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Precise LIDAR DEM and True Ortho Photos

UWE LOHR, Toposys, Ravensburg

ABSTRACT

A characteristic of digital true-ortho images is that each pixel of the image is at its geometrically correct position. This is an essential advantage when merging image data with other geografical information as it is done in a GIS.
Rectification of image data to a true-ortho projecting needs an elevation model which provides the heights of all 3D objects of a scene – exactly a feature of digital surface models from airborne LIDARs.
This paper summarizes some basics on true-ortho projection. The TopoSys LIDAR system is taken as an example for a successful integration of LIDAR and line scanner camera to produce true-ortho images. Finally some application are outlined which need true-ortho images.

1. INTRODUCTION

In the mid 90's LIDAR systems purely gathered data to produce elevation models. Recently, however, the trend goes more and more to multi-sensor systems and so today LIDAR manufacturers (and / or camera manufacturers) offer the capability to gather LIDAR and image data simultaneously. This approach offers various advantages: First of all there are elevation and image data available taken at exactly the same time. So, these data sets do not suffer from e.g. such problems that there are new buildings in one data set which in the older one do not exist. Another pro is that the LIDAR digital surface model (DSM) may be taken as data set to rectify image data to a true-ortho projection.

2. DTM, DSM AND TRUE ORTHO IMAGES

One input for rectification of aerial images is the elevation model. The traditional way to correct image geometry is by using a bare ground model (DTM: digital terrain model). The result of this kind of rectification is acceptable for small scale application; however, large scale images suffer from the fact that 3D objects have a lean. 3 D objects are not represented geometrically correct, because their height is not taken into account. In case of buildings, displacement of footprints and roofs is extremely unpleasant when e.g. merging such image data with other, geographically correct information.
In the past, 3D information of objects was frequently only extracted for "relevant" objects like building, bridges etc. Objects like trees, cars and other irrelevant objects were considered, because it was too much work to determine their heights.
Airborne Laserscanning is a means to generate a complete 3D model of the surface. A LIDAR DSM forms the ideal basis for a true-ortho rectification supposed that both scales (resolutions) of image data and LIDAR elevation data are harmonized. As result of such a work flow, Figure 1 shows a true-colour and a colour-infrared image of the TopoSys line scanner camera.

3. TOPOSYS LIDAR AND LINE SCANNER CAMERA

Since 1996 TopoSys produces high-resolution LIDAR DEM which mainly are used in large scale applications. Both the LIDAR systems operated by TopoSys GmbH for services in Europe are supplemented by line scanner cameras for about three years.

LIDAR system as well as line scanner camera are developments of TopoSys GmbH. The image processing package, which includes software to calculated true-ortho projection and software for radiometric correction, has been developed by TopoSys, too. This package is integral part of TOP-PIT, TopoSys processing software for LIDAR and image data.

Figure 1: True-ortho images rectified with help of a raster DEM.

3.1. Precision LIDAR

The TopoSys LIDAR is a glass fibre line scanner system, which generates 83,000 measurements per second. Due to its design the measurement pattern is a regular grid of parallel scan lines. At an aircraft speed of 70 m/sec and a survey altitude of about 900 m above ground the LIDAR provides an average density of 4 to 5 measurements per m².

