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USE OF AI ON RENOVATED EXISTING BUILDINGS

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ABSTRACT

Artificial intelligence is rapidly transforming our way of living and using resources. It is also playing an important role in making our buildings smart and more efficient but smart buildings are still not functioning properly and producing high energy output because of lack of user awareness, unnecessary use of technology in areas where it's not required and lack of technology at the same time. This research paper presents a comprehensive and significant research conducted on the impact of intelligent control systems for energy and comfort management in smart buildings. There are inherent difficulties with expectations for smart buildings and with making them viable; and with definitions and roles of 'users' in smart buildings. This study considers what a smart building might be and the problems that smart buildings might address. Methods to solve and overcome these problems. By studying international case studies, user experiences and arising questionnaires a detailed analysis has been done. Automation is simply a tool and real significance lies in how we use these tools and techniques.

Keywords: Artificial intelligence, smart buildings

INTRODUCTION

The topic of the following research is use of artificial intelligence in such a way to improve the efficiency of buildings. We are living in the era in which the use of technology is at its peak. Smart buildings enhance new and probably enormous opportunities to save energy. Whether it is green buildings, intelligent buildings or digital buildings, which in reality are all the same thing, a world is emerging which relies on people synthesizing applications of ideas from biology, physics, chemistry, materials science and the information of sciences but all involved ultimately in the life sciences which principally is about improving the quality of life in the widest sense for people whilst taking responsibility for respecting natural resources. The main aim of buildings must be to save the natural resources as much as possible. Because energy crises are very common these days and in the future.

LITERATURE REVIEW

An intelligent building can be defined as the building that combines the best available concepts, designs, materials, systems, and technologies in order to provide an interactive, adaptive, responsive, integrated and dynamic, intelligent environment for achieving the occupant's objectives. This scope of the review is limited to journal articles and research papers.

This review will not explore the post evaluation reports. Most of the research conducted on use of AI in buildings proposes a new model or calculations to improve the efficiency of systems. With lots of energy crisis in today's world, it is very important for architects, engineers and construction managers to think of such buildings which are energy efficient, and intelligent by their function and usage. Technologies applied in

intelligent buildings will improve the building environment and functionality for occupants, while reducing operational costs. An intelligent building has an implicit logic that effectively evolves with changing user requirements and technology, ensuring continued and improved intelligent operation, maintenance and optimization. (Kapadiya, 2015). (Darby, 2017) Stated that: A smart home is a residence equipped with a communications network, linking sensors, domestic appliances, and devices, that can be remotely monitored, accessed or controlled and which provides services that respond to the needs of its inhabitants.

That's all about the idea of what a smart building actually is and what different definitions of the smart building are. But the real question lies why these systems are not working and what are the causes of the failures of these life changing techniques and tools. This research paper will focus on the emerging problems and hurdles in smart buildings especially in India and the possibilities to overcome these challenges. The main problem lies with the term 'smart' itself, weighed down with many meanings and applied to many possibilities. There will be differences in terms of user involvement and outcomes between, say, a householder who decides to program a washing machine through a 'smart plug' so that it will not operate at peak times, one who makes storage heaters available to facilitate use of locally generated electricity. (Darby, 2017). Numerous research methods involving ethnography, theory building, tool building, data analysis, and action research are needed to understand where existing methods fail, and how to better fit and improve this platform in practice. (Haymaker, 2011)

In general, a high level of occupant well-being (thermal comfort, visual comfort and indoor air quality) requires a high amount of energy use; therefore, an optimized balance between well-being and energy saving is the target that one has to pursue for sustainable buildings. The problem of energy conservation and well-being in buildings is a multifaceted one; the optimization of the performance of the whole building is computationally intensive and extremely difficult to implement in real buildings. (Dounis, 2010). There can be a possible aspiration to provide an optimized solution of sustainability and intelligence that will help the program of living in a healthy, comfortable, and technologically advanced world. From a practical perspective, it can provide a way for developers or design teams to value sustainability of intelligent systems and lay emphasis on a sustainable design strategy. It can help set up industry standards in the future, which clients can refer to and decide the best suited intelligent green design for their organizational needs. It can also help to enhance the productivity and effectiveness of organizations by optimizing energy consumption, increase user satisfaction, minimize operating costs, and address key environmental issues. An intelligent building can use both technology and process to create a facility towards safe, healthy and comfortable and enables productivity and well-being of its occupant.

