Balancing Breakthrough & Ethics: Artificial Intelligence in Civil Engineering

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Introduction

New software utilizing artificial intelligence such as digital twins, data extraction tools, and 3D drawings have paved the way for a technological breakthrough in civil engineering. While these technologies provide ways to design, construct, and operate infrastructures in a more concise manner, they also pose new ethical challenges that were not previously considered. In the face of ambiguity surrounding ethical usage of AI for civil engineers, they must adhere to section 1H in the ASCE Code of Ethics, which states they must "consider the capabilities, limitations, and implications of current and emerging technologies" [1]. While the architecture, engineering, and construction (AEC) industry has historically been slow to adapt to new technologies, it has recently begun to understand the importance of making technological progress to drive efficiency. Companies such as structural engineering firm Thornton Tomasetti and engineering firm CDM Smith have developed carbon measurement tools and desktop-based energy analyzers to utilize AI-powered software to reduce waste in the industry [2]. Because of the industry's recent mindset shift regarding new technology adoption, it is important to set a guideline for how future generations of engineers should approach not only AI usage but also AI model development. These guidelines and discussions will pose as a compass while more engineering and construction firms begin to implement AI into their workflows. To comply with ASCE's Code of Ethics, engineers must ensure that AI models are created with unbiased data, creating outputs that favor inclusivity, and ensuring that AI is used to aid in work, not fully complete projects for them.

AI: An Unbiased Data-Driven Model

In simplest terms, creating an AI model requires three cyclical steps: data input, algorithm creation, and training. The first step requires creating a database of data points with which the AI model will be trained. The second step requires creating mathematical algorithms to allow the AI model to understand and analyze data as desired. The final step will be to import the database into the algorithm, guiding the model to use the data points to reach desired conclusions. Once the model works properly as defined by the engineering team, it can be implemented into real-life scenarios. While this continuous cycle allows for more accurate models, it also poses a higher risk for bias in models, leading to potential failures in projects and

harmful consequences to society. To mitigate the effects a biased model can have, engineers must work to solve the underlying issue: biased data used in AI model training.

Civil engineers are at the forefront of collecting and selecting data that will be utilized for training. Engineers must ensure that the data will lead to an unbiased AI model. For example, an engineer may be attempting to use only geotechnical reports from a previous project located in coastal Tampa, Florida to train a model to be used on a project in rocky Denver, Colorado. While different geotechnical conditions may expose the AI model to a wider range of possible soil conditions, the model may become accustomed to delivering solutions similar to the ones developed for the Florida geotechnical report if data is limited. This will create a bias in the model and solutions may be inaccurate. By doing so, the project may be at risk for structural failure or delay in the schedule. In this hypothetical case study, if the AI model creates recommendations for Denver based on Tampa's conditions, it may request soil remediation for sandy soils and water drainage whereas projects in Denver should rather focus on slope stability analysis and rockfall protection. This would result in improper site preparation and may lead to potential dangers. It violates the future occupants' right to safety as the soil may deteriorate over time and put the project at risk for collapse or sinkage. By failing to design the project with public safety in mind, engineers fail to "protect the health, safety, and welfare of the public," which is section 1A in the Code of Ethics [1].

In order to mitigate professional failures when using AI, engineers should make sure that they strictly use unbiased AI software. These software should account for measurement parameters equally unless desired to bias one or the other (such as deciding if wind or seismic loads govern in structural engineering) [3]. Since civil engineers are at the forefront of data collection and consultation for their firms, they have not only a moral obligation, but also a professional obligation to check each dataset for variability and diversity. They must complete their due diligence and ensure the improvement of society by debiasing AI models and only using ones that have met a definition of "unbiased" as set forth by ASCE and other organizations, which the organizations must develop. By doing so, engineers take an active role in using unbiased AI software that allows for its usage in projects of various sizes, locations, and complexity.

AI: A Vessel for Inclusivity

While civil engineers are currently working in a time of change and ambiguity, they must not forget to adhere to ASCE's movement of inclusivity when implementing AI in their daily tasks. ASCE's Code of Ethics was first published in 1914, with its most recent update in October 2020 highlighted by a major change in inclusive wording and pushing for a more inclusive workplace. These updates include Section 5F, which requests engineers to "encourage and enable the education and development of other engineers and prospective members of the profession" [1]. Coming from all backgrounds, engineers may not all have had the same level of accessibility to educational resources. Using AI in the workplace is an avenue for bridging the educational gap between peers. By utilizing AI software that help develop calculations or explain theories behind certain scopes of work, engineers can grow in their profession. AI models, with this use case, create fairness and equitability in the workplace, allowing coworkers to shorten knowledge gaps and break barriers caused by their unique backgrounds.

