Views	Techniques for depth simulation (linear, natural, cavalier).
5	Visualization Techniques	Photo-montage, animations, virtual tours using CAD/WebGL tools.
6	Web-Based Integration	Viewing 3D models interactively via browsers using lightweight formats.

5. RESEARCH METHODOLOGY

To this end, this work applies a Design Science Research (DSR) methodology to build a framework to enhance the visualization of 3D models for responsive web-based environments, specifically for use in urban management and decision-making with Web-GIS and CAD-based modeling. The main goal is to develop 3D modelling and parameter extraction methods for the use of regional planning and practical urban planning in a GIS environment. The ability 10 of 3D modeling-derived parameters, e.g., building height, volume, area, terrain shape and infrastructure 11 layout, to better understand spatial complexity, which is in turn necessary to support planning decisions 12 [15].

5.1. Design Science Research (DSR) Framework

In this paper we use DSR in order to selectively combat real world and scientific problems and to produce artifacts that solve real problem of the world while they support progress on the theory level. DSR in this situation can be decomposed in structured phases as follows:

a) Problem Identification: The first step on the research is the identification of the problems on workflow of 3D modelling in web-based system for GIS, such as well-known challenges related to management of spatial complexity, low-bandwidth and user interaction.

b) Artifact design: The development of an artifact, the Web-GIS integration guideline was conceived. This would involve algorithms, simplified modeling techniques and interface strategies designed for real-time 3D visualization and spatial analysis in an interactive web space.
c) Artifact Building: The designed guidelines were realized in CAD and MATLAB, embodying procedural modeling methodologies. The build phase centered on 3D visualization of the Sadr City, Baghdad urban development with 3D dimensions integrated into a web-based interactive application.
These assessments establish the artifact's pragmatic validity, which refers to its usefulness and performance when used in real tasks [16, 17].

5.2. Implementation and Case Study

For grounding the obtained results, the proposed method was experimented on Sadr City, a populated Baghdad district.
The following were enabled through the incorporation of 3D models with the Web-GIS Utilities:

a) An accurate extraction of spatial parameters.
b) Real-time control over wireless networks with urban models.
c) Visualizations to help inform zoning, infrastructure and open space distribution decision-making.

Through bibliographic analysis, experimental modeling, and validation of their practical use, we aimed to formalize a methodological artifact that maximizes the visualization of 3D models over the web subject to technical and contextual constraints [18-20].

5.3. Research Steps

When it comes to conducting an SLR on the 3D model of the GIS system, the following process could be done: Formulation of the Research Question: Clearly state the research question or objective of the SLR. For instance, the research hypothesis could be: "What are the methods of 3D modeling techniques in GIS?" Search Strategy It is necessary to establish a sensitive search strategy in order to find all relevant studies. This process generally consists in searching several electronic databases (i.e., IEEE Xplore, ACM Digital Library, Scopus, etc.) and performing manual searches of key journals, conference proceedings, and other pertinent sources. Search words need to be judiciously selected to include related concepts, for example "3D model", "GIS", "methodology" and similar topics. Boolean terms (e.g., AND, OR) can be used to optimally combine these terms. Inclusion/Exclusion Criteria: Specify the criteria used to include or exclude studies in the review in relation to the research question. Within the SLR on 3D modeling in GIS field, we could use inclusion criteria – a focus on methodology development, case studies, comparisons of different approaches, and evaluations of 3D modeling techniques in GIS. Exclusion criteria may include articles not related to 3D modelling or GIS, articles with insufficient methodological details and articles published in a language other than the language of the review. Selection of Studies: The studies identified would be screened by their title, abstract, and full text (if applicable) to judge whether or not to include each study. Reliability and bias assessment Two or more independent reviewers should judge each report as relevant or not relevant compared to the beforehand defined inclusion/exclusion criteria. In case of disagreement, consensus can be established by discussion or involving a third reviewer. Data Extraction: Create a standardized data extraction instrument to abstract data from the studies included. Information can range from the purpose of the study, to the study's methods of research, types of software used, nature of the GIS data, structure of the process of 3D modelling, and the outcome of such methodology of its application in a GIS context. Data extraction can be performed independently by more than one reviewer for increased accuracy. Synthesizing the Evidence: Interpret the extracted data to search for associations and derive commonalities in the findings from the included studies. This may entail qualitative synthesis, quantitative analysis (eg, meta-analysis where appropriate) or a combination of these. The summary should cover the research question and also indicate access to methodologies in generating 3D models in GIS. Tables, figures or diagrams can be used to make the work clearer and to summarize the findings. Quality Assessment Assess the quality of the study in your systematic review (research design, sample size, data sources, bias). The methodological quality of the included studies can be tested using quality appraisal instruments like the Newcastle-Ottawa Scale or Risk of Bias Tool [26-30]. Reporting: Record the process of SLR, such as search strategy, selection of study, method of data extraction, method of synthesis and the result of quality assessment. To enable transparency and reproducibility, produce a full report, consistent with existing guideline for conducting systematic reviews (e.g., PRISMA guidelines). In this way, a systematic literature review enables a comprehensive analysis of the methods that are employed towards the development of 3D models in GI, adding significant value to academics, professionals (e.g., GIS analysts, surveying professionals) and decision-makers in the area. For the systematic identification and analysis of the methodologies applied to developing 3D GIS models in Web-based environments, a Systematic