ARTIFICIAL INTELLIGENCE AND SMART BUILDINGS

Buildings consume a significant amount of energy all around the world, which is more or less one third of the total primary energy resources. This has raised concerns over energy supplies, rapid energy resource depletion, rising building service demands, improved comfort life styles along with the increased time spent in buildings; consequently, this has shown a rising energy demand in the near future. Building energy efficiency has turned out to be a multi-dimensional problem, when provided with the limitation for the satisfaction of the indoor comfort index. However, the comfort level of the occupants and their behavior have a significant effect on the pattern of the consumed energy. It is generally perceived that energy unaware activities can also add one-third to the building's energy performance. Researchers and investigators have been working with this issue for over a decade; yet it remains a challenge

In the coming decades, designers will design unprecedented amounts of new and refurbished buildings and infrastructure. Unfortunately the traditional, precedent based design processes used today are unsustainable financially, environmentally, and culturally. As land, energy, water, and materials become increasingly scarce, building technologies more numerous, and the impacts of the built environment more apparent. Today's buildings are too inefficient, that is they rely on systems such as heating, cooling, lighting, and several other systems. With artificial intelligence integrated into building systems, buildings become more than their brick-and-mortar shells. They start to function in a new way and provide customized patterns for users and add energy and cost savings.

A major challenge for the twenty-first century is to see how theories can be applied to solving problems in construction and thereby understanding the behavior of systems. Systems are complex because they involve the building; the processes which take place in operating the building; the information and communication systems; the people who are managing and using the building. Similar buildings in similar locations can for example demonstrate energy consumption and this mainly due to the different management systems involved in the buildings as well as the impact of the various behavior patterns of the users on the energy consumption. We need to apply our knowledge about chaos theory to construction.

The problem of energy conservation in buildings is a multidimensional one. Researchers from a variety of disciplines have been working on this problem. It remains a challenging and yet rewarding study. In the past three decades, an abundance of scientific and technological publications on energy conservation in buildings have been presented in international journals. In this research we discuss the potentiality of artificial intelligence (AI) as a design tool in building an automation system. The application of contemporary AI techniques creates intelligent buildings with the following main goals: energy efficiency, comfort, health and productivity in living spaces.

RESEARCH FRAMEWORK

Comparison of smart building technology between India and other countries:

Name Of Building	AI System Used In Building	Energy Efficiency
Adobe World Headquarters In San Jose, California Architect: Hellmuth, Obata & Kassabaum	Machine learning and other algorithms of big data help in changing costly energy bills into acceptable revenue streams for enterprise No need for installation of monitoring equipment and to wait for audits. Users or laymen simply type about what they know regarding buildings. Energy grader then benchmark about energy consumption of the building and compare it with others.	Building is open to the public. Glass domes give a 360 view of whole surroundings which include Berlin cityscape. To make the building environmentally friendly, a mirror cone present in the Centre of dome directs sunlight into the building. Other energy efficient features such as daylight shining through the mirrored coned are being applied which help in reducing carbon emissions of the whole building.

Two Pacific Place In Downtown Hong Kong. Architect: Wong & Ouyang	Coefficient of performance COP systems based on algorithms have been installed to determine the energy efficiency of chillers Overall 30 percent cost which is associated with cooling of buildings has been reduced by driving HVAC on the base of COP predictions.	IOT sensors and other machine learning techniques have been used to determine changings in the internal environment of the buildings by keeping weather and occupancy in mind. By cooling buildings systematically i.e. pre cooling which is the expected increase in occupancy helped in decreasing cost up to 30% and in lowering energy required for cooling.
Museum of the future, Dubai Architect: Shaun Killa	Tools of algorithm were being used for identification of favorable structure. Series of efficient options were being made to get the best efficient structure of the building's iconic shape.	CO2 sensors have been installed to improve the inside air quality. These systems have helped in reducing the optimization of energy for air filtration.
BBVA Headquarters Architect: Herzog and de Meuron	Energy and facility management software which are based on (AI) has been used. Tools have been connected to the building's control and different mathematical algorithms of data processing helps in identification and diagnosing issues in the building. Sufficient natural light coming into the required areas, the lights near the windows become adapted and which help in reducing the light they emit. Sensors measure the temperatures across the building throughout different times of the day. It determines what time is most appropriate for these specific units that treat the air to be turned on. These units are responsible for letting the air inside and outside of the building	The building's sustainable design and equipment are not solely responsible for this success: to optimize the bank's energy use, tools powered by artificial intelligence have also been used. CO2 sensors have been installed to improve the inside air quality

