Training and Educational Aspects of Remote Sensing Image geometry

by

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Abstract:

This paper deals with education and training aspects in the field of remote sensing, emphasising image geometry.
The development of suited algorithms for GIS systems is still a real market gap. Therefore it is one intention of the study of remote sensing, to prepare for algorithm development and improvement.
In an introduction part a synoptic syllabus for Remote sensing is stated. A tutorial sequence of the paper summarises the reasons for proper geometric corrections of remote sensing imagery. This is followed by emphasising the educational value of heuristic polynomial equations, to introduce into the field of remote sensing image geometry. Finally samples for the education in improvement of algorithms are stated and it is introduced into training aspects of orthophoto generation. For a more sophisticated study of this matter, in paper No. 338 details are given.

Keywords: Education, GIS/LIS, Remote Sensing, Standards, Training

1. INTRODUCTION

Photogrammetry and Remote Sensing , are obligate subjects within the course of studies in geodesy on a University level at the University of Hannover (Germany). According to the syllabus of the University of Hannover the basic education in Photogrammetry consists of Definitions, Dataaquisition, Interpretation and Image measurements, Evaluation of Image points, Stereo plotting, Handling of Vector data (GIS-input), Image Rectification using analogue imagedata and raster data, Application of Photogrammetry , Terrestrial Photogrammetry and History of Photogrammetry.
The syllabus for Remote Sensing in particular deals with Quantum Physics of Radiation, Basic Matter Energy Relationship, Sensors, Platforms and Digital Image Processing. The content of the lessons and exercises in Digital Image processing are Radiometric Corrections, grey level Changes, Filters, Classifications and Geometry as a typical course of studies at the Institute for Photogrammetry and Engineering Surveys in Hannover.
This course includes Geometric Sensor Models., DTM Corrections, the principle of conventional aerial Photogrammetry to be modified for mechanical Scanners, for optoelectronical Scanners, and for radar, etc.

2. EDUCATION IN GEOMETRIC IMAGE PROCESSING

2.1 Teaching on reasons for geometric image correction

The tradition in Hannover emphasises the role of geometry for the practical application of remote sensing techniques.

The didactic concept is permanently adapted to practical requirements. It starts with pointing to the fact, the main reason for geometric image processing is, to derive geometric correct positions of the pixels, which contain surface related grey value information, in order to achieve a reliable geocoding of geometric distorted remote sensing image data for the correlation with GIS- or map-data.

Thus the full success of a remote sensing mapping campaign depends on the ability of a proper rectification of geometric distortions, in particular, to avoid misinterpretations due to mismatching within a GIS.

Main objectives in this context are the providings of suited algorithms and software, necessary to produce (digital) geometric corrected raster data of remote sensing imagery in view of

- GIS Integration
- mosaicing,
- sensor comparison,
- updating etc..

This task has been solved by the development and improvement of suited algorithms, which at least allow to calculate 3 dimensional and not only 2 dimensional ground control point coordinate information.

2.2 Leading to geometric approaches

The transformation of imagedata into a map or GIS-coordinate system is an interpolation problem .

The interpolation process can be based on

- ground control point- and/or texture information,
- housekeeping data (like airborne GPS etc.) and on
- combinations of both types of data.

Ground control point data is derived from known numeric coordinate values, from GPS, from maps and/or from imagecoordinates of corresponding points, which can be verified manually, but increasingly by interactive digital (relative and absolute) correlation techniques.

There are in principal 3 categories of algorithms to solve the geometric problems for remote sensing imagery:

- non-parametric interpolation methods
- (physical) parametric methods and
- combined approaches.

Non-parametric interpolation methods are namely

- polynomial equations,
- spline functions,
- interpolation in a stochastic field, like moving average, weighted mean, linear prediction etc..

For images of flat terrain 2 dimensional heuristic polynomial equations for limited areas and stable flight conditions for some cases already allow to obtain sufficient accuracies for geometric calculations.

