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Unmanned Stores and Interior Architecture

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Abstract

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Unmanned stores represent a revolutionary shift in the retail industry, integrating artificial intelligence (AI), computer vision, and the Internet of Things (IoT) to streamline operations and enhance customer convenience. By eliminating traditional checkout processes, these cashier-less stores introduce new challenges and opportunities for interior architecture. This study explores the spatial implications of unmanned retail environments, focusing on store layout, wayfinding strategies, and material selection through a comparative case study of leading unmanned stores. Findings indicate that the success of these stores depends on flexible spatial configurations, intuitive navigation, AI-driven personalization, and adaptive lighting systems that enhance the user experience. However, concerns regarding security, data privacy, and accessibility remain significant challenges. As retail automation continues to evolve, interior architects must develop human-centered design strategies that balance technology with usability. Future trends suggest that augmented reality (AR), biometric authentication, and sustainable materials will further redefine the design of unmanned retail spaces.

Keywords: Unmanned Stores; Interior Architecture; Retail Automation; AI-Driven Design; User-Centered Spatial Planning.

İnsansız Mağazalar ve İç Mimarlık

Özet

İnsansız mağazalar, yapay zekâ (AI), bilgisayarla görme (computer vision) ve Nesnelerin İnterneti (IoT) teknolojilerini entegre ederek perakende sektöründe devrim niteliğinde bir dönüşümü temsil etmektedir. Geleneksel kasa işlemlerini ortadan kaldıran bu kasiyersiz mağazalar, iç mimarlık açısından hem yeni fırsatlar hem de çeşitli zorluklar ortaya koymaktadır. Bu çalışma, öncü insansız mağazaların karşılaştırmalı vaka analizi üzerinden mekânsal etkileri incelemekte; mağaza yerleşimi, yön bulma stratejileri ve malzeme seçimi gibi unsurlara odaklanmaktadır. Bulgular, bu mağazaların başarısının esnek mekânsal kurgulara, sezgisel yönlendirme sistemlerine, yapay zekâ destekli kişiselleştirmeye ve kullanıcı deneyimini geliştiren uyarlanabilir aydınlatma sistemlerine bağlı olduğunu göstermektedir. Ancak, güvenlik, veri gizliliği ve erişilebilirlik gibi konular hâlâ önemli sorunlar olarak varlığını sürdürmektedir. Perakende otomasyonu gelişmeye devam ettikçe, iç mimarların teknolojiyi kullanılabilirlikle dengeleyen insan odaklı tasarım stratejileri geliştirmesi gerekmektedir. Gelecekte artırılmış gerçeklik (AR), biyometrik kimlik doğrulama ve sürdürülebilir malzemelerin, insansız perakende mekânlarının tasarımını yeniden şekillendirmesi beklenmektedir.

Anahtar Kelimeler: İnsansız Mağazalar; İç Mimarlık; Perakende Otomasyonu; Yapay Zekâ Tabanlı Tasarım; Kullanıcı Odaklı Mekânsal Planlama.

1. Introduction

Retail environments have undergone continuous evolution in response to technological advancements, significantly influencing both store design and consumer behavior (Xu et al., 2020). The emergence of unmanned shopping stores represents a new phase in this transformation, as technologies such as artificial intelligence (AI), the Internet of Things (IoT), and machine learning are increasingly integrated into purchasing processes (Wang et al., 2024). Unlike conventional retail settings, unmanned stores demand a distinct interior architectural approach that prioritizes digital integration, automated logistics systems, and adaptable spatial organization (Allahdadi & Shokri, 2020).

In such stores, interior spatial arrangement becomes a fundamental factor shaping the user experience. Architectural elements such as spatial layout, material selection, and the integration of digital interfaces directly impact users' wayfinding, interactions, and overall satisfaction within the store environment (Hassan et al., 2010; Softaoğlu, 2024). This study aims to examine key interior design principles that enhance functionality, safety, and aesthetic coherence in unmanned retail environments and to discuss associated design strategies.

