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Architecture and Artificial Intelligence
A study from the perspective of a developing country like Bangladesh

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Abstract

The concept of Artificial Intelligence is quite old and widely established but is yet to be utilized in a developing country. With the advancement of technologies and the concept of digitalization, the existing tools with their Artificial Intelligence can be used to get holistic benefits in the field of Architecture and Design. Starting from the digital Bangladesh agenda of the election 2015 till the new Innovative Bangladesh for 2041, the country has aimed to facilitate the process of digitalization and innovation through using Information and Communication Technologies. The various Artificially Intelligent technologies that are already being used without collaborating, like embedded technologies with IoT (Internet of Things), GPS (Global Positioning System), GIS (Geographic Information Systems), BIM (Building Information Modeling), remote sensing technologies with photogrammetry, etc. can be incorporated with the existing conventional Architectural steps for better efficiency. This paper aims to study and analyze the scope of different Intelligent Technologies and the ways to incorporate them with the conventional Architectural design process to get the overall benefit of the machine and technological intelligence in a developing country like Bangladesh. The methodology includes a literature review, an analysis of conventional and AI-based design steps, and the challenges and possibilities faced with incorporating AI-based methods with conventional steps. The findings show that, to keep pace with the advancement of technologies and ensure future sustenance, the design, and Architecture of a developing country should adopt AI (Artificial Intelligence) in different conventional steps to broaden the scope of Architecture. Identifying the challenges to incorporate AI tools, guidelines for incorporating them in different steps of the conventional design process are proposed. Lack of any existing case study due to the topic's recency in the field is the research limitation identifying the application in a real project as the scope. In conclusion, it can be said that there is an immense scope for the use of AI as a strength rather than considering it as a threat.

Keywords: *Artificial Intelligence; Information technology; Machine Learning; Embedded technologies.*

1 Introduction

In the new era of technological advancement, Artificial Intelligence (AI) holds the potential for immense transformation in every sector of development (Velarde, 2019). Although quite an old concept coined in 1956 by John McCarthy, the adoption is spontaneous and even more impactful with a steady global growth rate of 35% due to the pandemic situation of COVID-19 in the history of AI (*IBM Global AI Adoption Index 2022*, 2022). The acceptance of AI has broadened the scope of development in the AEC (Architecture, Engineering, and Construction) industry beyond imagination (Archidust, 2023). The complex process of architectural design that deals with a lot of data and interconnected steps with the experts of different professionals is primarily concerned with user comfort, well-being, and welfare. The use of Artificially Intelligent technologies can go hand in hand with conventional design steps and even replace them and enhance the scope of architecture and design giving more flexibility to the imagination and reducing time constraints (Mahendra, 2021).

In the context of the developing country Bangladesh, already has a draft National Strategy for AI from 2019 to 2024 with the strategy to utilize AI to create a workforce. Globally, architectural practices have partially or fully adopted the use of AI into their workflow. But in Bangladesh, the challenges are the lack of technologies, infrastructures, resources, and skilled labor, and the collection, availability, management, privacy, and connectivity issue of relevant data (Government Bangladesh, 2019). Research can help overcome the challenges and systematically adopt different AI-associated technologies in various conventional steps in the architecture sector.

This paper seeks to investigate ways to incorporate the usage of AI into contemporary architectural practices in Bangladesh. It will also open the scope to fully transform to AI-based architectural design where the human imagination and comfort will be of priority, minimizing the time taken to generate and construct.

2 Aim and Objectives

The aim of this research is to explore the capabilities of artificial intelligence in various steps of Architectural design and find ways to incorporate them with the conventional process to extract the full benefits of AI for an effective design. The study focuses on the selected sample of architectural design fields in Bangladesh, a third-world country with various challenges in the emerging architecture sector.

The objectives to achieve the aim include exploring the step of conventional architectural design, analyzing different AI tools associated with each step of conventional architectural practice, analyzing the present scenario of architectural practices in Bangladesh, and examining ways to integrate AI tools and techniques for the best utilization in the context of Bangladesh.

3 Methodology

The primary purpose of this study is to identify and analyze potentials where AI could be utilized to enhance and streamline the conventional steps of the architectural design process. The research started with a literature review of relevant studies done on the steps of architectural practice and the availability of artificial intelligence and similar technologies that could aid in these steps. Work processes of contemporary architectural firms and companies of various sizes in Bangladesh were then observed to deduce a comprehensive list of the steps followed in conventional architectural practice. Artificial intelligence alternatives were then explored, followed by comparative analysis to assess which AI tools and methods could be used to create a more efficient workflow for contemporary architectural practices.