The advantages of 2 dimensional polynomial equations beside others are

- the didactic value for introducing into digital geometric image processing,
- suitability for quick programming
- satisfying for limited areas of flat terrain
- support for approximate value determination
- support for blunder detection

Some disadvantages of 2 dimensional polynomials are

- arbitrariness
- limited area of validation
- a blockadjustment based on arbitrary polynomial equations of higher than first order shows an extreme bad error propagation.
- restriction for 2 dimensions.

2.3 Education in improvement of algorithms

GIS systems still lack suited algorithms for geometric as well as for radiometric manipulation of the data. The development of suited algorithms for GIS systems is still a real market gap. Therefore it is one intention of the courses of study of remote sensing at the University of Hannover, to prepare the students for algorithm development and improvement.

In this context the formulation of strict geometric algorithms for remote sensing imagery is a typical sample for algorithm development. From the basic idea a physical parametric solution is envisaged, which allows to calculate

- the global and local behaviour of the sensor position and attitudes,
- 3dimensional ground control point coordinates and
- computation of imagecoordinates for 3 dimensional output raster data (resampling).

Extended collinearity equations as derived by the authors (see Konecny, Schuhr, 1986) can be considered as universal projection equations, independent from the sensor.
Linearized collinearity equations allow to derive polynomial equations of equivalent content, which are valid under particular flight behaviour assumptions. The principal idea of this formulation of algorithms goes back to Baker (1975), who applied it on line scanner imagery, which has been extended into an universal approach to solve problems of image geometry for any remote sensing imagery. In addition this approach allows to calculate variations in the sensor behaviour, in particular by calculating for the "real flight path", as gained from housekeeping GPS and by additional parameters , to fit smoother to the ground control point field.
As compared to heuristic approaches, which are still in use even for very advanced image processing devices, arbitrariness is subdued and the 3rd dimension can be calculated. The polynomial approach as derived from equivalent collinearity equations, successfully has been applied for recent remote sensing campaigns.
To use the advantages of existing bundle block adjustment software for conventional photography, an approximate transformation of the remote sensing image geometry into the conventional image geometry and vice versa also successfully has been carried out by modifying the BINGO- program of the Institute for Photogrammetry of the University of Hannover.
In addition, the following method gives an example for a combined approach between parametric and non-parametric solutions: image coordinates for ground coordinates of particular points with known object coordinates , including output pixels (e.g., anchor points), can be calculated from known ground control points . Supposing, roll-, pitch- and yaw-values are neglect able and under the condition, the object coordinate system and the image coordinate system are in parallel, the valid equations become relatively simple. The results improve by applying this approach onto several ground control points. The deviations of the resulting image coordinate pair can be reduced by the weighted mean approach. To apply this method, a great amount of ground control points is needed, which can be determined by block adjustment etc..

3. INTRODUCTION OF DIGITAL ORTHOPHOTOS

For tasks, which require map accuracy, like
- GIS-input
- mosaicing,
- multisensor imagery and
- change detection etc.,

for hilly and mountainous terrain, a digital geometric pixel by pixel image restitution, including terrain height effects is needed.
To handle larger output blocks and to calculate for regional or even particular pixel wise terrain heights, a particular method for digital image rectification has been established, according to suggestions of Egels and Massou d'Autume of the IGN (France) and Konecny (1985):For minimum and for maximum terrain height the image coordinates of the output pixels continuously are determined by bilinear interpolation within the corresponding output pixel block defined by 4 corresponding anchor points. The proper imagecoordinates of the output pixels are calculated from linear interpolation in between the image coordinates, using the actual terrain-height as the argument for interpolation.
The orthophoto derived, may also be generated with a digitally determined coordinate grid, as well as edge or gradient enhancement procedures may be utilised to generate quasi line maps. In order to verify a reliable
geocoding of remote sensing imagery for, e.g., GIS-input, the digital data is transformed into the GIS-coordinate system, which includes absolute positioning, north orientation and a uniform scale. The DEM- influences are already rectified, as well as changes in attitudes.

4. REFERENCES

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