



## **Applications of Smart Technologies in Residential Interior Design**

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### **Abstract**

Smart Technologies and their innovations are among the most significant outcomes of the industrial revolution. Their applications have expanded across many fields, including medicine, industry, agriculture, economics, the military, engineering, arts, education, and various other areas of life. Smart Technologies have developed rapidly, opening new opportunities for innovation that may lead to further industrial revolutions and bring substantial changes to human life and behavior. The rapid technological and Smart Technologies advancements, along with the transformations occurring under the Fourth Industrial Revolution, have positioned Smart Technologies as a key driver of growth, progress, and prosperity in recent years. As Smart Technologies have advanced across multiple fields, they are now increasingly present in residential environments and accessible to users. Human needs can often be met with the simple press of a button, and in the future, Smart Technologies may anticipate and fulfill needs automatically through smart home systems and sensors, potentially giving rise to innovations that may currently seem imaginative. The current signs of development and the continuous emergence of innovations indicate that this advanced environment is approaching, requiring a reconsideration of interior design practices and more focused studies to align with the requirements of the new era. This research addresses the problem and explores the theoretical framework, including the relationship between Smart Technologies and interior design. One of the main conclusions is that, when Smart Technologies are applied in interior environments, the primary goal of design is to create interactive living between humans and smart technologies. Function and beauty in interior design acquire new meaning that corresponds to the scale and sophistication of these technologies.

**Keywords:** Smart Technologies, Interior Design, Applications of Smart Homes

### **1.1 Research problem**

The research problem arises from the limited number of studies examining the integration of Smart Technologies in residential interior design. In particular, there is a lack of research exploring Smart Technologies' technological applications in interior spaces, as well as the absence of clear frameworks for their practical implementation. To address this gap, this study investigates how Smart Technologies can be effectively applied in residential interior design. The main research question is formulated as follows: "How can Smart Technologies and their technological applications be effectively integrated into residential interior design, and what frameworks can guide this integration?"

### **1.2 Research Significance**

- 1- This study contributes to knowledge by examining the role of Smart Technologies in residential interior design, offering insights that researchers can utilize in future investigations.
- 2- The research introduces a novel perspective in interior design by linking the principles of form and function with Smart Technologies, reflecting current scientific and technological developments.
- 3- The study provides a reference framework and scientific material that may support subsequent research in the field of interior design.



### **1.3 Research objective**

"To explore Smart Technologies and their applications in the residential interior environment in a way that expresses functional and aesthetic needs and aspirations."

### **1.4 Research limitations**

- 1- The study is thematically limited to exploring Smart Technologies and their technological applications in achieving comfort and safety within contemporary residential interior spaces.
- 2- It is spatially limited to examples drawn from residential interior environments worldwide.
- 3- The research is temporally bounded, covering the period from 2020 to 2026.

### **1.5 Terms Defined**

#### **Smart Technologies:**

##### **Smart (Linguistic Definition):**

The concept of smartness has been interpreted in various studies to explain its linguistic meaning. Its root comes from the word for intelligence, which is related to the verb. It conveys the following meanings: Completion or perfection of a thing, which is considered the original meaning of intelligence in the language (Al-Razi, Muhammad bin Abi Bakr, 1982, p. 233).

Smart: to become intense or inflamed, often used to describe someone sharp or keen. It also refers to the innate capacity of the senses in intelligence (Al-Alayli, Abdullah, 1974, p. 422).

##### **Smart (Terminological Definition):**

Smartness refers to a set of mental abilities that allow a person to process information using abstract, verbal, or symbolic materials. It involves innate cognitive skills, the gradual development of reasoning and information processing, and the integration of knowledge, focus, and behavior to achieve effective outcomes (Rochka, Alexander, 1989, p. 67).

##### **Technology (Linguistic Definition):**

The word comes from the root (Tech), which means mastery. For example, the verbs (taqqana), (atqana), and (atqanahu) mean "to perfect" or "to do something skillfully," showing someone's ability to handle things well. (Ibn Manzoor, 2003, p. 473) Mastery (Itqan): comes from the verb (atqana), meaning precision. For example, a craftsman completes his work carefully and skillfully. (Mas'ūd, Jibran. 1992 p. 18)

##### **Technology (Terminological Definition):**

The term refers to the principles or methods used to carry out tasks or achieve goals with scientific accuracy. It comes from "Techno," which means art and industry, as well as work and practical application. (Ibrahim Madkour, 1983, p. 53)

#### **Operational definition of the research:**

Smart Technologies are tools and systems designed to perform tasks efficiently and accurately. In residential interior design, they include devices and applications that enhance comfort, functionality, and responsiveness in living spaces.

