Impact of artificial intelligence on the future of architecture

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Abstract: The concept of artificial intelligence has existed for a long time. In Greek mythology, Hephaestus developed Talus the "mechanical man," a bronze statue with supernatural powers that imitates human behaviour. Marry Shelley developed Frankenstein in literature, and in movies Stanley Kubrick developed HAL in Space Odyssey after several failed tries and hypotheses. Like aliens, the idea of AI was a product of science fiction. AI is no longer associated with science fiction as computers advanced. Early computers were imagined as 'logical machines' or'mechanical brains' with human capacities like memory and arithmetic. The idea of AI has altered as a result of the quick advancement of technology and our growing understanding of how human brains work. The current emphasis of AI is on imitating human behaviour.There have already been a number of efforts to apply artificial intelligence to the subject of architecture(design, management, construction, real estate, urban planning, etc.). The majority of the modern technologies still require human intervention since they are only somewhat artificially intelligent. The majority of the work will be done through intervention and monitoring. In contrast to other industries, the application of AI in architecture is still not very common. Many technologies are currently available, but they have not yet been integrated into the industry, and there are still many untested concepts.
The following subject areas will be explored in this article:
What is AI? How does it function?
How does AI facilitate architecture?
What more is AI capable of?
Is the Architect dead?

***Index terms*: Artificial Intelligence,Deep Learning, Parametricism, Subjectivity, Crowded Database, Knowledge Center.**

1. INTRODUCTION

The guy who is credited with creating artificial intelligence, John McCarthy[1], described it as “the science and engineering of creating intelligent machines, especially intelligent computer programs”.

Artificial intelligence (AI) is the process of teaching a computer, a robot that is controlled by a computer, or a piece of software to think critically and intelligently, much like an intelligent human does. In order to create intelligent software and systems, it is necessary to first understand how the human brain works and how people learn, make decisions, and work together to solve problems. Computer science defines AI research as the study of “intelligent agents’: any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals”. (Poole & Mackworth, 1998)

[1]He was an American computer scientist and cognitive scientist.

1.1 IS AI A SUBSET OF COMPUTER SCIENCE?

It is not a true statement.The computer uses mathematical models and is deterministic. Calculations don't increase a computer's intelligence. They enhance efficiency. And no matter how complicated the calculations are, only the programmer can alter them; the computer is unable to do so. Of course, computer science is connected to artificial intelligence, but the field is interdisciplinary and involves a wide range of projects. The components of AI include philosophy, neurology, electronics, robotics, cybernetics, biology, psychology, semiotics, language, and cognition. The human being serves as the finest model, and both computers and humans are used in AI testing.

1.2 ARTIFICIAL INTELLIGENCEV/SDATA SCIENCE

In the multidisciplinary subject of data science, information and insights are derived from both organized and unstructured data using scientific techniques, procedures, algorithms, and systems.Data science is the same concept as data mining and big data: “use the most powerful hardware, the most powerful programming systems, and the most efficient algorithms to solve problems”. (Leskovec, 2001)

Big data is essential to artificial intelligence, but it extends beyond data science. Data science may perform or achieve tasks that are sometimes mistaken for those of artificial intelligence, including prediction (such as long-term climate projections), decision making, identifying previously unidentified correlations between components, descriptive analytics, and visualization. Advanced computer science methods, such as regression, decision trees, data mining, and time series analysis, are frequently used in non-AI data science.

1.3 HOW DOES AI WORK?

AI enables software to automatically learn from patterns or characteristics in the data by combining massive volumes of data with quick, repeated processing and clever algorithms. Machines may learn from their experiences, adapt to new inputs, and carry out activities similar to those performed by humans thanks to AI. Artificial intelligence mostly uses Machine Learning, Natural Language Processing, and Deep Learning.

1.3.1 Machine Learning (ML)

Machine Learning (ML) is a significant distinction between AI and computer science. It may be able to train computers to learn for themselves rather than teaching them all they need to know about the environment and how to do jobs. This can be accomplished by programming robots to think like humans and then connecting them to the internet to have access to all conceivable knowledge.

