Research Article

Intelligent Structures and Their Role in Creating Interactive Spaces

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Abstract: Urban planning has always been studied alongside its interaction with the surrounding environment. Yet, owing to the urban sprawl, the uncontrolled and poorly-managed population growth in the modern era, and the application of construction technology in a way inconsistent with the context, we are now witnessing an unrestricted growth in many urban areas of housing, commercial development, and roads over large expanses of land, with little concern for urban planning. Interactive architecture is a method that mostly deals with the interactive nature of architecture, humans, and the surrounding locations. Hence, the main quest in this discipline is to find ways to achieve, through innovative structures introduced as modern construction technologies, the ideal architecture and interactive spaces from the perspective of urban planning. In this regard, technological breakthroughs need to be reviewed and updated accordingly as an efficient tool in the processing method. One such breakthrough is intelligent structures that can respond appropriately and timely to the environment by receiving and processing environmental events and information through properties such as adaptability, selectivity, fast performance, automated performance, and dependency.

The current study employs a descriptive-analytical design and archival methods to examine the interaction between the context and the intelligent structures and the benefits thereto. The findings indicated that, with its particular emphasis on human senses, culture, and context, construction technology, in addition to its primary role of implementing innovations in architectural spaces, can create interactive spaces, strengthen the spirit of social interactions, alleviate social problems and improve the quality of service-entertainment spaces.

Keywords: Interactive spaces, new construction technology, interactive technology

1. Introduction

Architecture and the city are living, dynamic, and ever-evolving entities in the cycle of time and space, which is composed of physical and human components and complex relationships there between. One of the rising challenges of urban society is the disappearance of human interactions with the surrounding environments and designed space. Researchers argue that less interaction of this nature leads to humans losing their sense of belonging to the environment. The purpose of this study was to introduce interactive architecture as a new avenue for responding to the plethora of problems that have arisen in efficient urban management and organization. Studying this issue can result in a breakthrough for modern architecture, as urban planners who are equipped with the knowledge of modern facilities, methods, and technologies are highly able to come up with the proper tool required for problem-solving. This article intends to examine the examples in this field, to identify and how architectural structures relate to humans, nature, environment, and the benefits of using intelligent structures to create and improve the quality of spaces of collective interaction. This paper seeks to identify how architectural structures relate to humans, nature, and the environment and the benefits of using intelligent structures to create and improve the quality of spaces of collective interaction.

Accordingly, this study seeks to find ways to achieve, through innovative structures introduced as modern construction technologies, the ideal architecture and interactive spaces from the perspective of urban planning. In this regard, technological breakthroughs need to be reviewed and updated accordingly as an efficient tool in the processing method. One such breakthrough is intelligent structures that can respond appropriately and timely to the environment by receiving and processing environmental events and information through properties such as adaptability, selectivity, fast performance, automated performance, and dependency.

2. Research Background

Given the wide range of issues discussed in urban planning, the history of research on various topics and approaches such as the application of intelligence is highly diverse and extensive. Yet, interactive architecture and its place in creating a connection between man and the environment and the designed architectural space has been highly neglected by researchers. Nevertheless, various researchers have made valuable contributions to the literature. Fulong (2007) examined the revitalization of the dimensions and aspects of urban development through strategic planning and design using modern technologies for Chinese cities. Vance (2007) studied smart streets and their role in creating the social excitement of cities. Seif al-Dini (2013) examined the contexts and obstacles to the growth of a smart city in Khorramabad. Taghvaei et al. (2015) examined the physical development and sustainability using the approach of smart growth and compact city. Hashemnejad and Shenghehpour (2010) sought to achieve a virtual architecture model that can create a cultural and social interaction between users in virtual environments and increase the participation of different groups of people in the community.

3. Interaction

Interaction is reciprocal action based on relationship and solidarity. Interaction means establishing a give-and-take relationship with one another (Dehkhoda Dictionary, 1998). Human beings are only able to interact with the environment through establishing a sense of belonging and desire. Speaking, the term "Belonging" refers to the hanging on to something and establishing a connection, friendship, affection, attachment, desire, and attraction (Zolfagharizadeh, 2006).

The relationship between man and space is reciprocal and thus with two aspects, namely (1) the effects of behavior on space, and (2) the effects of space on behavior.

1. The effects of behavior on space: Space is a phenomenon that must be studied alongside people and their behaviors. The behavior of people in every space affects the qualitative characteristics of that space. Quality is a term that makes semantic association when employed in relation to human beings. Therefore, it can be said that space borrows some of its features, including its qualitative characteristics, from the effects of people's behavior in that space.
2. The effects of space on behavior: There is no doubt that, as an objective part of the environment, space can deeply affect behavior. Although the effects of space on behavior are not definite and unique, it can have undisputable impacts on behavior (Javadi, Budagh, and Makani, 2015).