### **2.1 Literature Review**

#### **The Relationship of Smart Technologies to Interior Design:**

Smart Technologies have become increasingly prominent in the field of interior design, closely linked to modern technologies that save time and effort. Interior design, in general, is a process of innovation and creation, which is greatly enhanced through the use of technology (Huda Mahmoud, 2004, p. 68). With the advancement of computer systems and the emergence of specialized interior design software, Smart Technologies



have played a vital role in project design. Interior designers now utilize 3D graphics to present and visualize their proposals. The introduction of computers as digital models and tools for implementation, or as means for displaying designs through specialized software, allows designers to manipulate layouts, adjust lighting, modify colors, and arrange furnishings without the use of traditional paper-based tools (Cindy Coleman, 2002, p. 247).

The impact of Smart Technologies and digital technology on interior design is evident in the transformation of conventional design language, the emergence of new tools and methodologies, and the influence on human activities within interior spaces. Since interior space reflects human activity within a building, it has also evolved: modern interior spaces now incorporate Smart Technologies and digital technologies, enabling users to interact with and manage the building from their seats. This integration has contributed to the optimization of spaces and the use of smart technology to meet human needs both now and, potentially, fully in the future. Recently, Smart Technologies have become more prominent in interior design, providing diverse services to users of interior spaces. Interior environments now include advanced electrical, mechanical, and digital systems powered by Smart Technologies. Interior designers focus on allocating and shaping these systems to support specific activities, describe spaces interactively, and enhance functionality. The widespread availability of microelectronics in the twenty-first century, along with digital networks containing artificial neural systems (Cindy Coleman, 2002, p. 49), and the integration of sensors within computer-controlled programs, further support the fulfillment of users' needs in interior spaces.

## **2.2 Stages of Development of Smart Technologies in Smart Buildings**

Smart buildings are an example of using Smart Technologies in interior design and architecture. The term "smart buildings" came up around 1980, referring to buildings where things like energy, temperature, lighting, sound, and communication are all connected. Smart buildings are seen as active and helpful structures that try to give users the best service (Bayan, 2015, pp. 12-13).

Smart buildings started in the United States, where they first used communication systems and ways to manage buildings remotely. From there, the idea kept growing with new technology, which made it possible to develop architecture and interior design. Smart buildings have grown fast compared to other areas, and they are usually divided into three types based on how they developed (Alaa Rafiq, 2017, pp. 14-15).

- 1- **Automated Buildings:** These came about between 1980 and 1985, when different communication technologies, both wired and wireless, were introduced. At first, these were used in homes, marking the first time technology was applied to control building systems.
- 2- **Responsive Buildings:** These appeared between 1986 and 1991. Responsive buildings were made to adapt to the changing needs of people using the spaces. They included technologies that could adjust and change building systems over time, depending on how the building was used.
- 3- **Effective Buildings:** This stage started in 1992, thanks to some IT consultants in Europe. Effective buildings focus on what people need to do and use technology to help with design and construction, instead of being the main part of the building. Even with all the progress in Smart Technologies and their use in interior design, the main goal is still to run spaces efficiently, keep costs low, and make the environment safe, comfortable, and healthy for everyone.

## **2.3 Interior Design of the Residential Environment as a Response to Transformation and Digitalization**

Smart Technologies are increasingly integrated into various fields, including modern interior design. Digitalization plays a major role in this transformation due to the



significant technological advancements it introduces. It involves organizing and planning the intellectual process according to subject, purpose, and function, applying knowledge and experience throughout the creative stages in interconnected steps based on scientific and intellectual systems. Digitalization studies technology and technical systems as tools for achievement and serves as both a need and a means to implement transformations in design (Huda, 2004, pp. 67-68).

Globalization and the digital revolution have brought new directions and philosophies, widely influencing many aspects of life. The philosophy of digital technology fits within modern theoretical frameworks, emerging from the requirements of this era and reflecting its renewed theories and trends (Al-Taweel, 2005, p. 68). The term “digital” refers to computer-based processes used to organize and transform forms, whether static or dynamic. These processes employ technologies and software to create dynamic designs with virtual reality that closely approximate the real world, allowing interior designers to test and refine their designs for further development. Design and construction techniques under digital technology are no longer conventional; instead, design has become dynamic, interactive, and adaptable (GAO, 2003, p. 12).

