TECH BRIEF

NCRST
NATIONAL CONSORTIUM ON REMOTE SENSING IN TRANSPORTATION
INFRASTRUCTURE

Grade and Cross-Slope
FROM LIDAR DATA

Roadway grade is necessary for a number of applications in transportation engineering. Grade is used to calculate stopping and passing sight distance on vertical curves. Vehicle operation, particularly heavy-truck, is affected by grade. The capacity of a roadway is also influenced by grade, depending on length and gradient of slope. Proper transverse slopes are necessary for pavement drainage. Common data collection methods for grade, cross-slope, and surface modeling include GPS, photogrammetry using high-resolution ortho-rectified images, use of as-built plans, and traditional surveying. GPS and surveying are time consuming and require data collectors to be located on-road. As-built plans may not accurately reflect existing conditions and photogrammetry can be both expensive and time-consuming and may be limited by environmental factors such as sun angle.

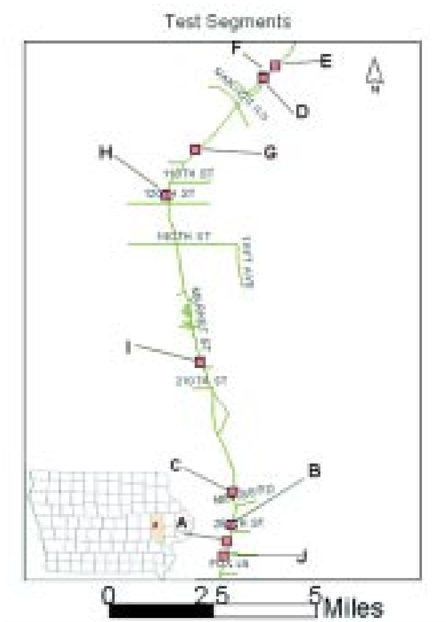

Figure 1. Location of test segments along Iowa Highway 1.

LIDAR derived terrain data were investigated to evaluate whether coordinate and elevation data from the LIDAR could be used to determine cross-slope and grade. A study corridor along Iowa Highway 1 was used as a test site. A commercial vendor provided LIDAR derived digital elevation data in the form of a point cloud consisting of an easting, northing and elevation (XYZ) with an average spacing of 2 meters. The laser unit utilized by the vendor sent out 4000 pulses per second and scanned across the aircraft's flight path. Additionally, GPS and Inertial Measurement Unit (IMU) data were collected to record the aircraft's position, as well as roll, pitch and yaw at the time each pulse was fired by the laser. Digital orthophotos were also collected during a separate flight from the LIDAR data collection. Digital images were of 1-foot resolution, with a horizontal accuracy of 2 meters. Imagery was orthorectified using airborne GPS data, platform attitude, and LIDAR DEM data. A six-inch resolution set of digital orthophotos was also available for the study area.

Ten test sections along the corridor were used to evaluate LIDAR. Each lane group (northbound and southbound) was evaluated separately by defining a polygon that encompassed the extent of the lane group. Both orthophotos and the LIDAR surface model were used to define the polygon. Regression analysis was then used to fit a plane through each polygon as shown in Figure 2. Regression equations were developed as a function of elevation changes. The equation coefficients derived were used to define the grade and cross-slope of each of the road segments. A field study was also performed using an autolevel to measure the elevation differences between the outer edge of the shoulder, pavement edge and the crown of the roadway. This provided the grade and cross-slope for each lane group for each of the ten sections. These datasets were compared against LIDAR. Results indicate that grade could be measured to within 1% in all cases and to within 0.5% in most cases. Cross-slope results indicated that LIDAR was not suitable for measurement. The difference between the two measurements is likely due to the fact that grade was measured using LIDAR points from a section that was 100-feet long while cross-slope sections were only as wide as the pavement or shoulder so, vertical error was distributed over a shorter horizontal distance.

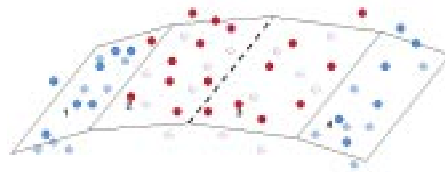

Figure 2. Regression Plane fitted to a cloud of LIDAR points.

Contacts: Iowa State University
Reg Souleyrette *reg@iastate.edu*
Shauna Hallmark, shallmar@iastate.edu

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