"Machine learning (ML) is the scientific study of algorithms and statistical models that computer systems use to perform a specific task without explicitly giving instructions, instead relying on patterns and inference." It is thought to be a subset of artificial intelligence. Machine learning algorithms construct a mathematical model using sample data known as "training data" in order to make predictions or judgements without being specifically programmed to do so." (Bishop, 2006)

1.3.2 Natural Language Processing (NLP)

"NLP" is a subfield of linguistics, computer science, information engineering, and artificial intelligence concerned with the interactions of computers and human (natural) languages, specifically how to programme computers to process and analyse large amounts of natural language data. (Hutchins, 2005)

AI is involved with NLP in an attempt to simulate more human behaviour. ML is employed here to assist robots in understanding the huge complexities of human language and learning to reply in a way that a specific audience is likely to understand. Speech recognition, natural language comprehension, and natural language production are all part of NLP In addition to language, "machines can now listen to a piece of music, determine whether it will make someone happy or sad, and find other pieces of music to match the mood." They can even produce their own music transmitting the same concepts in some circumstances." (Marr, 2016)

1.3.3 Deep Learning

Deep Learning is the process of providing a computer system with a large amount of data that it can use to make decisions regarding other data. This information is incorporated into neural networks. These networks are logical constructs that ask a series of binary true/false questions or derive a numerical value from a set of data. Every item of data that passes through them is classified based on the responses obtained. Because Deep Learning work focuses on developing these networks, they become Deep Neural Networks - logic networks with the complexity required to classify datasets as large as, say, Google's image library or Twitter's firehose of tweets. Deep Learning is used by Google in speech and image recognition algorithms, Netflix and Amazon in determining what you want to watch or buy next, and MIT scholars in forecasting the future.

2. HOW IS AI HELPING IN ARCHITECTURE

Data is being used by artificial intelligence to change the world. How might AI be changing architecture?The discipline of architecture (design, management, building, real estate, urban planning, etc.) has already seen a number of attempts to integrate artificial intelligence technology. The majority of modern technologies are artificially intelligent to some extent, yet they still rely heavily on human oversight and interaction to complete most tasks. In contrast to other industries, the application of AI in architecture is still not very common. A lot of technologies already on the market are not being employed in architecture, and there are still a lot of untested concepts. The technologies listed below assist architects in some way by using AI:

2.1 LAYING THE FOUNDATION & PLANNING

No matter if we are discussing architectural design or urban planning, it takes a long time for the architect or planner to begin the task. It takes countless hours of research to comprehend the design requirements and objectives, and then starting from the surface, getting oriented and looking at the overall case, then identifying issues as well as potential alternate solutions, then going deeper, performing analyses, gathering data, performing calculations that might provide insight, then formulating an action plan, listing any external concepts that can be applied, listing relevant qualities, etc.

An architect or planner might easily go through this prolonged process of study and data testing since AI has the capacity to take in a limitless amount of data. In this area, artificial intelligence (AI) is more precise, efficient, and allows for more alternatives, resulting in more opportunities. It also gives access to an enormous quantity of data, creates models, deciphers the built environment, and generates cost estimates.

In addition to age, gender, family size, and other demographic information, an AI system may provide an architect with quick and simple access to all zoning data, building code information. AI can serve as a tool that helps architects in creating design variants, allowing them to play a more conceptual role.

2.2 CONSTRUCTION

“The global industry has grown by only 1% per year over the past few decades. Compare this with a growth rate of 3.6% in manufacturing and 2.6% for the whole global economy. Productivity, or the total economic output per worker, has remained flat in construction. In comparison, productivity has grown 1500% in retail, manufacturing and agriculture since

1945.one of the reasons for this is that construction is one of the most under-digitized in the world and is slow to adopt new technologies.” (Mckinsey, 2017)

2.2.1 PREVENT COST OVERRUNS

By creating predictive models for time and cost, particularly in large-scale projects.
A simplified version of a brain's neurons, an artificial neural network (ANN) or connectionist system is the name of the technology that is being used. The neural network itself is not an algorithm; rather, it serves as a framework that allows several machine learning algorithms to cooperate and manage large amounts of complicated data.