It is also important to note that digital architecture is a product of smart architecture, which incorporates an ecological dimension. Buildings integrate systems connected to their surrounding environment, drawing energy from it. As a result, digital architecture aligns with trends such as bioclimatic, green, and sustainable architecture. It also introduces a technological dimension, giving rise to new concepts stemming from the evolving use of computers in design—from analysis and calculation tools to instruments that create dynamic, realistic visualizations (Khaled, 2006, p. 15).

These developments require interior designers to reinterpret traditional concepts to align with the era of smart design. The concept of function has evolved due to technological progress. Today, the primary goal of interior design is to create interactive living environments while considering both internal and external surroundings. Designs must allow for adjustments in form and function to meet future user needs. Interior design elements no longer retain the functional characteristics historically understood. Both internal and external environments have transformed: the external environment now acts as a complex interface, facilitating interaction between the inside and outside while integrating with the building’s systems and technologies (Rasha Ali, 2014, p. 6).

#### **2.4 Communication and Information Systems Pillars in Smart Buildings**

The operation of systems in smart buildings relies on a central computer (server) connected to an integrated network, functioning similarly to the human nervous system. Sensors are distributed across the entire perimeter of the building, collecting data from the indoor environment through pre-configured systems. This data is applied and controlled using the computer, internet connection, and mobile devices, as illustrated in Diagram No. (1).

The smart environment is composed of multiple layers, each containing technologies that support the production, classification, and analysis of data while maintaining the capacity to respond optimally. The functioning of these layers depends on a robust communications infrastructure or an integrated domain platform. Each layer is essential in creating a smart indoor environment, and they can be categorized as follows (Mega Kumar, 2015, p. 5):

##### **1-Communications:**

This layer includes various types of communication, such as cellular networks (3G, 4G, and 5G), Bluetooth, Wi-Fi, as well as data collection devices and sensors. A strong communications infrastructure ensures effective access to systems and efficient management of collected data.

## 2-DataCenters-Operations:

These centers are responsible for storing the large volumes of data produced and collected in public data warehouses. This ensures that the data is easily accessible for all applications and systems.

## 3-Analytics:

The smart environment uses the collected data to generate valuable insights and actions through structured data analysis. Programmed analytics guide procedures and help optimize the use of resources effectively.

## 4-Applications:

Applications allow data entry, retrieval, and collection across different platforms, including internet services and mobile devices such as smartphones, tablets, and sensors. They provide users with an integrated experience by linking services from multiple sources, thereby enhancing overall efficiency and information delivery.

