Journal of Cleaner Production 182 (2018) 82–95

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

A framework of indicators for assessing construction automation and robotics in the sustainability context

Mi Pan [a, *], Thomas Linner [b], Wei Pan [a], Huimin Cheng [b], Thomas Bock [b]

[a] Department of Civil Engineering, The University of Hong Kong, Pok Fu Lam, Hong Kong
[b] Chair of Building Realization and Robotics, Technical University of Munich, 80333 Munich, Germany

ARTICLE INFO

Article history:
Received 7 May 2017
Received in revised form
5 January 2018
Accepted 5 January 2018
Available online 7 February 2018

Keywords:
Construction automation and robotics
Sustainability
Building
Indicators
Assessment framework

ABSTRACT

"Building production" technology, i.e. construction automation and robotics (CAR), is on a worldwide level increasingly recognized as stating a key element of the future of construction, although CAR up to date has never experienced large-scale real-world implementation. However, the recent significantly growing demand for sustainability has the potential to serve as the necessitated trigger for CAR's large-scale deployment. In that context, systematic guidance for the construction industry is however missing, and there have been limited attempts to thoroughly investigate the impacts of utilizing CAR with regard to the sustainability performance of construction and buildings. The research presented in this paper makes a first step to fill this research gap by reviewing and investigating the available CAR strategies and technologies and developing for the first time a consistent framework of indicators for assessing the sustainability performance of utilizing CAR for buildings. The overall goal of the research is to develop, through this framework, a robust and reliable assessment method that can be used in the industrial context to assess the sustainability of building construction projects that consider using CAR. Beyond the development of the indicator framework, the research plan adopting the V-Model approach foresees to translate the framework into an assessment method which will then in several iteration cycles be verified and validated in real world.

© 2018 Elsevier Ltd. All rights reserved.

Contents

* Corresponding author.
E-mail address: panmi@hku.hk (M. Pan).

https://doi.org/10.1016/j.jclepro.2018.02.053
0959-6526/© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

The notion of “building construction” is about to change to a notion of “building production”. Construction automation and robotics (CAR) is on a worldwide level increasingly recognized as an advanced technology that indeed may in the future -similar as in other industries - build the basis for the “production” of buildings. For decades this has triggered a plethora of research and development efforts both in academia and industry. However, CAR (in particular on the construction site) up to date has never experienced large-scale, real-world implementation. A major reason for this is that CAR lacked so far a “killer application”, a major reason or circumstance that would have triggered or necessitated its large-scale use. Amongst others, the cost of human labor in construction up to date never was so high that CAR – a rather expensive technology – would have stated a feasible alternative; also, the demanded quality of buildings never urged contractors to use CAR. However, now the growing demand for sustainability may (in particular in combination with economic and productivity factors) serve as a trigger for the large-scale use of CAR. In that context, systematic guidance for construction industry is missing, and there have limited attempts been made to thoroughly investigate the impacts of utilizing CAR with regard to the sustainability performance of construction and buildings. The research presented in this paper, makes a first step to filling this research gap by reviewing and investigating the available CAR strategies and technologies and developing for the first time a consistent framework of indicators for assessing the sustainability performance of utilizing CAR for in the construction industry.

The application of automation and robotics has been recognized as one of the most radical innovations for construction, which has triggered a plethora of research development efforts for decades (Bock, 2015). But the real-world utilization is still in its infancy, and the lack of economic interest is deemed as the main hurdle (Bock, 2015; Cousineau and Miura, 1998; Mahbub, 2008). Meanwhile, the crucial role of the building sector in mitigating climate change and realizing sustainable development goals has been highlighted in global agendas (Paris Agreement, 2015; United Nations, 2015). Nevertheless, sustainable development and innovation in the building industry has always been considered a being problematic in many aspects (Pan and Ning, 2014). Performance gaps, and poor operational and management procedures hinder the achievement of sustainability, and require advanced technologies as a countermeasure (Goodier and Pan, 2010). In this regard, construction automation and robotics (CAR) is considered as a feasible solution to profoundly improve sustainability performance in multiple ways, such as construction waste reduction, natural resources savings, workplace safety improvements, and high-quality living environment (Bock and Linner, 2012; Castro-Lacouture, 2009; Cousineau and Miura, 1998).

Recently, the Europe Union, for example, has started to initiate and fund projects, in which improvements in construction automation and prefabrication shall bring down the cost for eco-friendly, highly energy-efficient components and buildings in order to foster their large-scale adoption in Europe (BERTIM, 2016; ZERO-PLUS, 2016). Furthermore, some construction companies have already used advanced construction technologies to reduce waste and resource consumption (Bock and Linner, 2015), and first approaches are on the way to employ automation and robotics for controlled disassembly of buildings and urban-mining (Lee et al., 2015). Although the literature reviewed indicates attempts to explore the environmental, economic and social advantages of utilizing CAR, their impacts on sustainability performance have not yet been thoroughly investigated in a systematic manner, and the potential adverse impacts remain largely unknown. Sustainability performance may vary among types of technologies and circumstances of consideration, requiring a comprehensive indicator system as a reliable assessment tool.

Additionally, incorporating the concept of sustainability into the field of technology management and practice has been investigated by several scholars. For example, Brent and Pretorius (2008) discussed the complexity of utilizing the concept of sustainable development and technology management practices, and established a conceptual framework and a criteria system for assessment. However, most of the research in that context focuses on the development and management of technology (Brent et al., 2006; Phaal et al., 2004), lacking a focused analysis of the impacts on sustainability by the adoption of a specific (not considered as green) technology. Also, CAR technologies have not been explicitly examined within the sustainability context.

Therefore, this paper develops a bespoke indicator framework of Construction Automation and Robotics for Sustainability

Download English Version:

https://daneshyari.com/en/article/8097252

Download Persian Version:

https://daneshyari.com/article/8097252

Daneshyari.com