PROJECTION OF TOPOGRAPHIC DATA INTO REMOTE SENSING IMAGES

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Abstract.
This article describes a method to transform vector data into an airborne
scanning image. This method consists of a global affine transformation and
a local affine transformation. To perform the local transformation, the total
area is divided into triangles, formed of the available ground control points.
After checking the method on a Daedalus airborne scanning image, the result
after transformation reached a standard deviation of less than 2 pixels.

1. Introduction.

The classification of digital remote sensing images is usually done as a
classification of individual pixels. Each pixel obtains the label according
to its spectral signature. By linking up the image coordinate system and
terrain coordinate system the pixel label can be assigned to the corresponding
terrain location.

Linear and aerial terrain objects like railways, rivers, fields, lakes, etc.
can in general be identified as physical characteristics e.g. size and shape.
In remote sensing image they are represented by pixels having an equal
spectral signature. Image classification aims to identify such objects so
that the pixel labels refer to the object rather then to its terrain location.
When a remote sensing image is considered as one of the input sources to
geographical information systems, some information on terrain objects e.g.
size and shape is given by their boundaries. Remote sensing is then used
only to assign a label to these objects (e.g. vegetation type on a certain
field, soil cover index, etc.).
In such a case the available information (topography, soil, vegetation) should
be used. One way is to project the boundaries onto the remote sensing image.
Advantages of this approach are:
1. Information loss in the remote sensing image, due to pixel resampling
   after transformation, will not occur.
2. Only the digitised boundary points have to be transformed, instead of
   each pixel in the image.

