EXPERIMENTS WITH AUTOMATIC FEATURE ANALYSIS USING
MAPS AND IMAGES

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ABSTRACT

The automatic location of features in a digital image is feasible if the recognition is supported by a digital map data base. We have conducted experiments with part of a digital LANDSAT-image of southern Germany and a map data base established from topographic maps at scale 1 : 50 000. In the test scene 13 features were recognized and the resulting image rectification leaves residual point errors of less than $\pm$ 1 pixel.

ZUSAMMENFASSUNG

Die automatische Erkennung von Merkmalen nach ihrer Form in einem digitalen Bild ist möglich, wenn das Verfahren durch eine Kartendatenbank unterstützt wird. Wir haben mit einem Teil eines LANDSAT-Bildes aus Süddeutschland und einer Kartendatenbank Experimente durchgeführt, wobei die Kartendaten aus topographischen Karten 1 : 50 000 entnommen wurden. In dem Testbild wurden 13 Merkmale erkannt; die daraus ermittelte geometrische Entzerrung ergibt Restklaffen von im Mittel weniger als 1 Pixel.

1. INTRODUCTION

Analyses and applications of remote sensing imagery progress from mere reconnaissance to refined methods of monitoring with large quantities of data. We can observe this in the context of elaborate digital information systems (e. g. McDonald and Hall, 1978). This results in a requirement to incorporate available data – such as ground truth – from an investigated area in the image analysis, typically in the form of merging the ground truth with image data. Recently this has led to efforts to create combined data sets from images and digitized graphical data such as maps (Bryant and Zobrist, 1977, Flonzat et al., 1979).

However, while such recent efforts were done in an essentially manual way, there are concepts to automize the merging of image and map. Such concepts have been described by Sties et al. (1977), Barrow et al. (1977), Tenenbaum et al. (1978), Kahl (1978), and our own approach has been reported in two previous symposium papers (Kropatsch and Leberl, 1978; Leberl and Kropatsch, 1979). We are dealing here with an application of automatic photo-interpretation. This concept itself may be looked-upon with some pessimism, but we have evidence that in the current application automated image analysis may be sucessful.

The task of merging images and maps has been denoted by Barrow et al.(1977) with the name *map-guided automatic photo-interpretation.* There are three areas

of emphasis in this work:

- organisation of digital map data

- analysis of areal features

- analysis of linear features.

We have developed a cartographic data bank suitable for map guided image analysis (Kropatsch, 1980). Our main effort has been with satellite images where linear features generally are rare. Therefore results have been obtained with areal features mainly: we report in this paper on our progress with the automatic recognition of map features in a LANDSAT scene and use of these features for a geometric rectification. In this application we have thus developed an automated control-point or control feature identification technique.

2. DESCRIPTION OF THE PROCEDURE

A map data bank must be available for the task where relations among features must be incorporated. In our case this is a data bank whose structure is based on a planar graph (Kropatsch, 1980). We have to assume that an approximate relationship is known between map and the image. Therefore features in the map data bank can be sorted out which are covered by the image. The technique consists then of the recognition of these features in the image. This is performed in two steps:

(a) generation of a binary matrix which could represent the feature in the image

(b) verification that the pixel collection in the binary matrix indeed represents the feature.

Both steps (a) and (b) can use all the information from the map, like surface, type of material, shape, location etc.

The features from the image could serve a variety of purposes, namely as training areas for a classification, as a reference for change detection, as control for geometric or radiometric rectification etc.

The map data bank must enable one to sort features according to geometric location and properties. One needs to extract feature contours, or skeletons of linear objects, from data bank and to construct a synthetic image in a raster format from the graphical data. This synthetic image serves as a guide to collect those image pixels that belong to the feature.

The collection of pixels of a feature can follow along many different lines. One can think here of techniques which select a certain number of pixels from the image according to location, neighbourhood and gray value. If an image has been pre-processed, then one can incorporate texture or location of a pixel in an n-dimensional feature space. As one example we mention the creation of a binary image after a threshold to collect pixels with a specific gray tone; this can then be followed by a noise cleaning routine deleting pixels not within the neighbourhood of a promising accumulation of pixels.

In the event that linear features such as roads or just the contours of an areal object are used, one arrives at techniques similar to those investigated by Nack (1975) and others. Essentially this leads to a shift of a mask over the image to measure correlation or similarity. Numerous techniques are feasible,

but conceptually one is dealing with the correlation of the actual image with a synthetic derivative of a map segment, where all the experiences from image correlation (Anuta, 1970) of from sequential similarity detection (Barnea and Silverman, 1972) can be employed.