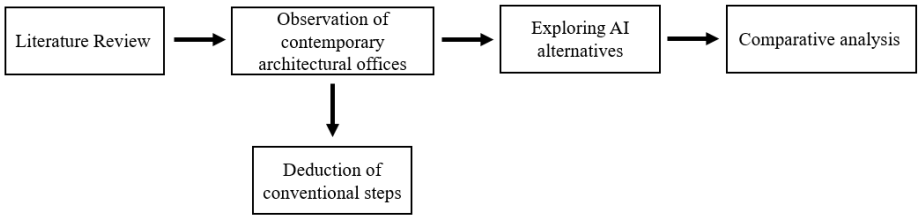

Figure 1. Methodology

3.1 Literature Review

Artificial Intelligence (AI) is gaining considerable attention in various industries, including architecture and design. Opportunities for improved decision-making, energy optimization, and cultural preservation are provided by the combination of embedded technology, BIM, and AI-based simulations. The key areas where AI can be leveraged are in the integration of embedded technologies with IoT (Internet of Things), GPS, GIS (Geographic Information Systems), and remote sensing technologies like photogrammetry. These technologies enable architects to gather real-time data on site conditions, environmental factors, and user preferences (Smith et al., 2018). Architects may make well-informed judgments, optimize design solutions, and enhance project outcomes by incorporating this data into the design process. Building Information Modeling (BIM) enables the creation of digital representations of buildings, facilitating collaboration, visualization, and data management throughout the project lifecycle (Mahdavi et al., 2020). In addition to increasing efficiency, AI can contribute to sustainable architecture in developing countries like Bangladesh. AI-based simulation models enable architects to assess energy performance, daylighting, and thermal comfort, aiding in the identification of energy-efficient strategies, building design optimization, and reduced environmental impact (Bertol et al., 2019). Moreover, it can support the preservation of cultural heritage by assisting in the conservation and restoration of historical buildings. Through the application of AI algorithms, architects can analyze and interpret complex historical data, ensuring the integration of cultural and historical context in contemporary designs (Li et al., 2021).

Despite the advantages AI provides, there are challenges to its implementation in architectural design within the context of developing countries. Limited access to resources, infrastructure, and expertise can hinder widespread adoption. Ethical considerations, including inclusive design, data privacy, and cultural sensitivity, also need to be addressed (Dominguez et al., 2019). However, studies have shown that the advantages of incorporating AI outweigh these challenges, suggesting that developing countries can utilize AI to fully leverage its potential and bypass traditional design practices (Smith et al., 2020).

3.2 Conventional Steps for Architectural Design

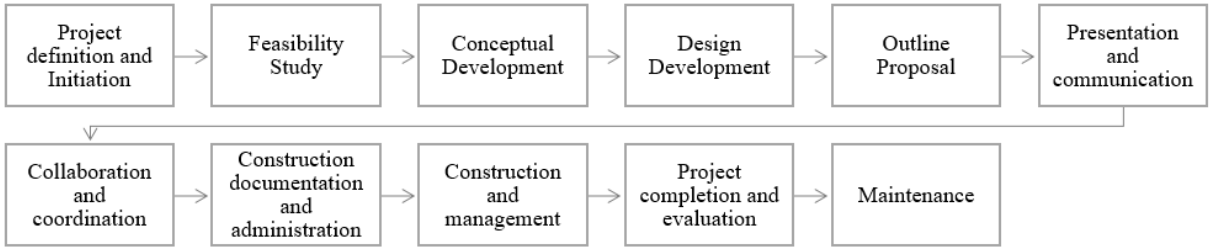

Figure 2. Conventional Steps for Architectural Design

3.2.1 Project Definition and Initiation

The first step of the architectural design process begins with initial client proposal, followed by subsequent communication with the client through verbal means, and terminates with the assignment of a team to this process.

3.2.2. Feasibility Study

The feasibility of the client proposal is analyzed in this step through field survey and climatic analysis using manual equipment's (e.g. base station, total station) and through manual data collection (annual rainfall, statistics, height restrictions, building codes) from local authorities. Examination of the legal issues, client requirements, contract drafting, and other are done manually. Recommendation are provided to the client at the end of this stage.

3.2.3 Concept Development

Using the determined constraints and considerations from the feasibility study, a conceptual design is conceived in this stage with a broad idea that will encompass the entire project. This stage involves manual illustration, study of context, typology, limitations, and discussions as a group.

3.2.4 Design Development

The conceptual design is developed into a complete architectural design and corresponding architectural drawings and visualizations are created for presentation. In conventional practices drafting, 3D modeling, rendering, and illustration software such as AutoCAD, SketchUp, Lumion, Photoshop etc. are used. Integrated softwares like Revit is also utilized in some practices.

