METHODS AND POSSIBILITIES OF REMOTE SENSING IN COASTAL AREAS

by

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1. Introduction

In the area of remote sensing and digital image processing in the Special Research Centre "Vermessungs- und Fernerkundungsverfahren and Küsten und Meeren" three projects with different tasks work on the evaluation of digital image data taken by sensors from satellites and planes as well as by an active ultasonic underwater system called SONAR. The aim is to process geometric rectificated topographic and thematic maps on the basis of these multispectral and multisensoral digital images in coastal areas. Only the processing of the monospectral SONAR-images deals with interferometric methods, which allow the determination of three-dimentional space coordinates from two-dimentional image coordinates from a single image with respect to a physical effect.

2. Interferometric Side - Scan - Sonar

Side-Scan-Sonar is an active and dynamic imaging system working under sea surface. Acoustic signals of high ferquency are transmitted by a transducer array mounted in a towed equipment. The beam pattern is vertically wide open and horizontal narrow bound, so that sound is only reflected from a small bottom strip. Each transmitted and received soundwave generates an image line on a special recorder due to different target ranges and echo intensities. This process is repeated as the tow fish proceeds, and an image from the sea bottom is built up line by line. However, it is not posible to reconstruct the topographic information of the bottom from stereoskopic image strips because of relative destortions in the image.
The determination of the depth information can be done by using SONAR-images with interferometric information in overlay. The so-called Lloyd-Mirror fringes are produced by phase interference of coherent signals from two sound waves, which are working in exact the same plane. If these two signals reaching a target point are in phase the echo getsreinforced otherwise it is extinguished. These situation depends on the path difference of the two signals and by that a geometic connection is given between water depth and interferometric pattern in the image.
Based on this fundamentals an new tow-fish model was built, which carries two transducers on one transmitting side. This system allows the artificial processing and recording of interferometric Sonar images.
The image data and in addition the outer orientation parameters are recorded on video-tape and are digitized for following digital image processing procedures.
First the images must be pre-processed to seperate the very high noise from the interference information. Simple line following procedures then lead to the image coordinates of the pattern. They are used as input in special software programs, which werde developped with respect to the geometric imaging model. This software takes the positioning and rotation parameters of the sensor into account. As result one gets a lot of space coordinates, which can be used for the interpolation of an Digatal Terrain Model with following automatically depth line plotting. On the other hand it is possible to use these coordinates as pass-points for the differential rectification of the synchroneous recorded standard SONAR-image to an orthophoto from the sea bottom.

3. Classification of Multitemporal data with additional Information

There exists principally two different ways of evaluating inages of the same region, acquired at different dates:

1. Each of the scenes is processed and interpreted separately at first. Afterwards the particular results are combined, for example by intersection, that means, the pattern vector is assigned to a class if and only if it belongs to this class for each sin-gle classification. By this method the number of uncertain or wrongly classified pixels shall be decreased.
2. Another way of combining K scenes of different dates is to consider the K·n spectral spectral bands as a single merged K·n dimentional scene. If the K scenes are images of the same sensor, one obtains normally redundance of some spectral bands. But even if the single scenes are images of different sensors, statistical analysis for dimentionality reduction is necessary.

Training areas have to be selected in the merged scene. If one has executed at first classification of each scene seperately, then the training areas for classification of the merged frame should be statisically best of all areas available from the single classifications. The classes to be discriminated do not have to be present in each scene: for example, in a frame merged of scenes from different seasons, one can classify vegetations, which are not present in each of the single scenes.
Geometrical preprocessing is necessary for both of the described methods. The method described first has the advantage that the training areas can be optimally determined for each scene. This is especially important if the multitemporal data are recorded at very large time intervals, so that one has to exspect geographical changes. On the other hand such changes can cause the percentage of unclassified pixels to become very high. The algorithm makes no difference between pixels which cannot be classified because they belong to different classes (that means real changes) and those pixels, which are rejected as not belonging to any of the classes due to another cause. In tidal areas changes happen in relatively small time intervals, for example the shape of a tidal run-off feature can shift up to 20 cm in position within one year. Thus the second method seems to be more appropriate for tidal lands classifications.
Another way of increasing information for discrimination of the classes is to introduce additional informations into the classification procedure. There exist two principally different methods: First one can use additional information to support the selection of training areas. This additional information information may, for example, be a thematic map or an aerial photograph. Second, the additional information can be introduced by using it as (n+1)th channel for classification. For this purpose it must be presented digitally in form of a picture. If the information exists only at discrete points it must be extended to all pixels of the scene to be classified.

4. Digital Rectification by Means of Correlation Techniques

Multisensoral image processing in remote sensing requires pixel-wise geometrical identity of images from different sensors and platforms. Therefore rectfication of remote sensing imagery is necessary either on a reference map or on the geometry of a reference picture. Rectification parameters can be derived from identical control points in different images. For this purpose at the Institute for Photogrammetry of Hannover University a software system for automatic controll point detection has been developped. This Digital Interactive Software Correlation system for image Rectification is operating by means of generalized correlation functions.
For various purposes common processing of hetergeneous remote sensing images is

desirable. Multisensoral and - temporal evaluation can increase classification accuracy, is necessary for detection of environmental changes in terrains of bad access and can serve as basis for map production. For this aims identical image geometry is required. This hold especially true for the "integrated digital data base systems" combining remote sensing images, thematic and physical digital maps and statistical data as ecological and economic planning base.
But the dissimilar recording techniques and the different recording platforms - varying in heigth and movement - generate remote sensing data with unequal image geometries. Therefore they must be rectified on a common geometric base for mutual evaluation.
Picture rectification requires the knowledge of identical points in different images of the same area. The determined geometric transformations between these "control points" allow the estimation of final rectification parameters according to the applied mathematical model. But the more important part of the system consists of the automatic identification of these control points in the search image which is to be rectified. This is done by similarity or generalized correlation methods. For this process 5 different objective functions can be applied:

1. The "normal" product moment correlation coefficient
2. The correlation intensity that has been derived from coherent optical considerations. The image signals are mapped on the complex plane and the intensity of the complex correlation function is weighted by the local variances around the control points.
3. The correlation intensity coefficient (like 2) weighted by the global image variances.
4. The Laplace coefficient, i.e. the summarized absolute differences of the image signals.
5. The phase correlation coefficient, i.e. the inverse Fourier transform of the normalized cross spectrum of the image signals.

The probabilitiy of these functions have been tested in Hanover with different sensor combinations.

5. Thermal Mapping

By use of thermal imagery it is possible to detect and map the surface temperature distribution of water areas synoptically. A prerequisite for quantitative application of thermal data is that accurate surface temperature values may be derived from the imagery. The airborne measured temperatures have errors due to atmospheric effects. An attempt has been made to account for these errors by different ways. The first approach consisted in a direct minimization of the temperature differences of remote sensed and directly measured temperatures by a quadratic polynomial. The obtained accuracies (± 0.2 - 0.3 K) show a very good result but have the disadvantage of a tremendous amount of logistics (boatmeasurements). Because of that another way of calculating for the absorption and emission of the atmosphere as well as the reflection of the sky radiance at the surface as a function of the amount of water vapour was used. The corrections were calculated by using the data of the vertical distribution of temperature and humidity as measured by a radiosonde. With thjs method it is possible to get an accuracy of ± 0.1 - 0.2 K of the remote sensed temperatures. With an accuracy of that order it is possible to monitor the discharge of power plant or any other nature in a quantitative way.

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