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(Review Article)

Automation and Robotics: Safety Implications of Construction Robots

Paschal Ikedi Azuruole *

Independent HSE Researcher, Nigeria.

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Abstract

The humanization of automation and robotics has changed construction methods by improving outcomes in efficiency and eliminating the need for human effort for high-risk tasks. These innovations, however, have brought about some emerging safety issues, particularly in human-robot interaction (HRI), mechanical failure, and lack of adequate training. This paper looks into safety measures that may emerge in the construction robots based on the extensive experience that H, S, and E have in terms of field performance with the support of literature. The paper offers practical measures such as collaborative planning, predictive maintenance, competency-based training, and tailored safety protocols to ensure safe technology deployment onto construction sites.

Keywords: Construction Safety; Robotics; Human-Robot Interaction; Automation; Occupational Health; Predictive Maintenance; Smart Construction

1. Introduction

For a long time now, the construction industry has been recognized as one of the most hazardous conditions of work. It has claimed 20 percent of workplace fatality cases across the globe (International Labour Organization, 2022). The persistent challenge in safety and efficiency has largely driven the integration of robotics and automations in these processes (Balaguer & Abderrahim, 2008). Tasks such as bricklaying, welding, demolition and inspection are performed today by robots instead of exposing their human workers to hazardous physical and environmental risks (Bock, 2015). While these systems offer increased precision and consistency, they also introduce new risks, particularly concerning safety protocols, operational errors, and human-robot interaction (Zhou, Ghasemi, & Noghabaei, 2017).

2. Practical Insights and Industry Experience

2.1. Benefits Observed from Robotic Integration

Field deployments across high-risk infrastructure and construction projects demonstrate several key advantages of construction robots:

- Reduced Manual Handling: Repetitive strain injuries have decreased significantly due to robotic substitution in heavy lifting and high-frequency manual tasks (Bock, 2015).
- Consistency in Precision Tasks: Unlike human workers who may tire or vary in accuracy, robots maintain programmed parameters in repetitive tasks such as concrete dispensing or robotic welding (Khoshnevis, Bellinger, & Kwon, 2006).
- Minimized Human Exposure: Robots have effectively reduced human presence in confined spaces and hazardous zones during demolition or underground inspections (Li et al., 2020).

* Corresponding author: Paschal Ikedi Azuruole

2.2. Emerging Safety Concerns

Despite their promise, robotics in construction introduces unique risks:

- Unpredictable Human-Robot Interactions: Robots operating in dynamic construction environments can misinterpret sensor inputs or fail to respond appropriately to human proximity, increasing collision risks (Zhou et al., 2017).
- System Malfunctions and Faulty Sensors: Real-world incidents involving robotic arms and 3D printers highlight the danger of sensor failure and software bugs (Zhong et al., 2020).
- Lack of Specialized Training: A significant portion of robot-related safety incidents arise from human error due to insufficient training and misunderstanding of robotic operating procedures (Yoon, Park, & Lee, 2021).
- Unstructured and Variable Environments: Unlike manufacturing floors, construction sites constantly evolve, introducing terrain, weather, and workflow unpredictability that many robots are not fully equipped to manage (Sawhney, Riley, & Irizarry, 2014).

3. Recommendations for Safe Integration

3.1. Competency-Based Training

The training programs must inculcate safety awareness on robotic operations, emergency responses, machine logic, and real-time interaction management (Zhou et al., 2017). VR-based simulations are proofing feasible for immersive hazard recognition scenarios.

3.2. Collaborative Risk Assessment

Pre-deployment collaboration among engineers, HSE officers, and project managers is essential for identifying risks associated with mechanics, behaviors, and interfaces (Guerin, 2021). Joint planning should delineate safety boundaries and initiate contingency protocols.

3.3. Predictive Maintenance Protocols

The scope of predictive analytics allows for early detection of wear and tear, software instability, or calibration drift, thus preventing safety-critical failures (Zhong et al., 2020).

3.4. Adaptive Standard Operating Procedures

SOPs should embrace robotic-related deployment scenarios encompassing system restart, manual override, fall protection of tall robotic units, and AI behavior modeling during power interruptions (Yoon et al., 2021).3.5 Integrated safety culture.

A technological safety culture focuses on ongoing learning, visibility, and the incorporation of robots in safety audits and discussions of toolbox talks (Sawhney, et al., 2014). The worker feedback loops and the anonymous incident reporting systems have to ensure that all near-miss interactions with robots are reported.

4. Conclusion

Construction robotics are able to transform in the way injuries could be minimized and productivity increased as well as fundamentally changing the way labor-intensive processes look. Such safety risks need a new way of thinking about preparing and positioning training, planning, and culture to handle them. Safe robotic integration has proven to be achievable through deliberate planning, investment in workforce education, and dynamic safety protocols that evolve with technology. Practical experiences at the site corroborated by global research highlight this assertion. Just as needed for societal development, so must innovation have an equal plate with health and well-being for mankind in order to have a future of construction sustainable and safe.

References

[1] Balaguer, C., & Abderrahim, M. (2008). Trends in robotics and automation in construction. *Automation in Construction*, 17(1), 2–3. https://doi.org/10.1016/j.autcon.2007.02.012

[2] Bock, T. (2015). The future of construction automation: Technological disruption and the upcoming ubiquity of robotics. *Automation in Construction*, 59, 113–121. https://doi.org/10.1016/j.autcon.2015.07.022

[3] Guerin, J. (2021). Human-robot interaction in dynamic construction sites: Safety perspectives. *Journal of Occupational Safety and Ergonomics*, 27(2), 145–156.

[4] International Labour Organization. (2022). *World Employment and Social Outlook – Trends 2022*. Geneva: ILO. https://www.ilo.org/global/research/global-reports/weso

[5] Khoshnevis, B., Bellinger, P., & Kwon, H. (2006). Contour crafting—A new automated construction technology. In *Proceedings of the International Symposium on Automation and Robotics in Construction* (pp. 41–46).

[6] Li, H., Kong, C. W., Pang, Y., Yu, M., & Chan, N. C. (2020). Smart construction robots in confined spaces. *Automation in Construction*, 119, 103358. https://doi.org/10.1016/j.autcon.2020.103358

[7] Sawhney, A., Riley, M., & Irizarry, J. (2014). *Construction 4.0: An Innovation Platform for the Built Environment*. Taylor & Francis.

[8] Yoon, J., Park, S., & Lee, H. (2021). Risk perception of construction workers toward collaborative robots. *Safety Science*, 134, 105079. https://doi.org/10.1016/j.ssci.2020.105079

[9] Zhong, R. Y., Peng, Y., Xue, F., Fang, J., Zou, W., Luo, H., & Lu, W. (2020). Prefabricated construction enabled by the Internet-of-Things and robotic assembly. *Automation in Construction*, 100, 120–136. https://doi.org/10.1016/j.autcon.2018.12.021

[10] Zhou, Y., Ghasemi, M., & Noghabaei, M. (2017). Human–robot collaboration in construction: A literature review and future directions. *Proceedings of the 2017 ASCE International Workshop on Computing in Civil Engineering*, 589–596. https://doi.org/10.1061/9780784480830.073.