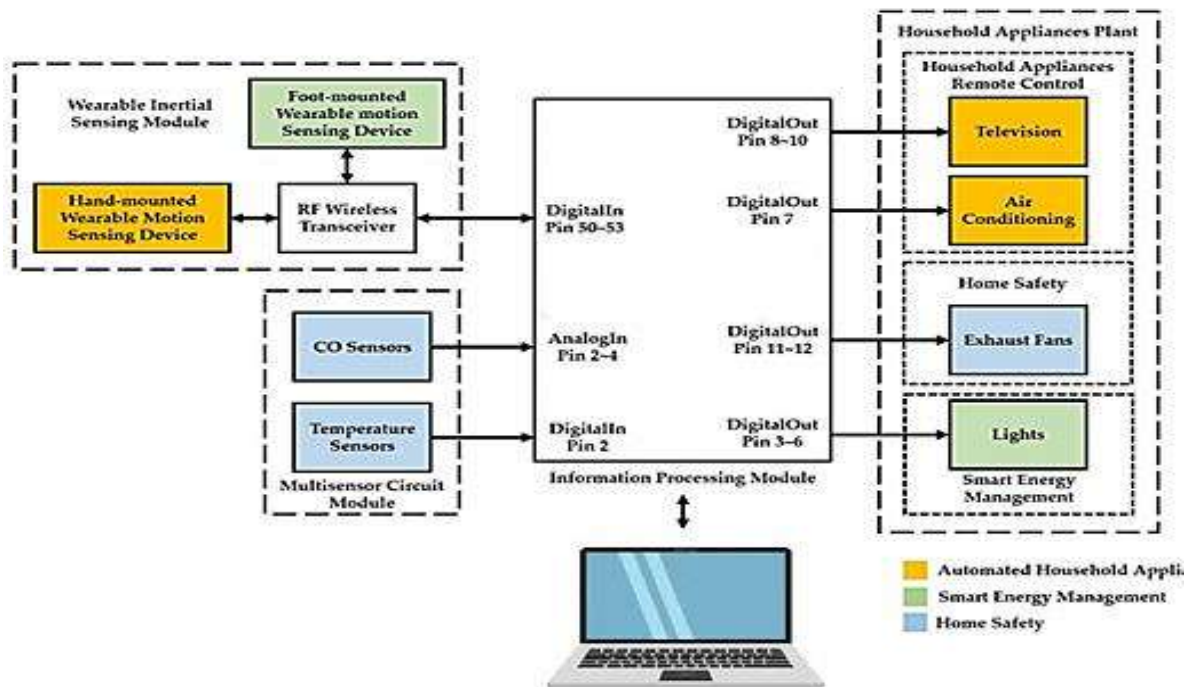


Diagram No. (1) is a model of the system architecture in a smart home.  
 Prepared by the researcher based on the source: (Group body, Design and  
 Implementation of a Smart Home System

## 2.5 Smart Systems in the Residential Interior Space Environment

Smart Technologies and systems in residential indoor environments can be classified into two main categories: communication systems and management systems. Each of these categories is further divided into building control and automation systems. All smart systems can be organized as shown in Table (1) and rely on smart devices designed according to the building's functional performance. These include digital internal video communication systems, monitoring, control, and statistical systems, as well as surveillance cameras. Other examples are digital systems, centralized television broadcasting networks, internet and Wi-Fi networks, and smart space systems.

In addition, there are independent applications such as fire detection and alarm systems, remote control systems, indoor air conditioning (cooling and heating) systems, smart lighting systems, renewable energy systems, and water conservation and heating systems. The operation of these systems also incorporates aspects of smart periodic maintenance for devices and systems, as summarized in Table (1).



Table 1: Smart Systems in the Residential Environment  
 (Prepared by the researcher based on the source: Muhammad, 2018, pp. 6-10)

<p>The internal space is managed through three main stages: first, data collection and statistical analysis; second, analyzing the collected data to support decision-making; and third, controlling the building by responding to external conditions and influencing factors. Within the smart environment, security and safety are ensured against threats such as intrusions, theft, and fire. The system's effectiveness relies on devices that operate automatically when a danger is detected, receiving signals through communication systems and minimizing the potential impact to the lowest possible level.</p>	<p>Digital Communications and Control System</p>	<p>Control of communication systems</p>
<p>A computer-based database assists in making decisions regarding the operation of air conditioning units to maintain a suitable indoor environment. This system relies on a database connected to the control devices, containing information about users, their preferences, and their needs. Additional systems manage thermal performance by adjusting the size of the conditioned space according to the number of occupants and their movement patterns. This is achieved through digital internal partitions that limit heat exchange with adjacent spaces, thereby reducing the overall heat load.</p>	<p>Controlling air conditioning units</p>	
<p>Its function is to monitor movement and activity both inside and outside the building. The system operates through sensors that activate recording when specific movements are detected within the space. Cameras are strategically distributed across the interior areas, while ensuring that zones with a certain level of privacy remain excluded.</p>	<p>Digital surveillance cameras</p>	
<p>It is a specialized network for receiving television channels, connected through cables and equipped with devices that provide high-definition and high-resolution broadcasting, making it available whenever required.</p>	<p>Centralized networks for receiving television broadcasts</p>	<p>Controlling management systems</p>
<p>It is connected to the safety and security system and functions to detect the onset of fires using sensors and heat detectors that identify gases and smoke. The system is directly linked to alarm mechanisms, enabling users to evacuate the building quickly. Simultaneously, the fire can be suppressed by the sprinkler-based extinguishing system. The entire setup is controlled centrally.</p>	<p>Fire alarm and suppression system</p>	
<p>Remote control of the heating, cooling, and ventilation systems.          Control of interior and exterior lighting units.          Management of locking and unlocking doors, windows, blinds, entrances, and the garage.          Control and monitoring of various building elements through mobile smart devices.</p>	<p>remote control system</p>	
<p>Interior lighting is managed by automatic timers that operate according to a preset schedule. Some systems employ infrared sensors to activate lights automatically when movement is detected. Other systems monitor the intensity of artificial lighting within interior spaces, adjusting light levels to maintain a constant brightness using solar cells, which enhances energy efficiency. Exterior lighting can be controlled by light sensors that synchronize illumination with the natural day-night cycle, resulting in substantial energy savings.</p>	<p>Smart lighting system</p>	