Verification of the previous pixel collection can be the independent repetition of feature recognition with another technique and checking of certain feature properties such as surface or shape.

3. CURRENT RESULTS

The current status of the project permits to demonstrate the overall procedure, where however no optimum techniques have yet been defined and experiences are still being acquired. Figure 1 shows a portion from a map data bank. The area is also covered by a LANDSAT-image. Indicated in Figure 1 are 13 features that were successfully recognized in an automatic procedure. The features are of different size, texture and gray tone. There are villages (WA-SEE-ORT, Schledorf), there is an island, a forest (Karpfau), grassland (Jochberg, Sachenbach, Wasuedufer, Wasuedufer 2, Wasuedufer 3, Kochelnord) and water bodies (Walchensee, Kochelsee, Karpfsee).
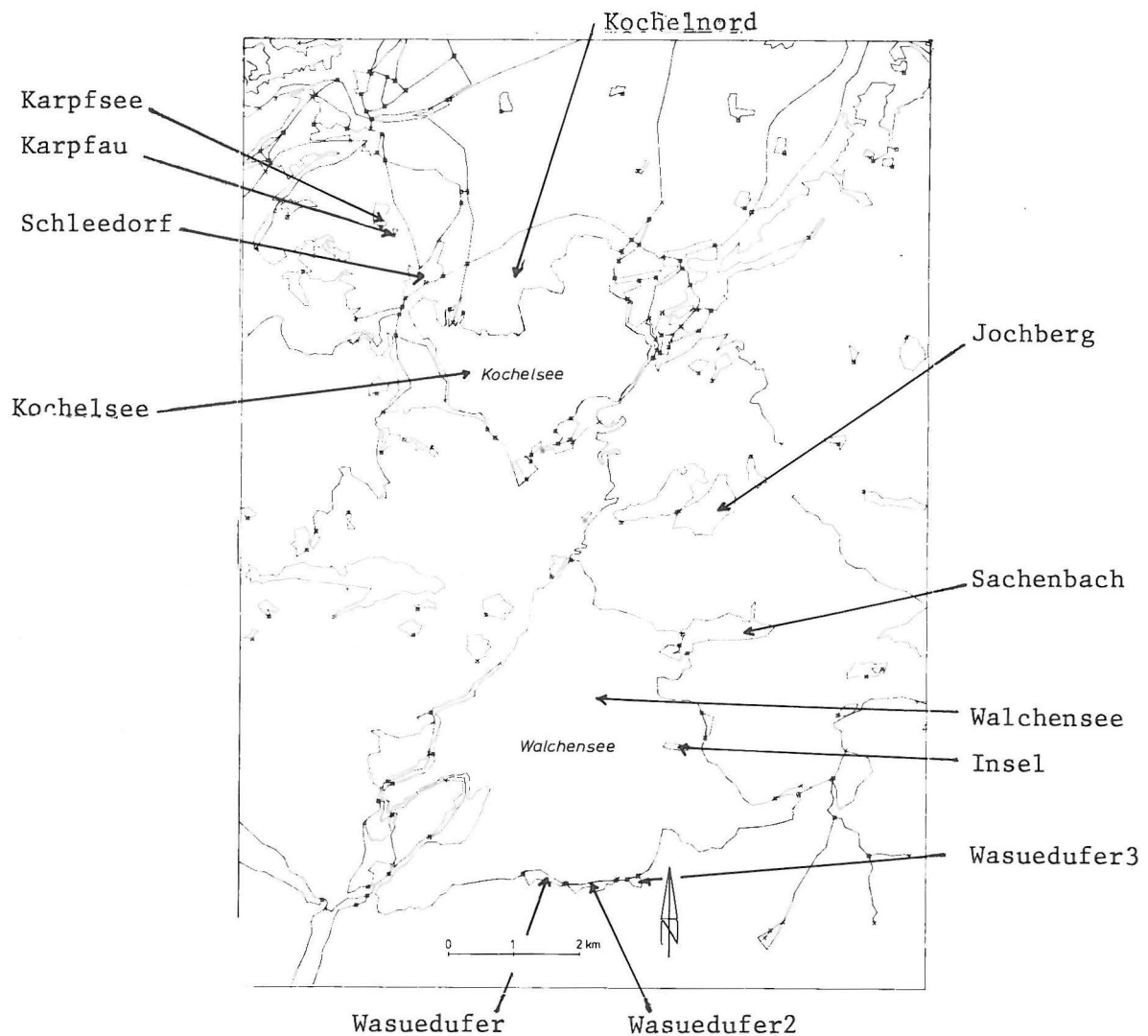

