THE NEW GENERATION TEAM SPIRIT: HUMAN-AI COLLABORATION IN THE CONSTRUCTION SECTOR

"More intelligent than intellect
More spiritual than spirit"
Mevlâna Celaleddin Rumi

Mr. Halil Kulluk, Chairman of the Board at İntekno Teknoloji Transfer San. ve Tic. A.Ş. discusses the transformative journey of artificial intelligence (AI) that began at Carnegie Mellon University. He explores how AI is shaping the future, its development, and its potential to revolutionize the construction industry and societies at large.

Artificial Intelligence (AI) has been a transformative force across various sectors, from healthcare to finance, and has recently started to revolutionize the construction industry as well. My journey with AI accelerated during my time as a graduate student at Carnegie Mellon University (CMU), and later as faculty member at CMU's Robotics Institute. The AI and Robotics environment at CMU was not just a learning platform but an ocean of knowledge, experience, and wisdom… In this intellectual ecosystem, I had the privilege of being guided by valuable professors such as Herbert Simon, Alan Newell, and Raj Reddy, who were pioneers in AI.

Nobel laureate Herbert Simon taught and demonstrated how machines can simulate human thinking through human and machine-focused approaches. Alan Newell, with his revolutionary work in cognitive psychology, showed that AI was as much about understanding how humans think as it was about teaching machines to learn and think. Raj Reddy, with his pioneering work in speech recognition, helped me realize the potential of AI in human-computer interaction. Their insights and ideas shaped my understanding of how AI could serve humanity and solve complex problems in the 1980s.

The Ocean of Wisdom at CMU: Learning from the Pioneers

At CMU, we were not just learning the theory of AI and the conventional approaches of the time; we were also reaching a broad vision of how AI could transform society. The lessons I learned from Simon, Newell, and Reddy, the fine details in their special presentations, and my observations in this vast ocean still continue resonate with me today. These pioneers believed that AI was not only a technical challenge but also a tool for improving human decision-making, increasing efficiency, and solving real-world problems.

At the same time, my collaborations with two other significant experts in AI and robotics were equally important… My research advisor, Prof. Paul Wright, coined the term "Manufacturing Intelligence," which involved making machines and robots intelligent with new software techniques, complemented by adaptive machinery and equipment, thus making flexible manufacturing systems more efficient. Under

his guidance, I embarked on the application of AI in manufacturing operations and researched how machines could be optimized to increase production efficiency along with flexibility.

Another valued mentor of mine, Prof. Fritz Prinz, a pioneer in robotic welding and computerized 3-D printing, opened the door to the future of manufacturing. His groundbreaking research demonstrated how robots could revolutionize traditional processes, achieve precision and efficiency previously thought impossible. The concepts I learned under his guidance, particularly around the automation of complex tasks, had a profound impact on my extrapolating and understanding of AI's potential in the other sectors including construction.

Within CMU's Robotics Institute, I had the opportunity to establish the Manufacturing Engineering & Technology Application Center (METAC) with the support of my esteemed professor and mentor, Raj Reddy, when I was just a 26 year-old, young engineer. As the founding director of METAC, I gained invaluable experience in building and applying AI systems directly in manufacturing environments – putting the actionable ideas into practice… This experience was crucial in understanding the challenges and transformative potential of AI in real-world industrial environments.

These esteemed, world-renowned professors and their innovative ideas helped fuel my passion for AI - both as a tool for automation and as a way to expand human potential. The collaborative spirit of collaboration they nurtured at CMU has remained with me as one of the most valuable life lessons, and this spirit is now more critical than ever in the rapidly evolving world of AI. At the time, we understood that AI would not reach its full potential unless it augmented human capabilities rather than replacing them.

Since my time at CMU, AI has made significant progress. Early AI systems were rule-based, relying on programmed instructions to make decisions. Today, with the rise of machine learning, AI systems can learn from data, recognize patterns and designs, and make predictions without explicit programming. Deep learning, a subset of machine learning, has unlocked new possibilities, allowing machines to recognize images, understand language, and even create art.

The role of AI is no longer limited to theoretical research or experimental applications. It is now integrated into our daily lives, from the recommendations we receive on our phones to the systems controlling entire industries. The construction sector, often considered traditional, is one of the latest industries to benefit from AI's transformative power.

AI in the Construction Sector

The construction industry, traditionally slow to adopt new technologies, is undergoing a transformative shift with the integration of artificial intelligence. This transformation is occurring in various ways. From design and planning to project execution and safety management, AI is becoming an indispensable tool. Predictive algorithms now help construction managers make more informed decisions, from identifying potential delays to optimizing resource allocation and improving safety protocols on site.

AI equipped drones and robots are becoming increasingly common in large construction projects. They can map sites, perform inspections, and even handle dangerous tasks, reducing risks for human workers. Additionally, generative design—AI-driven design solutions—enables architects and engineers to create multiple versions of a project with optimized structural integrity and cost efficiency.

Moreover, platforms like Aiforsite use real-time 360-degree site capture and condition monitoring systems to enhance transparency and streamline project workflows. AI-powered location tracking ensures that resources and personnel are deployed in the most efficient way. This combination of AI technologies helps ensure smooth project execution while improving collaboration and decision-making between human experts and machines

While the initial fear was that AI might replace human jobs, the reality is far more collaborative. AI is proving to be an indispensable partner, augmenting human abilities and fostering a new kind of team spirit that combines the best of both world In short, AI acts both as a co-worker and a facilitator, seamlessly integrating the physical and digital spheres.