2.2.2 BUILDING INFORMATION MODELING (BIM)

A facility's physical and functional qualities are represented digitally in BIM. A BIM is a well-known resource for data about a facility that serves as a reliable foundation for choices made throughout its life cycle, which is defined as existing from initial conception through demolition.

In 2016, the National BIM Standard The conventional approach to building design mostly utilized 2D technical drawings (plans, sections, elevations, details, etc.). The design process now includes more 3D modelling thanks to computer technology. Beyond the 3D physical dimensions, BIM also incorporates 4D (time) and 5D (expense). The 6D (environmental and sustainability analysis) and 7D (life-cycle facility management) dimensions have also recently been studied. (Bimpanzee, 2018)

2.2.3 RISK MITIGATION

The risk increases while working on large-scale projects with several teams (client, designers, consultants, primary contractors, subcontractors, etc.). AI helps in risk assessment and on-site job monitoring.

2.2.4 PROJECT PLANNING

Robots may be utilised to quickly and accurately provide reports that are related to the project schedule, collect site inspection data, and automatically acquire 3D images. This reduces labour costs and plan lag, both in terms of time and money. The method is known as Reinforcement Learning (RL), which is a branch of machine The method used is called Reinforcement Learning (RL), a division of machine learning that concentrates on how software agents should act in a certain environment to maximize a theoretical cumulative reward. (Bersekas, 1991)

2.2.5 ON SITE HIGHER PRODUCTIVITY

Robots, whether autonomous or semi-autonomous, can be programmed to carry out repetitive operations like excavating, erecting scaffolding, bending bars, welding, pouring concrete, assembling bricks, etc.

2.2.6 OFF SITE CONSTRUCTION

Robots in factories may assemble precast buildings, which are subsequently cast on site by workers. These constructions can include HVAC systems as well as structural components like post-tension beams, columns, slabs, or architectural building components like walls, panels, and cladding.

2.3 SMART CITIES

A city or urban region is expected to be home to 55% of the world's population as of the present, according to the Population Division report from the UN's Department of Economic and Social Affairs. In the decades to come, this percentage is anticipated to reach 68%. In 2018, Meredith Cities account for more than 70% of worldwide CO2 emissions even though they only make up 2% of the earth's surface. (Roven, 2018). Planners and architects must reimagine the typical city after studying these numbers.
A smart city is more than just "city planning plus technology" or "city planning plus internet". "A smart city is an urban region that makes use of various electronic Internet of Things (IoT) sensors to gather data, which is then used to manage resources and assets effectively. The data that is processed and analyzed to monitor and manage traffic and transport systems, power plants, water supply and networks, waste management, crime detection, information systems, schools, libraries, hospitals, and other community services includes data that is collected from people, devices, and assets. (McLaren & Agyeman, 2015)
The advancement of AI will make cities smarter, or self-aware to their members, infrastructure, and elements. To enhance living conditions and create more ecologically friendly communities, buildings, cellphones, autos, and public spaces will all connect with one another. Real-time data and feedback will power smart cities, which will be responsive like living organisms.

2.4 SMART HOMES

"Home automation, also known as demotics, is building automation for a home, also known as a smart house. Lighting, temperature, entertainment systems, and appliances may all be controlled by a home automation system. Security and alarm systems could also be included. (Hill, 2015) The smart house is comparable to the smart city is a sophisticated, data-driven living organism, not merely a residence with technology.

The difficulty for architects will be figuring out how to integrate artificial intelligence into the house's design in order to benefit the lives of the occupants. Both large-scale projects and routine everyday work can be assisted by AI in architecture. . Regardless of their level of education or language proficiency, it may be a user-friendly tool utilised by a variety of people. There are currently some AI-powered home appliances available, such as the Smart Kitchen.

