ROLE OF INTELLIGENT ADAPTIVE ARCHITECTURE IN THE QUALITY OF HEALTH-CARE SPACES

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ABSTRACT

Nowadays, the architecture of health-care centers has been changed from mere functionalism to create a healing environment. Among the most important components of creating such an environment is to create an interaction between the structure and the user, the way that makes these spaces more hospitable than before by using some methods to improve it. The purpose of this study is to provide a set of practical guidelines based on scientific evidences consistent with adaptive architectural characteristics along with increasing the quality of health-care spaces, which is practical for architects, interior designers and other professionals related to creating health-care environments. This research is investigated in an analytical-descriptive method. The role of intelligent architecture in the quality of health-care spaces was examined which finally led in creating favorable space in interaction with the user that contributes to reduce the stress of the patient and caregivers, the healing of the sick and creating satisfaction of the space.

Keywords: intelligent architecture, the architecture of health-care spaces, interaction of structure with the user, Quality of health-care spaces

INTRODUCTION

Health centers at various levels, from physician's office to specialized hospital are important in the diagnosis and treatment of disease and protection and recovery of people's health of a community and can also have main role in creating physical and mental balance of people which leads to public health in society. Nowadays, in addition to medical methods, architecture and interior design has also important role in treatment and recovery of patient. Because of the complexity of designing health-care, one of the biggest projects is in the field of architecture, health care organizations. So, these projects need to extensive consultation with clients, physicians, architects' engineers, designers and hospital experts and other professionals and final conclusion may take a long time.

On the other hand, buildings and how they are used is changed during past decades especially, two recent decades. In fact, it can be said that except for a few exceptions, the current buildings do not qualify to belong now and meet the users' needs. Organization of modern information societies in indebted to information technology and its impact is on current's science in today's world. Information Technology has created changes in the field of construction and architecture which includes change in manufacturing process, using concurrent engineering methods and new sciences like artificial intelligence, nervous networks and genetic algorithms in civil engineering. By developing in technology, materials, products and innovative manufacturing techniques, moving towards the buildings with higher performance and greater flexibility against environment and user is vital and inevitable.

Further step in the field of interaction of human and structure is intelligent adaptive which is aware of events which will be happened inside and outside due to dictated intelligence and can take most effective and best decisions along with changing and adapting for facing these events and creating desirable environment for users.

In this study, due to the importance of health-care spaces in communities, proceeding to issue of quality of aforementioned spaces and how to promote was studied. In this paper, the indicators of quality of health-care spaces and also different aspects of interaction of human and structure, an organized set of practical guidelines based on scientific evidences consistent with adaptive architecture will be provided in order to increase the quality of health-care spaces.

NECESSITY OF RESEARCH

Coincided with the growing population, the needs and demands of human modern societies will increase to provide the welfare and safety and ensuring health of people and on the other hand, technological and medical advances and more attention to physical recovery of patients and mental reinforcement makes necessity of making change in health-care spaces which are commonly mere functional, abstract and free of any variety obvious. Attention to this issue caused that most designers and researchers of developed countries take step in designing health-care spaces and proceeds designing spaces with more suitable performance. Health-care spaces like other spaces need proper design according to medical standards and human proportions, but in practice the human and psychological aspects aren't considered. Since one of the most important demands of human is to provide safety needs and welfare and comfort in life.

GOAL

The goal of this research is to access to scientific knowledge about intelligent adaptive architecture, indicators of quality of health-care spaces and interaction of human and environment which can create spaces with desired quality and promising and safe, efficient environment by interior designers and other concerned professionals.

RESEARCH METHODOLOGY

Due to the fact that the subject under study has no information literature in domestic references, so, the formation of study was determined based on content analysis of scientific literature. So, in a step by step process, first to review scientific literature by a systematic search, data were screened. Then, selected reliable documents were analyzed with the goal of determining key issues, in next step the output of the previous step was examined in analytical-descriptive method recommendations were given by interpreting results.

