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Original Article

Application of CHATGPT in civil engineering

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ABSTRACT

Artificial Intelligence, machine learning, and the Internet of Things (IoT) are changing the way tasks are accomplished. CHATGPT is a well-known conversational artificial intelligence (AI) system based on the generative pre-trained transformer (GPT) architecture, launched by OpenAI. CHATGPT is trained through reinforcement learning based on human feedback. There are advantages to the use of CHATGPT in Civil engineering, including but not limited to design and planning: structural analysis and simulation, code compliance and regulations construction management, knowledge repository and information retrieval, education, and research. The limitation of CHATGPT is the bias based on the datasets used in CHATGPT training, the requirement of sufficient input information, as well as the risk of bias and transparency issues, and negative consequences if generating inaccurate content. The use of CHATGPT and other language models in civil engineering requires careful consideration to ensure not bypassing expert consultation in particular cases. Deep Learning based language models would have a positive impact on civil engineering rather than replacing human expertise and improving the infrastructure development in the world and solving challenges facing mankind.

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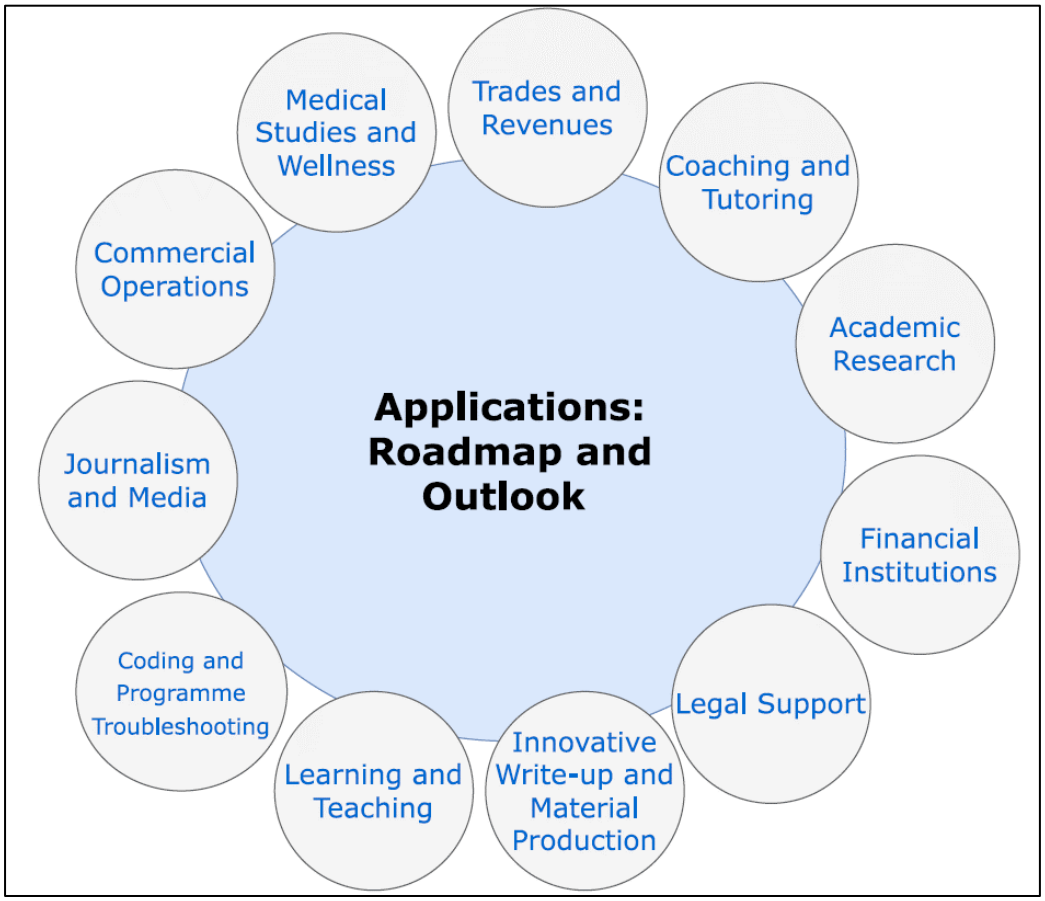
INTRODUCTION

