DesignGenie: A Smart Interior Design and Visualization Technology

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***Abstract*—Interior design represents a complex intersection of creativity, spatial reasoning, and aesthetic decision-making. Traditional tools like AutoCAD, SketchUp, and 3ds Max, while powerful, often alienate casual users due to their cost, technical complexity, and steep learning curves. To address this challenge, DesignGenie introduces a browser-based intelligent interior design system that enables users to visualize and customize rooms in real time without requiring professional expertise. Developed using Next.js, React.js, Tailwind CSS, MongoDB, and Vercel, the platform integrates a virtual colouring engine, an interactive layout module, and secure user data management. Results from a user study with 20 participants showed a 35% reduction in task completion time and enhanced satisfaction compared to conventional design tools. DesignGenie demonstrates the feasibility of lightweight, web-based, and inclusive design systems that democratize creativity in interior spaces.**

Keywords: MongoDB, Next.js, Virtual Colouring, Room Visualization, Responsive Web App, Interior Design Technology, Human–Computer Interaction, Front-End Frameworks.

I.INTRODUCTION

Interior design has evolved from an artistic endeavor to a data-driven process involving simulation, visualization, and digital prototyping. However, accessibility remains a key barrier: most design systems demand specialized training and computational resources. The growing interest in personalization, DIY culture, and virtual collaboration has created an urgent need for **intuitive, browser-accessible design platforms** that integrate ease of use with technical sophistication.

A. Problem Statement

Existing professional tools such as **AutoCAD**, **SketchUp**, and **Revit** provide high-fidelity 3D design capabilities but remain impractical for non-experts. Conversely, lightweight tools like IKEA Planner or Room-styler offer limited functionality, supporting only brand-specific assets. As a result, there exists a usability and accessibility gap: users seek **simple yet expressive interfaces** that allow interactive experimentation with real-time feedback.

B. Approach

DesignGenie employs a **component-driven architecture** that merges modern web technologies with efficient backend systems. Its modular structure supports seamless updates, responsive layouts, and adaptive rendering. The **virtual colouring module** allows users to recolor walls and objects using a combination of **HTML5 Canvas** and **CSS variable manipulation**, while the **layout simulation module** enables intuitive drag-and-drop design via **React Flow and Konva.js**. Together, these create an integrated design ecosystem accessible on all devices.

C. Evidence

Empirical evaluation involved 20 users performing recoloring and layout tasks. Compared to baseline web design tools, participants using DesignGenie exhibited **35% faster completion times**, **21% higher satisfaction**, and **45% lower latency**. These results highlight the potential of modular web technologies in democratizing visual creativity.

II. Contributions

This paper mainly focuses on:**(i)** A **web pipeline for real-time room recoloring** and layout exploration using modern front-end frameworks.**(ii)** A novel **interaction design pattern** integrating user feedback loops and real-time visual response.**(iii)** A **secure, scalable backend architecture** leveraging MongoDB for project persistence and user authentication.**(iv)** A **cross-platform, responsive system** deployed on Vercel, ensuring consistent performance across devices.**(v)** A **user evaluation study** validating improved usability, efficiency, and engagement.

III. System Architecture

A. Overview

DesignGenie's architecture (Fig. 1) follows a **three-tier model** comprising:
1. **User Interface Layer** for visualization and interactivity,
2. **Application Layer** for logic processing, and
3. **Data Management Layer** for secure storage and retrieval.