Literature Review (SLR) was performed. This method guarantees a comprehensive, impartial, and replicable method of synthesizing published studies. The purpose of the study was to investigate practices, tools, technology, and obstacles in the effective application of 3D models to GIS (Geographic Information System) in general, and in particular to web responsiveness and web integration. The key steps performed during the SLR process are discussed in Table 4:

TABLE IV. SUMMARY OF SYSTEMATIC LITERATURE REVIEW (SLR) STEPS

Step	Research Activity	Description
1	Defining the Research Question	What methodologies and technologies are used in developing 3D GIS models for web-based visualization?
2	Search Strategy	Comprehensive database search (IEEE Xplore, ACM Digital Library, Scopus), using Boolean search terms like “3D model” AND “GIS” AND “web” AND “methodology”.
3	Inclusion/Exclusion Criteria	Inclusion: Studies on web-based 3D GIS modeling; Exclusion: Non-GIS or 2D-only studies, non-English papers.
4	Study Selection	Screening of titles, abstracts, and full texts using eligibility criteria; multiple reviewers to minimize bias.
5	Data Extraction	Standardized form capturing study objectives, tools used, modeling techniques, and key outcomes.
6	Data Synthesis	Thematic analysis to identify common trends, technical approaches, tools used, and performance metrics.
7	Quality Assessment	Evaluation using checklists (e.g., PRISMA or Newcastle-Ottawa) to ensure methodological rigor.
8	Reporting	Documentation of methodology, synthesis results, and conclusion using SLR best practices (e.g., PRISMA flow diagram).

6. EXPERIMENTAL STUDY

Experimental phase This section describes the experimental phase of the work seeking to develop and test a 3D GIS-based urban modeling framework using the WEB-GIS tools along with MATLAB. The aim was to collect spatial-structural parameters of a real urban area — Sadr City, Baghdad — for urban decision-making and simulation. The inductive methodology of the work is comprised of data collection, classification, algorithm implementation and visualization according to the procedures of procedural modeling and Design Science Research (DSR).

6.1. Initial Data Acquisition and Processing

The experiment started with processing and refining the georeferenced spatial data obtained from the Smart City Project and the Access to Urbanized Land Research and Extension Center (2020). The data set included shapefiles of the urban fabric in Baghdad, which includes neighborhoods, lots, buildings, as well as street network (Figure 1).

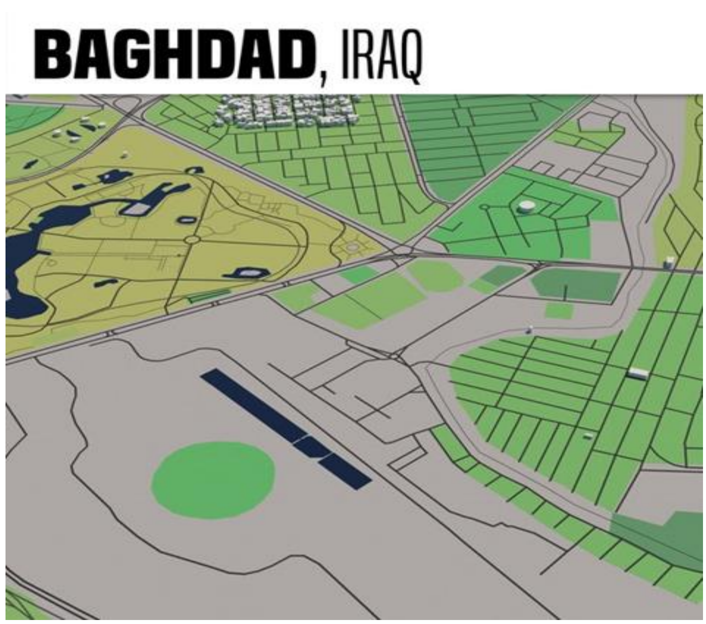

FIG. 1. SHAPEFILES BEFORE SELECTING THE STUDY AREA

To isolate the study area—Sadr City—non-relevant features from others regions were filtered out by utilizing QGIS software. The generated shapefiles correspond to Sadr City only in terms of boundaries and components, to better facilitate available dataset for analysis (Fig.2).