Civil engineering is a very wide discipline that deals with the design and construction of mega infrastructures such as roads, water supply systems, buildings, railways, and dams among others (Germano et al., 2023; Gindis & Kaebisch, 2023; Qin et al., 2023). Therefore, so much is required in feasibility studies, detailed design, tender documentation, and construction. These projects take time and require large numbers of personnel to undertake the work. The projects are also affected by unforeseen weather conditions leading to delayed completion. Delays in construction works lead to monetary compensation and may lead to litigations. Due to the complex nature of civil engineering work, artificial intelligence is a valuable tool for civil engineers (Ereiz et al., 2023; Naser, 2023; Wang et al., 2023). This includes CHATGPT.

CHATGPT is a well-known conversational artificial intelligence (AI) system based on the generative pre-trained transformer (GPT) architecture, launched by OpenAI. CHATGPT is trained through reinforcement learning based on human feedback. Many researchers are currently studying the application of CHATGPT in different disciplines such as finance, health, education, and biotechnology (Antaki et al., 2023; Branco et al., 2023; Dowling & Lucey, 2023; Dwivedi et al., 2023; Agathokleous, 2023; Gomez-Flores et al., 2023; Holzinger et al., 2023; Khogali & Mekid, 2023; Lecler et al., 2023; Li et al., 2023; McGrath et al., 2023; Peres et al., 2023; Saggu & Ante, 2023; Sitapure & Kwon, 2023; Valencia et al., 2023). In their short communication, Gill and Kaur examined the applications of CHATGPT as shown in Figure 1(Gill & Kaur, 2023). But civil engineering is missing in the discussion. Little published information is available on the application of CHATGPT in civil engineering yet there is significant potential.

Figure 1: Applications of CHATGPT



Source: (Gill & Kaur, 2023)

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The limitation of CHATGPT is the bias based on the datasets used in CHATGPT training, the requirement of sufficient input information, as well as the risk of bias and transparency issues and negative consequences if generating inaccurate content. The use of CHATGPT and other language models in civil engineering requires careful consideration to ensure not bypassing expert consultation in particular cases. Deep Learning Based language models would have a positive impact on civil engineering rather than replacing human expertise and improving the infrastructure development in the world and solving challenges facing mankind (Goldstein et al., 2023; Regona et al., 2022).

Despite the existence of a lot of publications on the application of CHATGPT in other professional disciplines such as medicine, there is no published literature on the application of CHATGPT in engineering, in particular, civil engineering. Hence, the objective of this research paper is to provide insights into the application of CHATGPT in civil engineering. This will go a long way in addressing the delays in civil engineering projects and saving on the high cost of projects. This will spur the much-needed infrastructure development, especially in developing countries such as Kenya. There are advantages to the use of CHATGPT in Civil engineering, including but not limited to Design and Planning, Structural Analysis and Simulation, Code Compliance and Regulations Construction Management, Knowledge Repository and Information Retrieval, education, and research.

DESIGN AND PLANNING

CHATGPT can assist in the design and planning phase of civil engineering projects. It can generate design alternatives based on given criteria and constraints, helping engineers explore different possibilities and evaluate their feasibility. The following are areas in which it can be used:

- Generation of preliminary design concepts based on given project requirements. The user can provide input parameters such as site conditions, functional needs, and design constraints.
- Optimizing design parameters. Engineers can input design variables such as dimensions, material properties, or structural configurations, and they can provide suggestions or perform iterative analysis to optimize the design for specific criteria, such as cost, structural performance, or sustainability.
- Evaluating the feasibility of design alternatives by analysing and providing insights on their technical viability, constructability, and potential challenges. It can consider factors such as site conditions, environmental impact, regulatory requirements, and budget constraints to assist in decision-making.
- Providing information on design codes, standards, and best practices to ensure that the proposed design meets the required safety and performance criteria. It can help engineers verify and validate the design against relevant regulations and guidelines.
- Generating design documentation, including reports, drawings, specifications, and calculations. It can help engineers draft design narratives, prepare technical drawings, and provide explanations or justifications for design decisions.
- Serving as a virtual reviewer by examining the design documentation and providing feedback on potential issues or areas for improvement. It can help identify inconsistencies, errors, or oversights in the design, promoting a more robust and accurate design process.