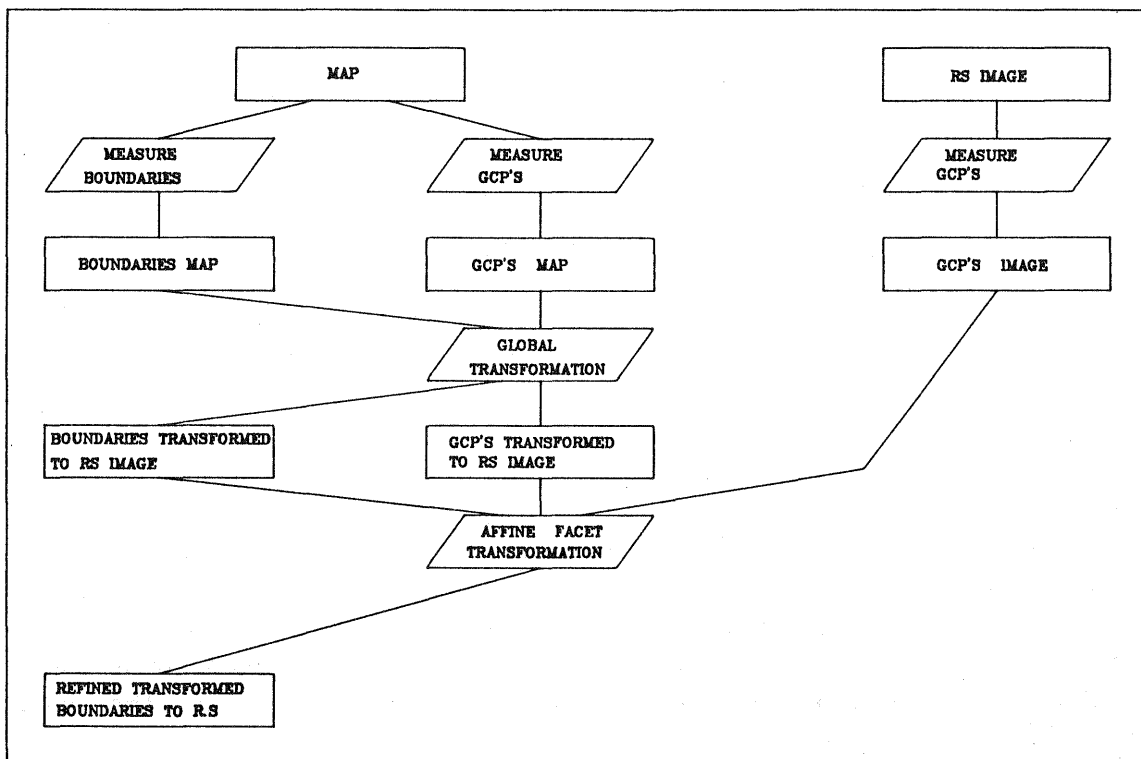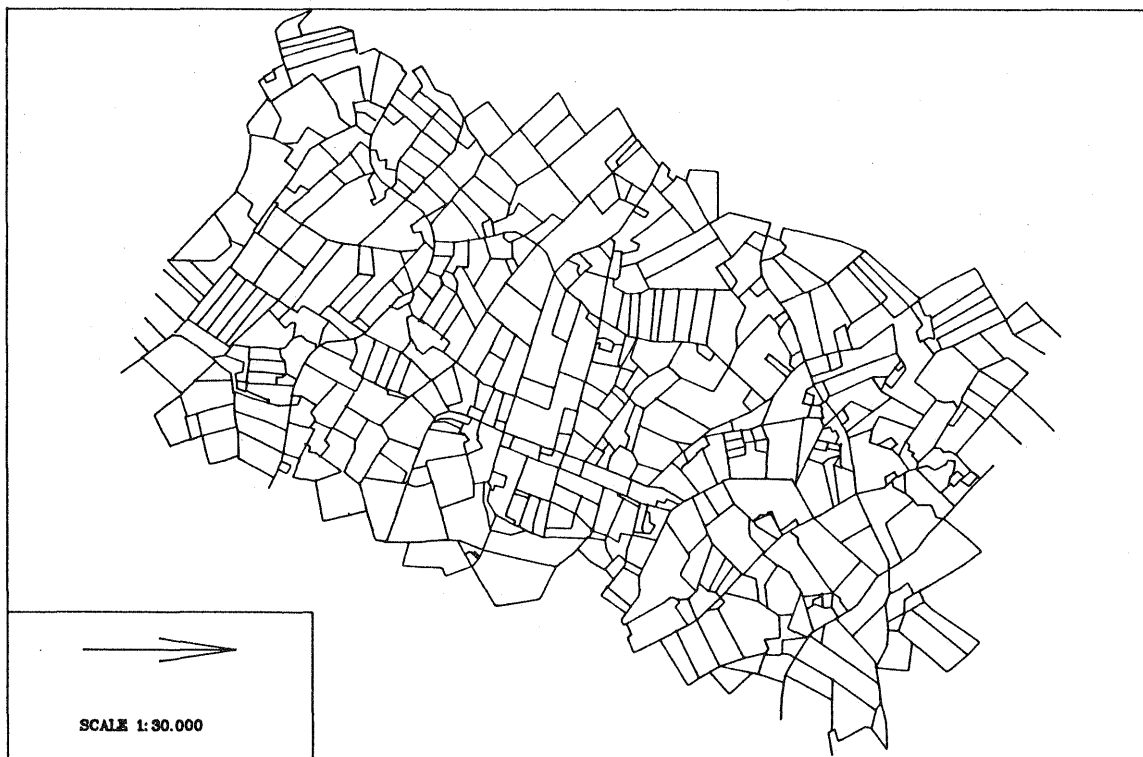Figure 1. Design of the procedure.

Figure 2. Test area.

Pixels inside the boundaries refer all to the same object and therefore are supposed to obtain equal labels. They can be classified as a group instead of being classified individually which may improve the reliability of the classification procedure. The label obtained from this procedure can then be assigned directly to the object instead of being assigned to the terrain coordinates.

For such an approach a good fit is required of the projected boundaries in the remote sensing image. This paper describes one of the possible procedures for the transformation of geometric topographic information onto a remote sensing image.

2. Design of the procedure.

Remote sensing images can be treated as a rectangular grid which geometry is defined by the geometry of the scanning system. Its relation to a reference terrain coordinate system depends on the behavior of the platform which carries the scanner-sensor system. It is assumed that the relation between the remote sensing image coordinate system and the terrain coordinate system can be described by a two-dimensional transformation.

As a first approximation an affine transformation is choosen to describe the relation between the reference coordinate system and the remote sensing image coordinate system. In order to obtain the influence of the optimal area size to be transformed, the affine transformation is applied to triangular segments of the image. Each segment is having its own transformation parameters.

