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THE ETHICAL AND SOCIAL DILEMMA OF AI USES IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Given the growth in data collection and application of Artificial Intelligence (AI) in the construction industry, there is a need to study the ethical and social considerations for employees in the industry and for society in general. AI could support more efficient ways of working where technology is better equipped for the tasks compared to humans. With new technologies such as AI, many decisions will be made by algorithms and not by humans. This paper explores the ethical and social dilemmas that are intrinsic in decision-making, and how they will also impact the decisions made by AI algorithms. The paper presents definitions of ethical and social dilemmas, a definition of AI, and summarizes current applications of AI in construction. It also discusses several questions associated with the current and future application of AI in the construction industry and the ethical and social dilemmas defined. This is an exploratory paper and the aim of the authors is to spark further research and discussion on the topic within the Lean Construction community, given that lean is based on respect for people and the implications of AI uses to individuals in our industry have not been understood.

KEYWORDS

Artificial intelligence, decision-making, ethical and social dilemma, biases.

INTRODUCTION

Artificial Intelligence (AI) has been on the horizon for our society since the late 1950s and recently projects and companies in the construction industry have incorporated it to support daily work routines. In the literature, we found conceptual frameworks to use AI in construction management. For example, Riad et al. (1991) present a theoretical approach for claim management in construction, where they developed algorithms for evaluating time impact analysis and to apportion damages in different delay/acceleration situations. Ko et al. (2003) developed and tested a hybrid AI model for decision-making to solve several construction management problems. In architecture and structural design, the use of AI in generative design has also been applied. For example, Oh et al. (2019) have used generative design and topology optimization to explore new design options, thus generating a large number of designs starting from limited previous design data. In

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a recent article in ENR (2021), several uses in construction are reported. For example, as applications for planning are growing quickly, companies like DPR construction are creating their own algorithms to help project teams make decisions in terms of production control or supporting owners in making facility management decisions (DPR Construction, 2019). Furthermore, commercial companies are offering algorithms to use AI for providing legal advice to small construction players to manage contractual risks.

This paper is inspired by The Social Dilemma documentary from Netflix and the book Homo Deus (Harari, 2019). These two references have sparked several philosophical discussions in all aspects of our lives, and we see the need to at least pose the questions for us, the international Lean Construction community, to discuss how ethical and social dilemmas related to the use of AI affect people in our industry. AI is used in several aspects of our daily life: automotive driving (Directions), searching for information (Google), choosing movies (Netflix), Social Platforms (FB, Instagram, LinkedIn) – all these influences what we see, which opinions we hear more, who we follow, what information is presented first, etc. AI use is already affecting not only our personal lives, but also our work lives in the construction industry. As lean practitioners, we seek to optimize processes, to work efficiently and to utilize technology where it enables us to either deliver more value or reduce waste. On the other hand, we should never forget that lean holds a common value of respect for people, and we want to make sure to preserve this in the future of the construction industry, given the probably inevitable coexistence of AI in construction (Schia et al. 2019). We think as a society all perspectives on using AI should be discussed in order to both gain the benefit and still keep asking the more fundamental and ethical questions. This should not be a discussion limited to AI developers who are trying to maximize their commercial value. Although the developers might have the best of intentions in aiming to increase the productivity of the construction industry, there might be unintended consequences of their actions.

In this paper we explore several questions associated with the current and future application of AI in the construction industry and the ethical and social dilemmas. This is an exploratory paper, and we look forward to sparking further research and discussion on the topic within our community.

METHODOLOGY

This paper uses exploratory research, which is open ended and interactive in nature; the structure is not predetermined, as opposed to confirmatory research (Stebbins, 2001). This type of research is appropriate for questions like how and why in fields where there is an absence of previous research data, as is in the case of this paper. The research question is how AI-based decisions in applications in the construction industry can present social and ethical dilemmas. Our purpose is to discuss the ethical and social dilemmas of using AI in the construction industry and the implications to preserving the respect for people working in construction. The authors have reviewed the literature 1) to first define AI as a field of study and its potentiality, and 2) to explain the ethical and social dilemmas. Then, we reviewed the literature and industry media to summarize current and potential future uses of AI in the construction industry. Finally, a discussion section is presented based on questions that emerged by associating AI applications in the construction industry with ethical and social dilemmas in decision-making.

BACKGROUND INFORMATION

Little research has been published on how AI impacts humans and human behavior. In this section, AI is defined through literature and the distinction between ethical and social dilemmas is discussed in the context of applications of AI to the construction industry.