Methods:In order to find out the answer to the problem statement, we adopted a cross sectional based study survey. On the basis of literature review we developed a self-administrated questionnaire. Chain referral sampling approach as being used in which users and people who are aware of AI such as engineers, architects working in different fields were invited to participate in the survey voluntarily. Chain referral sampling was being used to find out desired solutions across a wide range of context. Furthermore, we did case studies on international standards to determine how artificial intelligence and smart buildings are working around the world.

CONTEXT OF THE STUDY

Participants of this research included 85 persons (25 architects working in the field, 25 undergraduate student's volunteers, 35 engineer employees of NTDC, Wapda house. The average group of architects involved in this research were 24 to 30 years. Among them mostly architects were working in the field. The average age group

of engineers working as professionals are 35 to 40 year. The age group of undergraduate volunteers include ranging from 20 to 25 years. The reason why people of this specific age were a part of this research is because the younger generation and young professionals are more aware of modern technology. Engineers and architects knew more about methods of implementations and pros and cons of AI. They were aware regarding the working and scope of existing AI in building systems both on residential and commercial scale. Undergraduate students helped in determining the future of AI and How AI can help in improving energy efficiency of buildings. The questionnaire has been divided into 3 sections. Each section has eight questions based on artificial intelligence, key features of smart buildings and how this approach can be implemented everywhere. The sections cover introduction to artificial intelligence, where they have experienced AI such as houses, offices, AI systems are complex or not etc. The second section included use of AI in smart buildings such as lightning, different acoustic elements, supply of fresh air, expandable networking infrastructure of buildings, security systems, sensors, escalators, thermal control etc. And the third section consisted on how AI can be implemented in future in India to improve energy efficiency, climate conditions, reduce labor cost, increase security and need policies and public awareness.

DATA COLLECTION PROCEDURE

We included only basic questions regarding AI and Smart building to know how AI can be implemented in India. We explained the purpose of our research clearly in the questionnaire. Respondents were able to withdraw from the survey anytime as they were invited to take part voluntarily in the research. All the data kept confidential and names were anonymous. We provided 25 questionnaires to the manager of NTDC and we requested him to distribute these questionnaires among the engineers. We shared our questionnaire with architects and undergraduate students on Google forms. After a time period of 3 weeks we received 85 valid responses. Out of which 80 percent data was based on usable responses. All the respondents were young architects, users and individuals who were fully aware regarding Artificial Intelligence.

We used demographics to characterize the overall profile of respondents. On the basis of age, profession and experience we determined the viewpoints regarding implementation of AI. We made pie charts regarding the percentage of all the questions to know about the ratio between agreed and non-agree respondents. We compared the responses to withdraw the desired conclusion. Approximately 70 percent of respondents were male. The majority of the respondents which includes 60 percent were between the ages 25 – 30 and were young architects. Most of these had a bachelor's degree. Approximately 20 percent of the respondents worked in the engineering field and had an experience of working in a smart building office. All respondents were professionals and had full time jobs. About half of the respondents worked in a professional or senior position. Sixty percent of the respondents had an experience of 1 years and others had an experience of more than five years. Only 20 percent respondents were undergraduate students and among them many were working in their own firms. The following table shows the demographic profile of the respondents.

The result of the survey showed that 53.2% people were well aware of the term Artificial Intelligence and they have experienced it. However 46.8% gave this opinion that they know about this term but they haven't experienced it in India.

