UrbanScapes: An Interactive 3D Planning Platform for Urban Planners

[1]Dr B.V. Ramakrishna
Associate Professor
Department of AI & DS
Vignan Institute of Technology and Science, Hyderabad, India

[2]A. SudheshnaReddy
UG Student
Vignan Institute of Technology and Science, Hyderabad, India

[3]Ch. Varshith
UG Student
Vignan Institute of Technology and Science, Hyderabad, India

[4]B.Sanjay
UG Student
Vignan Institute of Technology and Science, Hyderabad, India

***Abstract*—**Urban capes is an interactive city simulation tool designed to assist urban planners in creating sustainable city designs. It features procedural city generation using a random walk algorithm, allowing for dynamic and diverse urban layouts. The platform integrates 3D visualization with real-time metric overlays, providing insights into energy consumption, pollution levels, and happiness indices. This innovative approach bridges the gap between city visualization, simulation, and data analytics, empowering planners to design more efficient and sustainable urban environments. This project show cases an interactive 3D city generator, enabling urban planners to visualize and simulate sustainable designs. Using procedural generation and customizable layouts, the tool creates diverse cityscapes while integrating dynamic heat maps to display metrics like energy consumption, pollution levels, and happiness indices. These metrics are updated based on user-defined parameters and city configurations, allowing planners to instantly see the effects of their decisions. For instance increasing green zones may lead to improved happiness and reduced pollution, which are immediately reflected on the city's heat map. The Development of plans using modern technologies such as Three.js, Web-GL, and Blender, the platform utilizes procedural city generation techniques to create dynamic, customizable urban layouts. n summary, UrbanScapes bridges the gap between traditional urban planning tools, simulation engines, and modern data visualization. By combining procedural generation, interactive 3D rendering, and real-time analytics, the platform offers a powerful, accessible, and future-focused environment for designing cities that are not only technically sound but also aligned with sustainability goals and human well-being..

***Keywords*— Urban planning, 3D visualization, procedural city generation, real-time simulation, sustainability metrics, pollution heat map, energy consumption, happiness index.**

I. INTRODUCTION

Urban planning has always been a crucial aspect of modern civilization, shaping the way cities grow and develop. Traditional urban planning methods primarily rely on architectural blueprints, GIS data, and static 3D models, which provide limited interactivity and lack real-time feedback. With the increasing complexity of urban environments and the rising demand for sustainable and efficient city planning, the need for an intelligent, data-driven, and highly interactive platform has become more evident. Conventional tools such as AutoCAD, GIS software and BIM (Building Information Modeling) allow planners to design city layouts but fail to incorporate real-time environmental insights like pollution levels, energy efficiency, and overall livability metrics. As a result, urban designers and researchers face significant challenges in assessing the long-term impact of their plans before execution.

To address these challenges, UrbanScapes has been developed as a next-generation 3D urban simulation tool that combines procedural city generation, interactive visualization, and environmental heat maps. This platform enables urban planners, researchers, and architects to experiment with different city layouts, assess sustainability factors, and make data-driven decisions in real time. Unlike traditional city modeling approaches, UrbanScapes is a web- based interactive platform that allows users to customize city elements dynamically, adjust layouts effortlessly, and integrate real-time data overlays for urban analytics.

By leveraging modern technologies such as Three.js, Blender, and Web-GL, this system ensures a smooth and visually appealing user experience, making urban planning more efficient, accessible, and adaptable to real-world scenarios. The rapid pace of urbanization in the 21st century has created an urgent need for smarter, more sustainable approaches to city planning. With increasing demands on infrastructure, energy, and environmental resources, urban planners are tasked with designing cities that are not only efficient and functional but also resilient, inclusive and adaptable to future challenges. Traditional planning methods often reliant on static maps, manual drawings, and isolated data sets struggle to keep pace with the complexity and dynamism of modern urban environments. This is where digital simulation and visualization tools can play a transformative role. Urbanization is accelerating at an unprecedented rate across the globe. According to United Nations projections, nearly 70% of the world's population will live in urban areas by 2050 as shown in figure 1. This demographic shift presents both immense opportunities and complex challenges ranging from housing shortages and traffic congestion to pollution, energy demands, and infrastructure strain. In this context, urban planning has evolved into a highly data-driven and multidisciplinary domain that must respond to diverse and dynamic needs.