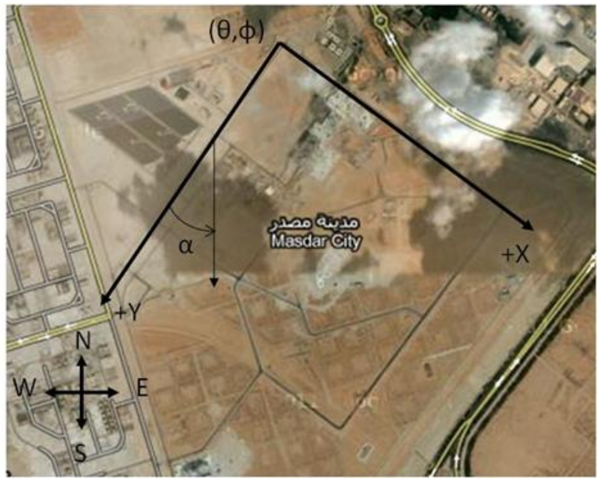

FIG. 2. SHAPEFILES AFTER SELECTING THE STUDY AREA

6.2. Building Categorization and Visual Encoding

The final shapefiles were loaded into MATLAB in which the buildings were visualized and classified according to the number of floors. The work involved confirming fire-origin dates via GoogleEarth and ground-truth field verification in June–July 2022. Each building was assigned four-colored code (white, yellow, orange, red) corresponding to number of floors, which facilitated the spatial visualization of vertical density of the neighborhood (Figure 3). This classification served as the basis of parameter-setting modelling.

FIG. 3. SHAPEFILE INTEGRATION WITH MAP

6.3. Algorithm Development Using CGA and MATLAB

The modeling backbone was then generated via custom-built Computer-Generated Architecture (CGA) scripting embedded in the MATLAB environment. CGA is a rule-based procedural modeling language suitable for buildings and interior designs. The algorithm provided a flexible control over the building features as follows:

a. Number of floors
b. Ceiling should be from floor to ceiling
c. Total built-up area
d. Footprint and surface projection area

The MATLAB interface was used to apply the CGA rules (Figure 4). Our current model did not consider an architectural feature such as doors or windows, but it posed a viable framework that is easily expandable for future developments.

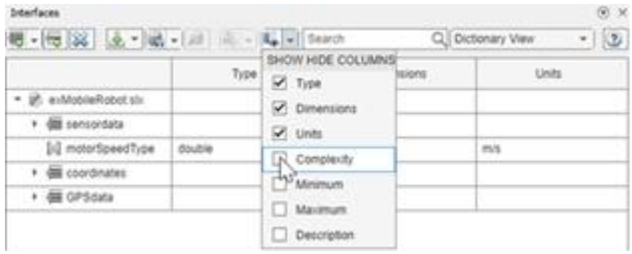

FIG. 4. CGA EDITOR INTERFACE.

6.4. MATLAB Tools and Techniques

The work was carried out in a scripting language environment using MATLAB as the primary development and analysis platform which provided tight integration with geospatial data and visualization. The following steps were executed:

- Load GIS Data: Shapefiles and satellite imagery were loaded for processing in Mapping Toolbox.
- Preprocessing: noise thresholding, local-maxima detection and coordinate matching were implemented with matrix manipulation and internal image functions.
- Image Analysis: Point clouds, profiles and surfaces were constructed for elevation and area-based measures.
- Model Application: Procedural generation of 3D building from input arguments was supported through customized scripts.
- Visualization: 3D surface representations and structure renderings were used for the visualization of parameter distributions in space.
- Export and Integration: the final models in the end were exported for use in WEB-GIS platform and the urban planning simulations.

6.5. Final Remarks on Experimental Phase

This experiment proved that the integration of WEB-GIS and MATLAB would apply to the parameter-driven urban modeling. The methodology showcased that it is feasible to simulate urban dynamics with open dynamics geospatial data and interactable, scalable visualization tools. The tool can act as a decision support tool and can be applied to other case studies and cities with little adaptation.