AI in Project Management and Planning

One of the most impactful applications of AI in construction is in project management. AI-driven tools are revolutionizing how projects are planned and executed. By analyzing vast amounts of data from past projects, AI can predict potential delays, optimize resource allocation, and even suggest the most efficient construction sequences. This not only helps in staying within budget but also ensures that projects are completed on time. AI's ability to process and learn from data far exceeds human capacity, yet it is the human project manager who interprets these insights and makes the final decisions, showcasing

the symbiotic relationship between AI and human intelligence.

Enhancing Safety and Risk Management

Construction sites are inherently risky, and ensuring worker safety is paramount. AI is playing a crucial role in minimizing risks through real-time monitoring and predictive analytics. For instance, AI-powered cameras can detect safety hazards like workers not wearing helmets or being in restricted areas, instantly alerting site managers. Additionally, AI can analyze data to predict accidents before they occur, allowing preventive measures to be taken. However, while AI provides the data, human intuition and experience remain critical in assessing and responding to these risks effectively.

AI in Design and Architecture

Generative design, an AI-driven process, is opening up new possibilities in architecture and construction. By inputting certain design parameters, AI can generate multiple design options, each optimized for various factors such as cost, sustainability, and aesthetics. This enables architects and engineers to explore a wider range of possibilities than ever before. While AI handles the heavy lifting in terms of computation, it is the creativity and vision of human designers that bring these designs to life.

Automation and Onsite Applications

AI is also driving automation on construction sites. Drones equipped with AI can conduct site inspections more quickly and accurately than human inspectors, while AI-powered robots can perform repetitive tasks like bricklaying or welding with precision. This automation not only speeds up construction but also allows human workers to focus on more complex and creative tasks. The result is a more efficient construction process where human and machine work side by side, each complementing the other's strengths.

Human-AI Collaboration in the Construction Sector

The future of construction is not just about automation or AI taking over tasks; it's about the collaboration between human ingenuity and AI-driven technologies. This theme was highlighted in workshop I attended in April 2024 at Carnegie Mellon University which was hosted and led by Prof. Burcu Akıncı, Head of the Department of Civil and Environmental Engineering. The theme of the workshop was "AI and Digital Twins: The Future of Civil and Environmental Engineering." The event featured several interesting presentations, from lessons learned through early investments in AI-based digital twins to how robots are changing infrastructure and job opportunities.

During her concluding remarks, Prof. Akıncı shared her valuable insights on AI applications and the future, highlighting issues that I believe are very important. Our esteemed professor emphasized that AI will ultimately challenge engineers to become better and elevate the importance of civil engineering. She noted that in the near future, where AI becomes even more widespread, teams composed of civil engineers and AI systems will be more efficient and effective for humanity. She reminded us once again of the irreplaceable importance of human expertise's intuitive, intellectual, and ethical values in an environment of advancing technologies.

Among the presentations, the one that particularly caught my attention and inspired me was "Human-AI Collaboration in Design and Construction" by Prof. Chris McComb from CMU's Mechanical Engineering Department. McComb's research demonstrates how AI can assist human designers and builders in making more informed and efficient decisions. His studies show how AI tools can augment human creativity and decision-making processes in real-time, whether during the design phase or during construction.

Through technologies like digital twins, which create real-time virtual replicas of physical infrastructure, and AI-powered predictive models, humans and machines can collaborate to optimize designs, monitor construction progress, and predict problems before they arise. This collaborative approach is transforming the construction process, from speeding up project completion to reducing risks and improving long-term sustainability.

McComb's research also shows that hybrid teams consisting of both humans and AI can outperform individual efforts. His studies reveal that AI-human teams can navigate and solve complex engineering challenges, such as designing systems under dynamic constraints, more efficiently. Human members adapt to unforeseen challenges, while AI handles data-heavy tasks and provides optimized solutions.

The New Generation Team Spirit

The construction industry is no longer about individual expertise or technology working in isolation. It is time to create a new generation of team spirit where AI and human experts collaborate to achieve what neither could accomplish alone. By integrating AI into construction processes, we are fostering a new team spirit that enhances creativity, increases efficiency, and improves safety.

Human intuition and creativity remain indispensable in construction, but AI amplifies these traits by providing data-driven insights and automating routine tasks. The real power of AI lies in its ability to work alongside humans, supporting decisions and offering options rather than dictating solutions.

Together, humans and AI form a cohesive team capable of navigating the complexities of modern construction projects.

The future of construction lies in this synergy; we are moving towards an era defined not by what we can achieve alone, but by what we can accomplish together, where human intelligence meets machine precision and the new generation team spirit is born. In this era, shifting educational paradigms to new dimensions and facilitating access to new knowledge, especially through digital platforms and online methods, will guide not only engineering but also other disciplines. Returning to our topic, the program "AI Engineering: Digital Twins and Analytics" developed at Carnegie Mellon University, capturing the interest of the new generation of engineers, is an effective and timely example (https://www.cmu.edu/online/aie-dta/admissions/index.html).

In conclusion, it is evident the world is changing... From analog to digital, from static to mobile... Offline to online... All things are getting connected... In fact, already connected... What was once here and there is now everywhere... Machines are learning and surpassing our ''bounded rationality''... Rather than having human intelligence compete with Artificial Intelligence, human beings should develop a mindset to change wisely and adapt to co-exist with machines... Hence, the move towards co-existential intelligence...

In this regard, Rumi beautifully said:

"Yesterday I was clever, so I wanted to change the world; today I am wise, so I am changing myself"

The author extends his special thanks to Prof. Burcu Akıncı and Prof. Chris McComb for their kind review and constructive feedback.