Impacts of Automated Machine Guidance (AMG) on Earthwork Operations

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Abstract

Automated machine guidance (AMG) links sophisticated design software with construction equipment to direct the operations of construction machinery with a high level of precision, improving the speed and accuracy of the transportation construction process. AMG technology has the potential to improve the overall quality and efficiency of transportation project construction. Many contractors are already using digital terrain models (DTMs) for estimating quantities, means and methods, constructability, quantity of the progress of work, and payment. This paper presents information regarding the following aspects of AMG, based on extensive literature review and survey conducted as part of the NCHRP 10-77 project: (a) potential productivity and cost gains, and (b) factors affecting the accuracy of the AMG process.

The equipment vendors indicated potential productivity gains of around 40% and potential cost savings of about 25 to 40% using AMG. On the other hand, a majority of the contractors indicated potential productivity gains of about 10 to 25% and cost savings of about 10 to 25% using AMG. The literature suggests productivity gains range from about 5 to 265% and cost savings range from about 10 to 68%, depending on the position measurement technology used and the application. Only a few case histories provide project specific productivity estimates for AMG for applications involving road construction, pipe trench excavation, and paving. A cost model is described in this presentation that relates productivity gain from AMG to cost savings.

The accuracy of the AMG process is primarily influenced by three variables: position measurement technology, construction process, and human errors. These parameters are either application-specific or machine-specific, and have not been thoroughly studied and or documented in the technical literature. The research team conducted interviews with various contractors to get feedback on various error detection and mitigation strategies.

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Survey results indicated that a majority (> 70%) of contractors, software/hardware vendors, and agencies who responded believe that the number of elevation data points used in creating the DTM is an important factor in the accuracy of the DTM. A gird of elevation data points was analyzed using six different interpolation methods to determine the absolute mean error (calculated as the average of absolute value of the difference between the actual and the estimate value). Results showed that the interpolation method and the spatial density of data points are important factors that contribute to the accuracy of the DTM.

A summary matrix was developed with attributes of accuracy, coverage range, measurement principle, and relative cost of various position measurement technologies that are typically used in construction applications. Laser, ultrasonic, robotic total station, RTK GPS, assisted GPS (via mobile phones), laser-augmented GPS, ultrasonic augmented GPS, GPS integrated with INS, locata (pseudolites), and infrared laser technologies are included in the matrix. Typical precision requirements and vertical accuracy requirements for earthwork and paving equipment/operations are summarized from sources identified in the literature.

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