Title: Efficient, Off-Grid LiDAR Scanning of Remote Field Sites

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As terrestrial LiDAR scanning systems become increasingly available, strategies for executing efficient field surveys in settings without access to the power grid are increasingly needed. To evaluate scan methods and develop an off-grid power system, we used a tripod-mounted laser scanner to create high resolution ($\leq$40 mm point spacing) topographic maps for use in neotectonic studies of active faulting in arid, high elevation settings. We required 1-2 cm internal precision within point clouds spanning field sites that were $\sim$300 x 300 m. Main components of our survey system included a Trimble GX DR200+ terrestrial laser scanner, a Leica TCR407power total station, a ruggedized laptop (2 GB RAM, 2.33 GHz dual-processor, and an Intel GMA 950 graphics card), batteries, and a portable photovoltaic array. Our first goal was to develop an efficient field-survey workflow. We started each survey project by using the total station for 1-2 days to locate an average of 8 ground control locations per site and to measure key geomorphic features within the project area. We then used the laser scanner to capture overlapping scans of the site, which required an average of six, 5-hour scanning sessions and an average of ten station setups. At each station, the scanner located itself on a particular point by measuring the relative positions of an average of four backsights, each of which is a $\sim$17 x 17cm reflective target mounted on a tripod over the ground control point. To locate the scanner at a particular station prior to scanning, we experimented with both setting up over known points as measured using the total station, and resectioning, by positioning the scanner over an unmeasured location and backsighting on previously scanned points. We found that resectioning provided the smallest errors in scan registration. We then framed and queued a series of scans from each station that optimized point density and minimized data repetition. We also increased the accuracy of the scanner location by adding backsight measurements between scans. During scanning, incoming data were displayed in real-time by the scanner software, allowing the user to check scan area, shadowing, and resolution by interactively visualizing the project point cloud individually or in the context of previously scanned point clouds. Because individual scans must be stitched to build the total point cloud, we are currently testing different scan registration techniques to better quantify which minimizes registration errors in the final point cloud. A second goal of our study was to develop a low-cost, off-grid method for powering the survey equipment. To this end, we used two sets of three, 65Ah, 12V sealed lead acid batteries, which we charged using two 55W and one 25W, 12V photovoltaic arrays. We found that key elements for maximizing efficiency included real-time data visualization for planning future scans, use of polygons to delimit scan area as tightly as possible, distance-limited scanning to minimize unnecessary measurements, target tear-down and set-up synchronous with scanning. Using these strategies, we completed two survey projects, each of which covered a field site of approximately 300 x 300 m with $\sim$31 million data points at an average point spacing of $\sim$37 mm. Our experience demonstrates the feasibility of executing terrestrial LiDAR scanning with an average of $\sim$5.2 million points per scan day in remote, off-grid field areas.