Behaviors can be reinforced or weakened based on the response they receive from the environment. This means that the quality and quantity of space can establish a pattern of behavior for people. Hence, space is part of the context of behavior and can play a role in controlling, that is, inducing or eliminating, behavior. Therefore, space can take an inspiring or encouraging role. As such, the environment consists of a set of behavioral sources that are located within each other and have common chapters. The main elements of these sources are the pattern of behavior indicator and physical environment (Lang, 2012).

Most human behaviors in the environment are influenced by the meaning of space of "place" rather than the objectivity of the environment of "space". In this sense, the association between man and place is inseparable, and there between is a link called identity. Therefore, man is believed to give identity to the place and vice versa. Hence, place and man become two inseparable fractions of a whole.

According to the theories of the Gestalt school, the human mind consists of meaningful general perceptions that are related to each other through association and thus interpret a diverse range of phenomena (Sadat Hosseini, 2008).

According to Nurberg Schultz, the sense of place is found in places with distinct personalities (i.e., an identity), and that particular personality is made of tangible things that have materials, shape, texture, and color. Therefore, considering that the sense of place is not just a simple way to explain how a person perceives a place, but rather a value and multidimensional concept, identity can be perceived as one of the ways to create and establish a sense of place and spaces and to fashion unity between man and place.

Interactive architecture

Interactive design can be perceived as a simple concept and in a simplified context, that is, not inherently simple. Interactive design is a type of design that arises from interactions between users and products. When people discuss interactive designs, they are more interested in software and digital products and services such as websites and applications. The goal of interactive design is to build products that can guide the user in the best possible way to achieve their goals.

In general, the purpose of interactive architecture is to design and build spaces that can adapt to the ever-changing demands and conditions of people, the environment, and the community in which they live. The transfer of information between two systems (i.e., two humans, two machines, one human, and one machine) is a fundamental principle of interaction. The basic point about interactive architecture systems is that the interaction therein forms a cycle, otherwise, the interaction does not take place and only one-way communication is said to take place (Isfahani, 2016).

Figure 1: Interactive virtual environments

Digital technology

In the age of information, we live in an environment where buildings are rapidly changing. Telecommunication systems are replacing propulsion systems. Today, spaces are usually occupied by telecommunication systems and computer systems. Digital appearances are increasingly replacing the physical appearances of the traditional world. Therefore, architecture plays an important role in organizing functions and the relationship between activities.

Figure 2: Combining technology, human and environment to be interactive

Among the most important effects of digital space on everyday activities and their spatial aspects are as follows is that the business processes and structures of today's companies are being increasingly virtualized. Instead of using the rational and historical structures of an architectural environment, physical spaces are diminishing daily through software applications and the Internet (Kashani Joo, 2003).

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Figure 3: Design of effective interactive surfaces in the architectural space

Digital technology and design of interactive spaces

The electronic age forces people to conceive of building as abstract art. Space must be a means by which man can freely trespass while collecting the information with which space is organized. In this regard, Wines argue that architecture is merely a state of affairs, that is, everything disappears, everything passes through it, and a man gets pre-occupied with the idea rather than form. According to Wines, the transparency of matter enables man to understand the relationship between nature and architecture, and the information communicated there between (Gary Gori, 2012)

Intelligent structures

NASA defines smart materials as those having the ability to remember structures and follow them under the influence of certain stimuli. The Encyclopedia of Chemical Technology offers a more comprehensive definition: Intelligent materials are phenomena that sense environmental events, process the resulting sensory information, and affect the environment accordingly (Eddington and Skodek, 2010). According to the aforementioned definitions, it is safe to say that intelligent materials sense the changes in the environment, process them, and then react to the information stored in their structure.

Types of smart materials

- Attribute-changing materials that some of their chemical, mechanical, electromagnetic, and/or thermal properties alter in direct reaction to changes in external stimuli.
- Energy-converting materials convert energy from one form to another.
- Materials belonging to two groups that have a reversible or a two-way feature, for example, they generate or exchange energy by applying electric current traction.

Case studies of interactive structures using intelligent structures:

- Interactive exteriors: interactive facades
- Interactive interiors: floor walls and...

Sidney & Lois Eskenazi Hospital Parking Garage/ Rob Ley Studio

This project was launched to challenge the typical concept of the parking structure as a type of unapproved infrastructure. A field of 7,000 angled metal panels combined with an articulated east / west color strategy creates a dynamic view system that offers observers a unique visual experience depending on their vantage point and speed through the site.

Figure 4: View of the parking lot of Ashkenazi Hospital / Rob Lee Studio

plinthos pavilion

The visual clarity formed by the perforated brick-wall is implemented as the channel of interaction between visitors and the structure. Interactive mechanisms are triggered by touching or shaking the light connections of the stem installed on the floor. Each of the mechanisms generates pre-recorded sounds that affect the brightness of the color-changing lights. This creates a layer of interwoven media reactions that engage the visitor in various ways.