Fig1. Urbanization in Modern Era

Traditional urban planning methods, which rely heavily on 2D maps, paper-based models, and disconnected data analytics, often fall short in capturing the spatial, environmental, and social complexities of modern cities. These approaches are not only time-consuming but also static, making it difficult to visualize future outcomes or explore alternative layouts efficiently. Moreover, the lack of real-time feedback and simulation capabilities limits planner's ability to make informed decisions that balance development with sustainability. To address these challenges, UrbanScapes introduces a new paradigm in city design an interactive, browser-based 3D simulation platform that enables the generation, visualization, and evaluation of city models in real-time. It integrates the power of procedural generation algorithms, particularly the random walk algorithm, to automatically generate diverse and lifelike urban layouts. This reduces manual design overhead while allowing for experimentation with different urban forms, zoning strategies, and infrastructure arrangements. The platform also encourages participatory planning. By simplifying access and providing clear visual feedback, UrbanScapes empowers stakeholders including local governments, citizens, NGOs, and educational institutions to be actively involved in the planning process. Whether used for academic purposes, governmental simulations, or public engagement, the tool fosters transparency, collaboration, and innovation. Historically, urban design involved manual zoning, paper-based layouts, and planning heuristics developed from years of localized experience. While foundational, these approaches lack the agility and adaptability required in today's rapidly changing socio-environmental landscape.

II. METHODOLOGY

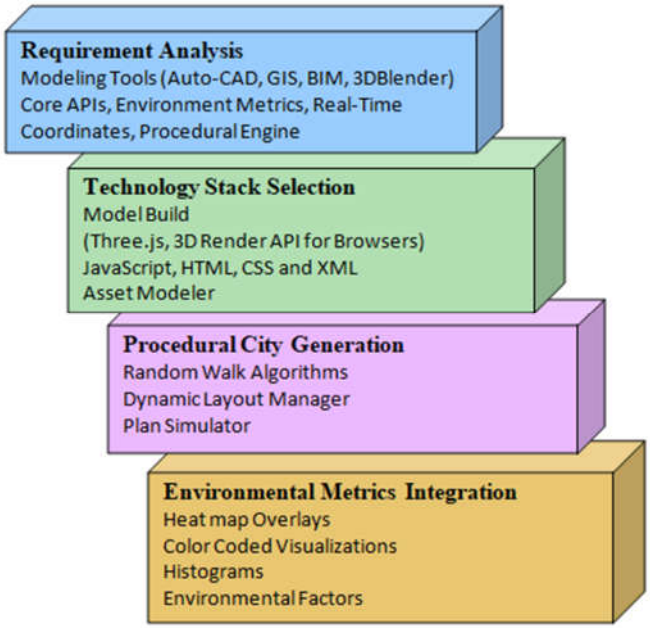

Fig2. Architectural Stack of Urban 3D Planning

The System Architecture as in figure 2 consists of four main layers such as Input, Processing, Visualization, and Data. The *Input Layer* captures user inputs for camera and building controls using Orbit Controls and Pointer Lock Controls. The *Processing Layer* handles scene creation, geometry, and material updates, ensuring dynamic rendering. The *Visualization Layer* leverages the Three.js Rendering Engine to generate 3D environments with buildings and roads. The *Data Layer* processes metrics and overlays heat maps on the visualization for analysis. The methodology adopted in the development of UrbanScapes follows a systematic, modular approach that integrates procedural generation, real-time visualization and interactive simulation.