3.2.5 Outline Proposal

In this step a brief is developed for initial communication with the client, and problems regarding cost, technical issues, design concerns etc. are addressed. Project proposal particulars are also decided. The entire process is done by manual methods without utilizing any artificial intelligence tools or techniques.

3.2.6 Presentation and Communication

The detailed brief is shared with the client in the step and relevant drawings and visualizations are issued and presented all through manual methods.

3.2.7 Collaboration and Coordination

Collaboration with engineers, specialists, approved authorities, and other responsible parties in this stage generates a complete set of construction drawings. Necessary documents for approval, created separately without the assistance of any integrated software, are also created and submitted in this stage.

3.2.8 Construction Documentation and Administration

In this step, all relevant construction, architectural, detail, and engineering drawings are incorporated into the architectural drawings. Cost estimations, specifications, and schedules are derived through a manual process from these drawings.

3.2.9 Construction and Management

Selection of materials, vendors, construction techniques are done by manual decision-making processes where past experiences where word-of-mouth reviews are also considered. On-site construction supervision is done periodically in this step and any issues raised during construction are also resolved. Final inspections are made to ensure all work has been done according to the drawings provided and decisions given by the project team.

3.2.10 Project Completion and Evaluation

The project is handed over to the client and final accounts are settled. Completion of all work in accordance with the contract is assured and any shortcomings are remedied. This step also includes the manual creation of as-built drawings.

3.2.11 Maintenance

Strategy for maintenance and upkeep is settled and the project team's commitment to future maintenance is agreed upon. Manual solutions are generated for upkeep.

3.3 AI tools supporting the conventional process

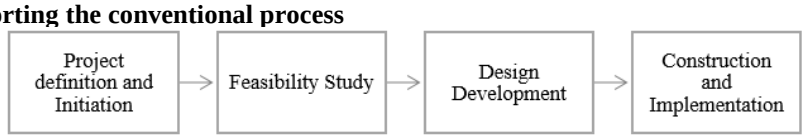

Figure 3. AI tools supporting the conventional process

The use of Artificial Intelligence can benefit the overall workflow of the project. The different steps of the conventional process can be merged using AI for enhanced interactivity by considering the entire process and merging the relevant steps to improve effectiveness (Pan & Zhang, n.d.).

3.3.1 Project Definition and Initial Research

To deal with the client and get the relevant basic requirements including briefs and documents through text and emails, the associated AI tools such as, “Natural language processing (NLP)” could be used. AI chatbots can help collect information from clients efficiently and accurately (Nimavat & Champaneria, 2017).

3.3.2 Feasibility Study

Various AI Tools can be used in each of the steps including Preliminary Data Analysis, Site analysis, geographical study, environmental analysis, preliminary cost estimation, financial analysis, risk assessment and analysis, regulatory and legal issue considerations, stakeholders' involvement, and others (*A Guide to Feasibility Studies – ArtscapeDIY*, n.d.). Machine learning can be used for data analysis, construction trends, economic overview, patterns, etc. Geospatial AI tools (ArcGIS, QGIS, Google Earth Pro, etc.) can be used for site analysis, land use study, topographic analysis, zoning, available amenities and infrastructures, and others. Photogrammetry AI tools can help site survey and 3D visualization (Qureshi et al., 2022). AI tools and software can be used for Environmental Analysis (Envi-Met, SimaPro, LCA software), Energy Modeling and Simulation (EnergyPlus, DesignBuilder, etc.), Climate Data Analysis (Climate Data Operators, ClimatePipes, Python libraries) for initial environmental analysis for design (Harish & Kumar, 2016).

3.3.3 Design Development

AI can help in design development by using AI-based search engines and computational and generative tools (Revit with Rhino and Dynamo, Rhino with Grasshopper) to develop design ideas. It can also assist in optimizing the generated designs (Rhino Grassopper Galapagos, Octopus, Wallacei), and in developing the design in the associated parametric and BIM softwares with livesync (Rhino, ArchiCAD, Revit, etc.) (Castro Pena et al., 2021).