The results showed that 61.3% people were well aware of technology of Artificial Intelligence and they have experienced it. However 25.8% gave this opinion that they know about this term but they haven't experienced it

in India. However, some of the individuals 12.9% said they cannot remember whether they have seen such systems anywhere or not.

Most of the people i.e 50.8% gave this opinion that they have used this technology in project exhibitions. 21.3% of people gave the opinion that they have experienced this technology in their mobile phones. However Architects gave the opinion that they have experienced this term in airports, malls, homes,offices, hotels.

Most of the people i.e 47.5% gave this opinion that they have experienced the use of this technology mostly in Automatic doors in India. Mostly architects and undergraduate students gave the opinion that they have seen use of this technology in HVAC systems and security systems.

77% educated people agreed to this fact 3that AI is bringing tangible results and is helping in monitoring and implementing better security systems. However, 13.1% mostly engineers gave this viewpoint that AI is helping in telecommunication and networking infrastructure.

Most of the respondents i.e. 95.2% agreed to this view point that systems of AI can be changed. According to respondents, unlike conventional systems they are more efficient.

Architects and students (53.2%) of them agree to this view point that AI is not making overall systems of buildings complex. However, engineers i.e 30.6% agreed to this point that AI based buildings are complex. Undergraduate students were not aware of this fact.

Most of the respondents i.e. 87.1% were aware of term energy efficiency while 8.1% of engineers were not fully sure about its merits and demerits.

The results of the survey showed that 95.2% people agreed that India is lacking behind in saving energy despite having advanced technology.

91.9% of all the respondents agreed to this fact that India is lacking in advanced technology. And there is an urgent need to make awareness in users about the use of AI in our country.

41.9% mostly architects agreed to this viewpoint that buildings in India are not performing efficiently due to lack of user awareness. Engineers do not have an idea about that, while some 25.8% gave the opinion i.e. the lack of proper systems is the reason buildings not performing efficiently

In India AI can help a lot in reducing labor cost in building construction. 64.5% people were agree to this fact however 21% gave the viewpoint that this technology cannot be implemented in India.

52.5% respondents agreed to the fact that functions like energy, elevators and access control are network-connected and generate, analyse and respond to data automatically. AI based buildings are smart, while architects i.e. 23% were not fully agreed.

83.9% Architects and undergraduate students and some highly income engineers agreed to this fact that they will implement this technology in their houses. However, some engineers said no as this technology is costly and according to them its maintenance is difficult.

80.6% of respondents agreed to this fact that AI is helping the world in making buildings more energy efficient and fighting against energy crisis while 16.1% of engineers were not aware of this fact.

72.6% architects and professionals agreed to this fact that the climate energy crisis can be overcome in India with the help of implementation of AI systems buildings.

88.5% architects and professionals agreed to this fact that this system of AI to improve energy efficiency of buildings should be implemented.

DISCUSSIONS

Discussing about problems that smart buildings are facing, the factors that we received were lack of exposure, single system failure, money, place and placement, energy sources, monitoring, sustainability, lack of awareness among people for use of smart technology, cost ineffectiveness and poor maintenance, complexity and expense, cultural acceptance, lack of understanding among the individuals. We can make users aware about saving energy through correct use of smart technology by applying it to routine based things, use of advertisements and social media, by awareness and training of technology. An important role in this scenario can be played by our government, by enforcing laws, public policies etc. but here the question arises that how public policy can encourage the interaction of AI and smart buildings. It can be done through proper legislation, by making building codes such that incorporating technologies, fundraising and by application of easement for the public. After applying all the techniques and technologies, how will AI affect the future of building automation. It is by making them smart and efficient, sustainable and conserving energy, reduced labor cost and increased effectiveness, by saving water and energy bills, by reducing time to work. The bigger question is what the key research areas and development needs to speed future implementation of AI and smart buildings. This can be done by reducing technology crisis, environmental control and security systems, research in the area of how AI affects the privacy of the people who interact with it, how it uses private information of its users, taking into confidence the concerns and hesitations of people who are the main consumers of the AI devices and technology, better resources for AI based systems are needed And AI based systems for common daily tasks should be provided at cheap costs.

