Enhancing Creativity and Efficiency in Furniture Design through Human-AI Collaboration

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Abstract

This paper explores the integration of artificial intelligence (AI) with human creativity in the context of furniture design, focusing on the development of an ergonomic office chair. As demand grows for sustainable, personalised, and innovative furniture, the study investigates how AI can augment traditional design practices through data-driven optimisation and augmented reality (AR) prototyping. A literature review highlights key developments in generative design, user interaction, and collaborative tools, while the proposed methodology combines user-centred design principles with machine learning and AR to streamline the design process. User studies involving professional designers and end-users evaluate the effectiveness of the AI-human collaboration, measuring design quality, satisfaction, and efficiency. The research presents a hybrid design framework where AI serves as a co-creator, ultimately enhancing creativity, usability, and production workflows in the furniture industry.

Introduction

The furniture design industry stands at a pivotal intersection of creativity and technology, where traditional craftsmanship meets the transformative potential of AI. As global demand for sustainable, personalised, and innovative furniture grows, projected to reach a market value of $800 billion by 2030 (Fortune Business Insights 2023), designers face mounting pressure to balance aesthetic appeal, functionality, and efficiency. AI, with its capacity for data-driven insights, generative modelling, and rapid prototyping, offers unprecedented tools to augment human ingenuity (Brynjolfsson and McAfee 2017). Yet, the core of furniture design remains deeply human: rooted in cultural narratives, emotional resonance, and physical experience (Inie, Falk, and Tanimoto 2023; Figoli, Rampino, and Mattioli 2022; Verganti, Vendraminelli, and Iansiti 2020; Chen et al. 2019; Zahra 2023; Nafea 2025). This research paper explores the synergy between AI and human collaboration in furniture design, examining how this partnership can redefine creative processes, optimize production, and meet evolving consumer needs. By integrating AI's analytical precision with the designer's intuitive vision, we investigate a hybrid approach that promises not only to enhance design outcomes but also to reimagine the role of technology as a co-creator in a traditionally artisanal field (Norman 2013, 2019). The methodology investigates the design of an office chair as a starting point for this research work.

Literature Review

The goal of this research is to explore how AI can effectively collaborate with human designers in the furniture design process, balancing automation with human creativity, and improving the overall design experience. The research will focus on developing a framework that integrates AI-generated suggestions with human input, ensuring that the final designs are both innovative and aligned with user preferences. One example of related research is the study by McCormack et al. (McCormack, Gifford, and Hutchings 2019). This work explores the balance between human creativity and AI automation in artistic design, emphasizing the importance of maintaining human agency and creativity while leveraging AI for efficiency. The study highlights the need for iterative feedback loops and ethical considerations, which are directly applicable to furniture design. A notable example for AI collaboration with humans is SELF™ it is a generative design platform that allows users to co-create custom, AI-assisted furniture (Lahens 2023). Traditional computer-aided design (CAD) systems provide precise designs tailored for engineers and professionals (Xie 2023), and show how CAD can assist with furniture design, but CAD requires expertise in design software, and designs cannot be easily visualised in the real world. However, various papers such as Hui (Hui 2015) demonstrate how AR technology can provide users with a more interactive and user-friendly design process, allowing non-designers to work on designing their own furniture. Wang et al. (Wang, Lian, and Jia 2018) address the challenge of converting 2D interior photographs into simplified 3D models through a combination of 2D to cuboid modelling, automatic arrangement, and lighting rendering, they generated simplified 3D plans that can be further enhanced. This system enabled designers to start with a simple photograph of a user's home to create an initial 3D floor plan.

Other works, such as Zagermann et al. (Zagermann et al. 2021), have explored collaborative 3D object manipulation between two users using three approaches. In the Separation approach, each user controls a different degree of freedom,

in the Composition method, both users control the same degree of freedom simultaneously, with their inputs merged, a Hybrid approach lets users switch between these methods as needed. S. T. R. et al. (R. et al. 2024), for example, is a Visual-Inertial Simultaneous Localisation and Mapping (VISLAM) approach to AR furniture visualisation allowing clients to see how their furniture would look like in their living space and also interact with it by estimating spatial depth.

Additionally, the integration of 3D scanning and printing technologies in furniture design presents further opportunities for collaboration. Muminović et al. (Muminović et al. 2024) discuss how 3D scanning can enhance the manufacturing process, enabling the creation of accurate furniture models that serve as a foundation for further design iteration and customisation. While Jiang et al. (Jiang, Lu, and Zhao 2023) emphasised the role of 3D printing in fostering personalisation by merging traditional design methods with advanced technology, effectively meeting user customisation demands. Together, these studies underscore the shifting paradigm in furniture design where AI coexists with human creativity, ultimately leading to innovative and user-centred outcomes.

Moreover, research by Liu and Wang (Liu and Wang 2022) provides insights into how AI can augment the furniture design process through customised solutions based on 3D modelling technology. They argue that integrating these intelligent systems reduces design cycles and improves market competitiveness, offering designers enhanced flexibility and efficiency.

Research Objective

The goal of this research is to explore how AI could effectively collaborate with human designers in the field of furniture design process, balancing automation with human creativity, and improving the overall design experience. The research will focus on developing a framework that integrates AI-generated suggestions with human input, ensuring that the final designs are both innovative and aligned with user preferences.

Key Research Questions

1. How can AI systems accurately interpret and translate human design preferences into actionable suggestions?
2. How can iterative feedback loops between humans and AI improve the quality and personalisation of furniture designs?

Methodology

The application of AI in furniture design, particularly for an office chair, enhances creativity and efficiency by generating aesthetically pleasing and functional design options. The methodology below outlines a streamlined approach to designing an ergonomic office chair by employing AI and AR (Azuma 1997; Bimber and Raskar 2005), combining user-centred design, data-driven optimisation, and involving visualisation. The process starts with collecting user requirements through surveys, and interviews, guided by ergonomic standards like ISO 9241-5. Next, AI models, such as convolutional neural networks and reinforcement learning (implemented via TensorFlow or PyTorch), analyse datasets (e.g., ANSUR II) to optimise chair parameters like seat height and backrest angle, ensuring ergonomic comfort.

AR technology, using platforms like Unity3D with ARCore or ARKit, facilitates virtual prototyping, enabling users to interact with 3D chair models in simulated office environments via smartphones or headsets like Microsoft HoloLens. User testing in these AR settings, supported by tools like Motiv-ARCHE and AI-driven feedback analysis, captures subjective and objective data (e.g., posture tracking with wearable sensors) to iteratively refine the design through methods like design-based research. The final stage involves generating detailed CAD models (using SolidWorks), simulating the chair in AR for stakeholder approval, and applying AI to optimise material selection and manufacturing costs, referencing datasets like MatWeb (Gao and Liu 2013). This methodology delivers a user-focused, efficient design process.

User Studies

1. Conduct experiments with professional designers and end-users to evaluate the effectiveness of the AI-human collaboration framework: AR interfaces can be unintuitive for users unfamiliar with the technology. Designing an AR system that is easy to use and understand, especially for non-technical users, is a significant challenge (Norman 2019). Balancing the ability to customize furniture designs (e.g., size, color, material) with the simplicity of the AR interface is challenging. Too many options can overwhelm users, while too few can limit creativity (Karjalainen 2007).
2. Measure outcomes such as design quality, user satisfaction, and time efficiency.

Conclusions

This research aims to bridge the gap between AI automation and human creativity in furniture design, creating a collaborative framework that enhances both efficiency and innovation. By addressing technical, user experience, and ethical challenges, the study will contribute to the growing field of human-AI collaboration in design.

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