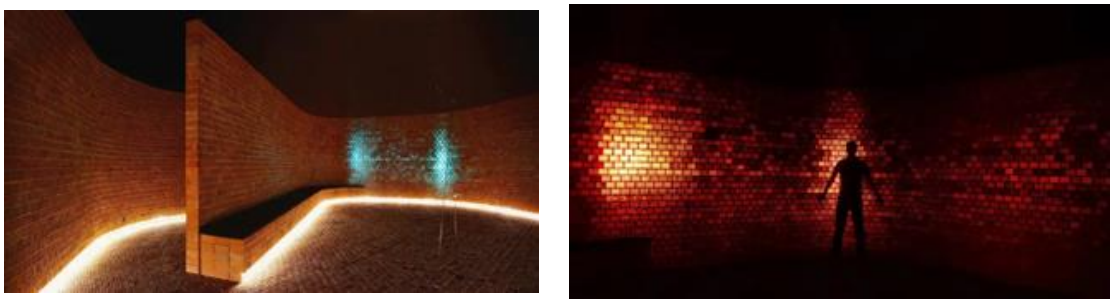

Figure 5: Plinthos pavilion

Spheres

All spheres are controlled by proprietary open-source software that can convert input data into motion, color, and form. A data-responsive intervention is established as a dynamic control relationship between buildings and their occupants. This project will allow the residents of the office environment to have more control over the behavior of their building and to stimulate unexpected interactions and creative results.

Figure 6: Sphere's project

Social sensory architecture is a research project implemented to design multi-sensory spaces for children with autism disorder. The project includes therapeutic advances aimed at empowering multisensory experiences and improving skills that are associated with small movements, social reactions, and auditory functions

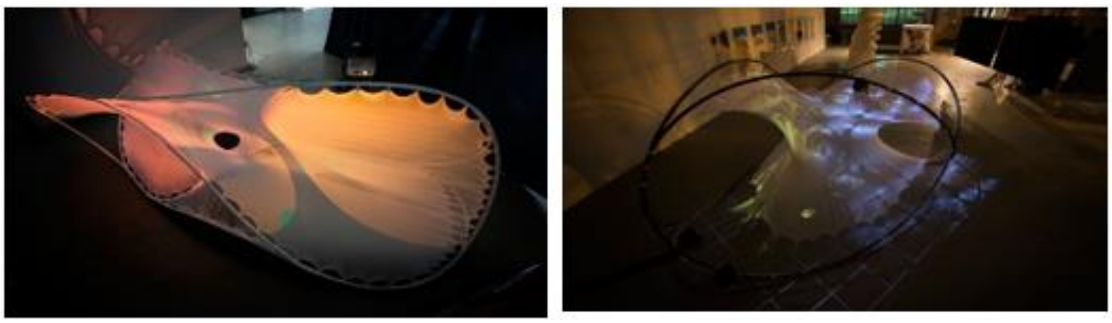

Figure 7: Social sensory architecture

Table 1: Intelligent materials based on input and output actuators (Source: Eddington, Skodek, 2010)

Smart material	Input	Output	Comments
Attribute-changing materials			
Thermochromics	Temperature difference	Color change	They absorb heat and this leads to chemical reactions or phase changes. Uses: As common thermometer strips that are placed on the forehead of people are designed to be sensitive to certain levels of temperature.
Photochromics	Light radiation	Color change	They absorb electromagnetic energy in the ultraviolet range to create an internal property change.
Mechanochromic	Transformation	Color change	Visual properties change due to pressure or deformations dependent on external forces.

Chemochromics	Chemical density	Color change	Their properties are sensitive to different chemical environments
Electrochromics	Electric potential difference	Color change	When activated electrically, they change color
Liquid crystals	Electric potential difference	Color change	
Particles	Electric potential difference	Color change	
Electrorheological	Electric potential difference	Hardness/adhesion	
Magnetorheological	Electric potential difference	Hardness/adhesion	
		Energy converters	
Electroluminescent	Electric potential difference	light	The term luminescence generally refers to light emitted by energy collisions
Photoluminescent	Light radiation	light	
Chemiluminescent	Chemical density	light	
Thermoluminescent	Temperature difference	light	
Light-emitting diodes	Electric potential difference	light	
Photovoltaics	Light radiation	Electric potential difference	
		Reversible materials	
Piezoelectric	Transformation	Electric potential difference	The main component of all types of microphones and speakers and ... Applying mechanical force produces a deformation followed by an electrical voltage or vice versa.
Pyroelectric	Temperature difference	Electric potential difference	
Thermoelectric	Temperature difference	Electric potential difference	
Electro-restrictive	Electric potential difference	Transformation	

4. Results

There are a plethora of advantages to intelligent and flexible structures, which can be tailored to the environment at any time, and the possibilities that a dynamic and changeable space provide, compared to the fixed and unchanging spaces that have been experienced so far. Increased security, reduced environmental pollution, and the possibility of achieving flexible physical programs are among the simplest functions perceivable for interactive buildings. The ultimate purpose of interactive design is to improve the quality of the user experience. Another advantage of intelligent structures employed with an interactive approach is providing a practical solution to achieve sustainable architecture. The application of interactive technology focusing on the facade of buildings as the outermost layer of the building, which are directly related to environmental factors, can lead to the optimal energy performance of buildings, better social and psychological effects, and improved social interactions.

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