III. METHODOLOGY

In this work we proposed architecture aligned stacked optimization layers. Each layer significantly supports enhanced tools and mechanisms to develop urban 3D spaces along with meaningful information extraction. The simulators provide greater flexibility for planning. Keeping in mind environmental factors various productivity maps scheduled for alternative planning model assessments. With adoption of machine learning techniques this platform offers good decision support to reach milestones in real-time projects quickly. Highly interactive platform offers optimization in projecting visualizations and focusing over sustainability goals. In future VR/AR models integration with AI-Driven self governance enhances the platform more productive to designers. Looking forward, the integration of AI-driven predictive analytics, VR/AR-based immersive simulations, and expanded environmental impact assessments will take Urban scape to the next level of intelligent urban planning. These advancements will ensure that urban designers, architects, and policymakers have access to a future-ready planning tool that is both highly interactive and scientifically robust. With these planned enhancements, UrbanScapes is set to become a leading digital solution for sustainable and data-driven city planning in the years to come. By allowing users to visualize key environmental factors like pollution, energy use, and overall livability through interactive heat maps, the platform helps support more informed and responsible urban planning decisions.

IV. WORKFLOW

The simulation environment subjected to testing over UI responsiveness and city generation with metric updates. Various validations applied to check the operation wellness in 3D space visualization generations with accuracy. The UrbanScapes platform was successfully implemented as a fully functional, browser-based interactive 3D simulation tool for urban planning.

Fig3. Procedural 3D urban space simulation

The core functional modules are:

Procedural City Generation: Cities of varying sizes and densities were dynamically generated using a random walk algorithm.

Heat map Integration: Pollution levels, energy consumption, and happiness indices were visualized as real- time overlays. These overlays update distantly based on city modifications.
Real-Time Interactivity: Users were able to drag, drop or modify buildings and roads interactively. UI controls such as sliders, dropdowns, and toggles responded fluidly. The UrbanScapes 3D Simulation System acts as the entry point for users to begin designing and analyzing urban layouts. It features a clean and modern interface with a welcoming visual theme that reflects futuristic city planning. At the center, a prominent title 'URBANSCAPES' communicates the system's identity, accompanied by a concise tagline emphasizing real-time simulation and interactive 3D modeling.

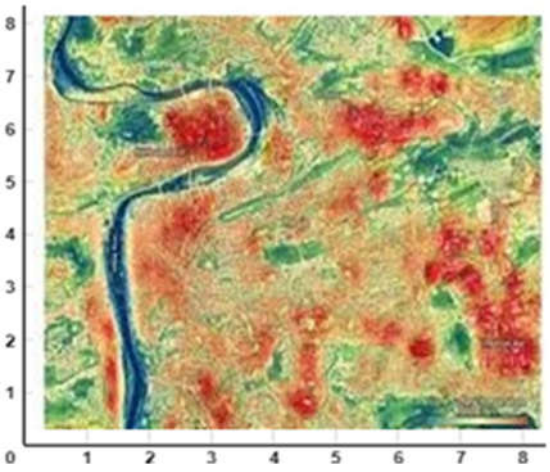

Fig4. Heat Map representing Greenery zones in Urban

Fig5. Heat Map representing various zones in Urban

The heat map in the UrbanScapes 3D Simulation System provides a powerful visual representation of key environmental metrics such as pollution levels, energy consumption, and happiness index. It overlays color-coded data onto the 3D city layout, allowing users to intuitively identify areas of concern or improvement. Each building or block is assigned as hade based on metric intensity typically using red for high pollution, orange for high energy usage and green for high livability or happiness as shown in figure 5.

Challenges in Simulation 3D UrbanSpace System are

Urban planning tools currently in use suffer from several key limitations that restrict their effectiveness in modern city development. Existing tools primarily focus on structural layouts without considering real-time environmental factors such as pollution, energy consumption, and quality of life metrics. Moreover, static blueprints and traditional CAD models lack interactive feedback, making it difficult for planners to experiment and optimize their designs efficiently.

