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Views & Comments

Benefits Realization Management of Computer Vision in Construction: A Missed, Yet Not Lost, Opportunity

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1. Introduction

While the applications of computer visions are varied in construction, research has tended to focus on measuring the accuracy of object detectors such as faster region-based-convolution neural networks (Faster R-CNN) and single shot detector algorithms (SDD) [1]. Limited, if any, attention has focused on determining the benefits of such technology in construction beyond the claims that it can help detect problems quickly and accurately. Reinforcing this point are the numerous review papers that have frequented the literature [2,3].

Research in construction has seldom addressed how organizations can effectively manage and use computer vision to realize its benefits in their operations—this opportunity is missing from the literature, but it is not lost! There is a growing need to realize the tangible and intangible benefits, as well as the disbenefits, of computer vision, amongst other artificial intelligence (AI)-enabled technologies, so that they can be effectively used to generate business value and improve managerial practice [4]. Despite many software vendors readily claiming the tangible benefits of using computer vision in construction, including improvements in productivity and safety performance, bolstering the measurement of quality, and significantly increasing a project's profitability, there is currently no empirical evidence to support these assertions.

More noticeably, the datasets used for training algorithms in the various studies are small in construction, rendering the results akin to a "proof-of-concept." Under such circumstances, overfitting becomes problematic. Although steps have been taken to address this issue (e.g., through data augmentation, feature selection, cross-validation, regularization, and ensembling), in such cases, the small dataset is manipulated to fit the problem. In their extensive review of computer vision studies, Paneru and Jeelani [2] confirm the problem of small datasets and correspondingly observe that there is a "lack of a visual dataset specific to construction environments needed to train different neural networks" in order to produce reliable and valid outputs. Despite the wealth of studies undertaken to date on computer vision, many challenges (e.g., privacy issues, acquiring good quality data, data fusion, and the extraction of semantic understanding) need to be addressed before we can begin to realize its benefits [2,3].

The present article calls for computer vision research to begin engaging in a strategy of benefits realization management (BRM) to help accelerate the investment justification process and the adoption of this technology by construction organizations, based on a scientific underpinning. Failure to do so may cause construction organizations to become disillusioned with computer vision as it fails to deliver its benefits in practice [4]. Thus, construction organizations must understand why and how they can acquire the benefits of computer vision so as not to succumb to the so-called "Red Queen effect," in which businesses must continually move forward or risk falling behind [4,5].

2. Benefits realization management: Managing change

The information systems literature abounds with studies examining the role of and methods associated with a BRM strategy. While many definitions for BRM exist, Bradley's [6] definition is concise and comprehensive, describing it as "the process of organizing and managing, so that potential benefits arising from investment in change are actually achieved." Thus, in the context of this article, two questions come to the fore for consideration: ① How can a construction organization obtain business value from investing in computer-vision-enabled applications; and ② do construction organizations have the resource capability to realize the benefits of computer vision?

Addressing these questions is challenging, mainly because computer vision is underdeveloped in construction, despite the vast body of knowledge that has already been published in this area. A similar problem has been found to exist with building information modeling (BIM), with Love et al. [7] drawing on resource-based theory to develop a BRM framework for ensuring that benefits can be realized within the setting of construction. Underpinning this framework are four key themes that are identified as providing business value: ① *alignment* (i.e., are we doing the right things?); ② *integration* (i.e., are we doing them in the

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right way?); ③ *capability* (i.e., are we getting things done well?); and ④ *benefits* (i.e., are we receiving the benefits?). We suggest that the BRM framework developed by Love et al. [7] provides a basis for determining how construction organizations can create value from computer-vision-enabled developments. This framework has also been used to ensure that organizations realize the benefits of implementing a systems information model [4,5].

Change management is an innate feature of BRM [4]. However, the impact of changing work practices and procedures using computer vision in construction has not been addressed—there is an assumption that doing so will resolve the problem it aims to tackle, regardless of a lack of empirical evidence. Furthermore, research has not considered the benefits, costs (e.g., direct and indirect), and risks of adopting computer vision in construction. The benefits of computer vision cannot be delivered without enacting change (e.g., in terms of people's behavior and work practices), and change without benefits cannot be sustained. Moreover, it would be inappropriate for construction organizations to financially invest in computer vision without undertaking some form of investment justification. This equally applies to any potential technology to be adopted, including augmented reality (AR), BIM, blockchain, and robotics. Nonetheless, minimal attention has been paid to the investment justification of technology in construction and, when it has occurred, the focus has simply been on traditional appraisal techniques such as "return on investment" [4].

For example, many computer vision applications examining safety tend to focus on identifying whether a person is wearing personal protective equipment, entering a hazardous area where heavy equipment is being operated, or showing correct posture when lifting heavy equipment [3]. In fact, behavioral changes are required to prevent such actions from reoccurring after they have been identified; however, studies do not follow up with an explanation of how this can be effectively undertaken.