<p>An example of this includes infrared faucets, which automatically turn the water on and off when hands are placed under or removed from them, resulting in significant water savings. Similarly, there are flushing devices that activate immediately after bathroom use, chair heating systems that operate as soon as a person sits, and hand and paper towel dryers that function through sensors. Garden irrigation systems are also programmed to operate based on a schedule. Regarding heating, solar energy systems, known as solar water heaters, operate with high efficiency and contribute to energy conservation.</p>	Smart systems for water conservation and heating	

## 2.6 Smart Technologies in Interior Design Elements Used in Residential Environments

### 1- Smart Home Furniture:

Furniture design and production have experienced a qualitative leap in both functionality and aesthetics due to the integration of Smart Technologies and digital technologies. Furniture is no longer a static object used in its traditional form; it now has the ability to sense, recognize, interact with, and respond to user needs. This is achieved through the incorporation of computers and electronic components within the furniture, including sensors, wiring, microprocessors, and other supporting devices that allow each piece to operate automatically.

What sets smart furniture apart from ordinary furniture is the addition of computer applications, which provide an additional dimension to its use and performance. Moreover, the design of furniture has evolved to accommodate these new features, with geometric shapes becoming a prominent trend in this type of design. Smart furniture items are interconnected through a home network, enabling seamless data transfer between different pieces (T. Prante, 2004, pp. 47–54).

#### Key features of smart furniture include:

- Providing excellent service through sensors:** For example, a mirror can recognize the user and display personalized information while brushing teeth, or a bed can monitor the user's body and adjust the climate control system accordingly (Figures 1 and 2).
- Responsiveness to user activities:** Smart furniture is programmable and interactive, utilizing touch-screen surfaces for control.
- Multiple functions:** It supports a range of virtual activities, entertainment, relaxation, work, and the management of other devices, including controlling the building's climate system.



Figure (1) Smart Bed Source:  
<https://www.aliexpress.com/item/1005003784596859.html?gatewayAdapt=ara2glo>



Figure (2) Smart mirror Source:  
<https://ar.pinterest.com/pin/459930180700680149/>

## 2- The Smart Kitchen Table:

The smart kitchen table is one of the Smart Technologies employed in smart homes, emerging recently within the concept of the smart kitchen (Figures 3 and 4). It is a multi-purpose interactive table that transforms the kitchen into a comfortable space for relaxation, even while preparing food. Through this technology, users can enjoy a more flexible cooking experience, and guests can also participate in food preparation. The table allows users to work, enjoy their meals, and entertain themselves simultaneously. It is designed for low energy consumption and includes a waste disposal feature (website 1).

Other notable features of the smart kitchen table include:

- a) **Touchscreen interface:** The table features a touchscreen with numerous user interactions, allowing users to browse the internet on the countertop while cooking.
- b) **Multimedia integration:** It supports multimedia networks, enabling various electrical appliances to communicate with and control each other via the internet. This includes access to a recipe database, a television for displaying channels, and the ability to control other services within the space (website 2).
- c) **Dynamic tabletop interface:** The tabletop is powered wirelessly, allowing unplanned cooking anywhere on its surface. Wireless power follows the dishes as they move across the table, while the control panel is displayed on the top surface. This provides users with a flexible cooking experience without safety concerns, as kettles or pans can be passed to others to finish preparation. Cooking and cooling can occur simultaneously (website 1).
- d) **Wireless sensing networks:** The table is equipped with wireless sensors that can detect user activities and respond to their needs.



Figure (3) Model (A) of the smart kitchen table Source: <https://www.pinterest.com/kacpe16>



Figure (4) Model (B) of the smart kitchen table Source: <https://pt.ihodl.com/technologies/2015-07-12/a-sua-cozinha-em-2025-de-acordo-com-o-ikea/>

## 3-Smart walls:

Smart walls represent a modern innovation in interior design, as they incorporate technological features that may serve as a replacement for conventional walls in the near future. It is worth noting that the concept itself is not entirely new, having been previously implemented in the digital home designed (Al-Nizari, 2009, p. 63).

What distinguishes these walls is their versatility, achieved through hidden internal equipment and devices, such as cameras and sensors, which operate via television and computer systems. These walls can be utilized in both enclosed and open environments, allowing users to create interactive work and living spaces.

The goal of smart walls, as illustrated in Figure (website 2), is to provide the following features:

- a) Multi-featured, customizable display systems: These displays appear on the wall and can incorporate entertainment elements as well as internal wall sensors.



