Terrestrial Laser Scanner High Station to Control the Quality of DEM Data

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***Abstract*— Currently many Digital Elevation Models (DEMs) are derived from surveys obtained by LiDAR flights. The quality of both products is usually assessed using control point-based techniques. Although it seems that this way of reporting quality is not fully adequate because the superficial nature of both the DEMs and the area covered by the LiDAR survey. For this last reason (the superficial nature of the objects to be controlled), according to the ideas contribution in Geoprocessing we propose to control the quality of the DEMs and LiDAR flights by means of a Terrestrial Laser Scanner (TLS) located on a pole at 6 or 7 m from the ground. We propose a configuration of 4 scan stations registered in a single point cloud and georeferenced, so that its accuracy is greater than the product that is intended to be controlled.**

Keywords- LiDAR; DEMs; quality; terrestrial scanner laser; georreference; accuracy

I. INTRODUCTION

It is very important to know the Light Detection And Ranging (LiDAR) surveys quality and the DEMs derived from them. These two types of geospatial data are the basis to develop a large number of products in sciences, such as Civil Engineering, the Environment, Hydrology, Geology, etc. But in order to derive quality products, such as drainage networks, flood zones, slope maps, etc. it is necessary to know the quality of the original data (LiDAR and DEMs). And to report the quality of LiDAR and DEMs it is necessary to carry out expensive quality controls [1]. Traditionally, quality assessment has been based on control points, as for example shown in [2], where conventional parameters are used (Root Mean Square Error RMSE), μ, σ, Normalized Median Absolute Deviation (NMAD), etc.), [4]. Many of these parameters assume normality in the data distribution, which is not usually true. This point-centered approach allows for numerous positional control methods [5], one of the most recent being the one proposed in [2], although on many occasions it requires the point to be controlled to be well identified. Additionally, if it is intended to evaluate the quality of a DEM, which has a superficial nature, it seems more appropriate that its positional accuracy be evaluated and controlled by a sample whose elements are also superficial. For this reason, in this study we propose to use patches to study the quality of both LiDAR and DEMs data. This approach is novel, since we have not found anything similar in the reviews we have carried out [6] on the study of the quality of both LiDAR or DEMs data. To test the application of this methodology, we propose to use an existing LiDAR flight that is controlled by a survey with TLS stationed on a pole at 6 and 7 m from ground. This greater height of the TLS setup tries to get a greater perpendicularity between the incident rays and the ground and consequently a lower precision dilution.

The advantage from the above proposal compared to the traditional control points approach is that the patch includes more information than only one point, and the corresponding point cloud is able to derive different statistics that can be used in simulation parametric models.

In section II it is explained the method and material used in this research from the LiDAR product to the reference captured data. In section III the results are shown and some comments about the method proposed and linked to accuracy are included.

II. MATERIAL AND METHOD

As a product to be controlled, an existing LiDAR flight will be used, which we will call (Mpro). This model was an experimental LiDAR flight with a density of 14 points per square meter as shown in Figure 1.

Figure 1. LiDAR sample for the Mpro

The Reference Model (Mref) Figure 2 will be obtained by means of a Leica TLS (BLK360) whose distance measurement accuracy is 6 mm according to its specifications. The BLK360 will be mounted on a pole 6 or 7 meters high and stabilized by a tripod that can be extended up to 4.5m. Usually it will not be necessary to use the tripod maximum extension; only in windy situations that can cause the pole to flex will the tripod extend to its maximum length.

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Figure 2. Mref from the TLS stations registration

The scanner was placed on the pole in an inverted position so that no shadow areas were created due to the scanner base, to get that setting an arm adapted to the pole was used to hold the scanner Figure 3.

Figure 3. BLK36 scanner mounted on pole in tripod

It is intended to take an area with such an extension that it allows to extract a square surface of 50x50 m; those dimensions will be the patch size that will be used to control both the LiDAR point cloud and its derived DEM. To get the patch, 4 scan stations are used divided in two groups. A group is composed of 2 scans where the vertical axis of the pole remains fixed while the position of the second scan in the group is achieved by turning the pole 180º on its own axis. In Figure 4 2 yellow pyramids are shown at one end of the line: the pyramids represent the 2 scan stations corresponding to group 1. At the other end of the line, the 2 scans of group 2 will be located.

Figure 4. Scan stations from the same group (yellow pyramids)

The 4 scans were georeferenced and registered using the Cyclone Register 360 software, which required the coordinates of several targets, obtained through GNSS RTK in differential mode connected to the server through Ntrip. The Figure 5 shows the targets distribution and the errors obtained after registering.

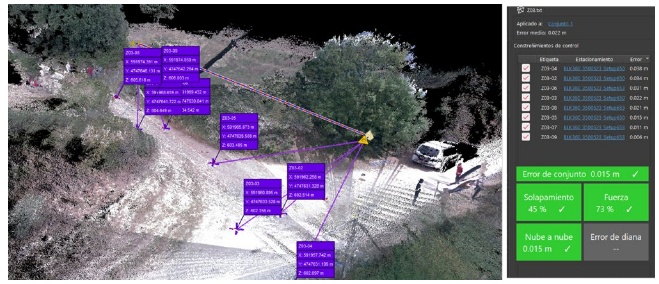

Figure 5. Registration using target coordinates

III. RESULTS AND CONCLUSIONS

After filtering the registered point cloud we get the Mref that could be compared to the Mpro in order to compute the Mpro quality. As shown in Figure 6, the set error in every registration is smaller than 0.03 m and the RSME for target points is smaller than 0.04 m (Mref). Because the RSME for the Mpro is 0.15 m, according to the LiDAR flight specifications, the registered and filtered Mref is suitable for controlling the Mpro LiDAR quality.

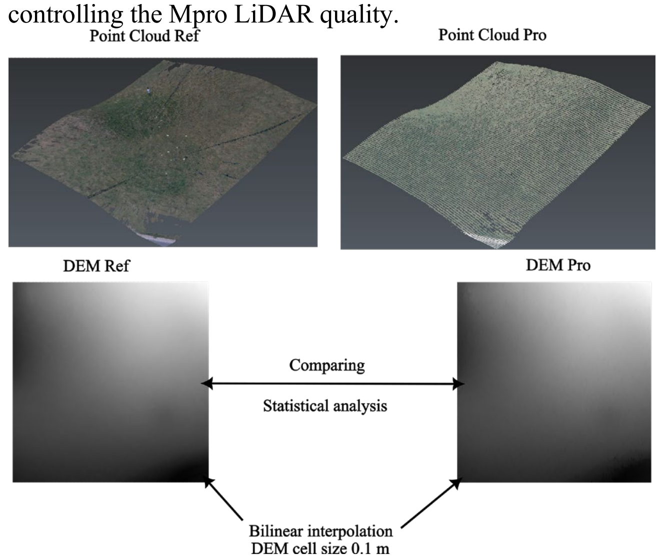

Figure 6. Mref and Mpro both LiDAR and derived DEMs

Our proposal, also include controlling the DEM quality starting from the Mpro and Mref point cloud. Before computing the DEMpro quality it is necessary determine a method to pass from Mpro and Mref to DEMpro and DEMref. We propose a bilinear interpolation to derive both DEMs with a cell size of 0.1 m.

The quality control can be performed from two point of view (altimetric and planimetric). The altimetric quality can be analyzed through the cumulative error distribution function and the planimetric one can be addressed by contours as proposed in [7].

The data used in this study was the experimental LiDAR flight from the area of Navarra in Spain (10391 km^2) and the futures plans are to extend the methodology to Andalusia in Spain (87599 km^2).

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