The boundaries of the parcels, measured in the terrain (map) coordinate system, are transformed by the corresponding transformation parameters.

The triangular pattern within which the smallest coordinate differences between transformed and measured coordinates of boundary points are obtained will be representative for the type of terrain and type of remote sensing image choosen. The design of the procedure is given in figure 1.

3. Technical design.

The program, written for this purpose, is divided into four segments:
1. Calculation of the parameters for the global transformation.
2. Creation of the triangles.
3. Calculation of the parameters for the triangular transformation.
4. Transformation of the boundary points.

ad 1.
Before calculating the parameters for the global transformation, three ground control points are choosen. This is done in such a way that the three ground control points cover a great part of the area involved. In this step, the ground control points and the boundary points measured in the map are transformed.

ad 2.
The triangles are created in a way that when starting at a given base line, a third point is choosen with a maximum top angle. This approach is called the Delauney method (Koch, 1985).

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ad 3.

For each triangle created in step 3 the transformation parameters are
calculated.

ad 4.

Each boundary line consists of points. For each of these points the presence
in the triangular pattern has to be examined. If a point lays outside of any
triangle, a message will be written to the output file. If a point is within
one of the triangles, the transformation according to the belonging parameter
set will take place. The result is also written to the output file.

The program is developed at the Department of Surveying and Remote Sensing.
It was written in the Turbo Pascal programming language and realised on a
MS-DOS personal computer.

In- and output of the program is according to the standards of the Department
in order to use the digitising and plotting programs available at the
Department.

Figure 3. Triangular pattern with 59 triangles.

SCALE 1:30.000
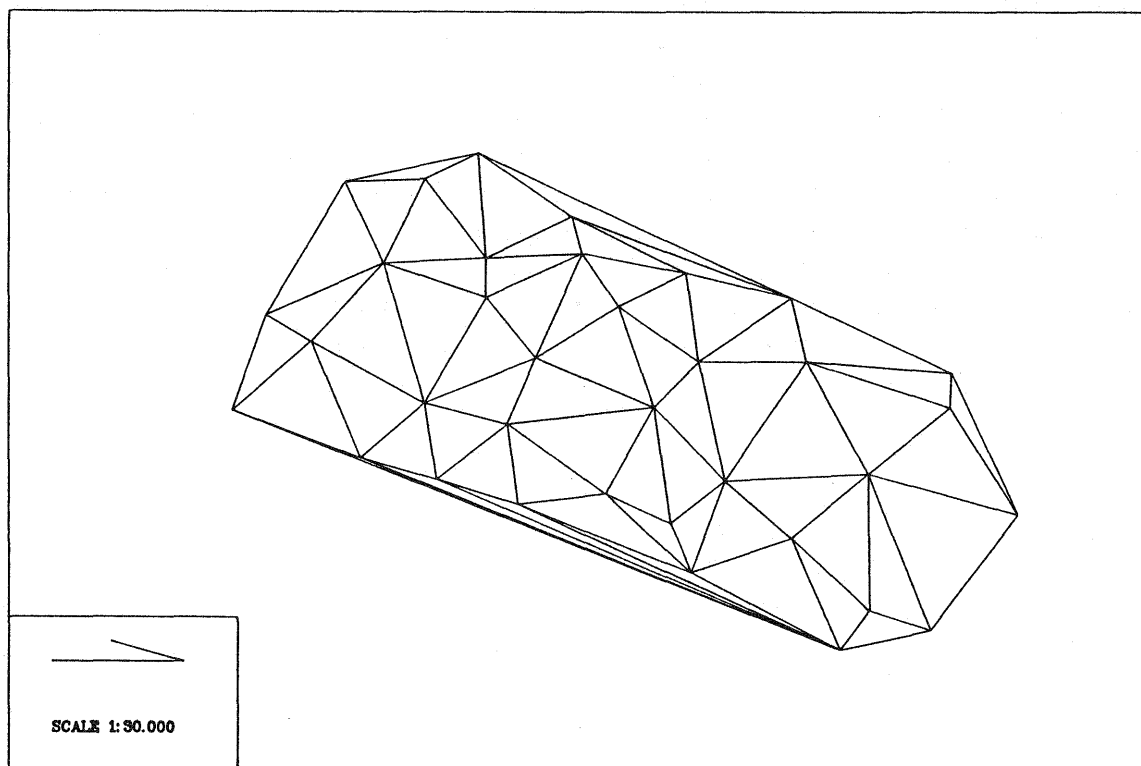
4. Test performance.