RESEARCH LITERATURE

Different meanings been proposed in different periods for adaptive word which each implies a different level of versatility. Decker noted that interaction can be considered as a change index in an environment or facilities which a person can enter mechanical, physical and psychological concepts into this field. According to Adler, dynamic architecture or adaptive structures are formed with different needs of users to interact with environmental conditions or request and ideas of designers. In Runner's literature, clever architecture is referred to built-in forms which their integrated systems are able to predict domestic and foreign phenomena and points to the problems that can affect the performance of a building and its components. Clever architecture responds to users and the environment (local and global)

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quite sensitively and appropriately. Another definition has been proposed by Runenberg which suggests that the end of a flexible internal space is something that is completely amorphous and portable and has changeability in shape, color, lighting, acoustics and temperature such that residents can move in horizontal surfaces and distinct levels of hard and soft, warm and cold, wet and dry. In defining various aspects of versatility, number of technical terms are involved which their recognition helps us in better understanding of the purpose of this research.

Information Technology: Information Technology Association of America defines the aforementioned term as study, design, development, implementation, management and support of computer-based systems, particularly computer software and hardware applications. Other different definitions are provided for aforementioned term which its most important ones can be referred: information technology is referred to all activities involved in collection, transport, storage and recovery, processing, publication and display of information (6). IT is the generic term used to broaden the products and electronic services resulting from computer and telecommunication innovations (7).

Intelligent building: term of intelligence was used at the beginning of decade of 80 buildings for the first time about the buildings in the United States of America. According to the research, more than 30 definitions are presented regarding intelligent buildings. For example, intelligent buildings are defined as a building with fully-automated control systems. "Intelligent Building Institute" considers intelligent building in Washington as an integrated set of multiple systems for effective management of resources, technical capabilities, saving in investment, operational flexibility costs. Some experts consider it as a building which meets the needs of users (residents or clients). Intelligent building is a dynamic architecture which creates suitable productivity with suitable interactions between four main elements including location (building and facilities), process (automation, control and system), person (services and users) and management (maintenance and performance) (2).

We face lots of efforts and measures in creating spaces with approach of intelligent adaptive architecture. The date of intelligent adaptive architecture dates back to 1935 when the first full-electronic houses were designed. These developments were beginning of attempts which will be described under title of "interactive environments" or "intelligent environments" (8).

FIELD OF STUDY

1- Levels of versatility

In this study, the term of adaptive architecture is used as a general definition of architecture which its components can change versus external changes (users or the environment). Figure 1 shows different levels of versatility in terms of the level of position. This position promotes from left to right.

Figure 1. Levels of versatility

A. Flexible

The first step of adaptive architecture is flexibility. The goal of flexible architecture is the possibility of change in building's elements. This happens quietly with user control which these elements are not able to change.

B. Active

Active building elements react in a specific change. This will be made by the environment or user. An example is sensitive lights. Building elements respond to a predetermined action on changes of the environment or users.

C. Dynamic

Dynamic architecture is able to give multiple outputs towards certain inputs. Action and reaction relation isn't a close relationship. So, more facilities and adjustments can be possible in a system. Initially, these possibilities will be regulated and defined. Also, the technology of computers is essential for dynamic versatility and this technology is used since 1980 in architecture.

D. Interactive

A further step is taken in interactive architecture so that it has the ability of bilateral dialogue with the user or the environment. An interaction between the user and the system is configured. In fact, an integrated system is required for an interactive communication.

E. Smart

According to Kouliyer and Telen, the definition of being smart is that users experience a smart system that not only understands the inputs of language in addition to instruction but also allows the initiative to operate. If the system adjusts itself to the user, interest and interaction are in priority and works to collaborate with user in order to achieve certain goals by using more resources than the knowledge so that meet the needs of user, such a system is called smart. By smart architecture, the configurations or changes of building's components will be made by means of system as an external reaction. Building alone can decide in certain situations. So, the reactions on repeated situations don't logically lead to a change or reasonable adaptation and system is able to learn from the environment or performance of users.

The computer is able to compute from one position unlimitedly. It can do the computations faster than human's brain and do chess with high speed with professional chess-players and becomes winner. Since this apparatus thinks while it competes can have faster reaction. According to the comment of professional chess players, computer can do chess like the ability of humans and can do something that human get mistake. The only thing which this computer can do is doing chess. So, the research cannot be clever. Clever versatility needs more enabled computers with more advanced software.