Research and development budget should be allocated, developing research facilities for AI, promotion in education and initiating industrial and commercial boom.AI should have a separate compulsory course in engineering and medical colleges. AI can also be promoted by launching various smart applications that people can interact with, public awareness programs and strict local government policies. Authorities must not approve construction plans without AI and smart buildings options. Research should be more accurate and elaborate to help implement AI in our buildings.

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HOW AI CAN BE IMPLEMENTED IN INDIA

Required smart building technologies	Basic building systems Systems integration User interface Web-oriented Open protocol architecture Automatic work order generation Basic building systems Energy management Building condition monitoring Common communications infrastructure

Level of importance of smart building technologies	The building technologies are changing and developing every day and their essence too. Firstly, the basic building systems are the most important then the condition monitoring energy management of those systems. Secondly, it is the integration of systems with the integrated communication and its infrastructure, and also standards and protocols. Finally, intelligent controllers and smart sensors play a vital role.
Primary on-focus benefits from utilizing smart buildings technologies.	Reduced cost and increased productivity Simple upgrade modifications of control systems Increased individual environmental control Ability to manage building independently and securely. Reduced energy consumption Increase occupant safety and security Improve operation and maintenance labor efficiency
Current practices of utilizing hi-tech smart buildings	India is still far behind in utilization of hi-tech smart technologies. In this survey, the buildings were: 15 % with appropriate utilization 85 % without appropriate utilization
Main challenges of integrating smart building technologies	Financial impact of life cycle costing. Requires an integrated design with construction processes. Ability to upgrade functional capabilities.

CONCLUSION

Paper investigated the emerging technology that is Artificial Intelligence in smart building Technologies for high-rise buildings in India. Some of the major findings articulated in this study Includes The level of importance of AI in smart building technologies for office as well as for residential buildings in India is quite high. The current practices of using AI in making buildings smart are not even at the early stages of development in India. Very few of the buildings have smart building technologies that are partially integrated while some buildings have either smart technologies as standalone systems that are not integrated within a comprehensive or partial automated systems. The major types of buildings that are practicing the implementation of artificial intelligence include Malls (50.8 % according to survey), while the minor type includes offices (21.3%), airports (9.8%). The major benefits of hi-tech smart buildings technologies (according to surveys conducted among professionals) are reducing energy consumption, increasing occupant safety and security, and improving the operation and maintenance. Other benefits with lesser focus include increasing occupant safety, life-cycle, enhanced building operations allowing better space utilization and flexibility. The most important challenge for integrating artificial intelligence into building technologies for buildings in India (based on the survey results), is the lack of awareness. This issue might have affected the infancy level of intelligent and smart buildings in the local construction industry as is portrayed by the second highest challenge of other internal factors and lack of proper systems. Further challenges include high initial cost or lack of funding, lack of executive support from high administration or building owners, and immaturity of today's technology solutions. There is a strong need (based on the survey results), for additional features of smart

building technologies in India. Such features include sensing and detection, automated air conditioning and thermostat, automated security alarms, fire alarms, fire protection systems, automated lighting and motion detection lights, timer base cooling systems, earthquake detectors, and security and safety systems. Other additional features can involve inter-operable systems that can help in easily integrating with the current smart technology without essential modification.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The study is subject to some limitations. First, we invited architects and professionals who had full-time jobs along with some of the engineers and undergraduate students. This referral sampling technique might influence the representatives of our samples. Nevertheless, judging from the demographic profile of respondents, we found that most respondents were aged between 20 and 29 years, had a bachelor and/or master's degree, worked in different services industries, and had more than 2 years of work experience. The respondents of this age group have more interest in smart and sustainable systems, buildings, and cities. Second, the sample size was modest and there were less than 100 respondents. Hence, the replication of the study on a larger sample is desirable. Third, the study was conducted in Lahore. Since the climatic, social, and cultural conditions depend on the region and vary from place to place, that's why the ratings and principles of smart and sustainable building features should be generalized to other cities and regions with great caution. Finally, the study was a cross-sectional study. Further research should consider examining changes in smart and sustainable building features as technologies evolve very rapidly in India. Future research should also include other cities of India and conjointly embrace alternative cities of Asian countries with comparison of existing technology with developed countries.

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