The designed procedure was tested on an area near Lichtenvoorde in The
Netherlands (see figure 2).

The data sources for the selection and measurements of the ground control
points were Daedalus airborne scanner data, recorded for the Oost-Gelderland
project (Project Team Remote Sensing Study Project, 1985), false colour
positives scale 1:8,000 and the topographic map scale 1:10,000. On the

selected agricultural area, covering about 600 ha of agricultural land, 77
transformation points were selected.
In order to obtain the terrain (map) coordinates, the transformation points
and boundaries were measured on the aerial photographs. They were transformed
into the map coordinate system by the MONOPLOT system, designed and
operationalised by the Department of Landsurveying and Remote Sensing
(Molenaar, 1987). The remote sensing image coordinates were obtained by
measuring the points on the screened image. Four different triangular patterns
for transformation were used, namely with 2, 23, 59 and 138 triangular
segments, created from the transformation points. Figure 3 shows the triangular
pattern with 59 triangle segments.
While executing the transformation for the boundary points, the location of
each boundary point within the triangular pattern was determined. The affine
transformation parameters, computed for each triangular segment were used to
transform the boundary points to the remote sensing image coordinate system.
The result of the transformation using 35 ground control points (59 triangles)
can be seen in figure 4.

Figure 4. Result of transformation using 59 triangles.
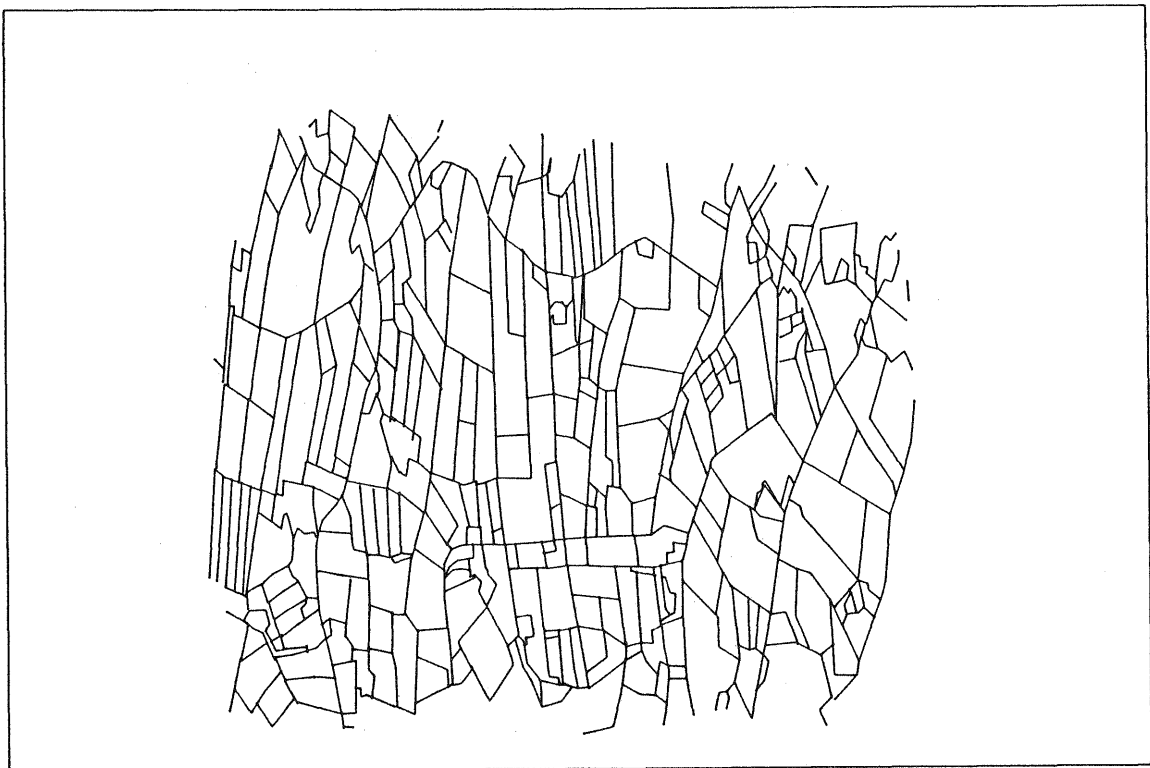
4. Results.