F. Intelligent

Intelligent architectural elements have the ability of spontaneity. An intelligent system is completely in interaction with life, behaviour of users and the environment. This system has the ability of learning. Venistent has exactly explained that the end of an intelligent structure is in a manner that can design itself. Intelligent systems are inclusive systems with knowledge. Clever limited systems wish to reach intelligent systems. Technology and knowledge should work with each other in a clever system but has this ability if one part of a system is out of order will be replaced. Clever system should meet demands of environment and user without having thought power. An intelligent system should be an expanded tool which can be regulated with user's will. Intelligent architecture means that unlimited computations should move forward to digital relations. These relations should be parallel to interaction of humans based on feelings and understanding. In order to create intelligent versatility, new techniques are required which aren't available. These advances are dependent on Quantum physics and computer DNAs [4].

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2- Adaptive intelligent architecture based on information technology

Nowadays, intelligence of buildings is an important issue for building architects and designers. As intelligent buildings are one of aspect of using information technology in the field of architecture, we more exact examination of the effects of information technology on field of architecture.

a) Using intelligent control systems and removing role of human in direct execution of some tasks cause reducing need of human force in some units of organization and consequently limitation of required space.
b) The existence of information process and flow of network-based information will reduce the need for movement of people between different organizational units.
c) Digitization of information increases the possibility of forming databases and simpler storage of information and makes the allocation of spaces of information's archive unnecessary.
d) Information requirements of staff and clients, and necessity of quick access by meaning of the existence of new and certain locations such as coffee-nets, network-based units in the building entrance, notification system installed in public places and intelligent bulletin boards in addition to providing required organizational information makes employees' tracing possible.
e) Quick access of people to each other based on communication network reduces the necessity of proximity of the staff due to employment in a field. This means that the possibility of revision of traditional arrangement of organizational units in the building.
f) Utilizing IT in doing job duties by employees means using new tools in performing missions properly which required side conditions and how they should be settled will be considered.
g) Intelligent collection of environmental information due to transfer, processing and using them properly will be possible by utilizing different sensors in different parts of the building. For example, cameras, smoke sensors, heat, sound, atmospheric pollutants and etc are required to arrange in suitable parts of the building and do intelligent control of facilities do. You can also reinforce the strength of building in case of occurring earthquake by using sensors of measuring load and pressure in building's construct and intelligent control and distribution of load and a suitable environment will be created to achieve the informational goals of the organization.
h) Achievement of all web-based applications is possible by using suitable infrastructure and so, required software and hardware have important role which affects the field of construction and architecture. For example, the space needed for crossing communication channels in using computer networks and automation of the organization and also in intelligent control system and management of the building, required connections, switches, central control room, intelligent installation systems, server room and computer center can be noted (2).

According to the definition of intelligence in relation to IT, it can be concluded that a building is intelligent if it has mentioned capabilities in table.

3- Features of intelligent buildings

A. Features Intelligent Buildings

a) The input of system functions as receiving information by receiving tools (sensors)
b) Processing and analysis of information data (controllers)
c) The output of system after processing, necessary action (operators)

d) Time consideration up to decisions taken in appointed time
e) The ability of learning
f) Indicators of intelligent architecture

B. Main features proposed in intelligent architecture are

a) Important dimensions of function of an intelligent building include the convenience of individuals, organizational flexibility, technological adaptability and environmental performance.
b) Main component of an intelligent building are: security, safety, comfort, energy management, communication and integration systems.
c) Intelligent buildings contain 10 main topics: 1. the health of the building; 2. using the space and flexibility; 3. cost effectiveness; 4. human comfort in building; 5. the efficiency of duties; 6. safety and security of the building; 7. culture; 8. The image of advanced technologies; 9. Construction and structure process; 10. A lovely environment, energy conservation and environmental health.

A summary of the indicators of intelligent architecture is presented in table.

4- Indicators of Intelligence degree of building

a) The existence of automatic control systems.
b) People's comfort, organizational flexibility, technological adaptability, and environmental performance.
c) Security, safety, comfort, energy management, communication and integration systems.
d) Sanitation, using the space properly and flexibility, cost effectiveness, human comfort in building, efficiency of tasks, safety and security, culture, advanced technology, construction and structure, environment, energy conservation and environmental health.
e) The existence of appropriate interaction between building and installations, automation, control systems, users and services, maintenance management, maintenance and performance of building.

QUALITY OF HEALTH-CARE SPACES

Healing architecture is the architecture to improve the environmental effects on the patient. Healing architecture refers to humanistic architecture to create welfare in health-care spaces, Welfare which causes reducing the duration of treatment. The goal is to accelerate healing the health of mind, body, and spirit through the promotion of quality of health-care space. There's a significant relation between healing architectural principles and duration of treatment. Observing criteria and healing architectural principles in health-care spaces have noticeable influence on relaxation and comfort of patients.