WHAT IS AI?

Russell and Norvig (2019) studied several definitions of AI and classified them into systems (including machines) which think or act like a human, and systems which think or act rationally. These definitions create a need to study the definition of human thinking and acting, and how we define what rational acting or thinking is. Therefore, they stated that "Artificial intelligence or AI, attempts to understand intelligent entities. Thus, one reason to study it is to learn more about ourselves. But unlike philosophy and psychology, which are also concerned with intelligence, AI strives to build intelligent entities as well as understand them." To provide a satisfactory operational definition of intelligence to judge whether or not a system is acting humanly, Alan Turing (1950) designed the so-called Turing test. The test is passed if the system can demonstrate the following capabilities:

- Natural language processing to enable it to communicate successfully in English (or some other human language);
- Knowledge representation to store information provided before or during the interrogation;
- Automated reasoning to use the stored information to answer questions and to draw new conclusions;
- Machine learning to adapt to new circumstances and to detect and extrapolate patterns.

In a famous critique to AI research, Dreyfus (1972) published "What Computers Can't Do". He argued that human intelligence and expertise depend primarily on unconscious processes rather than conscious symbolic manipulation, and that these unconscious skills can never be fully captured in formal rules. Dreyfus' point is still valid to date: how can we use algorithms that try to replicate human behavior if we have not yet understood it? On the other hand, some AI algorithms are so complex that we cannot even understand them fully in retrospective.

Russell and Norvig (2019) also point out that AI has produced many significant and impressive products, even at this early stage in its development. Although no one can predict the future in detail, it is clear that AI will have a huge impact on our everyday lives and on the future course of civilization. Harari (2019) raises questions about the difference between human and AI, and asks what would happen if AI achieves superhuman intelligence: would AI then be more valuable than humans?

WHAT ARE ETHICAL AND SOCIAL DILEMMAS?

An **ethical dilemma** occurs when a decision has to be made between two alternatives in which both alternatives are not fully acceptable ethically. For example, you have to choose between two road designs. One alternative is perceived as safer by the road users, whereas the other alternative is eliminating fewer protected areas. What are you going to choose, perceived safer or preserving more nature? How would an AI algorithm judge these ethical decisions? "[E]thical dilemmas will often result in unethical behavior" (Sims

1992, p. 510). **Ethical behavior** means we are following the values, norms and rules of our society. Schermerhorn (1989) introduced four perspectives on ethical behavior: (1) justice (act based on fundamental rights), (2) moral rights (fair treatment), (3) individualism (long-term self-interest), and (4) utilitarian (best for most people). Those four perspectives can create dilemmas based on long-term vs. short-term advantage and which perspective gets prioritized. Also, the American psychologist Lawrence Kohlberg defines the highest level of moral reasoning, "Postconventional moral reasoning", as the ability to question "What is ethically right?" and "What are the wider long-term consequences?" An example is the importance of applying the spirit of the law rather than the letter of the law. Thus, when we use AI in the construction industry, we need to consider how the AI is designed, operates and learns, and how the algorithm works in the context of ethical and social problems. AI has to cope with dilemmas and, in comparison with human decision-making, which we are quick to judge, are we critically assessing the information AI delivers?

A **social dilemma** occurs in a situation where there is a conflict between self and collective interest (Van Lange et al., 2013; Dawes and Messick, 2000). For example, a social dilemma exists if the architect and the MEP designer are locally optimizing based on each separate perspective. The two designs are interdependent and therefore the fragmented views may result in a suboptimal and inefficient building. If a generative design is used to optimize only one perspective, it may not be the best for the whole project.

CURRENT USES OF AI IN CONSTRUCTION

This section presents different current uses of AI in the construction industry. Uses for the construction industry include but are not limited to automatic schedule generation for planning and control, design automation techniques like generative design or parametric design, contractual document analysis, and facility management.

PLANNING AND CONTROL

There are several AI applications currently being used in construction projects, especially around project scheduling analysis performed based on machine-learning algorithms (ENR 2021). One of the software vendors to optimize schedules (ALICE) states in an ENR article published in 2021 that the aim of this technology is to help teams avoid tedious planning tasks. He points out "Why would anyone in their right mind want to spend time crunching all the constraints on a project? It's mind-numbingly boring." This technology, based on commercially available AI algorithms, extrapolates thousands of possible ways of executing a project by running simulations of a project's 4D schedule and BIM, readjusting as variable inputs are tweaked in the project "recipe". Users make adjustments to the inputs, and the AI algorithm tells them how it will affect the construction schedule. The software developer says that the idea is not to cede decision-making to the algorithm; rather, it is about automating the process of generating possible alternate schedules (ENR 2021). These algorithms can help optimize the schedule of a project based on certain parameters; for example, the algorithm can explore crane placement and task sequencing for a construction project. But, how does the algorithm work? Since these companies have commercial interest the detailed understanding of how it works is not accessible to most people.