3.3.4 Construction and Implementation

The overall benefit of AI can be acquired by using it in every step including collaboration with the structural and MEP (Mechanical, Electrical, and Plumbing) along with cost estimators, interior designers, and site engineers. BIM tools (like Revit, ArchiCAD, etc.) for interactive modeling can be used for teamwork and collaboration with stakeholders for design generation, issue management, and renovation. AI can help project automation for user interphase with BMS (Building Management System) (McGibney, 2016). BIM can be used for real-time immersive experiences and address sustainability, human comfort, environmental sustenance, structure, material, and lifecycle assessment (Kim & Maher, 2023). The AI-incorporated workflow ensures a single model concept for construction documents, administration, and management. Construction management can incorporate the Internet of Things, sensors and actuators, and relevant robotics for automated and comprehensive construction monitoring (Halder & Afsari, 2023). The as-built model drawings are also generated using Building Information Modeling, computer vision, and 3D scanning. The project can be evaluated with embedded technologies analyzing user behaviors to help ensure user comfort and minimize future issues. The maintenance and issue management of the project can be done using AI Algorithms. The BIM model can be upgraded to Digital Twin for automatic checkups and give recovery solutions (Mahmoodian et al., 2022).

3.4 Challenges and Opportunities in Implementing AI in Bangladesh

Lack of availability of technologies, tools, and software, and knowledge of the proper tools pose a major threat to implementing AI usage in conventional practices. Further scope remains for the development of artificial intelligence based on the requirement in various stages of architectural design and its acceptability. Another challenge is faced due to the lack of available, reliable, and relevant data. While data collection might become easier with the advancement of technologies, suitable tools, and techniques will need to be utilized for an effective process. Questions regarding data privacy might also arise, requiring classification. Lack of proper training and skill development might become a major drawback during the initial stages. Despite AI's potential to produce more cost-efficient design and implementation processes, reluctance in the initial investment is to be expected, due to the larger financial commitment upfront. The work process might be hindered if AI-based tools and techniques are only implemented by the architectural offices while the collaborators continue using conventional methods. In the context of Bangladesh, social acceptance of artificial technology is a major issue, and general skepticism is to be expected. However, proper adoption of this system provides a scope to develop a convenient workflow for future projects. Steps that cannot be adopted now due to various constraints may be incorporated in the future.

4 Result and Findings

Following the observation of existing practices, their alternatives, and comparative analysis, certain findings have been deduced.

4.1 Project Definition and Initial Research

Verbal communication in the initial communication stage might be better for a natural conversation with the client that can switch according to the context and flow of the conversation.

4.2 Feasibility study

Time spent collecting and sorting data from local authorities and stakeholders could be greatly reduced if they were input and updated into the GIS database, allowing instant data collection once the location was set. Proper utilization of this feature would require regular updates and optimizations based on the availability of new data.

4.3 Design development

The time-consuming task of manually studying context, typology, limitations, etc. could be made more efficient with artificial intelligence based on the design context. AI’s ability to provide parametric and computational data can help concept development. AI can help to create an integrated design with design development, generation of various design drawings and visualizations, and collaboration with relevant field experts, with real-time updates.

4.4 Construction and Implementation

Utilization of an integrated design process based on artificial intelligence would ensure an easy and effective workflow that allows effective communication between the concerned design and on-site parties including architects, engineers, and clients. Automated construction maintenance with error-handling capabilities would ensure exact construction and would provide instant solutions on-site based on the design parameters. Simulation and optimization scopes could be explored to provide feedback. Performance monitoring and post-occupancy evaluation can ensure the structure is running in the intended way and can provide data for future projects.

The findings show that the different steps in conventional Architectural Practice are more detached, and collaboration is quite time-consuming. The incorporation of AI could ensure an integrated design process that will reduce the time for individual steps and prevent loss of design information in the manual drafting of drawings.

5 Limitations, Future scopes, and Recommendations

A major limitation to the use of AI in the design process is its comparative recency and the consequent lack of in-depth data and study in the relevant fields. Comparing the workflow of conventional steps and AI integration in a real project through real-time assessment and further analysis might help deduce which stages require further research and adaptation before having the potential to be fully integrated into a practical project. Adaptations of AI usage into the policy and regulatory frameworks will allow efficient utilization of its potential. Further investment is needed in AI research and infrastructure to devise a more in-depth look into the potential of artificial intelligence in the context of Bangladesh and ensure effective collaboration between architects, engineers, and academia. Further scope in this field could be explored through more data collection and standardization efforts. Additional research could be done to open new areas of exploration in the field of architecture and AI.

6 Conclusion

In conclusion, to keep pace with the present situation there is no alternative to adopting new technologies for development. In contemporary architectural practices in Bangladesh, manual systems hold a greater precedence in most stages of the work process where the use of AI is minimal and not utilized to its full potential. AI can be used to make up for the limitations in traditional practices, specifically in the design development, collaboration and construction management stages. Considering AI as a strength rather than a threat, developing countries can evolve their architectural practices, improve design outcomes, and contribute to the larger field of architecture.

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