The current urban planning tools and systems face several limitations that hinder their effectiveness in dynamic and sustainability-focused urban development. Traditional software platforms like CAD, BIM, and GIS are static, costly, and require a high degree of technical expertise, which limits their accessibility, especially in academic settings or resource-constrained environments.

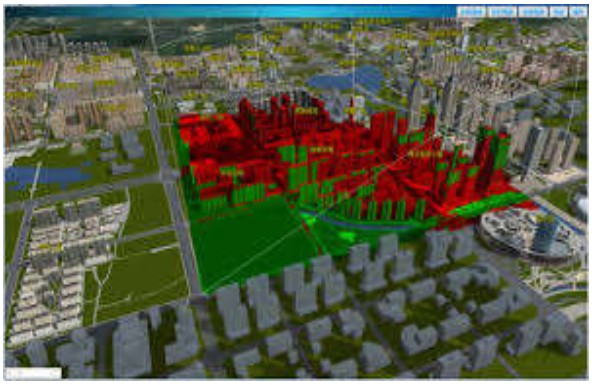
Fig6. Super-Map representation with GIS connection

The super-map handles interactive GIS plan for urban areas with vast range of surrounding coverage and provide good information about eco friendly systems and pollution zones. The resource observation is intensive in this map.

REFERENCES

[1] Abdulrahman Alymani, Wassim Jabi, Padraig Corcoran, "Graph machine learning classification using architectural 3D topological models", Simulation: Transactions of the Society for Modeling and Simulation International Journal, Sage Journals, Vol.99, Issue-11, DOI:10.1177/00375497221105894, pp. 18-31, 2022.

[2] Mukesh Kumar Rohil,Yemineni Ashok,"Visualization of urban development 3D layout plans with augmented reality", Results in Engineering Journal, Elsevier, Vol.14, Issue-2, 2022.

[3] A. Noyman, T. Holtz, J. Kroger, J. R. Noennig, and K. Larson,"Finding Places: HCI Platform for Public Participation in Refugees' Accommodation Process," in Proceedia Computer Science, vol. 112, 2017.

[4] T.Alatalo, T.Koskela, M.Pouke, P.Alavesa, "Virtual Oulu: Collaborative, Immersive and Extensible 3D City Model on the Web," in Proceedings of the 21st International Conference on Web3D Technology, 2016.

[5] A. Kempenaar, J. Westerink, M. van Lierop, M. Brinkhuijsen, and A. van den Brink, "'Design Makes You Understand'—Mapping the Contributions of Designing to Regional Planning and Development in Landscape and Urban Planning, IJAES, vol. 149, 2016.

[6] A. Lovett, K. Appleton, B. Warren-Kretzschmar, and C. Von Haaren, "Using 3D Visualization Methods in Landscape Planning: An Evaluation of Options and Practical Issues," in Landscape and Urban Planning, vol. 142, 2015.

[7] D. Schmalstieg and D. Wagner, "Experiences with

Handheld Augmented Reality," in Proceedings of the 2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality, Nara, Japan, 2007.

[8] G. Kelly and H. McCabe, "A Survey of Procedural Techniques for City Generation", ITB-Journal, vol.16, pp.79- 108, 2007.

[9] N. Marvie, G. Haumont, and E. Galin, "Animation of Reactive Extrusion for Modeling Intersecting Tree Branches", Computer Graphics Forum, vol.24, Issue-.3, pp. 329-338, Sept. 2005.

[10] H. Ishii, C. Ratti, B. Piper, Y. Wang, A. Biderman, and E. Ben-Joseph, “Bringing Clay and Sand into Digital Design Continuous Tangible User Interfaces”, BT Technology Journal, vol. 22, no. 4, 2004.

[11] B D. Schilling, J. Bolling, and C. Nagel, “Using GL-TF for Streaming City GML 3D City Models,” in Proceedings of the 21st International Conference on Web3D, 2002.