Geosci. Instrum. Method. Data Syst. Discuss.,
https://doi.org/10.5194/gi-2020-3-AC1, 2020

Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "Dense point cloud acquisition with a low-cost Velodyne VLP-16" *by* Jason Bula et al.

Jason Bula et al.

jason.bula@unil.ch

Received and published: 25 May 2020

Dear Editors and Reviewers, Thank you for your detailed comments and suggestions about our manuscript entitled "Dense point cloud acquisition with a low-cost Velodyne VLP-16". In the following point-by-point replies, RC denotes a reviewer comment and AC denotes our response to the comment. Hoping that these responses will fulfill your expectations, Best regards, Jason Bula, Gregoire Mariethoz and Marc-Henri Derron.

RC: I like the idea to create a 3D terrestrial laser scanner from low-cost components. The combination of a profile scanner (e.g. Velodyne) with a rotation drive on a tripod is reasonable but not novel in principle. The authors demonstrate that the concept

works in general and they describe the system and the processing scheme adequately. However, I have some critical points to address. Here are the main points which argue for "major revision", other and more detailed comments and suggestions can be found in the attached document.

AC: We thank the reviewer for the positive feedback on our ideas. All comments are addressed below.

RC: There are other projects where 2D profile scanner used to form a low-cost 3D scanner and this is not mentioned at all. Some examples are given as comments in the attached commented document.

AC: A complete review of the different projects developing low-cost lidar scanner of similar as the one developed in this study will be added in the revised version.

RC: There are several publications on geometric modeling and calibration of terrestrial 3D laser scanners. The authors give no credit on that and does ignore these approaches completely. They develop there own geometric model and calibration instead, which is at least questionable (as they conclude by themselves)

AC: Our research focuses on the use of a low-cost lidar scanner (Velodyne VLP-16) to create a terrestrial laser scanner (TLS). Our goal was to recreate a dense scan by positioning the lidar on a rotating motor. The continuous recording of the points coupled with the rotation of the motor allowed us to recreate a dense 360-degree image. The term calibration may be inappropriate; we should be talking about an adjustment. We assumed that the lidar system sold by Velodyne was calibrated (will be clearer in the revised version). We have chosen to use our own geometric model based mainly on the assembly of the motor and lidar, as the system components (lidar, motor, ball head) are disassembled after each use. Our research has shown that when the system is reassembled or moved, the parameters governing the reconstruction of a dense scan vary, which implies the need to perform an adjustment (automatic in post-processing) after each new measurement. This is why the use of an on-site method of calibration/adjustment (use of target, planar feature, or a direct georeferencing with GNSS) is in our opinion not optimal for such a system because it would imply to renew the approach after each measurement. Additionally, it would make our device more expensive. Adjustment could be avoided after each measurement if the system components were welded together. However, we wanted to keep the possibility to separate these elements in order to use the lidar for other projects for example. This will be discussed in the revised manuscript.

RC: The above mentioned geometric models as well mostly base on the know error sources of geodetic instruments (theodolite, total station) which have the same structure as terrestrial 3D laser scanners and also the presented device. The parameters are different axis and eccentricity errors, where equations are presented in geodetic standard literature. Why is that not considered? There are no equations given at all.

AC: Our project focuses mainly on the addition of the rotary motor allowing the densification of the point cloud. The geometrical model is thus based only on the influence of the motor and the assembly (the alpha 1 and alpha 2 parameters) and leaves aside the errors inherent to the lidar. For this reason, the parameters generally studied in the literature are not considered here.

RC: The evaluation part is not very scientific to assess the performance of the system. It seems the system works, and the authors claim it works well for their applications. However, the readers might like to wish a better proof in terms of a thorough scientific analysis in order to be able to assess the suitability of the instrument for other applications as well. To mention some examples: the analysis bases only on a fitted plane to the point cloud of the floor and does not cover the whole field of view. There are only 4 scans which produced completely different calibration values and there is no hint on the parameter's significance. The reproducibility test compares only 2 scans for different scanning speeds, which does not really allow for conclusions. Why the data are not compared to a reference model or reference scan with a superior precision? Some illustrating figures (color-coded point cloud comparison) would be more than de-

sirable (even though only with the fitted plane and the floor points). The most often used approach would be the use of 3D check points and a thorough comparison of the coordinates (RMSE). There are some more comments within the attached document.

AC: Our study was carried out to determine if it is possible to get a TLS for a lower price while still being able to disassemble the system but we agree that the system evaluation tests are indeed incomplete. Concerning the reproducibility test; we will do more in the revised version. The few tests carried out allowed us to see that the system is unstable (adjustment necessary after each measurement), which we address with a post-processing adjustment procedure. This will be confirmed in the revised version using a reference scan from a superior precision lidar and 3D check points. However, tests in known environments will be an indication of the quality of the fit because the nature of the scanned scene influences the quality of the adjustment (the algorithm used to find the alpha1 and alpha2 parameters is less powerful when it is about environments with complex characteristics).

RC: I can not really understand why the presented system is always compared to IMU- or SLAM-based mobile scanners. From my point of view this is not reasonable, as MLS and TLS have different advantages and subsequently different applications scenarios. It is obvious that the point cloud of a tripod-based device is more precise as the whole point cloud from one position is within the same coordinate system per definition than a handheld mobile device where each single point has to be tracked. Therefore I would absolutely prefer a comparison with other (maybe "low-cost“ 3D scanners), such as Leica BLK 360 oder FARO FocusM 70 (ca. 20.000 $ second hand below 10.000 $ or for rent 100-200$ per day), this would be more fair in terms of an adequate assessment of the device at hand.

AC: The use of a SLAM system in our study is for the unique purpose of validating the quality of the data. The Geoslam (GeoSLAM ZEB-Revo) allows data acquisition to an accuracy of 1-3 cm according to the manufacturers (3 cm for the VLP-16). But, as mentioned earlier, we will have access to a more accurate lidar system, which will allow us to make comparisons for the revised version.

Interactive comment on Geosci. Instrum. Method. Data Syst. Discuss., https://doi.org/10.5194/gi-2020-3, 2020.