

Research on Topographic Map Updating

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Abstract

The investigation of interpretability of panchromatic satellite image IRS-1C integrated with multispectral Landsat TM image with the purpose of updating the topographic map sheet at the scale of 1:25 000 has been described. The geocoding of source map was based on trigonometric points of the map sheet. Satellite images were geocoded using control points selected from the map. The contents of map have been vectorized and topographic database designed. The digital image processing improved the interpretability of images. Then, the vectorization of new contents was made. The change detection of the forest and water area was defined by using unsupervised classification of spatial and spectral merged images. Verification of the results was made using corresponding aerial photographs. Although this methodology could not insure the complete updating of topographic map at the scale of 1:25 000, the database has been updated with huge amount of data. Erdas Imagine 8.3 software was used.

1. Introduction

The system of satellite data gathering about the earth's surface, as one of the remote sensing branches, has become in the recent decades an inevitable area in solving various professional and scientific problems arising from the research of the Earth.

Referring to the obsolescence of topographic map contents of the Republic of Croatia being even more than 25 years old for some areas, the basic idea of this work is to present the interpretability of satellite images to be used in topographic map updating. There has been chosen the area of the topographic map sheet at the scale of 1:25 000 and made in 1975. The fundamental source of the new content were the panchromatic satellite image IRS-1C from 1997 with the spatial resolution of 5.8 m and the multispectral image Landsat TM from 1994. The source has been geocoded, the original images have been spatially and spectrally merged, the map contents have been vectorized and the database created, the interpretation and classification of satellite images have been done in order to detect the changes, and the new state has been vectorized, i.e. the database updated, and finally the digital cartographic presentation carried out. The software ERDAS IMAGINE 8.3 has been used for that purpose.

2. Methodology

2.1. Geocoding

The original topographic map sheet TK25 Osijek(326)-4-3 has been scanned with the resolution of 600 dpi. Before geocoding the resolution has been reduced to 400 dpi because of an extensive data amount. The procedure of geocoding the topographic map sheet has been carried out on the basis of trigonometric points as control points.

Table 1. Cartographic demands (Francula et al., 1994)

Positional accuracy	
scale	± 0.2 mm at the scale
1:25000	± 5 m
1:50000	± 10 m
Ability of details to be recognised	
buildings in a city	2 m
paths	2 m
subordinate roads	5 m
small streams	5 m
main roads	10 m
building blocks	10 m

In order to make it possible for satellite image to be used in the production or updating of maps, it is also indispensable to geocode them, i.e. to restructure the image elements so that they are in accordance with the position in a specific map projection. There are parameter and non-parameter transformations used for the transformation of points between map projection and satellite image, depending on whether the sensor parameters are determined in the transformation procedure or not. The most frequent solution is the non-parameter transformation applying polynomials. The rectification is carried out without applying digital height model since it was the issue of plane area, and in this case the remaining errors can be neglected.

Table 1 gives the cartographic demands on positional accuracy, as well as the ability of details to be recognised in the estimation of the extent to which the measured data obtained by satellites are adequate for the production or updating of topographic maps.

2.2. Digitalization and database

The transformation of analogous sources into digital vector format is carried out by means of vectorization. Geocoded topographic map TK25 – Osijek(326)-4-3 is vectorized manually. According to the conceptual project STOKIS (Paj, 1995), the topographic objects are classified into object classes according to their characteristics and then further organised into object groups, and object groups into object entities. Thus, the vector data making a digital topographic model, saved as points, lines or polygons, systematically (thematically and according to the presentation manner) are organised into spatial layers, i.e. object entities. The object groups within larger object entities are designed on the basis of TK25 and by means of the collection of topographic symbols so that they can be identified on a map. The system of codes and additional attributes (descriptions, names and similar) are attached to the topographic contents for each object entity, groups and the object itself.

2.3. Digital image processing

Many techniques of image processing and analysis have been developed for the purpose of interpreting and obtaining as much information as possible from the images gathered by means of remote sensing. The selection of specific techniques or algorithms depends on the purpose of each individual project.

