

A Computer Vision-Driven Framework for Interactive Visual Communication in Mobile Environments

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ABSTRACT

In the digital age, visual communication design is shifting from static aesthetics to dynamic interaction. This paper examines how computer vision can enhance interactivity in mobile environments. This study propose a real-time interactive framework that captures user behavior, analyzes intent, and dynamically updates visual feedback. Grounded in human-computer interaction principles, the model bridges technical logic and user experience. The system leverages camera-based input and lightweight vision algorithms for on-device processing. Experimental results show improved response, coherence, and user satisfaction compared to traditional designs. The framework supports adaptive, context-aware interactions on handheld and wearable devices. The results contribute to mobile HCI by advancing responsive visual design for immersive and user-centered applications. Findings offer practical guidance for designing intelligent, perception-driven interfaces in real-world mobile contexts.

KEYWORDS

Visual Communication, Interactivity, Computer Vision, Mobile HCI, User Experience, Real-Time Feedback

INTRODUCTION

In recent years, with the rapid development of digital technology, visual communication design is undergoing a profound paradigm shift (Guan & Wang, 2022; Perez, 2004). The traditional design model focused on static elements like graphics, colors, and text. This model has gradually become unable to meet modern users' increasingly diverse interactive needs (Xie, 2023). As information density continues to rise and communication methods become more visualized, the function of visual communication has expanded from merely informing to encompassing roles such as guiding, participating, and even co-creating (Hall, 2023; Jones, 2018). This evolution reflects a broader transformation in how audiences engage with visual content. It demands new design approaches that can accommodate users' dynamic behaviors and evolving expectations.

The embedded support of computer technology has significantly influenced this transition, promoting the reconstruction of interface logic and enabling dynamic scheduling of information architecture (Noguera & Badia, 2004). As a result, designers are now required to consider not only aesthetic composition but also complex factors such as user behavior paths, interactive response mechanisms, and the data infrastructure that underpins these interactions (Sedig & Parsons, 2013).

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This deep-seated change has elevated interactivity from a peripheral feature to a central force in design, making it a core dimension for evaluating the effectiveness of visual communication strategies (Shao et al., 2024). However, interactivity is not merely a functional attribute but also a socio-technical and cultural construct. It mediates how users perceive, interpret, and co-create meaning within digital environments, thereby influencing knowledge formation and social engagement. This broader perspective underscores that effective interactive design must consider not only technical responsiveness but also its role in shaping user cognition and cultural experience.

Despite its growing importance, interactivity as a research topic remains unevenly explored within the domain of visual communication. While existing literature has long addressed aspects of interactivity—particularly focusing on perceptual evaluations of interface aesthetics and user experience (Rizzi et al., 2017)—there is still a notable lack of comprehensive studies modeling or analyzing the computational logic behind interactive mechanisms (Prakken & Sartor, 2002). Moreover, in actual design practice, there exists no unified theoretical framework that systematically constructs the relationship between visual expression and interactive pathways (Roth, 2012), leaving a gap between creative intent and technical execution.

Compounding this issue is the increasing diversity of platforms, devices, and application scenarios, which has led to a highly fragmented landscape in interactive design (Kasapakis & Gavalas, 2015). These challenges call for a more holistic and integrated approach—one that can harmonize emotional expression with rational structure in the context of digital environments (Ho & Siu, 2012). To operationalize this work’s framework, the study used a multidimensional system as one that integrates perceptual (e.g., aesthetic experience), behavioral (e.g., interaction patterns), and technical (e.g., computational logic) layers into a unified design structure. The interactive model denotes the dynamic mechanism within this system that enables real-time user engagement and adaptive visual response. Therefore, this study aimed to propose an interactive model of visual communication rooted in a multidimensional system supported by computer technology. By doing so, it sought to bridge the divide between the experiential and structural dimensions of design, offering a cohesive methodology for addressing contemporary design complexities.

At the methodological level, the study adopted a dual-track approach combining theoretical modeling with practical verification. It emphasizes both the perceptual layer of user experience and the logical rigor of technical implementation (Zheng et al., 2017). Through iterative cycles of design, testing, and refinement, the research endeavored to establish a comprehensive framework that can be applied across various contexts. Ultimately, the goal was to develop a scalable and adaptable solution that holds promise for broader promotion and adoption in both academic and professional settings (Lee et al., 2024).

LITERATURE REVIEW

Interactive visual communication design is based on the basic principles of human-computer interaction, especially the user-centered design (Nie et al., 2023) and usability heuristic principle (Z. Liu & Yang, 2025). In the past 5 years, this field has developed rapidly with the progress of digital technology, artificial intelligence, and a deeper understanding of human cognition and behavior (Zu, 2022). This paper summarizes the recent research results and classifies them into several thematic categories to identify key trends, innovations, challenges, and emerging development directions.

A dominant trend in recent research is the development of responsive and adaptive visual systems that dynamically align with user behavior. Several studies have introduced models that establish real-time coupling between user actions and interface responses. For example, the visual response–user behavior coupling model synchronizes design elements with user navigation patterns. This approach significantly reduces interface latency and enhances user engagement. Complementing this, dynamic adaptation algorithms have emerged that intelligently reconfigure visual focus based on interaction frequency and contextual usage data (S. Liu & Ding, 2025). These systems prioritize

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