Schia et al. (2019) present interviews and a case study of using AI for planning on a project in Norway (studying ALICE). The study concludes that, when it comes to AI, the

human-AI trust will be the most decisive factor for a successful implementation. Furthermore, it will be difficult for a worker to understand how ALICE arrives at the output, and further trust the output. Currently, the algorithm depends on human data input, but in the future when the AI algorithm has enough historical data, human input will no longer be necessary (Schia et al. 2019). This sparked other questions regarding scheduling algorithms, such as, is the schedule optimization algorithm based on the critical path method? Does it use lean principles? How collaborative is it? How does the algorithm balance different interests? Can workers input their preferences for task sequencing? How does the algorithm learn? How do we know it is successful?

GENERATIVE DESIGN

Different AI algorithms have been used in construction projects, with the purpose of optimizing the design. This type of AI application looks to generate numerous design options which are not only aesthetic but also optimized for engineering performance. Oh et al. (2019) use generative models to create design alternatives and the topology optimization to help designers choose a design alternative in an iterative manner. According to Oh et al. (2019), their framework manifests better aesthetics, diversity and robustness of generated designs than previous generative design methods.

Newton (2019) argues that Generative Adversarial Networks (GANs) are an emerging research area in deep learning that have demonstrated impressive abilities to synthesize designs; however, their application in architectural design has been limited. Newton (2019) tested the creation of 2D and 3D designs from specific architectural styles and experimented on how to train the algorithms to a desired design to control the "fidelity" and "diversity" of the design. Our questions here are: how do you define a successful design? What do "fidelity" and "diversity" mean? How do you measure them? And who is the judge behind the design? Is design transferable from project to project? Again, this raises the question of how biased the algorithm is. How does the optimization algorithm make trade-offs between designs, who decides which factors are considered in the decision? Usually, optimization algorithms seek to optimize one or two parameters or have a priority system. How aware are designers of these assumptions? Are there biases included in the algorithms?

CLAIM ANALYSIS

According to Riad at al. (1991), delays are the major cause of construction disputes; mediation is usually an effective solution, but a preventive and comprehensive approach is lacking. Riad at al. (1991) developed an AI algorithm for time-based claim management, which analyzes disputes that arise due to different types of delays (excusable/compensable, excusable/noncompensable, nonexcusable; independent, concurrent, serial) and helps determine the responsibility of each party. The algorithm utilizes a procedure called 'Time Impact Analysis' and involves the use of network-based scheduling tools to identify, quantify and explain the cause of a schedule variance (Riad at al., 1991). But, who developed the AI algorithm used in case of a claim? And, is the algorithm trustworthy?

ENVIRONMENTAL PERFORMANCE

Fernandez et al. (2019) presents the development of an equation that uses Artificial Neural Networks to predict the environmental performance of buildings in Brazil, in terms of energy, water and waste generation. Fernandez et al. (2019) argue that these equations help managers obtain a benchmark based on the current building stage and they

can promote improvements in its environmental performance. But, given that the algorithms are based on data from other buildings' performance, is the benchmark appropriate? Should building design aim to perform based on the goals of society?

DISCUSSION

In this section, we discuss the concerns the authors have around AI and how AI uses could lead to ethical and social dilemmas. We acknowledge the potential benefits of current and future uses of AI. However, in this discussion we are attempting to articulate our point of view, not as a definitive conclusion, but as a starting point where we need to learn more and hope to encourage others to explore the challenges of using AI in the construction industry and the people that are affected by it. Table 1 presents a relationship between the dilemmas presented in AI uses and the discussion questions. This structure was developed retrospectively as the research is exploratory and we did not define a predetermined structure in the methodology; we are presenting it first to help the reader.

Table 1: Social and Ethical Dilemmas and Discussion Questions.