2.3.1. Resolution merge

The image Landsat TM with seven spectral channels and spatial resolution of 30 m was merged with the panchromatic image of high spatial resolution. The merging has been carried out according to the principal components method. Such a combination provides the best characteristics of both sensors resulting multispectral data of high resolution. These data are expected to yield better interpretation of linear and polygon objects being of interest for cartographic application.

2.3.2. Image enhancement

Filters are usually used for correction and renewal of images damaged by bad functioning of a system, for image enhancement for the purpose of visual interpretation and recognition of characteristics. In all spatial enhancement procedures, the purpose is to create a new image from the source image data with increased information quantity that can be visually interpreted (Javorovic, 1994). Techniques of spatial enhancement modify the values of pixel based on grey values of the surrounding pixels. They change the characteristics of spatial image frequencies by averaging the grey value within the defined window around the pixel that needs to be modified.

In order to have the image IRC-1C better interpreted, the “high-boost” filter or the filter with emphasised high frequencies (Viher, 1998), has been used here. This filter is applied when one wants to emphasise local change in a small environment of pixels, i.e. in the cases when one wants to detect and locate small objects and details on objects that possess very weak, but sudden change of intensity.

2.3.3. Image interpretation

Referring to the complexity of digital image data, the approach to their interpretation and analysis is very distinctive. Their basic division refers to visual and computer aided interpretation. Visual interpretation is significant in obtaining potential information that is saved in remote sensing data on the basis of human observation. The advantage of such (human) interpretation is the ability of recognising a context, texture and shape on the image. With the help of aerial photographs and on the basis of spectrally merged and filtered images the line objects have been visually interpreted and vectorized (traffic routes and water bodies being line objects in cartographic presentations).

The settlements can be digitized as points or as polygons. The image resolution leads us to the presentation of settlements as polygons so that a group of houses is turned into block by means of subjective generalisation. Such polygon presentation of settlements is not adequate to the presentation of settlements on the topographic map at the scale of 1:25 000. Since the possibilities of updating the map in the above mentioned scale are being examined, we come to the conclusion that the stated image cannot be used for mapping the settlements at the scale of 1:25 000.

The detection of polygon objects, water bodies and vegetation has been left to the process of classification.