Structural Analysis and Simulation

CHATGPT can aid in structural analysis by providing information on various analytical and computational methods. It can help engineers understand and interpret complex structural behaviours and assist in performing simulations

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or modelling structural systems. The following are areas in which it can be used:

- Explaining the principles and concepts behind structural behaviour. It can provide information on different types of structural systems, load distribution, material properties, and response under various loading conditions. This can aid engineers in understanding the fundamentals of structural analysis.
- Explaining different analytical and computational methods used in structural analysis. It can provide insights into techniques like finite element analysis (FEA), structural dynamics, stability analysis, and other numerical methods. Engineers can gain a better understanding of these methods and their applications.
- Providing guidance on structural analysis software packages. It can explain the capabilities, features, and limitations of popular software tools used for structural analysis and simulation. Engineers can obtain recommendations and insights on selecting the appropriate software for specific projects.
- Assisting in creating and setting up simulation models. It can help engineers define boundary conditions, material properties, and loadings for a structural system. Additionally, it can explain different modelling techniques and approaches to improve the accuracy and reliability of simulations.
- Assisting in interpreting the simulation results. It can explain the significance of various output parameters, such as stresses, displacements, and deformations. Engineers can gain a better understanding of the structural response and evaluate the performance of the analysed system.
- Provide troubleshooting guidance when encountering issues in structural analysis. It can offer suggestions to resolve convergence problems, model instabilities, or discrepancies in simulation results. Furthermore, CHATGPT can assist in optimization techniques to improve structural performance or meet specific design objectives.

Code Compliance and Regulations

Civil engineering involves adherence to building codes and regulations. CHATGPT can provide guidance on specific code requirements and help engineers ensure compliance with local, regional, or international standards. The following are areas in which it can be used:

- Interpreting specific provisions of building codes and regulations. You can provide excerpts or descriptions of code requirements, and it can offer explanations and clarify any ambiguities or uncertainties.
- Provide guidance on how to comply with specific code requirements. By describing the project parameters and design constraints, you can seek advice on code-compliant solutions or strategies to address certain design aspects.
- Assist in comparing and identifying differences between multiple sets of building codes or regulations. It can help highlight variations in requirements across different jurisdictions or standards.
- Providing information and guidance on accessibility codes and standards. It can explain the requirements related to wheelchair accessibility, ramps, elevators, door clearances, and other accessibility features.
- Assist in understanding fire and life safety codes. It can provide insights into fire protection systems, means of egress requirements, fire resistance ratings, occupancy classifications, and other safety-related provisions.
- As sustainability becomes increasingly important in civil engineering, CHATGPT can help navigate sustainability codes and regulations. It can provide information on green building certifications, energy

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efficiency requirements, renewable energy standards, and sustainable material practices.

Construction Management

CHATGPT can assist in construction management tasks by providing project scheduling advice, estimating material quantities, and analysing construction methodologies. It can help optimize construction processes, manage resources, and address potential challenges. The following are areas in which it can be used:

- Provide guidance on project scheduling techniques and methodologies. It can assist in developing project schedules, explaining critical path methods (CPM), resource levelling, and other scheduling techniques. Additionally, it can help analyse potential schedule delays and propose mitigation strategies.
- Assist in managing project resources effectively. It can provide insights into resource allocation, equipment planning, and labour optimization. By considering project requirements and constraints, it can offer suggestions for efficient resource utilization.
- Assist in cost estimation and budgeting processes. It can provide information on cost factors, unit rates, and industry benchmarks. Engineers can input project specifications, and it can offer estimates for various cost elements, helping to create budgets and monitor expenses.
- Explaining different construction methods and techniques. It can provide information on traditional and innovative construction approaches, equipment selection, construction sequencing, and temporary structures. This knowledge can aid in determining the most suitable methods for specific projects.
- Assist in identifying and managing project risks. It can provide insights on risk assessment, contingency planning, and mitigation strategies. Engineers can input project details, and CHATGPT can help identify potential risks and offer recommendations for risk reduction or avoidance.
- Assist in generating construction-related documentation. It can provide guidance on preparing project reports, progress updates, change orders, and other contractual documents. This can help streamline the documentation process and ensure accurate and clear communication.
- Offer guidance on quality control and assurance processes. It can explain quality management techniques, inspection methods, and quality standards. Engineers can seek advice on implementing quality control measures and ensuring compliance with specifications.