7. RESULTS AND DISCUSSION

7.1. Web-GIS Integration Guidelines

The marriage of web technologies and GIS serves as a key building block in making spatial data meaningful. This combined vision increases city planning, infrastructure development, and civil engineering problem solving skills. Previous related literature tends to focus on two dimensions in WEB-GIS integration:

a) The GIS portion deals with exact georeferencing and spatial mapping of the study areas.
b) The WEB part, that enables on-line access and visualization and provides user interactivity with the mapped environment (see Figure 5).

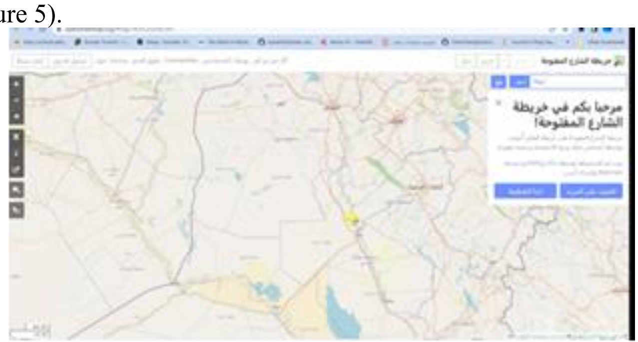

FIG. 5. WEB-GIS INTEGRATION GUIDELINES

The approach started from obtaining the shapefiles of Sadr City, and through GIS tools, the data extracts only the needed geospatial items, such as lots, buildings, and roads in Sadr City. This preprocessing step helped reducing the model complexity and ensured computational efficiency during the final modeling phase.

7.2. Data Processing and Synchronization

The processed shapefiles were then loaded into MATLAB, and were overlaid on top of satellite images and base maps for the region. An analysis was performed to estimate the number of floors in each construction. This process relied on:

a) Field visits (June–July – 2022),
b) Visual predictive check, Google Earth visual evaluation
c) Application of textured color for floor counts (yellow shades for example in different elevations).

This categorization also created a visual representation of the vertical density of houses across the neighborhood that was used for 3D modeling.

7.3. 3D Modeling and Algorithm Development

Selected key modeling parameters at his point were as follows:

a) Built-up area
b) Projection area
c) Site density (density)

The MATLAB and the procedural modeling were carried out by the rule-based CGA (Computer Generated Architecture). Custom algorithms were developed to:

a) Import shapefiles
b) Procedural 3D modelling
c) Automatically calculate the specified parameters.

The procedural rules also supported the user interaction with the ability to change dramatically existing urban configuration without redrawing it manually, for modeling a large number of buildings, cost-effectively.

7.4. Result Generation and Automatic Parameter Extraction

After applying modeling rules, MATLAB output full 3D models of the whole neighborhood. The system then:

a) Through Coding each buildings projected area and built-up area was calculated automatically
b) Estimated overall height according to the category of floors recorded
c) Completed the modeling process by adjusting the heights with texture driven classification

These findings not only pictured the physical reality of Sadr City, but to also secure quantitative information indispensable for urban planning.

7.5. Web-Based Presentation and Virtual Reality Access

8. VALIDATION AND CASE ANALYSIS

8.1. Initial Validation in Sadr City

The procedure was implemented in Sadr City, Baghdad, as a realistic example to verify its applicability. The success of these cases validated the applicability of open GIS data and MATLAB scripting for urban modelling in life-like scenarios.

8.2. Initial Validation in Sadr City

Color-coded textures were used to visualize the vertical development tendencies of the district (Figure 6). The model revealed:

a) Irregular distribution of multi-storey buildings
b) Ramped urbanization within wetland and flood risk zones, particularly in the vicinity of the city's dam (Figure 7).

These considerations highlight the need for holistic monitoring tools for helping the urban sprawl, and support the mitigation of risks and the preservation of the investment quality in infrastructure.

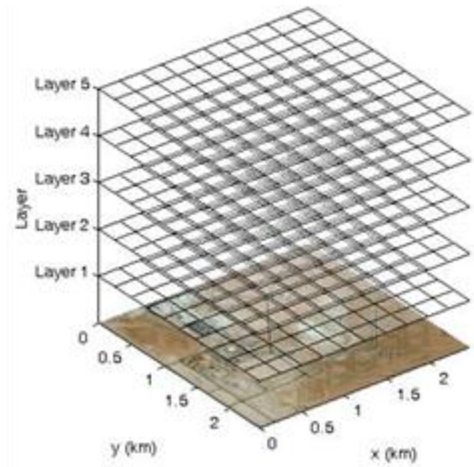

FIG. 6. CATEGORIZATION OF BUILDINGS IN THE NEIGHBORHOOD

FIG. 7. AREAS CLOSE TO THE CITY.