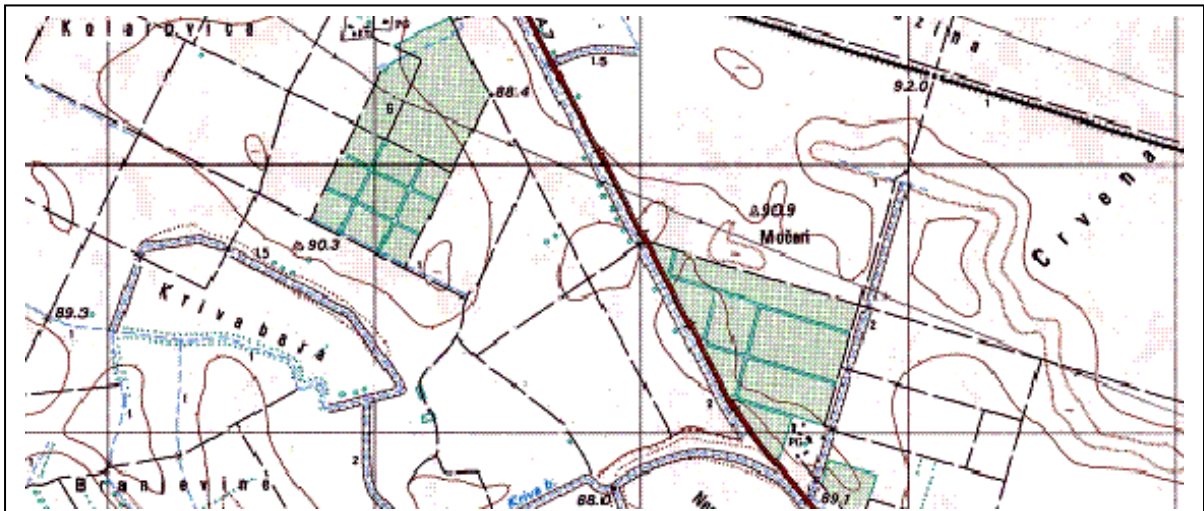


Fig. 1. Part cut out from a source map

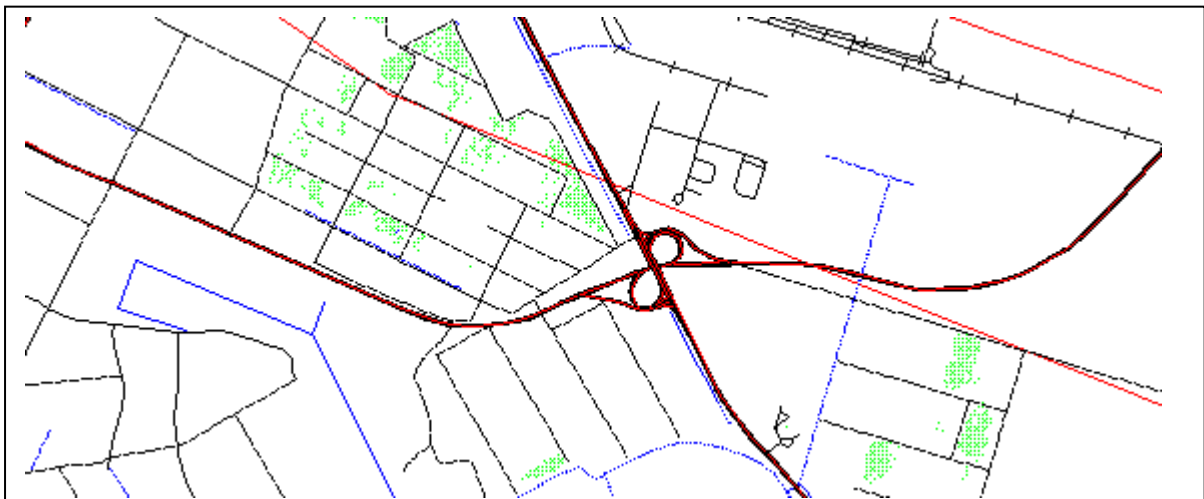


Fig. 2. Part cut out of the same area with supplemented new contents

2.3.4 Classification

The goal of classification is to replace the visual analysis of image data by the methods for automating the scene characteristic identification. This includes the analysis of multispectral image data and the application of statistically based rules for the determination of land coverage identity for each scene pixel. The pixels are appointed to the classes. These classes can be connected with known characteristics of the terrain or they can only present the areas that look different to the computer algorithm.

For the classification of the merged multispectral image in the combination of panchromatic IRS-1C and multispectral Landsat TM intended for obtaining the data about vegetation there has been a repeated unsupervised classification applied. In the first iteration

of ISODATA algorithm, the class means can be determined arbitrarily. After each iteration there is a new mean computed based on actual spectral locations of pixels in the group. These new means are then used for defining the groups of the next iteration. The process is continued up to minimum change among iterations (ERDAS, 1997).

