Deep Reinforcement Learning-based Digital Twin for Risk Improved Decision Making in Transportation Construction

Improving the risk in transportation construction with novel decision making tools

Project Number:

22COLSU39

Start Date:

04/01/2022

Principal Inverstigator(s):

Yong-Cheol Lee

Louisiana State University

Lead Institution:

Louisiana State University

Funding Source(s):

Tran-SET

Louisiana State University

Total Project Cost:

$ 120,000

Each state in the U.S. including Louisiana is responsible to oversee an enormous number of construction and maintenance projects of transportation infrastructure systems such as highways, bridges, tunnels, and other infrastructure structures. In addition, with the increase in the need for constructing and repairing transportation systems, the state DOTs are daunted with the mammoth task of multiple projects and unexpected maintenance caused by recent natural disasters. This pandemic period has also been a strong driving force for DOTs to consider an advanced approach to remotely govern and support these multiple transportation projects. Organizing and overseeing a large number of transportation construction and maintenance projects that generally entail several miles of a worksite are a critical burden for each DOT. In addition, it requires manual monitoring of project or construction managers to identify a progress status, a work activity, and a safety issue in a job site. Because of the projected huge volume, complexity, significant impacts of future transportation infrastructure projects, it is evident that we are now facing a critical need to create a means of improving the results of work zone management and evaluating their impacts on our society. The primary goal of this project is to identify the characteristics of the digital twin technology that are applicable to transportation construction and develop a conceptual framework of the prototype with a participatory sensing concept to improve the construction process monitoring, performance evaluation, and safety.

Problem Statement

Because of the projected huge volume, complexity, significant impacts of future transportation infrastructure projects, it is evident that we are now facing a critical need to create a means of improving the results of work zone management and evaluating their impacts on our society. In addition, multiple work zones of a large-scale highway construction project usually have to be managed and monitored by a human effort on site, which is slow, inaccurate, and expensive. Several studies pointed out that manual field data collection in a highway construction project frequently results in missing and inaccurate work data log as well as critical problems in project management, scheduling, and logistics. These research studies also indicated that an automated construction field and safety monitoring solution is required for improving project/safety management and reducing management cost by automated activity log generation. Even though some transportation construction projects adopted the expensive vision based monitoring system using on-site cameras or drones, these methods generally involve a tremendous amount of a visual data analysis and are vulnerable to numerous blind spots of any site. They also require computationally heavy-weight processing, which hinders real-time analytics and monitoring and require a certain level of illumination. One primary problem in this situation is that it has been increasingly challenging for each DOT to consistently monitor progress of all projects in each state as well as efficiently evaluate work performance. With limited human resources and time, DOTs in Region 6 States have managed large-scale transportation construction and maintenance projects by a human inspection and recovered direct and indirect damages of transportation infrastructure systems caused from the recent natural disasters. Another critical issue is that this problem has prevented urban-level and integrated project management. Since it is not feasible to identify the status and the progress of numerous transportation infrastructure projects in real-time, DOTs cannot flexibly organize project resources and schedule according to diverse external factors including uncertainties in a worksite, mobility, natural disaster, and others.

Objectives

The primary goal of this project is to identify the characteristics of the digital twin technology that are applicable to transportation construction and develop a conceptual framework of the prototype with a participatory sensing concept to improve the construction process monitoring, performance evaluation, and safety. The digital twin model incorporating the project information

and schedules analyzes on-going activities and conducts thereby urban-level monitoring of all worksites.

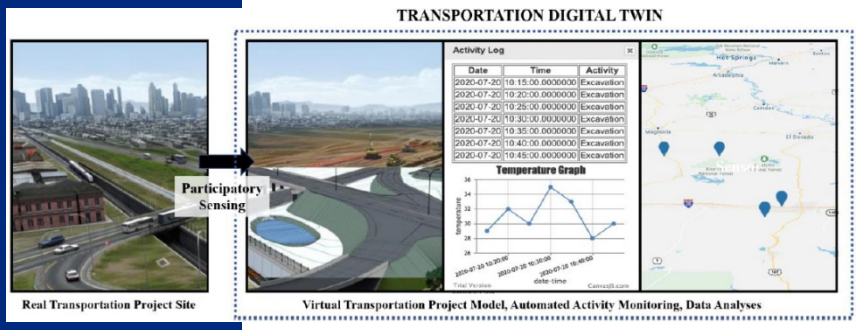

Figure 1. Transportation Digital Twin and Participatory Sensing-based Real-Time Data Analyses

Intended Implementation of Research

Workforce Development, Education, and Outreach: The major deliverables from this project include the intuitive implementation guidebook for educating and assisting practitioners in DOTs in Region 6's States. To disseminate the results of this project in audio-based remote site monitoring and safety surveillance of transportation construction and maintenance, the guidebook and its education materials will be used for workforce development including district engineers, planners, and decision-makers in Region 6's state transportation agencies. In addition, the PIs will closely work together with Dane LeCoq, who is an engineer in LaDOTD, to integrate our new approach into existing LaDOTD's project management systems.

Anticipated Impacts/Benefits of Implementation

Even though the PIs have already developed the major features of the proposed framework including sound recognition algorithms, the PIs need additional efforts to develop a digital twin model and an approach to integrate participatory sensing-based monitoring and data analysis frameworks at real transportation construction sites to provide the reliable system for state highway agencies. If this project is successful, the state highway agencies will easily adopt this system with low-cost sound sensors (approximately per $50) for remote monitoring transportation construction and maintenance work zones. In addition, through WiFi transceivers or LTE cellular networks, sound data captured from the sensors will be transmitted to a computer of a state highway agency and a project manager, which implement a sound recognition framework for categorizing a work type, representing task duration, and identifying any safety issues. For the readily application of this system, the PIs will actively help DOT practitioners in Region 6's States implement this low-cost audio-sensor based surveillance framework and integrate it with their existing project management systems.

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.