- b) Internet connectivity for remote activities: The walls enable a variety of remote functions, including distance learning, telecare, online meetings, and remote work, while supporting fast and interactive virtual communication.
- c) Environmental control capabilities: The smart wall interacts with user functions by managing the climate control system and both natural and artificial lighting, creating a suitable atmosphere within the residential environment. In addition, users can control other household appliances through the smart wall (T. Prante, 2004, pp. 47–54).



Figure (5) Smart Wall, Source:  
<https://inno-vatech.com/service03/>

#### **4-Smart Floor:**

The smart floor wall is one of the modern innovations in smart residential environments. It is distinguished by its ability to detect abnormal user behavior patterns within the indoor space. The system monitors and tracks any situation that could pose a problem and activates rescue procedures in the event of a fall or other emergencies. This functionality is achieved through sensors that detect the number, weight, shape, and location of objects and people, using foot pressure sensing technology. The smart floor wall represents one of the key technologies integrated into the design of residential spaces to enhance security and safety, and it is primarily implemented in smart homes (K. Yin & D. K, 2003, pp. 329–338) (Figure 6).



Figure (6) Smart Floor Source:  
<https://video-ekran.ru/konstrukcii/neobychnyje/svetodiodnyj-pol.html>

## 5-Smart windows:

Smart windows are a kind of smart home technology used inside smart homes. As a new innovation, they are used in Western countries and in some rich Arab countries. These windows have technologies that let them do important jobs for users, especially helping to save energy. (Li et al., 2017, pp. 538–539).

When the outside temperature is high, smart windows turn opaque white to block unwanted solar heat from entering the building. Conversely, when temperatures drop, they become transparent, allowing natural light to pass through. The method by which smart windows control light transmission relies on various physical phenomena that respond to light, each with its own advantages and limitations (website 3), as shown in Figures 7 and 8. Some of these phenomena include:

1. Thermal optics
2. Light color changing
3. Liquid crystals
4. Particle screens
5. Color change via electricity

The applications of smart windows continue to evolve thanks to Smart Technologies. Recent studies demonstrate ongoing innovations in this field. A new development in smart windows enables users to customize the view from their residential unit. For example, a unit no longer needs to overlook the sea, a river, green spaces, or even snowy landscapes; smart windows allow users to change their view according to personal preferences. This innovation is especially useful in densely populated areas with closely packed buildings.



Figure (7) shows the control over the use of smart windows through electronic settings.  
Source:  
<https://muhandes.net/?p=2196>



Figure (8) shows the use of smart windows in hot and cold climates. Source:  
<https://muhandes.net/?p=2196>

## Conclusions and Recommendations

### Conclusions:

This study has led to several conclusions that help us understand the role of Smart Technologies in residential interior design. These conclusions can be summarized as follows:

1. When Smart Technologies are used in interior spaces, the main goal of design becomes creating a living environment where humans and smart technologies interact naturally. Both function and aesthetics in design now take on new meanings that match the capabilities of these technologies.
2. Smart Technologies help improve energy efficiency by managing systems like lighting and temperature inside homes.
3. Smart devices allow smooth connectivity throughout the house, making it easy for users to control their spaces quickly and efficiently using sensors.



4. Adding Smart Technologies to traditional interior design changes the way designers work. It shifts the usual design language and introduces new methods using sensors, equipment, and computers, requiring designers to rethink traditional principles.
5. All Smart Technologies-powered products in smart homes are designed with the environment in mind. They support sustainable architecture by reducing energy use, conserving resources, and protecting the environment.
6. Technology and Smart Technologies are tools to help with design and construction, rather than being the main foundation of a building. Smart buildings are basically regular buildings improved with technology to make interiors more efficient, safe, healthy, and comfortable.
7. As Smart Technologies advance rapidly, smart homes are likely to become more common soon. New equipment will be cheaper and more widely available, making smart homes accessible to more people.
8. The meaning of "function" in smart homes has changed. Design now focuses on interactive living while considering both the inside and outside environments. Interior spaces should be flexible, allowing adjustments in form and function to meet the needs of future users.

### **Recommendations**

The research recommends that specialists in the field of interior design, as well as graduate students, undertake modern studies focusing on Smart Technologies. It encourages the development of scientific plans and programs by experts and professionals in a manner that contributes to expanding future prospects for both the public and private sectors. This approach will help Iraq keep pace with global advancements and facilitate the implementation of smart building concepts.

Additionally, the research emphasizes the importance of raising societal awareness about the economic value of smart buildings, highlighting the solutions they provide as suitable alternatives within the interior environment. These solutions should align with contemporary requirements while promoting reduced consumption, energy savings, and environmental preservation.

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