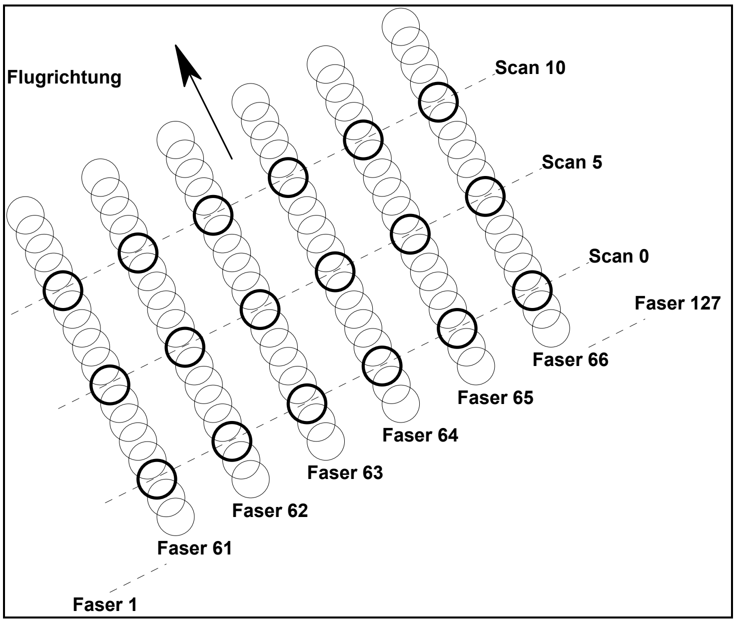

Figure 2: Scan pattern of the TopoSys LIDAR

Measurement rate	83000 measurements per second
Laser wave length	1.5 µm (eye-safe)
Field of view	14°
range	< 1600 m
Swath width (at max. range)	390 m
Average measurement density (at max. range)	3 measurements / m²
Registration of first and last echo	
Intensity recording	

Table 1: Some parameters of TopoSys LIDAR.

3.2. TopoSys line scanner camera

The TopoSys line scanner camera gathers image data in four spectral channels. The design requirement was that image data should have double the resolution of the raster elevation models. So, from e.g. a survey altitude of about 900 m above ground, image pixel size is 0.5 m, while DEM raster width is 1.0 m.

Pixel size (at survey height:900 m above ground)	0.5 m
Field of view	21°
Pixel per line	682
Spectral channels	(1) 440 - 490 nm (2) 500 – 580 nm (3) 580 – 660 nm (4) 770 – 890 nm

Table 2: Parameters of TopoSys Line Scanner Camera.

Image data in true-ortho projection may be delivered either as four separate channels or as true-colour (R,G,B) and / or colour-infrared composites (NIR, R,G) in Geo-TIF format.

3.3. Amount of data

Operating line scanner camera and LIDAR system simultaneously nearly doubles the amount of data to be stored during a survey flight. Table 3 gives shows the amount of data collected during the survey flight when assuming a scan area of 60 km² and a survey height of 900 m above ground.

Data amount after survey flight	
Navigation data	0.1 GByte
LIDAR data	3 GByte
Image data	4 Gbyte

Data amount during processing	
Navigation data	0.5... 1 GByte
LIDAR data	1.5.... 6 GByte
Image data	11....86 GByte

Table 3: Amount of LIDAR and image data after survey flight and during processing

Really significant is the storage capacity needed during data processing, when merging image strips to a complete image and applying radiometric correction.

4. LARGE SCALE APPLICATIONS

Because in true-ortho images each pixel is geometrically correct, images can commonly evaluated or used with other georeferenced information. Some examples are:

- Automatic segmentation of objects
  Based on true-ortho images and LIDAR DSM, objects like buildings, trees etc. can automatically be extracted. This was successfully shown by means of ECOGNITION software.

- Elevation information system
  When true-ortho images and DSM of a scene are proper georeferenced, the user may navigate in images data, while reading out of elevations under the position of the cursor. This simple means allows a user to move in a more common true-colour image and determine heights.

- Draping of 3D city models with true-colour images
  TopoSys LIDAR DSM is used to derive 3D vector models of buildings. Experience shows that LIDAR DSM for such an application must be available in a 1 m or even 0.5 m resolution.
  After vectorisation the 3D model is draped with the true-ortho image in order to get texture on roofs and pavements. Additionally taken images from ground may be put on walls to get a model, which looks close to reality.
  Figure 3 shows the result after vectorisation of TopoSys LIDAR DSM and overlay of airborne and terrestrially taken images.