After comparison of the transformed boundary points with points measured on
the remote sensing image, one identification error was found. The transformed
boundary points were compared with the exact location of these points in the
remote sensing image, in order to analyse the accuracy of each of the

triangular pattern (2, 23, 59 and 138 triangles). The result of the analysis in terms of standard deviation is summarized in figure 5.
Taking into account that the accuracy in measurement of ground control points is about 1 pixel, a good result of transformation can be reached by using about 0.1 ground control point per ha for this kind of terrain and this kind of scanner.

Figure 5. Summarized results of transformation.
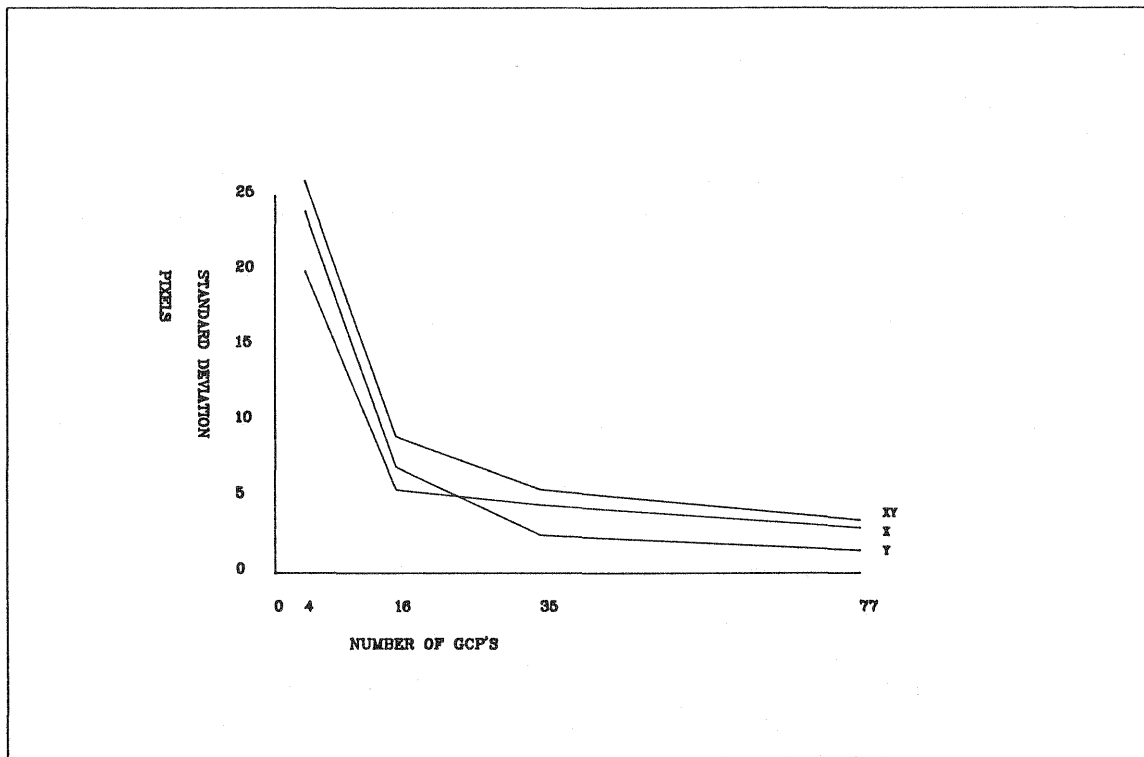
5. Conclusions.

The results show that the method of triangular transformation is very useful to integrate airborne scanning data into a geographical information system. However, the described method is only one step in realising this integration. Future research should concentrate on the other steps to reach the integration like the extraction of thematic information from the scanning image and the use of topographic data to optimise the classification of the scanning data.

Literature.

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