Examples:

- LG Smart Oven
- Haier Smart Fridge
- Siemens Connected Coffee Maker
- HAPIfork

3. FURTHER PROSPECTS

3.1 ARTIFICIAL INTELLIGENCE LIMITATIONS

Artificial intelligence now has obvious constraints in creative activity like design. It learns from data. There isn't any other method to assimilate knowledge. The findings will be affected by data inaccuracies. The AI of today has been programmed to do a certain task (A chess-playing machine is unable to play solitaire or poker). Artificial intelligence is still operating at the level of huge databases, rapid computing capacity, and artificial logic chains. (Cai, 2018)

However, as theory and technology advance, artificial intelligence will be able to perform more subjective, adaptable, and creative work instead of just finishing tasks using a mechanical objective assessment system. The design process is broken down into five main stages by Professor Broadbent of the University of Plymouth in the UK: analysis, synthesis, assessment, selection, and expression. (Broadbent, 1988) AI is increasingly being used in the creative process of architectural design, and instead of doing monotonous tasks, it may be involved in all the stages that Broadbent mentions.

3.2 PARAMETRICISM AS A METHOD

Parametricism was described as a "style" by Patrick Schumacher in his paper "The Parametric Epoch." As AI advances, parametric design may now be employed as a method rather than as an aesthetic choice. Since AI relies on data to function, it may automatically obtain data and convert it to parameters. It can simulate design suggestions, compare them, and analyze them. I shall now categorize the sort of data into quantitative and qualitative as architecture is by definition a blend of art and engineering. Sensors can obtain quantitative data, which Deep Learning can then process.

Some examples:

• Climate (wind ,sun, humidity, temperature, etc.)

• Topography (landfill, soil, altitudes, topographic points; etc.)

• Land (location, dimension, area, etc.)

• Land use (accessibility, FAR, legal recess, zoning; etc.)

• Site (trees, water features, other existing buildings, rocks, etc.)

• Numeric (rooms, number of floors, louvers, stairs, etc.)

• Formal (frequency, size, shape, color, etc.)

This information can be used by an Artificial Intelligent Agent as parameters to start a design. This would include the use of software that performs site analysis, geographical distribution, orientation, access and accessibility, and even function layout automatically. Instead of sketching pre-existing or developed shapes, parametric design employs simulation and design engines to find form. Although we currently have this technology, it is still only capable of measuring quantitative factors. Subjectivity may be reduced to empirical parameters through the decoding of architecture languages, which can then be used in design tools, such as Grasshopper. On grasshopper, we often refer to parameters as nodes; their parameters are mathematical. Can'style' be used as a parameter?

3.3 A STEP INTO SUBJECTIVITY

3.3.1 CAN YOU EDUCATE A MACHINE TO HAVE QUALITATIVE KNOWLEDGE?

Subjectivity and qualitative knowledge first appear to be the exact opposite of machine learning. We need to break down the subjective concept into its corresponding symbols and organize it into a language that the machine can able to comprehend and process. When using the development direction of digitally assisted design, formal architectural language can be converted into computer language.

The three components of the future CAAD research development are 'Excavating the formal language of architecture' and 'Building a spatial connection database'. and 'to achieve automatic optimisation and generation of building schemes’. (Likai, 2012) As a result, the computer will be able to take part in the design process and institutionalise random knowledge from earlier descriptions of architectural aspects. A firm foundation is provided by structural understanding of the architectural language. It is possible to suggest symbol-based processing techniques that modularize information to mimic the human thought process and that aim to translate architectural language into computer language in order to describe knowledge using specific symbols. Data may be used as parameters in this architectural symbol database to create simulations of artificially intelligent design. Artificial intelligence will be able to develop complete systems that fulfils both objective limitations and subjective ideas connected to regional culture and aesthetics if computers are able to match subjective concepts to corresponding particular symbols. It is quantified by integrating subjective elements into the parameter system.

It is simple to modularize and alter when fundamental rules are known, and it may be effectively coupled with a symbol database without the need for much specific expertise. This can be useful, for instance, when designing conventional architecture, since an artificial intelligence agent can choose and construct components from an index of architectonics. It requires teamwork to learn more complicated information, such as architectural theory, styles, identities, and aesthetics. To compile the knowledge of architecture, it takes a lot of time and labour. This would require a knowledge base that disassembles architecture into language that artificially intelligent agents can understand. In an effort to compile a database of architecture language that is objective, we might agree or disagree on styles, processes, materials, and other relevant topics. A single individual cannot divide the language of architecture. Different viewpoints should be included in an ongoing process. Additionally, empirical definitions of architectural styles and methods will be created after discussions and agreements are reached in order to create a database that will support artificially intelligent agents. Then, this shared understanding can be translated into computer language, which serves as an empirical guide for architecture. To initially divide objects and components of architecture into several categories, human understanding and interaction are required. Anything and everything that is discussed in the context of architecture can fall under these categories.

