8th BILATERAL GEODETIC MEETING POLAND - ITALY Wrocław, Poland, 22 - 24 June 2006

SURFACE BREAK LINES INTERPOLATION ON THE BASIS OF LASER SCANNING DATA

Andrzej Borkowski, Ewelina Ziemba
Institute of Geodesy and Geoinformatics
Agricultural University of Wrocław, Poland

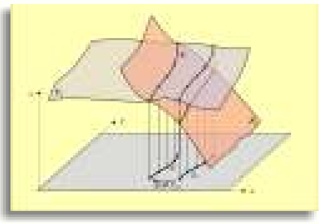
Introduction

Information about break lines, which are simply places where two patches overlap, is essential for high quality laser scanning models. Interpolation is the only way to get a 3D vector representation of the break lines.

This paper presents the application of the interpolation method invented by Borkowski (2004); Borkowski and Keller (2005), which uses Snake – active contour function for total energy minimization, for surface break lines modelling using terrestial laser scanner data sets. Credibility of this method was also designated by comparing the results of interpolation to the results of more accurate tachimetric measurements of break lines.

The method

Break line may be found as the intersection curve between two surfaces



Laser scanning points are approximated with functions: F_1 and F_2. The break line is modelled with snake. Snake model is received as a solution of variational problem, in which external and internal energy of the curve are minimized.

$$\int_0^1 (E_{int} + E_{ext})ds \rightarrow \min$$

Solution of this task leads to Euler's equations which are solved iteratively

$$\mathbf{v}_t = (\mathbf{A} + \mathbf{I})^{-1}(\mathbf{v}_{t-1} - \mathbf{E_v}|_{t-1})$$

where

$$\mathbf{v} := [x = x(s) \;\; y = y(s)]^\top$$

$$\mathbf{A} = \begin{bmatrix} a & b & c & 0 & 0 & 0 & \dots \\ b & a & b & c & 0 & 0 & \dots \\ c & b & a & b & c & 0 & \dots \\ 0 & c & b & a & b & c & \dots \\ 0 & 0 & c & b & a & b & \dots \\ 0 & 0 & 0 & c & b & a & \dots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix} \qquad \begin{aligned} a &= 2\alpha + 6\beta, \\ b &= -\alpha - 4\beta, \\ c &= \beta \end{aligned}$$

α β - free parameters

$$\mathbf{E_v} := \begin{bmatrix} \frac{\partial E_{ext}}{\partial x} \\ \frac{\partial E_{ext}}{\partial y} \end{bmatrix} = \mu(z_2 - z_1) \begin{bmatrix} \frac{\partial f_2(x,y)}{\partial x} - \frac{\partial f_1(x,y)}{\partial x} \\ \frac{\partial f_2(x,y)}{\partial y} - \frac{\partial f_1(x,y)}{\partial y} \end{bmatrix}$$

In our case, for functional description of the point claud *thin plate spline* is applied.

$$z(x,y) = \frac{1}{2}\sum_{i=1}^{n} \lambda_i r_i^2 \ln r_i^2 + \nu_{00} + \nu_{10}x + \nu_{01}y$$

$$r_i^2 = (x - x_i)^2 + (y - y_i)^2$$

where

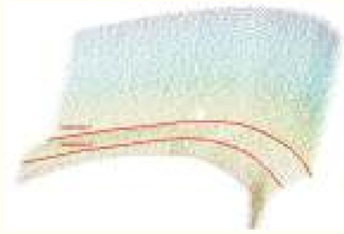
$$r_i^2 = (x - x_i)^2 + (y - y_i)^2$$

λ , μ control parameters

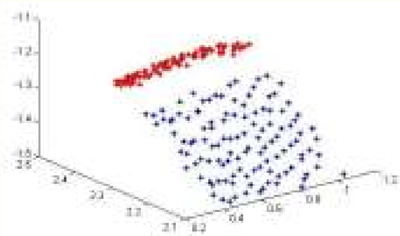
Data processing

- Processing and filtering of laser scanner data,
- Classification of points assigned to particular surfaces,
- Transformation of laser scanning data and tachimetric measurements to common coordinate system.

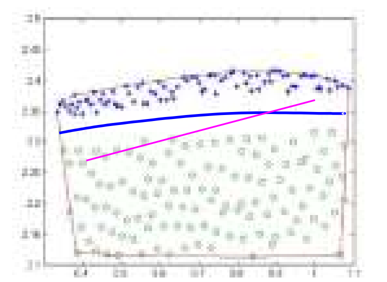
Break lines modelling



Point claud and break lines to be modelled (fragment)



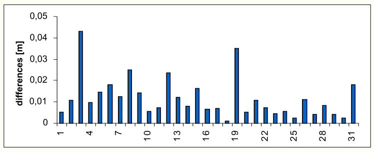
Two different patches presented respectively by blue and red stars



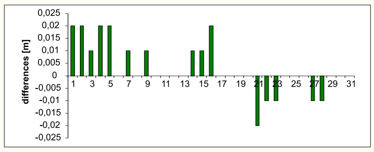
Horizontal projection of two adjacent patches, initial snake (red) and the interpolated break line (blue)

Results

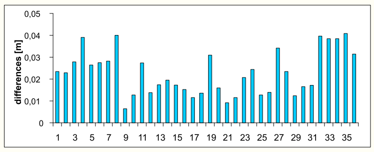
For the evaluation of break line modelling horizontal distances between interpolated and measured break line were computed.



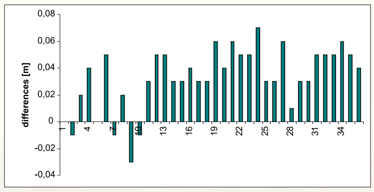
First break line: Horizontal deviation of the modelled break line from the measured one.



First break line: Vertical deviation of the modelled break line from the measured one.



Second break line: Horizontal deviation of the modelled break line from the measured one.

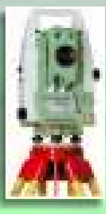


Second break line: Vertical deviation of the modelled break line from the measured one.

Measurements

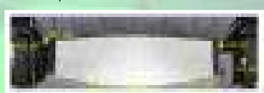
The object of meausrements was an excavator's simulator inside.

Excavator's interior was scanned with Riegl LMS-Z420i laser scanner which was equipped with Nikon D100 digital camera.



Break lines situated in the lower part of simulator's inside were measured with tachimeter Leica TCR 1103.

Co-ordination of tachimetry and laser scanning was possible by means of seven flat cylindrical reflectors placed in the simulator's inside.



Conclusions

On the basis of this research, one may judge that break line may be quite precisely determined on the basis of laser scanning data. However, the accuracy of interpolation depends on:

- the intersection angle of two surfaces
- appropriate classification method for points which are used in interpolation
- appropriate filtering step to limit data redundancy and avoid misclassification errors

References

BORKOWSKI, A. (2004). *Modellierung von Oberflachen mit Diskontinuitaten*. Deutsche Geodätische Kommission, Reihe C, Heft Nr 575.

BORKOWSKI A., KELLER W. (2005). *Global and local method for tracking the intersection curve between two surfaces.* Journal of Geodesy vol. 79 pp. 1-10

Acknowledgements

The measurements for this paper were made at the Dresden University of Technology. The authors would like to thank Professor **Hans-Gerd Maas** and Mr **Danilo Schneider** from TUD for providing with laser scanner data and for support while taking measurements and data processing.