As is clear from the definition, the quality is a broad and continued concept which needs to be changed to promote. Unfortunately, in our society the factors involved in promoting the quality are merely logical or computed factors and the promotion of quality is considered synonymous with observance of some standards and as the only official organization of maintaining quality is bureau of standards. As quality is a feature based on the existence or the existence of a subject, is undeniably linked to its existence or its quantitative characteristics. Quality is twin with quantity and the definition of one isn't possible without definition of other one (10).

Each part of health-care spaces due to their nature should have a special space for doing specific activities efficiently. In fact, health-care spaces are a place container with specific

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functions and its design isn't unique to layout of equipment among some walls. Creating a favourable and efficient environment is a multi-directional interaction between the components of a space i.e. the people and objects that relate to a space and the function which is intended, each creates different and multiple parameters in correct and efficient shaping. Many factors play a role in the quality of health-care spaces which the most important ones are presented in the following table.

Result	Operators	Sensors	Indicators of Quality of health-care centers
Minimal physical contact of user with building components to minimize infection outbreak and transmission	The use of automatic doors and intelligent valves	Proximity sensors	Environmental Health
By using these material in the floor, ceiling, walls..... Absorbing pollution can be prevented.	The use of intelligent materials (nanotechnology, self-cleaning)		
Dominance of medical staff on patients will be made due to faster aid.	CCTV to monitor embedding CCTVs for monitoring spaces	Image sensors	Speed of service
It reduces the necessity of transportation between different units, so, speed of service will be increased.	Flow of network-based information in space		
Paths are easily recognized by the unconscious user to environment, which causes confusion and reduce the stress and anxiety in clients	Embedding guide information of users in the body of architecture by using digital intelligent signs and signals	Motion sensors	Space readability, ease of access
The ability to understand the environment, a sense of mastery and control over conditions in users sense of belongings to space, enjoying the space and etc	Embedding controller equipment of environmental factors such as adjustable air vents	Types of sensors (contact, proximity, temperature, smell, sound and etc)	Environmental factors (light, sound, air conditioning and etc)

INDICATOR OF HEALTH-CARE SPACES

a) Environmental Health
b) The speed of service
c) Architecture and Interior Design
d) Space readability, ease of access
e) The interaction of user and building

f) Environmental factors (lighting, air conditioning, sound...)

5- Intelligent health-care spaces

Intelligent systems can easily be adapted to different spatial needs due to sensors which needs of a health-care space or hospital can be referred. Use of technology and scientific creativity in designing health-care spaces causes enhancing the effectiveness and interaction of user and building. In intelligent architecture by equipping building (wall, ceiling, etc) with advanced electronic, audio, video systems, the mutual will be established between the building and the user. The function of sensors as the first link in the chain of active control systems can be used in designing appropriate spaces for patients, disabled and etc. For example, sensors that react to certain sound or movement or lights will be on/off by moving hands or saying certain words and there's no need for distances by disabled person to do so (9).

The ultra-modern systems, CCTV (closed-circuit) and control computers can be used for awareness about the condition of the patient, the elderly and medical care. Monitoring of operating rooms and video conferencing are other services of such systems. CCTVs which are planned by algorithms of artificial intelligence can recognize which patients need help. In this section a summary of the intelligence results of health-care space is presented in above table.

CONCLUSION

So, intelligent architecture is the highest level of adaptive architecture which we proceed creating places by using materials and intelligent technological equipment where interactions among humans, space, place and environment will be established. In other words, all facilities of design, equipment and technology and immediate local and environmental information will be used for comfort and establishing relation between user and building. What examined in this research was applied role of intelligent architecture in increasing quality of health-care spaces which include: control systems, proper enjoyment of the space and flexibility, technological adaptation and environmental performance and etc. Also, indicators of quality health-care spaces include environmental health, the speed of service, environmental factors and etc which lead to an understanding of space of the needs of the patient, observing maximum health, direct control of user (patient) on environmental factors (lighting, air conditioning and etc) and comfort and convenience of user which using them can bring results like patient's stress reduction, creating relaxation and improving environmental behaviours, reducing length of hospitalization, increasing pain tolerance threshold, increasing patient's pleasure of space.

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