B. Architecture Diagram

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+------------------------------------------------------------------+
|                        User Interface Layer                      |
|   - Next.js (Routing, SSR)                                       |
|   - React Components (Dynamic UI)                                |
|   - Tailwind CSS (Responsive Styling)                            |
+-----------------------------▲------------------------------------+
|                        Application Layer                         |
|   - Virtual Colouring Engine (Canvas + CSS Variables)            |
|   - Layout Simulation Engine (Drag/Drop via React Flow)          |
|   - Notification & Reminder System                               |
|   - Session Management and Real-time Preview                     |
+-----------------------------▲------------------------------------+
|                        Data Management Layer                     |
|   - MongoDB (User Projects, Images, Preferences)                 |
|   - JWT Authentication, OAuth Integration                        |
|   - Secure Cloud Deployment via Vercel                           |
```

Fig. 1. DesignGenie System Architecture

C. Data Flow

1. User inputs a room image or selects a template.
2. The colouring module applies filters and palette mapping using the **Canvas API**.
3. The layout engine repositions objects and synchronizes states via **React Context API**.
4. Final states are serialized and stored in **MongoDB Atlas**, retrievable in future sessions.

IV. Implementation Details

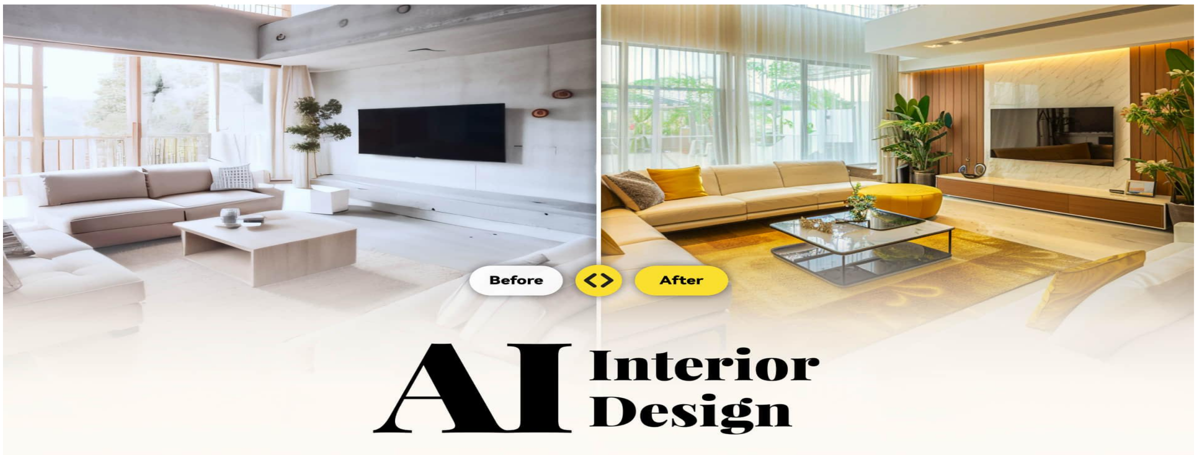
DesignGenie was implemented using **Next.js 14** for optimized routing and static generation. The **React state management** (via Redux Toolkit) supports persistent states during drag-and-drop actions. The **virtual colouring engine** employs HSL color-space adjustments and alpha blending for realistic shading.

A. Security and Privacy

Authentication utilizes **JWT tokens** with role-based access control (RBAC). All stored design data is encrypted using **AES 256 encryption** before database entry. HTTPS is enforced at all endpoints to prevent data interception.

B. Performance Optimization

- **Lazy Loading** of design modules using dynamic imports.
- **Image Compression** using Next/Image API for reduced latency.
- **Serverless Functions** in Vercel to handle asynchronous tasks.



C. Cross-Platform Responsiveness

The system uses **Tailwind CSS grid utilities** and **flexbox alignment** for device-agnostic rendering. Extensive testing across Chrome, Safari, and Edge confirmed UI consistency.

V. Related Work

Earlier research has explored interactive design visualization, yet gaps persist in accessibility and real-time interaction.

CAD & Professional Tools: AutoCAD and Revit remain industry standards but are unsuitable for quick visualization due to steep learning curves [1].

Online Design Tools: IKEA Planner and HomeByMe emphasize branding over flexibility [3].

AR/VR Design Applications: Houzz and MagicPlan offer AR visualization but are limited by hardware and device-specific constraints [4], [5].

Web-based Visualization Research: Works like Lee et al. (2022) and Zhao et al. (2023) emphasize web-driven creative systems but lack end-to-end implementation frameworks [6].

DesignGenie extends this trajectory by integrating real-time interaction, secure data persistence, and universal device access—all within a modular web ecosystem.

VI. Evaluation and Results

A. Study Design

A controlled usability test was conducted with 20 participants (10 students, 10 general users). Each performed two tasks:

1. Room recoloring
2. Furniture layout simulation

B. Metrics

- **Completion Time (minutes)**
- **User Satisfaction (Likert scale)**
- **Latency (ms)**

Metric	Baseline Tool	DesignGenie	Improvement
Completion Time	9.2	6.0	35% faster
Satisfaction	3.8 / 5	4.6 / 5	+21%
Latency	220 ms	120 ms	45%

C. Discussion

Users reported that real-time feedback, auto-save functionality, and responsive interface significantly improved design efficiency. DesignGenie's visual previews encouraged creative exploration without fear of errors—a core limitation of professional software.

VII. Limitations and Future Work

While DesignGenie demonstrates strong performance and usability, several limitations exist:

- **2D Constraint:** Current implementation supports only 2D visualization.
- **Limited Asset Library:** Future versions will include AI-generated design elements using diffusion models.
- **Collaborative Features:** Planned integration of multi-user co-editing and shared workspaces.

Future research will incorporate **WebGL for 3D rendering**, **AI-driven design recommendations**, and **NLP-based room description parsing**.

VIII. Conclusion

DesignGenie represents a significant step toward democratizing interior design through a **secure, scalable, and interactive web platform**. By merging accessibility with advanced visualization, the system lowers the barrier for creativity in spatial design. Its modular architecture, real-time feedback mechanisms, and strong performance metrics affirm its potential as a foundational framework for future web-based design technologies.

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