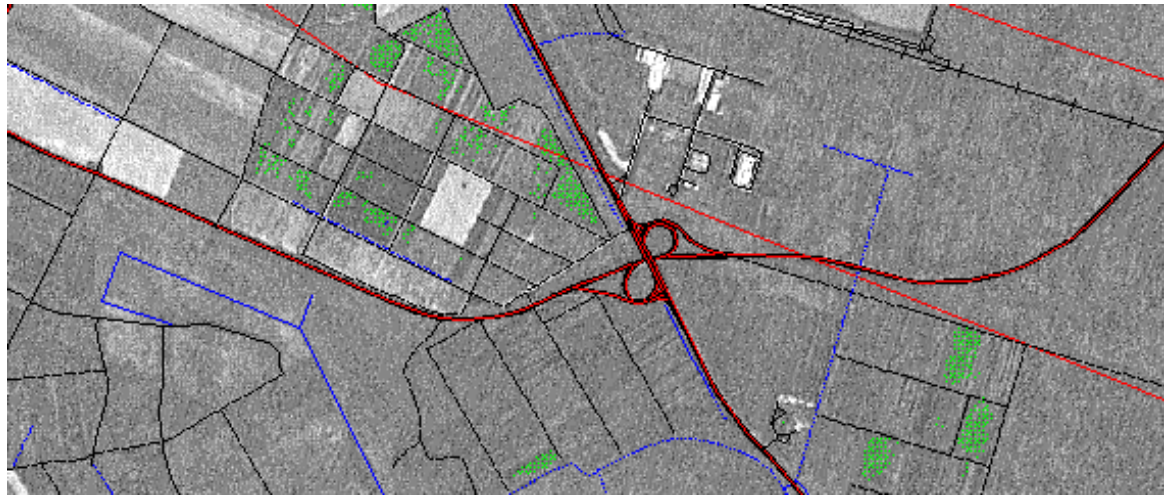


Fig. 3. Satellite image with the presentation of new map contents

The contents of the map sheet Osijek(326)-4-3 was very demanding for the classification analysis. The most of the sheet is covered by the areas of the Nature Park *Kopacki rit*, rich in biotic and hydrological structure. For cartographic purposes it was necessary to separate the marshland from forests and water bodies. In the classification there have been all spectral channels applied except the thermal one. After the initial unsupervised classification has been carried out, the potential forest classes have been separated from the set of 25 classes. On thus separated area, and on the basis of new spectral properties of the selected forest area, there have been two forest classes defined that are introduced into the unsupervised classification separating ten new classes. Those classes that do not represent a forest have been abandoned, and the accuracy estimation for the other classes has been carried out running up to 87.5%. Three classes have been separated with their accuracy being unsatisfactory, and the area under these classes has undergone one more unsupervised classification. After selecting the classes, the accuracy of classification runs up to 91.1%. The references for determining the accuracy of classes have been the satellite image IRS-1C enhanced by means of a filter and aerial photographs.

The area of “clean” water has been separated by the unsupervised classification as well. The marshland is classified by a few classes, and on the basis of an image being a summer image in this case, with a lot of vegetation and obviously longer dry period, it was not possible to define it with certainty. Similarly, the polygons of water bodies cannot be defined on this image in a satisfactory manner.

3. Conclusions

On the basis of the research carried out about cartographic potential of panchromatic satellite image IRS-1C in combination with Landsat TM image used for updating the map at the scale of 1:25 000 we come to the following conclusions:

- The majority of linear objects on maps at this scale can be identified again on the stated images. Worse paths cannot be completely identified, and pedestrian pavements and streams are impossible to be detected on the image of this resolution.
- New line objects of the object group presenting road traffic up to the category of worse paths are easily identified (Fig. 1-3). Traffic, transport and communication objects cannot be identified.
- The afore-mentioned image cannot be used for mapping the settlements at the scale of 1:25 000. Larger public and industrial surfaces can be identified.
- Polygon objects of vegetation and water bodies are determined by means of classification. Forests and clean water are easily identified. The marshland is defined by several classes, and on the basis of one image taken during the extensive vegetation and longer dry period it is impossible to identify it with certainty. It is recommended for such marshland to use images from various seasons in order to define the presence of water more accurately and to produce a *dynamic map*, or the map of changes. In order to obtain more accurate classification it would be necessary to have more verification in the field and to combine information.

Although the updating of topographic maps at the scale of 1:25 000 is not provided fully by the above stated methodology, the database was supplemented with a great quantity of data that can be further enriched by the usage of aerial photographs or satellite images of better resolution. Moreover, the database can be generalised and used for the production of a topographic map at some smaller scale than 1:25 000.

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