Figure 1: Plot of part of the digital map data bank for the test area in Southern Germany. The indicated features were used in the test of the procedure.
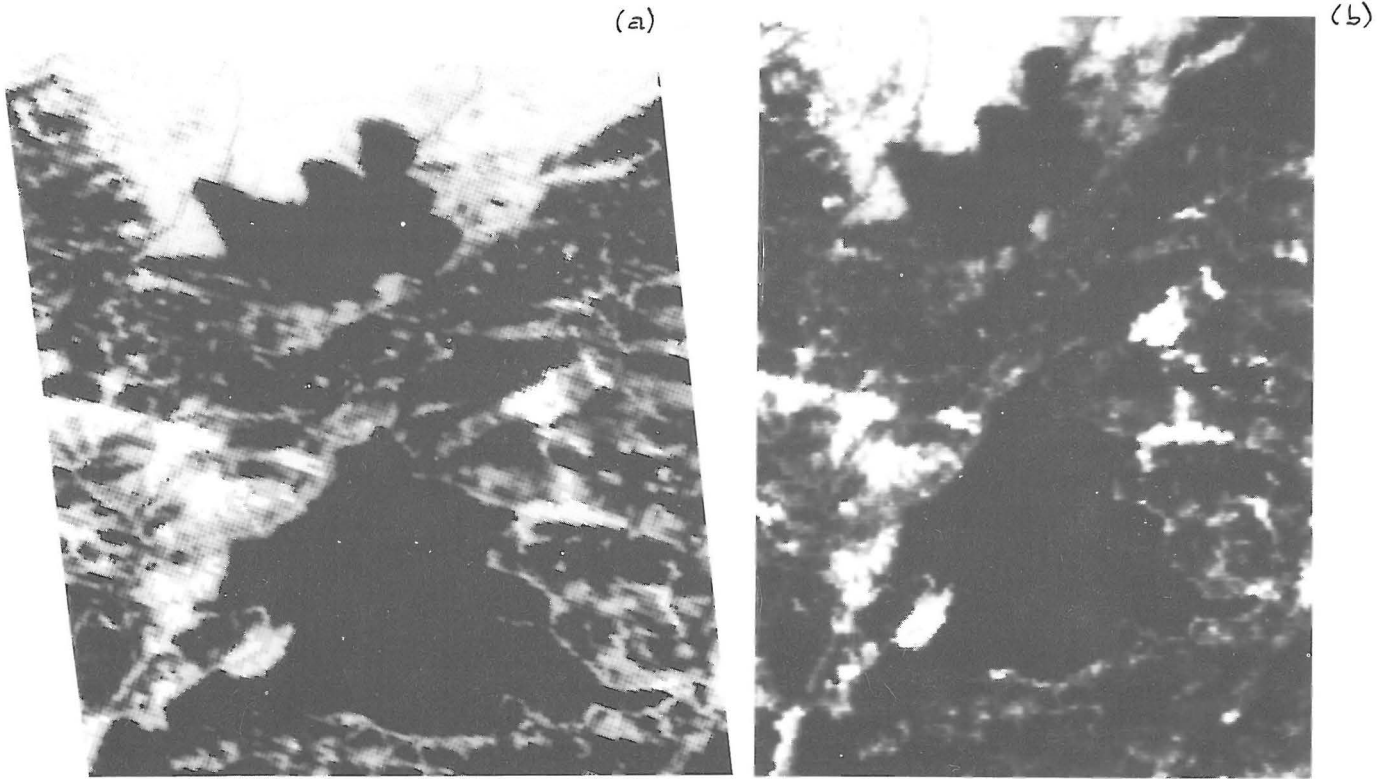
453.