When a technological solution is advocated, corresponding changes in practice need to be considered, but this has been overlooked in the context of computer-vision-based studies in construction. Suffice it to say, the lack of accompanying change to practice has been case for many of the technological solutions that have been proposed to improve productivity and performance in construction [4]. There are many reasons why the construction industry suffers from low productivity; nevertheless, the problem is exacerbated by organizations' inability to adapt and respond to the need to embrace changes in the work practices and processes that are typically impacted by technology adoption.

Over the last decade, we have repeatedly seen studies focused on applying algorithms developed in computer science to highlight object detection accuracy for a range of construction problems. As a matter of fact, in the countless number of papers published in construction, we have rarely—if ever—seen the propagation of new object detection algorithms to support the use of computer vision. Instead, we generally only see modifications to the hyperparameters of object detectors, such as convolutional neural networks (CNNs), being made.

While marginal improvements may be made to detection accuracy, this does not help construction organizations to justify and understand how computer vision applications can be utilized in practice to generate business value. If no progress is made beyond "object detection" with computer vision and its fusion with other technologies (e.g., AR and BIM) to examine how work will change for the better (i.e., performance and productivity improvements), then research will reside in the realm of "so what?" We must use technology to address a problem that confronts practice rather than proposing a solution to a problem that does not exist or can be solved by other means. As Ackoff [8] cogently reminds us, "successful problem solving requires finding the right solution to the right problem. We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem."

3. Computer vision research: Moving forward

There is little doubt that computer vision can potentially yield productivity and performance benefits to organizations across all facets of an asset's life cycle. Similarly, there are dis-benefits, particularly surrounding data security, data privacy, and onsite hardware limitations (i.e., over-reliance on edge computing devices). However, the lack of exploration based on a solid empirical setting hinders the adoption of computer vision in construction. Five underlying principles must be considered if the benefits of implementing computer vision are to be realized by construction organizations [9]:

(1) Just having computer vision-enabled technology in place will not confer any benefit or create value. Adopting computer vision is costly (e.g., a requirement for edge computing), and benefits will only materialize from its use.

(2) Benefits will arise when computer vision enables the organization and its people to do things differently.

(3) Benefits result from changes and innovations in how people work, so only business managers, users, and customers can make these changes.

(4) The use of computer vision can produce adverse outcomes and may even negatively affect the organization's competitive positioning.

(5) Benefits must be actively managed so that they can be obtained. The benefits of computer vision will not arise if a construction organization does not carefully plan and guard against known pitfalls.

We suggest a shift in research focus away from explaining why we should use computer vision, which is now well understood and documented, and toward asking a series of questions about how to ensure that computer vision adds value to activities in construction and across an asset's life [4]. Indeed, addressing the "how" will be a challenge, as only a few construction organizations (e.g., Obayashi and Skanska), to our knowledge, are attempting to use computer-vision-enabled technology as part of their everyday operations (e.g., in safety). We are also aware that some construction organizations are working with universities to experiment with the application of computer vision to varying routines and tasks, with no quantification of the benefits being made or presented for consideration. In these cases, comparisons of "old" and "new" ways of working could be considered by quantifying the acquired benefits (e.g., productivity improvements) and documenting changes to work practices.

While comparing old and new ways of working through an experimental study can kickstart and set the tone for embracing BRM, we suggest that research should focus on supporting organizations in developing a strategy for adopting computer vision technology. A process for producing a BRM strategy typically comprises five stages, which are documented by Love and Matthews [4]: ① identifying and structuring benefits; ② planning benefits realization; ③ executing the benefits realization plan; ④ evaluating and reviewing results; and ⑤ discovering the potential for further benefits. This approach enables benefits (tangible and intangible), costs (direct and indirect), risks, and changes in practice to be readily identified and managed. The concept of BRM is not new and is well established in technology-related fields. Nevertheless, BRM has been and continues to be overlooked by researchers in construction, as there has been a "natural assumption that the adoption of digital technologies will result in productivity improvements" [4]. Yet this assumption is highly questionable, as workplace change and process re-engineering are often required to unlock the benefits of digital technologies.

4. Conclusions

A cursory review of the computer vision literature in construction reveals an increasing appetite for research in this area, as shown by the sheer mass of articles published on numerous relevant problems in this field. Empirical evidence demonstrating the benefits of this technology is missing in the construction literature. Such evidence is needed for construction organizations to justify investments in computer-vision-enabled technology and ensure that it will contribute to improving their competitive advantage. This gap provides the motivation for this article and acts as a call for researchers and practitioners alike to grasp the opportunity to fill the BRM void missing from computer-vision-enabled studies.

Ultimately, we need empirical research to justify the benefits of computer vision; otherwise, construction organizations will undoubtedly be left asking, "so what?" At this point in time, the tangible benefits of implementing computer vision are absent from the literature, despite the rhetoric we repeatedly hear from software vendors that, under the auspices of AI, computer vision will transform practice and result in performance and productivity improvements in construction.

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