Driven by automation and digitalization, the retail sector has undergone significant structural shifts (Hagberg, Sundström, & Egels-Zandén, 2016; Reinartz, Wiegand, & Imschloß, 2019). The unmanned store concept, pioneered by ventures like Amazon Go, has redefined the shopping experience by eliminating traditional checkout stations and replacing them with seamless, automated systems (Gallery, 2024). These stores utilize smart sensors, cameras, and AI-supported algorithms to track products and fully automate payment processes (Wolniak, Stecula, & Aydın, 2024). Studies indicate that while retail automation increases efficiency and cost-effectiveness, it also introduces new debates regarding data security and consumer trust (Evanschitzky et al., 2015). Previous studies have examined the evolution of the unmanned store concept in relation to technological innovations that have supported its widespread adoption. Although the concept of unmanned shopping is not entirely new—with vending machines and self-service kiosks serving as early precursors—the development of RFID technology marked a significant breakthrough by enabling inventory tracking without human intervention (Ali, 2012). The subsequent rise of AI and big data analytics further accelerated the development of cashier-less store models, culminating in the launch of Amazon Go in 2018, which achieved tangible commercial success. This milestone spurred the global proliferation of similar systems that integrate digital payment technologies with real-time inventory management (Nam & Kannan, 2020).

The widespread adoption of unmanned stores has introduced both novel opportunities and unique design challenges to the field of interior architecture. While traditional retail spaces rely heavily on human interaction for customer assistance and guidance, unmanned stores must fulfill these functions through architectural means, including spatial planning, lighting schemes, signage systems, and digital user interfaces (Lo & Wang, 2019). As such, effective space utilization and circulation design are of critical importance in ensuring that users can navigate the environment intuitively and experience a seamless shopping process (Mesly & Réthoré, 2024).

The interior design of unmanned retail stores must be guided by specific design principles to ensure the successful integration of technology and an optimal user experience. In this context, the following considerations are of particular importance:

- **Wayfinding and Circulation:** In the absence of personnel, store layouts must be intuitively designed to guide users clearly and efficiently. Zonal planning, digital signage, and interactive interfaces play a critical role in supporting user navigation and orientation throughout the space (Huang et al., 2018; Amen et al. 2023; Amen and Nia 2020).
- **Ergonomics and Accessibility:** The lack of human assistance necessitates solutions that cater to a wide range of user profiles. Shelf heights, product placement, and payment stations should be designed to be inclusive and easily accessible, particularly for individuals with disabilities (Calderón & Galván, 2025).
- **Aesthetics and Psychological Impact:** The use of AI and digital interfaces may create a futuristic atmosphere; however, ensuring a sense of warmth and spatial comfort is essential to maintaining user satisfaction (Hanna & Parvaresh, 2024).
- **Security and Surveillance Design:** Cashier-less retail systems require robust surveillance infrastructures. These security measures must be seamlessly integrated into the architectural layout in a manner that ensures safety without compromising the user experience or overwhelming the spatial aesthetics (Rane, 2023).

Challenges in Consumer Adoption of Unmanned Stores

Despite the conveniences offered by unmanned stores, their widespread consumer adoption continues to face several barriers:

- **Data Privacy Concerns:** The extensive data collection and surveillance capabilities inherent in AI-based systems raise significant privacy concerns among consumers, leading to hesitations regarding personal data security (Singh, 2024).
- **Technological Adaptation Difficulties:** Users with limited digital literacy or those belonging to older age groups may find it challenging to interact with the advanced technological systems employed in unmanned stores (Lee & Lee, 2020).
- **Reliability Issues:** Errors in product recognition or system malfunctions can result in incorrect charges or disrupted service, undermining consumer trust in the reliability of automated retail environments (Peacock & Friedman, 2010)

Future Perspectives

The future of unmanned retail stores largely depends on the advancement of current technologies and the resolution of existing limitations. In this context:

- **Blockchain technologies** offer promising potential for enhancing data security and ensuring the integrity of transaction systems.
- **Augmented Reality (AR) systems** may facilitate virtual guidance, improving user navigation and product selection within the store environment.