The most crucial component of such a database is that it is open source (i.e., a collaborative project in which additional information may always be added) and that it is a continuous activity, which distinguishes it from any other computer database. Here, the distinction between computer science and artificial intelligence is clearly shown; AI can accumulate knowledge through Enactivism[3] . The database accumulates and adjusts automatically and there is always the human intervention to manage and control.

3.3.1 DOES AI KILL THE ARCHITECT?

In reality, the function of the architect or designer is going to change with the help of AI. In the future, artificial intelligence will be able to produce quickly in large quantities, and designers will simply need to determine its limitations and filter the AI scheme in accordance with aesthetics, client or market requirement. Artificial intelligence has the capacity to quickly generate a wide range of styles in addition to completely taking into account the quantitative processing of many subjective and objective criteria.

“The results will no longer be preset by us. Even in a sense, the results will completely exceed our imagination... the designer needs to do It is through the aesthetic and human intuition of space, judging the final result that the designer wants.” (Cai, 2018)

“The 'agent' controls the design from a macro level and gives it a mandatory direction, such as government regulations, styles, architects' layout, streamlines... and 'environment' allows for self-agent freedom from the micro level. The emergence of ground movements, and even "disturbance," enables the modification of behavioural norms to produce variety and diversity.” (Likai, 2012)

Artificial intelligence may merge perceptual and logical decision-making with the aid of indexed subjective characteristics. The computer must evaluate the outcomes of the screening process after producing a huge number of "creative" alternatives. The standards for judging excellent and poor design are more nuanced. We have rigid rules of physics in mechanics, which can be readily appraised by a machine, and subjective level of cultural aesthetics. These two parts of evaluation are objective logic based on mechanical laws and subjective experience based on culture and aesthetics. Subjective judgement requires human input first, after which an AI computer can use the results. Then, a huge database of 'judgements' can be created. An artificial tool for intelligent judgement may then be created by using intelligent learning algorithms. Deep Learning is once again the technology employed.

3.3.2 EDUCATION

Architecture project evaluation has always been a personal matter. It depends on the assessment context and the jury's background. Architecture is not an equation with right or incorrect answers, and evaluating an architectural design is not a true-false activity. Projects in architecture can occasionally be interpreted incorrectly, which can lead to unfair evaluations. Architecture projects may be evaluated objectively with the use of an artificially intelligent database with judgmental logic. An artificial intelligence architecture database can aid in teaching students what teachers see as "empirical knowledge"—for instance, "the golden ratio"—in addition to aiding in evaluation. In our Bachelor of Architecture course, we all have studied the golden ratio.It serves as an illustration of how one may quantify beauty using mathematics. Think about how much AI could expand this spectrum.

3.3.3 EXPLAINATION

Typically, when the architect meets with the client, the architect uses presentations, images, similes, statistics, numbers, prices, case studies, and any other media to communicate the design in a language that people outside the domain can understand. This procedure may be accelerated and made more effective by using a database with artificial intelligence architecture. Furthermore, it is also reversible.

The client said, "Show me a Modern design."

Modernist samples are shown by the machine.

Client: Show me something else, anything "sexy"; this is so dull.

Architect: “Machine, can you please show Mr. Client something more contemporary?”

The system analyses what "sexy" means using speech recognition, the database, and other information. It then passes over uninteresting buildings and displays "sexy" "contemporary" ones.It follows the same procedure as Google. But based on the client's specifications, the machine automatically generates a number of design proposals.

It is basically an arbitrary illustration of what might take place. This may indicate that the architect is no longer alive. The architect is still alive and working on new endeavors.

"It’s unfounded that AI can replace humans, especially as designers." - Patrick Hebron

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