

Mobile Terrestrial Laser Scanning for Highway Applications

Benefit: High accuracy, feature-rich point clouds obtained from within a vehicle moving at highway speed. Keeps surveyors safe as they are not exposed to traffic. Supports “survey on demand” by extracting desired features and attributes from the point cloud without the need to return to the field for measurements.

AHMCT researchers are working with Caltrans Office of Land Surveys to study Mobile Terrestrial Laser Scanning (MTLS) and its applicability for surveys, pavements, bridge structures, roadside assets, and other Caltrans applications areas. The work includes development of best practices, methods for accuracy improvements, and tools for feature and attribute extraction.

Why We Are Pursuing This Research

Surveyors are exposed to high-speed traffic, often with no positive barrier or protection, putting them at high risk when surveying the highway. MTLS provides a tool for surveyors to do their job in an innovative way while working safely from a vehicle moving at highway speed. In addition to the clear safety improvement provided, MTLS provides multiple efficiency improvements. First the collection occurs at highway speed so that many miles of roadway can be collected in a single day. Second, the system collects location, image, and intensity for a huge number of points every second, generating a so-called point cloud. Using this point cloud, surveyors, engineers, and others can extract information, for example dimensions, while in the office, removing the need to return to the field for measurements. Availability of the point cloud enables innovative applications including visualization and virtual design and construction.

Land-based mobile laser scanning systems are similar to airborne LiDAR (laser scanning) systems. Figure 1 illustrates the basic system architecture concept. The system consists of a dual-frequency RTK GNSS receiver(s), a six degree-of-freedom IMU (typically three accelerometers and three gyros orthogonally mounted), Distance Measuring Indicator (DMI), LiDAR scanner(s), data synchronization electronics, data logging computer(s), and digital camera(s). The computer(s) collects the synchronized data of GNSS carrier-phase measurements, IMU and DMI outputs, digital photographs and LiDAR scanner data for the post-processing software. Combining GNSS base station raw data collected at the same time, the GNSS measurement, IMU, and DMI data of the rover, the software will provide position and orientation solution (at 100 to 1,000 Hz update frequency) of the sensors platform containing the LiDAR scanners and digital cameras. To achieve the highest possible accuracy, the raw GNSS/IMU data is post-processed with GNSS base station(s) raw data with high accuracy satellite orbital measurements. Furthermore, the system may have multiple LiDAR scanning sensors with digital cameras in visible light wavelength, Near Infrared (NIR) or Ultraviolet (UV) wavelength. NIR and UV camera may be used to better determine health of certain plant species or in poor lighting conditions.

What Is MTLS?

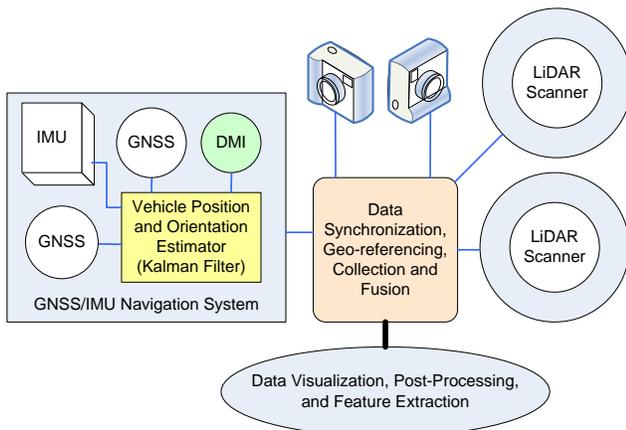


Figure 1 – MTLS system architecture block diagram



Figure 2: Available mobile LiDAR mapping systems

The land-based LiDAR scanners are usually shorter in range but higher in accuracy than those used in airborne systems. The LiDAR scanner produces distance and angular measurement to objects as well as the amplitude of the light return signal. The amplitude depends on the reflectance of the object surface as well as range and incidence angle to the object. It allows the software to identify the highly reflective painted lane lines, signs, and raised pavement markers. By combining the GNSS/IMU and laser range scanner data, the global coordinate of every scan point can be calculated. Thus, the position of the painted lane line will also be established. After that, the digital terrain model (DTM) of the road surface can be generated for Surveys' customers. In addition, other roadside and roadway features can be identified and located using the resulting point cloud and geo-referenced photographs.

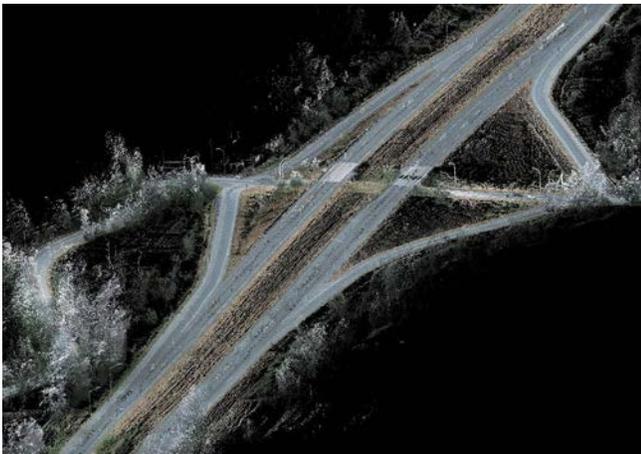


Figure 3 – Sample MTLs point clouds

What We Are Doing

AHMCT is working in four main areas for its MTLs research.

- AHMCT is developing best practices and workflows for MTLs. This includes working with a large number of software packages to determine their features, strengths, and areas for improvement. Each software package is being documented to illustrate the best workflow for that package in appropriate Caltrans applications and deliverable requirements. We are also working with Caltrans to document best field practices for MTLs, and have contributed to Chapter 15 in the Caltrans surveys manual.
- AHMCT examined a few MTLs data sets and compared them with data collected using total station, digital levels, or stationary laser scanner. We have assessed point cloud accuracy provided by a few MTLs systems. While MTLs is very accurate in general, there are a number of sources for errors in the solution, and thus room for accuracy improvements. AHMCT is investigating methods for improving the accuracy of MTLs.
- AHMCT is collecting cost data from various Caltrans and other DOT projects using MTLs. At the same time, we are assessing the benefit of MTLs to various Caltrans applications. These data are used for cost-benefit analysis for various deployment methods and applications.
- Finally, AHMCT is investigating methods and tools for feature and attribute extraction from the point clouds generated by MTLs. These methods and tools are specifically targeted to extract the type of features and attributes in key Caltrans applications. Application areas include surveys, pavements, bridge structures, and roadside assets. The result will be open-source software available to Caltrans and other State DOTs.

For Additional Information

Arvern Lofton (916) 324-2295 Arvern_Lofton@dot.ca.gov
 Caltrans Project Manager

Bahram Ravani (530) 754-6130 bravani@ucdavis.edu
 Principal investigator

Ty A. Lasky (530) 752-6366 talasky@ucdavis.edu
 Co-Principal investigator

Kin S. Yen (530) 754-7401 ksyen@ucdavis.edu
 Primary contact

Visit us at www.ahmct.ucdavis.edu