

Development, Education, and Implementation of A Low-Cost Audio Sensor-based Autonomous Surveillance System for Smart and Connected Transportation Infrastructure Construction and Maintenance

Developing an audio-based transportation construction site monitoring system

Each DOT has to govern and oversee an enormous number of transportation construction and maintenance projects. However, since a transportation construction project entails several miles of a job site including numerous work tasks and equipment operations, 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. In this demanding situation, DOT practitioners and project managers have long recognized the importance of automated monitoring and surveillance of transportation construction and maintenance processes that helps consistently track work progress and take immediate remedial action.

As one promising supplement for site monitoring and human inspection, this project proposes a new approach for low-cost audio sensor-based autonomous site and safety surveillance of transportation construction and maintenance, which allows for faster, more convenient, and more accurate work zone monitoring. The proposed innovation using the sound-based site and safety monitoring framework possesses several competitive advantages over traditional site management and existing vision-based work monitoring methods, which not only sounds can be easily recognized and instantly analyzed by diverse sound sensors. In addition, this sound-based monitoring approach supports an unlimited range of monitoring angles and illumination levels with lightweight data processing and comparatively quick analytics.

Problem Statement

Each DOT has to govern and oversee an enormous number of transportation construction and maintenance projects such as new bridge construction or highway maintenance. However, since a transportation construction project generally entails several miles of a job site including numerous work tasks and equipment operations, 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. In particular, 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. In this demanding situation, DOT practitioners and project managers have long recognized the importance of automated monitoring and surveillance of transportation construction and maintenance processes that helps consistently track work progress and take immediate remedial action. A highway construction and maintenance project also has sought advanced approaches to enhance automated field management and remote site/safety monitoring. The lack of a performance monitoring system in the transportation construction industry results in significant cost and schedule overruns in almost 90 percent of construction projects. Therefore, fulfilling the demand for improved transportation construction processes and establishing a robust unmanned field and safety monitoring framework is one of high priority needs for Region 6 States.

Objectives

To achieve the defined goals, this study will involve the following steps. First, this system will entail a schedule-based sound recognition approach using dynamic sound data training. By using project schedule including daily work activities, this system dynamically restricts the types of sound training data, significantly enhancing sound classification accuracy. Second, this system will involve a low-cost wearable audio-sensor for automated work zone monitoring and real-time activity log generation. The light-weight sound data can be readily captured, analyzed, shared, and visualized for real-time site monitoring and activity log generation that have not been achieved by the current methods because of limited human resource for in-person site monitoring and heavy-weight video data processing. This new intelligent site and safety surveillance system is expected to support real-time monitoring of construction progress, evaluation of task performance, and rapid

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identification of safety issues in transportation construction and maintenance projects.

Intended Implementation of Research

Workforce development: 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. Furthermore, the PIs will offer one-day tech-transfer workshops to deploy research results to the State professionals. For local districts in suburban areas in Region 6, the PIs will provide a webinar or a virtual education session. This will also be uploaded to a designated YouTube channel for engineers to view, ask questions, or make comments.

Outreach activities: This proposed research includes not only technical, theoretical, and field applications, but also critical outreach and educational efforts that can dramatically improve the final outcomes. The PIs will actively present the research outcomes at regional meetings of Parishes in Louisiana as well as quarterly meetings of the Construction Industry Advisory Council, industry support groups of the LSU Construction Management department. In addition to presentations at reputable conferences, the research team will disseminate the research results through publications in prominent professional journals and diverse media. This project should result in a minimum of five top-tier peer-reviewed publications: 1 journal (e.g., TRB and ASCE's Computing in Civil Engineering Journal) and 2 conference proceedings.

Education: Success in this research also promises significant impacts on engineering education. The findings and methods of this project are highly interrelated with the PIs' educational activities. The research results will be used to create educational material in the Dr. Lee's graduate course, Construction Data Modeling and Analysis, as well as the Dr. Choi's graduate course relevant to sensors and electronics. In addition, the project will incorporate its knowledge and research findings into a comprehensive educational plan

for underclassmen, underrepresented and community college students, through the following three programs: (1) a hands-on Summer School of the LSU Cain Center in sound data collection and analytics; (2) LSU ENGage program for teaching middle school students audio-based civil infrastructure information analysis; and (3) a regional science fair with the sound perception for civil infrastructure information collection and management. The PIs will also present this project to K-12 teachers at an annual teacher summit, and they will disseminate their learned knowledge to K-12 students.

Anticipated Impacts/Benefits of Implementation

It will provide real-time activity monitoring and leveraged decision making with historical work log data.

Web links

- [TranSET's website](https://transet.lsu.edu/research-in-progress/)
- [TRB's Research in Progress \(RIP\) database](https://rip.trb.org/View/1644227)

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 Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.