In addition to inclusivity in the workplace, the Code of Ethics also promotes inclusivity in developed solutions. In Section 1G, the Code of Ethics requests engineers to "acknowledge the diverse historical, social, and cultural needs of the community, and incorporate these considerations in their work" [1]. This statement must be ever-present in engineers' daily work as they use AI to create solutions for their projects. Engineers have an ethical duty to ensure that AI models output results that take into account the needs of the project's community. For outputs to be inclusive of the community, engineers must make sure that the inputs they use are inclusive in themselves [4]. To do so, engineers must create prompts that not only describe the project and problem in detail, but also state the ethical implications this project may have on the nearby occupants. Engineers should create inputs that comply with Section 1G of the Code of Ethics and address the needs of the community. The AI software will then be able to analyze not only the engineering problem presented but also the cultural and social aspects of said problem. This will allow the unbiased AI model to create solutions that solve the engineering problem while upholding the project's ethical duty to maintain the community's autonomy to live freely in accordance with their desired way of living. By doing so, engineers are completing their ethical responsibility to support the preservation of communities through the development of projects.

AI: A Tool in an Engineer's Toolbox

Society has seen widespread utilization of AI in the past 1-2 years and AI is projected to grow more, with an annual increase in adoption rate of 38 percent [5]. While AI is becoming more complex and beneficial in work environments, engineers must remember that AI software are tools to aid them in developing conclusions, not guaranteed solutions. Due to the variability of each project's scope, civil engineering relies just as heavily on historical data and personal experiences as it does on raw sensory data [6].

While AI models can be trained on historical data in addition to raw sensory data, human judgment plays an important role in decision-making in civil engineering. As of early 2024, AI models fail the Turing Test, which states that AI can be considered a living being if it proves that it has a conscience and moral compass [7]. Since AI models cannot empathize with humans and account for human emotions when creating solutions, they lack the necessary qualities of a human that lead to solutions that not only solve problems but also minimize detrimental impacts to affected groups. This lack of consideration for human emotions should shy engineers away from relying on AI software to develop solutions. If engineers were to rely heavily on results produced from AI software, they may be violating Section 1B of the Code of Ethics which states that engineers are to "enhance the quality of life for humanity" [1]. While a given solution may be the most effective, it also has the potential to harm humanity if the solution fails to consider emotional and human factors. AI software, due to the lack of consciousness, may treat humans as a means to the best solution, rather than an end. Thus, it can be argued that under Deontology, the ethical framework that says humanity must be considered an end rather than a means, AI software acting by itself can be labeled as unethical. This can be refuted, however, if engineers view AI as a helper tool. Engineers should take AI-generated solutions with a grain of salt and examine the solutions from a humanity-as-an-ends perspective. By doing so, they'll have accounted for ethical implications of the solution and modify it to adhere to Section 1B.

Additionally, a high reliance on AI software puts engineer's freedom to think independently at risk. As humans have the autonomy to think, high usage of AI may diminish the engineer's basic human right to do so. While an AI-designed infrastructure network may run efficiently, humans will lose their autonomy to create and think independently, losing a trait that makes humans unique from AI models. Engineers should understand these potential risks and aim to use AI as an assistant in creating a path to a final solution. This conscious decision to limit

AI reliance will allow engineers to maintain ownership of the proposed solutions while maximizing the benefits that AI can bring in an ethical manner.

Conclusion

While artificial intelligence brings many benefits to the civil engineering industry, engineers must ensure that they utilize AI in an ethical manner. As engineering firms begin to utilize AI software, engineers must validate them as unbiased models to ensure fair and safe solutions. ASCE and other professional organizations must define unbiased versus biased models to give engineers a baseline for judgment. Engineers must also create inputs for AI models that adhere to the ASCE Code of Ethics to allow for generation of results that consider social, financial, and cultural implications. AI can and should also be used for employee training and creating a more inclusive workplace, allowing coworkers to bridge gaps stemming from their unique backgrounds and educations. While projects may become able to be fully designed, constructed, and operated by AI, engineers must understand the ethical drawbacks of high reliance on AI and only utilize AI as an aid tool during the development of a project. By understanding their ethical responsibilities that adhere to ASCE's Code of Ethics regarding AI usage in their work, engineers will be able to utilize the strengths of computational softwares while combining its results with human consciousness to develop the best solution that upholds human autonomy.

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