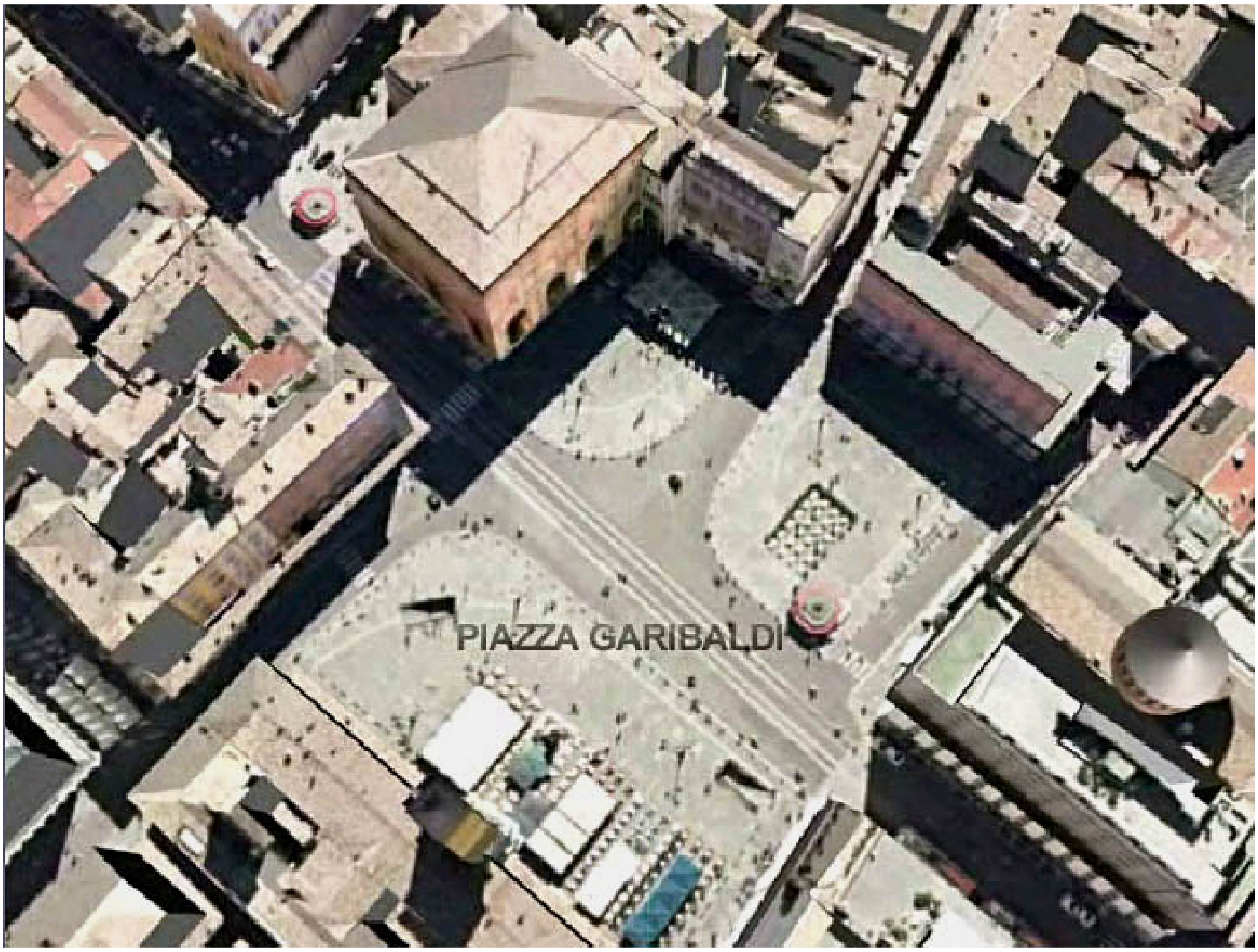

Figure 3: True-ortho images draped over the 3D vector model of Parma.
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5. CONCLUSIONS

During the relatively short time in which LIDAR plus line scanner camera are operational, it turned out that more and more customers asked for both elevation and images data. As all data is digital from the beginning, data processing is done relatively quick and automatic - only quality control is done need operator support.
Another observation is that there is a request for data of even higher resolution than 1 m raster data DSM and 0.5 m image data. TopoSys GmbH already initiated developments to meet this demand.

6. REFERENCES

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