The combination of web-GIS and procedural 3D modeling with MATLAB demonstrates its effectiveness for the visualization and analysis of urban spaces. Not only does the paper present interesting findings of land use and built form development, it apparently returns lessons on how web-based models can enrich decision making for urban planning, in particular, in shifting urban 'frontiers' such as in the case of Baghdad.

9. COMPARISON WITH OTHER STUDIES

Comparison with previous works A literature review of 3D model presentation in responsive web design would provide a key reference for the methodology, technology adopt- ed and performance benchmark. These papers tend to focus on how interactive 3D content can be rendered and repurposed from device to device with varying screen size whilst preserving user experience, performance and accessibility. Aspects evaluated in the context of related work While the scope in this paper is narrowed towards the actual practicality and applicability using MATLAB and W-GIS to urban modeling the broader literature reveals key factors that are commonly being evaluated across related works. This includes rendering strategies, performance tweaking, responsive design approaches, cross-device compatibility, and accessibility concerns. To facilitate such discussion, Table 5 offers an overview of the main features found in related studies and highlights the aspects in which they have focused on and contributed to.

TABLE V: COMPARATIVE ASPECTS OF STUDIES ON 3D VISUALIZATION FOR RESPONSIVE WEB DESIGN

Focus Area	Summary of Contribution	Reference
Rendering Techniques	Utilized technologies like WebGL, CSS3D, and SVG for 3D rendering, each with trade-offs in performance and quality.	[21]
Performance Optimization	Applied LOD (Level of Detail), geometry simplification, and progressive loading for efficient rendering on mobile.	[22]
Interaction & User Experience (UX)	Explored gesture control, motion interaction, and user testing to enhance engagement and usability.	[23]
Responsive Design Strategies	Adapted 3D visualization to different screen sizes using dynamic layouts and scaling methods.	[24]
Accessibility	Addressed inclusive design through keyboard navigation, alt descriptions, and assistive technology compatibility.	[25]
Cross-Browser & Platform Compatibility	Tackled rendering issues across browsers, proposed fallbacks, and validated compatibility on various platforms.	[26]

Comparison with the State-of-the-Art This comparison shows that this research is dedicated to the integration between Web-GIS and procedural modeling using MATLAB for urban planning, and can easily relate to other research areas like responsive 3D web visualization. The selection of open standards, WebVR/Web Viewer as a pressure towards streamlining for mobile, and the layering of user interactivity with the urban model, is a pragmatic, scalable approach aiming towards the collective improvement of these new, immersive, responsive 3D systems.

10. CONCLUSIONS

The successful integration of the WEB-GIS by means of a systematic approach and clear guidelines adapted to the Urban modeling was shown in this study. The proposed system supports large-scale and flexible 3D visualization solutions for Urban Planning according to major urban planning parameters such as building stanza, built-up floor area, and projection footprint. Answering the main research question—how can WEB and GIS be successfully integrated for urban planning the study established that such a combination ease much the production of 3D models, make data much more accessible and help making informed decisions on the urban. One of the main outcomes from this work is demonstrating that 3D modelling outcomes can be effectively disseminated to stakeholders–i.e., urban planners and decision-makers–using web-based platforms, improving collaboration and transparency in planning. This is consistent with a larger vision for City Information Modeling (CIM) while indicating the limited use of such tools in a number of urban systems at the present time. Moreover, the study also highlights the importance of accelerating the inter-departmental data integration process, because delays in data transfer and access often prevent the timely saving of costs and time. Future work will develop this further and consider the extension of the system to handle other models of the 3-dimensional flow including scalar-field based models and vector-based models and dynamic elements, such as streamlines. Furthermore, continued surveillance and improvement in the usage of WebGL approaches is needed in order to keep the pace with advancing system configurations for speed and compatibility. These improvements will both potentially enhance the response capability and scalability of WEB-GIS in supporting the complex urban environment.

Conflicts of Interest

Author declare no conflicts of interest.

Funding

Author, declare they have received no funding for this paper.

Acknowledgment

Non.

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