- **Collaborations between AI developers and retail companies** could lead to highly personalized shopping experiences through predictive analytics and real-time data processing (Rane, 2023; Amen 2024).

It is evident that governments and regulatory authorities will play a critical role in ensuring that the evolution of these systems proceeds in an ethical, secure, and user-centered manner.

The primary aim of this study is to analyze the impact of unmanned retail stores on interior architecture. Specifically, the research investigates how digital integration, wayfinding strategies, and spatial design influence consumer behavior. Through a comparative analysis of pioneering unmanned store models, the study seeks to identify best practices for enhancing user experience, implementing effective security measures, and ensuring spatial accessibility.

2. Materials and Methods

This study employs a comparative case study methodology, analyzing five prominent unmanned store models: Amazon Go, Alibaba Hema, JD.com, BingoBox, and Auchan Minute. Selection criteria included global relevance, innovative technological solutions, and distinct operational strategies.

Three primary dimensions were assessed:

1. **Technological Integration:** AI, IoT, RFID, and machine learning technologies in automation, inventory, and checkout processes.
2. **Spatial Planning:** Layouts, circulation patterns, product placement, and wayfinding systems.
3. **User Interaction Strategies:** Mobile applications, personalized services, and loyalty programs.

Data sources included official reports, academic literature, user feedback, and observational analysis from virtual store tours and visual materials.

3. Results

3.1 Comparative Store Profiles

Amazon Go

Amazon Go revolutionized retail by introducing the "Just Walk Out" technology, which utilizes a combination of computer vision, sensor fusion, and deep learning algorithms to enable customers to shop without traditional checkout lines. Shoppers enter the store by scanning the Amazon Go app, pick up desired items, and simply leave, with their accounts automatically charged for the items taken. This system relies on a network of cameras and shelf sensors to track customer interactions and product selections. However, reports have indicated that the technology also depends on human oversight, with employees reviewing transactions to ensure accuracy.

Alibaba Hema (Freshippo)

Alibaba's Hema stores exemplify the "New Retail" concept by seamlessly integrating online and offline shopping experiences. Customers can shop in-store or use the Hema app to place orders, which are fulfilled from the store's own warehouse and delivered within 30 minutes to locations within a 3-kilometer radius. The stores feature app-based navigation, modular displays, and automated delivery systems, enhancing operational efficiency and customer convenience.

JD.com

JD.com's unmanned stores leverage advanced technologies such as facial recognition and dynamic product arrangement to personalize the shopping experience. Ceiling-mounted cameras identify customers and track their movements, enabling the system to offer tailored product recommendations through interactive screens and adaptive layouts. This approach not only streamlines the shopping process but also provides valuable data on consumer behavior.

BingoBox

BingoBox offers a compact, container-based retail solution that operates 24/7 without staff. Utilizing RFID technology, the store tracks products as customers select them, facilitating a seamless checkout process. The minimalist design emphasizes vertical storage, maximizing space efficiency and catering to urban environments where space is at a premium. This model demonstrates the potential for scalable, automated retail solutions in various settings.

Auchan Minute

Auchan Minute represents a foray into sustainable, modular retail construction. These unmanned stores are prefabricated off-site and assembled quickly on location, reducing construction waste and environmental impact. The design incorporates energy-efficient features and environmentally conscious materials, aligning with growing consumer demand for sustainable retail practices (Auchan, n.d.).

3.2. Spatial Strategies and Technology Integration

The success of unmanned retail environments is closely linked to the effective integration of spatial strategies and advanced digital technologies. These elements are not only essential for operational efficiency but also serve as critical determinants of user experience, navigation, and interaction quality.