Knowledge Repository and Information Retrieval

With its vast knowledge base, CHATGPT can serve as a repository of civil engineering information. It can quickly retrieve information on specific topics, historical projects, best practices, and case studies, saving engineers time and effort in research.

- Provide information on a wide range of civil engineering topics. Engineers and researchers can ask questions or provide specific keywords to retrieve relevant information, historical data, academic studies, industry standards, or best practices.
- Offer access to a repository of case studies and project examples in civil engineering. It can provide details about successful projects, their challenges, design solutions, and lessons learned. These examples can help engineers gain insights and apply them to their projects.
- Retrieve historical data and trends related to civil engineering. It can provide information on past projects, construction methodologies, materials, and technological advancements. Engineers can use this data to analyse trends, evaluate performance, and make informed decisions.

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- It can be a valuable resource for accessing civil engineering standards and codes. It can provide information on local, regional, or international codes and regulations. Engineers can retrieve specific code requirements, design criteria, and guidance for compliance purposes.
- Offer guidance on best practices and guidelines in civil engineering. It can provide information on industry-recognized practices, design approaches, and construction methodologies. Engineers can leverage this knowledge to enhance project efficiency, quality, and sustainability.
- Help in retrieving research papers, articles, and journals related to civil engineering. Engineers can seek references to scholarly works, recent research, or specific topics of interest. It can provide summaries, abstracts, or direct links to relevant sources.
- Keep civil engineers informed about the latest developments in the field of civil engineering. It can provide updates on new materials, construction techniques, technologies, and emerging trends. Engineers can stay up to date with industry advancements through regular interactions with CHATGPT.

Educational and Research Tool

CHATGPT can be utilized as an educational resource, providing explanations, examples, and demonstrations of civil engineering concepts. It can help students and aspiring engineers learn fundamental principles and practical applications of civil engineering.

- Explaining fundamental concepts and theories in civil engineering. It can provide definitions, and explanations, and clarify complex topics. Students can ask questions about specific subjects, such as structural analysis, geotechnical engineering, transportation planning, or construction management, and it can provide detailed explanations.
- Assist students in solving civil engineering problems. By presenting problem statements or equations, students can seek step-by-step solutions or guidance from CHATGPT. It can help with calculations, and numerical methods, and provide problem-solving strategies.
- Offer design examples and case studies to illustrate practical applications of civil engineering principles. Students can learn about the design process, design considerations, and best practices by examining real-world examples. CHATGPT can explain design decisions, constraints, and potential alternatives.
- While CHATGPT is primarily a text-based model, it can still provide verbal descriptions of visualizations and simulations. Students can describe or input parameters of a simulation, and CHATGPT can explain the expected outcomes or behaviour of the system being simulated.
- Assist students in preparing for exams or quizzes. It can provide practice questions, explain solution approaches, and review key concepts. Additionally, CHATGPT can help clarify doubts or misconceptions related to specific exam topics.
- Offer insights into different career paths and opportunities within civil engineering. Students can ask about job roles, industry trends, and required skills. CHATGPT can provide information on continuing education, certifications, and professional development options.

CONCLUSION

Use of CHATGPT in Civil engineering, including but not limited to design and planning: structural analysis and simulation, code compliance and regulations construction management, knowledge repository and information retrieval, education, and research., it should not replace the expertise and experience of qualified civil engineers. It can serve as a tool to enhance efficiency, provide guidance, and supplement decision-making

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processes in the field. This will make decision-making faster and more effective. Also, the time taken to implement projects will significantly reduce leading to rapid economic growth, especially for nations with low numbers of skilled workers.

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Competing Interests

No existing or perceived conflicts of interest.

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