Dilemma	Discussion Questions and Key Points
Ethical Dilemma	**What is the source of data?**
(alternatives are not fully acceptable ethically)	AI applications will make trade-offs among ethically unacceptable alternatives.
Ethical behavior	**Can we Trust AI Decisions?**
(following values, norms and rules of the society)	AI applications should follow society's values and norms as they evolve. There is a risk that AI cannot adjust to ethical norms.
Social dilemma	**Are AI algorithms biased?**
(conflict between self and collective interest)	AI applications will have conflict regarding whose interests are prioritized, and most likely will carry bias from their creators.
	Do we need to please the algorithm?
	AI algorithms can also reinforce their preferences.
	Does AI impact project team motivation?
	We may be creating a problem if AI makes more decisions for us.

WHAT IS THE SOURCE OF DATA?

AI algorithms need data to learn. As these algorithms find more uses in the construction industry, they will also need large amounts of data to be trained. Having access to data means having access to better algorithms and the more data is used the more powerful the algorithm will be. Additionally, the AI decision-making process is impacted by the political, economic, social, technological, environmental and legal dimensions as well as by ethical boundaries and the ethical code of conduct (Brendel 2021), and "[t]o make an ethical decision [the machine] must know what an ethical conflict is [a situation where ethical rules clash with an agent's own self-interest]" (McDermott 2008, p. 6). Furthermore, based on the database and different approaches, the self-learning quality of AI is different within organizations (Brendel 2021).

Construction companies will need to decide which data to collect, and for what purposes. Finally, "When we assume information is objective, we forget that information doesn't create itself" (Flores 2012, p. 43). Often it is not considered if all the data is useful and thus needed. One point can be that we do not know if we might need the data in the future. Another point is the fear of missing something by not seeing the whole picture, having information asymmetry or by being limited by our cognition. But can AI consider everything a decision requires such as different political, moral and social interests as well as biases? Who decides which algorithm will be more successful? Which algorithm

has more commercial value? Which algorithms are going to be backed by venture capital? Which companies will lead the competition on AI development? In addition, if we want to keep humans engaged in processing the information, too much data can lead to analysis paralysis or just plain confusion.

CAN WE TRUST AI DECISIONS?

Science is not always right; significant discoveries have been made that change our previous understanding. For example, in the 70s we believed that our chromosomes never change in our lives. In the 80s, scientists discovered that chromosomes could grow back due to a hormone called telomerase that is increased by healthy behaviors (Jaskelioff et al. 2011). What does this have to do with AI? AI replicates patterns, because it is learning from patterns that exist. The algorithm is learning based on the status quo of knowledge, but we discover and learn new things on a daily basis. Thus, we are imperfect, and our knowledge is not all-embracing, and neither is AI. Thus, new knowledge and experiences change our values and norms and need to be considered in the algorithm. So, are we trusting AI too much? Should we be more critical? How does it impact our daily work business? Some questions to raise regarding this topic are:

- What happens if someone believes that the algorithm is incorrect? What happens if you do not follow a recommendation made by the algorithm on a task sequence or schedule? What happened to those critical people in an organization?
- Are our brains going to become lazy if we often rely on algorithms' suggestions about what to do next without questioning them? Is AI going to be the new superhuman?
- How does AI impact the design phase of projects when relying on a generative design? What is the role of designers? Will designers be ultimately responsible for the design or will they be responsible only for providing data to feed the algorithm? Does the algorithm know what is best for us?

Moreover, some people assume that AI is objective, because the algorithm itself has no feelings. We agree, AI is more reliable, has no emotions, no moods, does not get sick, it does not require time off, and always has energy as long as it gets power. However, even though machines do not feel (for now), the task they perform uses the belief system and biases of their creators. Therefore, thinking that the algorithm is objective may not be correct if the data it used to be trained perpetuates subjective behaviors based on outdated belief systems. For example, if you want to select a successful project team, you will only be able to judge project teams based on the data available regarding their past performance and interactions.

ARE AI ALGORITHMS BIASED?

Many people think that AI can prevent or avoid biases and create an objective decision, that the data is fully transparent and traceable. It is well known that humans carry biases: if you think, you have biases. For example, we tend to more easily believe the opinions of people that have similar backgrounds and life experiences to ourselves (Nickerson et al., 1998). Even when we may be aware of our biases, we still cannot get rid of them; intensive training and a diverse group is needed to counteract them. AI is created by humans and biases are applied to a greater scale when using the algorithms. One very well-known bias is groupthink. Groupthink occurs when group members avoid disagreement (Janis and Mann 1979, 1982; Johnson and Johnson, 2009) and thus results