Across different store models, various combinations of Artificial Intelligence (AI), Internet of Things (IoT), Radio Frequency Identification (RFID), and facial recognition technologies have been implemented. These systems influence

spatial layout, automation level, and the degree of personalization. The comparative integration strategies of five leading unmanned store models are summarized in Table 1.

Table 1. Spatial Strategies and Technology Integration.

Store	AI Use	IoT	RFID	Facial Recognition
Amazon Go	High	Yes	No	No
Hema	Moderate	Yes	Yes	No
JD.com	High	Yes	Yes	Yes
BingoBox	Low	Yes	Yes	No
Auchan Minute	Low	No	Yes	No

3.3 User Interaction and Mobile Strategy

User interaction strategies in unmanned retail environments play a vital role in shaping customer experience, engagement, and retention. In the absence of staff, these systems rely heavily on mobile applications, digital loyalty programs, and personalized promotions to foster interaction and create brand value. The degree to which these strategies are integrated varies significantly across different store models, as outlined in Table 2.

Table 2. User Interaction and Mobile Strategy.

Store	Mobile App	Loyalty Program	Personalized Promos
Amazon Go	Yes	No	Limited
Hema	Yes	Yes	Extensive
JD.com	Yes	Yes	High
BingoBox	Limited	No	Minimal
Auchan Minute	No	No	None

The success of unmanned retail environments relies heavily on digital platforms that mediate the customer journey in the absence of human assistance. Across various store models, mobile applications, loyalty mechanisms, and personalization strategies form the foundation of user engagement systems. Table 2 presents a comparative summary of these strategies.

Amazon Go utilizes a proprietary mobile application that enables customers to enter stores, track items in real-time, and receive receipts automatically after checkout. The app’s primary goal is to provide a frictionless and time-efficient experience through its "Just Walk Out" technology. However, it offers limited personalized promotions and does not include a traditional loyalty program, focusing instead on reducing transactional friction (Amazon.com, n.d.; Devoteam, n.d.).

Alibaba’s Hema (Freshippo) integrates a robust digital ecosystem in which the mobile app serves as the primary interface for both physical and online shopping. The platform supports real-time personalized recommendations, location-based offers, and an integrated digital loyalty program, which enhances customer retention. These features are supported by AI-driven analytics that tailor services to individual consumption habits (Splio, 2019).

JD.com offers one of the most advanced mobile retail environments, leveraging AI technologies to deliver predictive shopping suggestions, navigation assistance, and customized user experiences. In addition to personalized services, JD.com incorporates gamified loyalty systems and tiered rewards to enhance engagement and increase retention (JD.com, 2024).

BingoBox, while pioneering in automated container-based retail, provides only limited mobile interactivity. The app primarily serves for entry authentication and payment, lacking advanced personalization or loyalty functions. Despite these limitations, its cost-effective infrastructure and RFID-enabled checkout make it viable in densely populated urban environments (PYMNTS.com, 2018).

Auchan Minute, oriented toward low-overhead scalability, does not offer a mobile app for personalized engagement or loyalty. The absence of such digital platforms aligns with its focus on rapid deployment, automation, and sustainable construction.

As summarized in Table 2, there is a clear correlation between the technological maturity of the mobile ecosystem and the level of personalization and loyalty integration. Retailers such as JD.com and Hema demonstrate how sophisticated apps can act as digital intermediaries, effectively replacing in-store staff and reshaping user interaction into a highly adaptive and data-informed process.

4. Discussion

The comparative analysis of five unmanned retail models reveals a broad spectrum of technological sophistication and spatial strategies aligned with each retailer’s operational priorities and target customer profiles. Notably, Amazon Go and JD.com represent highly automated environments supported by advanced AI and sensor-based ecosystems, offering

seamless shopping experiences with minimal human intervention. Amazon Go's "Just Walk Out" system uses a combination of computer vision, deep learning, and sensor fusion to track purchases in real-time and automatically process transactions (Amazon, n.d.; AWS, n.d.).