Figure 2: LANDSAT-scene from Southern Germany, with raw version in (a) and rectified image in (b), using 13 features.
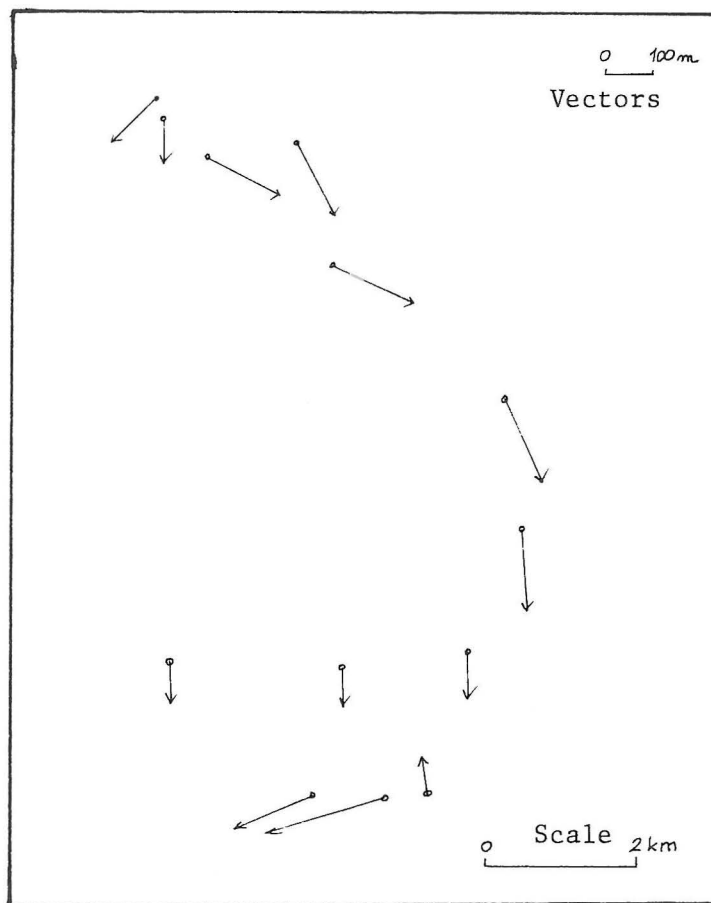

Figure 3: Deformation vectors as obtained from the recognised 13 features. After correction of these deformations, the image is rctified as in Figure 2(b).

The indicated feature names are used in the data bank to identify the features. These names are acquired during digitisation. A data bank user can obtain information about a feature by interaction with the computer via the name of the feature.

An approximate geometric relationship must be established prior to the automated recognition process. The map data are therefore projected into the image with an approximate a-priori 6-parameter transformation. This approximation may, for example, derive from the satellite orbit data. Then the recognition procedures begin.

All indicated features of Figure 1 have been treated with the same recognition procedure in an effort to test the overall concept. This particular recognition is based on the similarity detection according to Barnea and Silverman (1972).

For this purpose each considered map feature is converted from a polygon format into a binary matrix or image and is used as a mask to detect the homologous image feature. The 13 features served to compute centres of gravity. This leads then to a set of control points for a rectification. Figures 2 a, b present the result of the rectification, while Figure 3 illustrates the image deformations encountered in the approximately transformed 13 features.

This result is a first fully automatic run through the entire procedure. We have not yet optimised the type of recognition and verification routines for various types of features, and have not yet implemented pre-processing techniques. However, the purpose of the test was a demonstration of the overall flow of computation and automated processing. We have already applied other recognition procedures to certain features (compare Leberl and Kropatsch, 1979), but at the present time have insufficient results to draw definitive conclusions on the applicability of certain techniques to given feature types. But it is obvious that significant differences will exist in results depending on procedures and features.

4. OUTLOOK

There is hardly a limit to the variety of pattern recognition techniques that can be implemented in the framework of the proposed procedure. We have only begun to develop this concept and have been encouraged by our early results - in the example presented here, 13 features were used to rectify a LANDSAT-image with residuals of less than 1 pixel. The relational map data bank has been found useful in its current organisation. The fact that the data bank of Sties et al. (1977) has a similar relational structure has been encouraging and points to the applicability of this approach.

Our next steps will be to broaden the spectrum of experiences to include more and other types of data and various recognition methods. Satellite images of a mountainous area must be treated differently from an image with large agricultural pattern or dominating drainage features. Similarly a larger scale aerial image will exhibit a much more significant percentage of linear features as a result of human activities.

Apart from widening the scope of image data we are considering the incorporation at a later stage of topographic height data into the process. This will open up a spectrum of techniques involving height relief and non-natural images as obtained from shaded relief maps (Horn and Bachmann, 1978).

The map-guided image analysis is a logical step further from reconnaissance type, smale scale mapping with remote sensing imagery. Complete automation may be difficult to achieve, but there is confidence that the procedures under development will be helpful in an interactive mode to support the human manual routine analysis of large quantities of remote sensing image data.

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