Development of Robotics & Automation Roadmap for Road Construction/Maintenance Projects

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Development of decision supporting framework to deploy robots for construction

Over the past decades, construction industry has gained a growing momentum to develop and implement innovative technologies driven by the market pressure to improve productivity, efficiency, safety, and quality. One of the most noteworthy emerging technologies, which demonstrated its great potential to abate the high labor intensity, is construction robotic technologies. Effectiveness and availability of robots motivate an imperative research question: how can the civil infrastructure industry utilize the robotic solutions in the construction and maintenance process? To answer this question, it is essential to explore not only what robotic technologies are appropriate to adopt but also how these technologies can be seamlessly integrated into the current practices to form an effective human-robot team. To this end, this study aims to understand the current existing road construction operations, identify the needs and expectations from the various stakeholders, and propose a decision-making framework for road construction robot adoption model from the user-centric perspectives. To do so, this study proposes to leverage the knowledge and insights from construction professionals in addition to robotic developers via in-depth interviews and surveys.

Problem Statement

Civil infrastructure projects can leverage this emerging robotic technology to not only handle the impacts of Covid-19 outbreak but also to overcome the persistent workforce-related issues. Acknowledging the fact that the current human-dependent operations can inevitably lead to various issues like shortage of skilled labor, stagnant productivity, and high cost, robots for highway/road construction projects can transform the current workplace as well as workflow to a more efficient and safer end. In this regard, their effectiveness and availability motivate an imperative research question: how can the civil infrastructure industry utilize the robotic solutions in the construction and maintenance process? Because the construction environments are unstructured and the nature of construction work are complex and collaborative, these robots are likely to work with/alongside human workers who have complementary capabilities necessary for such dynamic environment or tasks. As a result, the researchers should explore not only what robotic technologies are appropriate to adopt but also how these technologies can be seamlessly integrated into the current practices to form an effective human-robot team. In pursuit of above-mentioned research need, the proposal facilitates the development of framework for robotic technology adoption in the context of highway and road construction.

Objectives

Although the demand for new technologies and innovation is growing, the civil infrastructure industry lacks a decision-making mechanism, and as a result, the actual implementation is still very limited. To address this gap in practice, the goal of this study is to develop a decision supporting framework to deploy robots with specific designs for a certain construction and maintenance work. Considering the complex nature of civil infrastructure projects as well as human-robot collaborative interaction, whether or not a technology is useful is affected by a number of factors such as organization, individual within the organization, project constraints, the limitation of technologies, and so on. As a consequence, in order to establish a decisionsupporting framework to determine the most effective robotic technologies to implement, it is necessary to explore and evaluate such various aspects of the task and the corresponding environment. Thus, this study proposes a hierarchical decisionsupporting framework which first identify key factors from previous literatures and domain experts' knowledge that influence robot adoption decision making process. Given the identified multicriteria, it provides evaluation method to supports the decision whether or not to adopt robotic technologies for a target task, and subsequently to determine detailed design of human-robot collaborative teaming. This proposed framework will allow to spurring the robot diffusion on the jobsite. The technical objectives to achieve this goal include:

- Review the state-of-the-art robotic technologies and/or applications relevant to road construction;
- Identify the construction practitioners' perceptions of onsite construction robots;
- Identify factors determining whether or not to robotize a road construction/maintenance task, and develop a guideline for prioritizing tasks for robotization;
- Develop a user-centric practical guideline for the construction robot deployment and integration process; on how to configure a human-robot collaboration team for road construction/maintenance tasks

Figure 1. Examples of Construction Robots for Road Construction and Maintenance

Intended Implementation of Research

This proposal seeks to develop and support the future and current workforce in the highway and road construction domain throughout this study. Mainly, this study will support at least two graduate student whose research focus aligns with the goal of this project. This proposal will provide education and research opportunities for underrepresented students. The Construction Science Department at Texas A&M University, where the PI is currently working, has a summer camp for Hispanic students who are interested in design, engineering, and construction. During the summer camp, they can learn fundamental engineering knowledge and explore their career paths in the aforementioned disciplines. It is also expected to increase their environmental awareness by illustrating the importance of functioning infrastructure systems in modern society. The outreach activities of this project, to the student groups mentioned as well as others, will positively attract minority and female students' interests in STEM fields. All findings obtained from this study will be made available to industry practitioners as well as the students. We will develop a course module related to the resulting outcomes to educate those students to enhance their knowledge. The outcomes will be also presented via the graduate seminar.

Anticipated Impacts/Benefits of Implementation

The outcomes of our proposed study boost our knowledge about designing efficient and effective road construction and maintenance work environment and support the development of an advanced innovative road construction operation which can address the challenging issues we face today. It provides a fundamental foundation on the determining contextual factors from various view points for designing the shared construction work environment for human and robot.
Thus, the findings of our study will be of interests to both organizations and professionals for better integrating robotic solutions to the workplace, accelerating the development and implementation of construction robots. Also, this study contributes to the body of knowledge in the field of human robot interaction by analyzing primary factors that affect robot adoption decision in the road construction and maintenance. It also provides recommendations for robot adoption roadmap harnessing the perception of the potential users.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.