JD.com, on the other hand, utilizes facial recognition and dynamic shelving systems that respond to customer behavior, setting a new benchmark for personalization and intelligent retail design (JD.com, 2024). These technologies allow for predictive interaction and adaptation, enabling the retail environment to respond to users in real time.

In contrast, Auchan Minute follows a resource-efficient and modular retail approach that prioritizes cost-effectiveness, scalability, and sustainability. While it employs RFID for inventory tracking, it intentionally avoids the complexity and expense associated with IoT and biometric systems (Fleet Owner, 2022). This duality illustrates the flexibility of the unmanned store paradigm—ranging from high-tech intelligent environments to minimalistic yet functional solutions.

In terms of spatial strategies, distinct interior architectural logics are evident across store types. Amazon Go employs open-plan layouts with clearly marked entry and exit points to support frictionless circulation. Alibaba's Hema integrates modular display units and digital wayfinding to facilitate hybrid usability and in-store navigation (Hiranand, 2021). Meanwhile, BingoBox illustrates a compact, vertical retail design that fits within constrained urban environments and minimizes spatial footprint while still ensuring RFID-enabled autonomous service (PYMNTS, 2018).

A key observation is the increasing role of biometric systems and real-time analytics in shaping spatial interaction. JD.com's use of facial recognition extends beyond payment, supporting adaptive environmental design based on user presence and behavior. Hema complements this with app-based navigation and dynamic recommendations—signifying a shift toward data-informed spatial environments (PMR, 2022).

However, the proliferation of such technologies introduces notable design challenges. First, ensuring accessibility for digitally marginalized populations—such as the elderly or those with limited digital literacy—remains a pressing concern. Second, the use of facial recognition and behavioral tracking raises ethical issues, particularly regarding user consent and surveillance (WTW, 2024). Third, highly digitized environments may risk diminishing psychological comfort and spatial warmth, especially when biophilic and human-centered design cues are lacking (Diker & Demirkan, 2023).

To address these concerns, interior architects must adopt human-centered design strategies that balance automation with clarity, comfort, and inclusivity. This includes designing intuitive wayfinding paths, integrating biometric systems discreetly, and preserving environmental cues that support orientation and well-being. As unmanned retail evolves, spatial design must serve not only functional needs but also ethical and emotional dimensions of user experience.

5. Conclusion

This study has examined the impact of unmanned retail stores on interior architecture within the context of technological integration, spatial organization, and user interaction strategies, revealing profound shifts in the design paradigm of retail spaces. Through a comparative analysis of five leading models—Amazon Go, Alibaba Hema, JD.com, BingoBox, and Auchan Minute—it has been demonstrated that interior architecture is no longer a passive backdrop but has evolved into an active interface between user behavior and automated systems.

The findings indicate that technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and Radio Frequency Identification (RFID) have transformed retail interiors into dynamic and responsive environments. Store planning is no longer confined to circulation and visibility; instead, it is conceived to facilitate seamless interaction between users and digital interfaces. Spatial configuration, product placement, and wayfinding strategies must be designed to ensure a fast, intuitive, and frictionless shopping experience without the need for human assistance. Furthermore, the principles of ergonomics, accessibility, and inclusivity have become indispensable in catering to a diverse user base.

Although these new store models offer significant advantages in terms of efficiency and scalability, they also introduce ethical and psychological challenges, including data security risks, technological inequality, and emotional detachment. Therefore, interior architectural solutions must go beyond mere functionality to embrace a design philosophy that is user-centered, trustworthy, and aesthetically meaningful.

In conclusion, the discipline of interior architecture assumes a new professional role in unmanned retail environments—one that manages user experience and integrates seamlessly with digital systems. Future design models should adopt holistic approaches that blend technological innovation with human-centeredness, ethical responsibility, and sustainability.

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Conflict of Interests

The Author(s) declare(s) that there is no conflict of interest.

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