are "caused by a lack of diverse thinking" (Schöttle et al. 2019, p. 799). Is the algorithm catalyzing groupthink? Are we going to avoid difficult conversations by relying on solutions from AI? Will it lead us to overlook important ethical dilemmas, just because we do not see the conflict? Are we able to have authentic discussions and productive conflicts in the workplace if we rely on AI? McDermott (2008, p. 6) argues that "the mere facts that the program has an explicit representation of the ethical rules, and that the humans who wrote or use the program know the rules are ethical does not make an 'explicit ethical reasoner' an ethical agent at all. For that, the agent must know that the issues covered by the rules are ethical." So, is an algorithm able to make an ethical decision without free will and emotions? Is the algorithm able to make a decision in a social complex setting? Does the person programming the algorithm have a full understanding of the social complexity and are they able to program such an algorithm? As written above, decision-making often results in trade-offs. But how does the AI decide in terms of trade-offs and does an AI have decision-making autonomy?

DO WE NEED TO PLEASE THE ALGORITHM?

Humans have the power to develop algorithms, but people that work for an algorithm often do not understand the outcome. For example, Harari in his book Homo Deus (2018) describes how Google's search algorithm is so complex that we cannot predict what the search result will be, even more if someone wants to create a successful website they have to do it so it is promoted by the algorithm (so the website's client is the algorithm not humans), people then just see what the algorithm likes. Thus, our world is shaped by how we pleased the algorithm. In the construction industry, this issue can be created when a schedule is decided by an algorithm, and now the subcontractor has to please the algorithm to get a good evaluation. There may be the case that circumstances change and following the original plan may no longer be optimal. Another example that often occurs is that structural engineering software often prescribes an amount of reinforcement in the building structure, which causes the problem of using more steel than necessary and having issues concerning compressing the concrete. Although structural engineers know this, they please the algorithm and thus produce waste. This causes a dilemma regarding sustainability and costs, and sometimes limits human creativity.

DOES AI IMPACT PROJECT TEAM MOTIVATION?

Another point that needs to be considered arises in terms of motivation. As known from the self-determination theory (SDT), autonomous motivation, necessary to accomplish engagement and self-interest for creative problem solving, is based on the fulfilment of the three psychological needs: autonomy, competence and relatedness (e.g., Deci et al. 2017; Deci and Ryan 2014; Gagné and Deci 2005; Ryan and Deci 2000; Deci and Ryan 1985). All three factors will be impacted by AI. If we trust AI, are we really making decisions autonomously? If we rely on AI, are we going to have productive conflicts from which we grow and strengthen our relationships? Are we going to learn from failure or is AI hindering humans from improving? What does collaboration in a project team look like when AI takes over? If we let AI decide for us, what does this do to our motivation and the motivation and performance of a project team (see Schöttle (2020))? Is this creating a dilemma in terms of motivation and performance? Also, if the AI chooses an alternative with which you do not agree, you are in a conflict. Will AI take over all the repetitive and standard work, and free up humans to deal with creative thinking? Will AI provide the designers with alternatives that need to be assessed by competent experts?

CONCLUSION

This paper explores AI and its uses in the construction industry. There are currently some uses in planning and control, generic design and claim management. We explored how AI-based decisions in applications in the construction industry can present social and ethical dilemmas. Finally, we discussed how using AI algorithms will pose relevant questions concerning the future of the construction industry.

There are many potential benefits to the use of AI in the construction industry, from supporting better decisions, to optimizing schedules and reducing environmental impacts. As lean practitioners, we want to make the design, planning and construction process as efficient as possible, and, if AI can help do this, it should be part of our toolkit. But we should also keep being skeptical and ask questions to make sure we do not end up with an inappropriate solution just because it is complicated to understand the process behind it. When we are busy, we are more likely to overlook potential conflicts and biases. So, when using an AI tool to work more efficiently, we might fall into the trap of a social or ethical dilemma without exploring it, and risk ending up with an inappropriate solution despite our intentions.

The authors believe that the future of construction will include more and more AI algorithms as we get better at collecting data and training the algorithms. We are not specialists within AI, and some might find our use of non-scientific references such as a documentary on Netflix confusing. But, as we also know from the use of e.g. the Last Planner System, it is when we start to respectfully question other disciplines that we proactively identify waste and build on each other's ideas to drive real innovative thinking. We want to invite the industry and the lean community to engage in debating the benefits and also potential pitfalls of using AI to improve the construction industry, to ensure the optimization is balanced, and also consider benefits for the wider society. "What is ethically right? "What are the wider long-term consequences?"

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