FLOOD RISK MAPPING BASED ON AIRBORNE LASER SCANNER DATA: CASE OF THE LLOBREGAT RIVER

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SUMMARY

The application of LIDAR data to flood risk mapping has been tested in an area of Llobregat river, close to Barcelona, Spain. The accuracy and high density of the data allowed a detailed representation of the flooded areas. Model size limitations in standard software have been found.

Keywords: flood, laser scanning, LIDAR, mapping

1. INTRODUCTION

Extreme flood events are a major natural hazard in the Spanish Mediterranean basin. In the past decades many flood control structures, mainly dams, have been built. Many of these dams were originally designed for hydropower or irrigation purposes many years ago.
In the last decade efforts to perform better flood management comprise real time hydrological warning systems, remote control, weather forecast information systems, computer simulation of mathematical models, etc. Now these can take advantage of cutting-edge technologies like meteorological radar and satellite communications systems.
Light Detection And Ranging (LIDAR) has proved to be an accurate and practical alternative to conventional methods for the generation of Digital Surface Models (DSMs) for hydraulic modelling and flood mapping. A test area of 15 km along the Llobregat River has been chosen in which floodplain is invaded by urban development.
The scopes of the study are:

1) Check the accuracy of DSMs derived from LIDAR technology.
2) Check its usefulness for hydraulic computations and floodplain delineation computations.
3) To establish the guidelines for the forthcoming flood risk-mapping programs in Catalonia.

2. LIDAR DATA

Table 2-1: LIDAR survey parameters

Plane	Partenavia P-68C Observer
Speed	120 knots
LIDAR system	ALTM 1210
Frequency	10,000 points/s
Flying height	800 m AVG
Scan angle	15º
Scan frequency	24 Hz
Points measured	8826860
Point density	0.64 points/ m^2
Scanned surface	1378 Ha

Initial terrain data was by an airborne laser-scanner operated by the company Aquater Spa Italy. The system parameters are shown in Table 2-1. The number of flying lines was 8 and it required 44 min of flying time.
With the last pulse points a DSM with one metre grid step was computed and vegetation and small buildings were removed automatically. Points on bridges were removed by hand editing. Large buildings and other obstacles to water flow like containing walls were preserved in this high-resolution model. Bridges were surveyed with the help of a total station. No other topographic data was used in addition to the LIDAR DEM. Bathimetric profiles were not surveyed because the river level was so low that it was considered negligible in front of the flow during a flooding event.
Five sport fields to be used as control fields were surveyed by RTK GPS. The heights in these flat areas were used to check the LIDAR DSM. In each field a minimum of 15 points were measured. The LIDAR values in each of the areas were

Table 2-2. Checking of LIDAR data

Zone	N	<z>	Std dev
1	12	0.14	0.07
2	14	0.22	0.04
3	14	0.20	0.03
4	13	0.23	0.05
5	18	0.14	0.06

triangulated and an interpolated height was computed and compared to the LIDAR DSM. Triangles with height differences larger than 30 cm were neglected.
There was a systematic difference of 18 cm between surveyed points and LIDAR (Table 2-2). LIDAR values were always lower. This difference could be due to a systematic shift in the GPS/INS trajectory solution of the plane, to the geoid or a geodetic network error. As it was a constant we were able to remove it and it had no influence on the results.

3. PHOTOGRAMMETRIC DATA

Comparable photogrammetric data has been collected from aerial photographs at 1:5000 scale. A 1:1000 topographic map with 1 m contours has been drawn. We tried to capture a 3D model of the buildings and bridges but many mistakes in the data classification made very difficult to accomplish this purpose. Also, the restitution complexity moved us to simplify the classification of captured data.
At the moment of writing this report we still have not been able to repeat the hydraulic computations with the photogrammetric data.

4. HYDRAULIC MODELLING

Hydraulic simulation models like HEC RAS and MIKE can be linked to GIS systems thanks to pre-processing and post-processing modules. Computation of water levels and velocities and mapping show up details such as which particular streets are flooded, which areas remain safe, what is the water depth in flooded areas and how much time the flood lasts. These results are necessary to develop flood emergency plans.
The LIDAR DSM was used to extract the cross sections for the hydraulic modelling and also to perform automatic flood delineation. HEC RAS and Mike-11 modelling programs were used to determine floodplains corresponding to 100 and 500 years return period, encroachment areas and legal buffer zones. Simulations were conducted for models with and without bridges and for stationary and non-stationary flows.
Existing GIS post-processing modules HEC GeoRAS and MIKE 11 GIS for HEC RAS and MIKE 11 in PC systems seem to be limited by a maximum of 10.000.000 cells. If a 2 m cell grid is used then the area covered is 40 km^2 which is not too large.

5. CONCLUSIONS

The LIDAR technique has shown to be accurate for generating DSM for flood hazard mapping at 1:5000 map scale. The high data density of the LIDAR DSM results in an automatically delineated flooded area that covers some streets but not surrounding buildings. Also, the low standard deviation of height differences demonstrates the high accuracy of this technique.
At the moment of writing this report the comparison with photogrammetric data has not been performed yet but LIDAR data seems to be enough for flood modelling at this scale and only bridges require a topographic survey from the ground. No other topographic or photogrammetric data was required in this test area.

REFERENCES

Baltsavias, E.P. Airborne laser scanning: basic relations and formulas. ISPRS J. Photogr. Rem. Sensing 54 (2/3), 199-214.

Wehr, A., Lohr, U., (1999): Airbornelaser scanning – an introduction and overview. ISPRS J. Photogr. Rem. Sensing 54 (2/3), 68-82.

Mandlburger, G., Brockmann H. (2001) MOdelling a watercourse DTM based on airborne laser-scanner data using the example of the River Oder along the German/Polish Border. OEEPE-Workshop, “Airborne Laser-scanning and Interferometric SAR for Detailed Digital Elevation Models”. Stockholm.