U.S. Department of Transportation
Office of the Secretary of Transportation

UTC Spotlight

University Transportation Centers Program

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Studying the Impacts of Autonomous and Robotically Controlled Road-Building Equipment

The Center for Earthworks Engineering Research (CEER) at Iowa State University (ISU) is conducting a multidisciplinary research project focused on the impacts of automated machine control and guidance on road construction safety, efficiency, and quality. The project is funded by ISU's Midwest Transportation Center (MTC, the Region 7 University Transportation Center), Caterpillar Inc., and ISU's Center for Industrial Research and Service.

The challenge

In manufacturing, the use of autonomous and robotic machine control is now routine, and for good reason. When repetitive, dirty, dull, or dangerous operations are automated, safety and efficiency are generally enhanced, and products are consistently of a higher quality. This can result in significant cost savings.

David White

Site-level monitoring of excavator and three haul trucks to evaluate cycle time efficiency.

Like manufacturing processes, constructing long-lasting roadways requires careful process control. But operating earth compaction equipment, pavers, and other road construction equipment can be repetitive and often dangerous work that doesn't lend itself to high precision process control.

The use of autonomous and robotically controlled road-building equipment has great potential to enhance safety, efficiency, and consistency of quality. Ultimately, the use of such equipment can help reduce construction costs across the country, currently upward of $180 billion a year.

Advancements in autonomous and robotic road-building technologies are occurring quickly, and state roadway agencies are welcoming them. Examples include state agencies moving toward 3D design and providing electronic design files to contractors for upload to machines that support automated machine guidance for earthwork grading and paving.

Still, some challenges need to be addressed before robotic and co-robotic (machines and humans working together) technologies become as widespread in roadway construction as they are in manufacturing.

In particular, the impacts of autonomous and robotic-guided equipment on productivity and safety need to be studied and quantified and a detailed "process control" structure formulated. Technology advancements with sensors, wireless data communication, big data analytics, and information visualization are setting the stage for a whole new generation of road-building equipment.

A three-phase project

First, CEER is organizing a June 2015 international stakeholder workshop for industry, government agencies, and academia at ISU (for details please see www.ceer.iastate.edu/CARCI/Index.cfm).

The goals will be the following:

- learn about the current state of autonomous/robotic development and implementation in roadway construction across the country and globe, and
- identify gaps and opportunities for continued innovation and broader application of these technologies.

Second, CEER staff will conduct three to five field studies across the country. The goal is to assess autonomous/

robotic operations on actual projects to determine their effects on productivity, quality, and safety.

Sites will be selected that cover a broad range of roadway construction project types and deploy existing or new autonomous/robotic-controlled construction equipment. The $850,000 CEER/ISU geotechnical mobile lab will be used to collect field data.

Some of the types and features of autonomous and robotic technologies that may be evaluated include the following:

- wheel loaders and trucks,
- excavators and trucks,
- bulldozers and graders, and
- scrapers and push bulldozers.

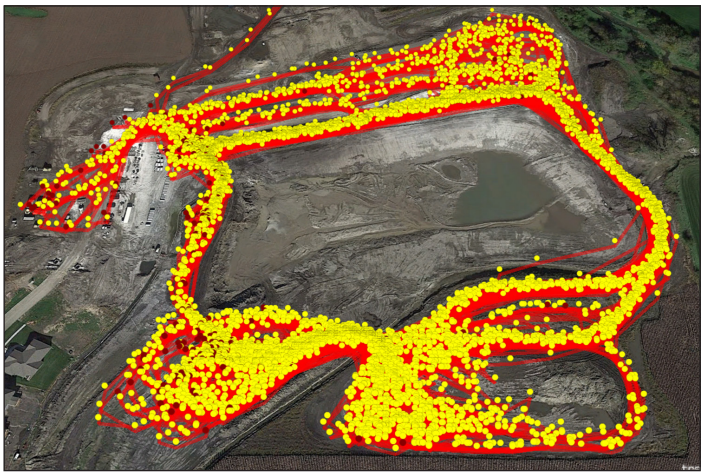
For all field studies, the machine-to-any-machine and the machine-to-human proximity awareness and accident avoidance system will be evaluated.

Finally, the results of these studies will be broadly disseminated. Using satellite communications on the geotechnical mobile lab, early results from project sites will be broadcast live to interested stakeholders. Data collected during the study will be made available to national and international researchers via a dedicated website. A webinar will be conducted to disseminate key findings.

University-industry collaboration

This project is a collaboration between academic researchers and industry partners.

The CEER team combines knowledge in areas of intelligent compaction systems, control theory, artificial intelligence, integrated sensor systems, autonomous vehicle path planning, statistical analysis, digital terrain modeling, geospatial data handling, road construction and materials, and data visualization.



David White

Position information collected from haul truck operation (5 days) at earthwork site.

Caterpillar, Inc. will provide access to new machine technologies in the areas of earthwork and excavation systems. The company will also help identify project sites for field studies.

Implications

The innovative advancements and knowledge gained from this project include potentially transformative approaches to infrastructure design, development, and construction. These could affect not only roadway construction but other types of infrastructure construction, such as formulating a process control system and developing construction site-level studies. The theory, definitions, and system parameters and operations will likely be relevant nationwide.

About This Project

The director of MTC is Shauna Hallmark (shallmar@iastate.edu). The principal investigator for this project is David J. White, Ph.D. (djwhite@iastate.edu), Director of CEER and holder of the Richard L. Handy Professorship in the Department of Civil, Construction, and Environmental Engineering (CCEE). Other team members are Pavana Vennapusa, Ph.D., Assistant Director, CEER; Julie Dickerson, Ph.D., Professor of Electrical and Computer Engineering; Max Morris, Ph.D., Professor and Chair of the Department of Statistics; Caroline Westort, Ph.D., Assistant Professor of Landscape Architecture; Simon Laflamme, Ph.D., Assistant Professor of CCEE; and Raj Aggarwal, Ph.D., Adjunct Professor of Electrical and Computer Engineering.