The Second International Conference "Problems of Cybernetics and Informatics"
September 10-12, 2008, Baku, Azerbaijan. Section #2 "Intellectual Systems"
www.pci2008.science.az/2/01.pdf

TECHNOLOGIES FOR INTERPRETATION OF REMOTE SENSING IMAGES AND DIGITAL MAPS AND THEIR USAGE FOR APPLIED TASKS

Sergey Ablameyko[1], Alexander Kryuchkov[2], Sergey Zolotoy[3]

[1,2]United Institute of Informatics Problems, National Academy of Sciences,Minsk, Belarus
abl@newman.bas-net.by

[3]Enterprise "Geoinformation systems", National Academy of Sciences, Minsk, Belarus
zolotoy@itk2.bas-net.by

1. INTRODUCTION

During last five years, Belarusian space system is created that includes space and ground segments. It was made the first attempt to launch Belarusian satellite in 2006 but unfortunately it was not successful. At present, the second satellite is in the process of construction. Simultaneously, the ground segment is developed that includes several information receiving stations at various ministries.

Aim of this paper is to show how Belarusian space system is developed. Mainly, we will concentrate at ground segment and remote sensing data processing technologies.

One of the most important channels in updating digital maps is remote sensing images obtained from a satellite. Images can be efficiently used to update a digital map, i.e. to introduce new objects from image that are absent in digital map or to modify existed in map objects.

However, to be used for this task, remote sensing images (RSI) first should be transformed in a map projection and scale, i.e. matching of remote sensing images with digital maps (DM) should be performed. In spite of quite many papers published on his topic, there are still many problems with accuracy of matching and convenient user-friendly tools for object extraction from RSI and map updating. Matched remote sensing images are used to update digital maps to solve applied tasks.

2. MAP AND IMAGE REPRESENTATION

Digital map consists of map objects that are stored in vector form. Every object five main parameters: type, name, geometry, semantics and links with other objects.

Object type is defined from its classificator category. Name is an identificator allowing to define object in database. The geometry (object coordinates) is determined from the object's position on the image and will be different for different object types. Line objects are represented by their skeletons, symbols - by one or two points, and regions - by their contours. Semantics reflect some of the characteristics (geometric, constructive, and others) of the real terrain object by an appropriate graphical pattern on the map. Object links show its connections with other map objects. For every object in map this information should be defined.

Remote sensing image is represented as standard gray-scale image in raster format.

3. MAP UPDATING PROCEDURE

The main stages of the developed procedure of DM updating by RSI are the following:

1) Image quality enhancement. If necessary shift, rotation and other transformations can be performed. It is performed with help of automatic image processing tools.

2) Indication of reference points by interactive tools. The operator uses mouse to single out the corresponding reference points on two images, which are marked for the visual control. Image and map of the same area are extracted and displayed simultaneously (Fig.1). As reference points,

some well defined objects are chosen (road intersection, heights, etc.). Reference points can be seen in Fig.1.

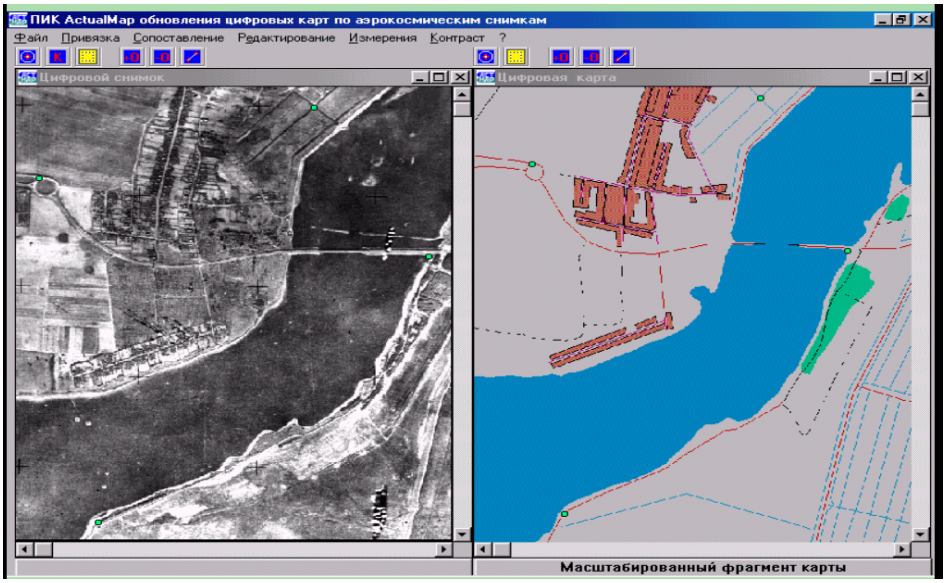

Fig.1. RSI and digital map for the same territory

3) Image transformation in Gauss-Kruger projection by using elements of internal and external orientation. Geometric and photometric distortions are reduced simultaneously. This is done by automatic tools. In the result, reference points are identified as well as their coordinates.

4) Extraction of image fragment with desired objects that have to be modified. For the comparison and visual evaluation of further results, image is superimposed on the map (Fig.2).

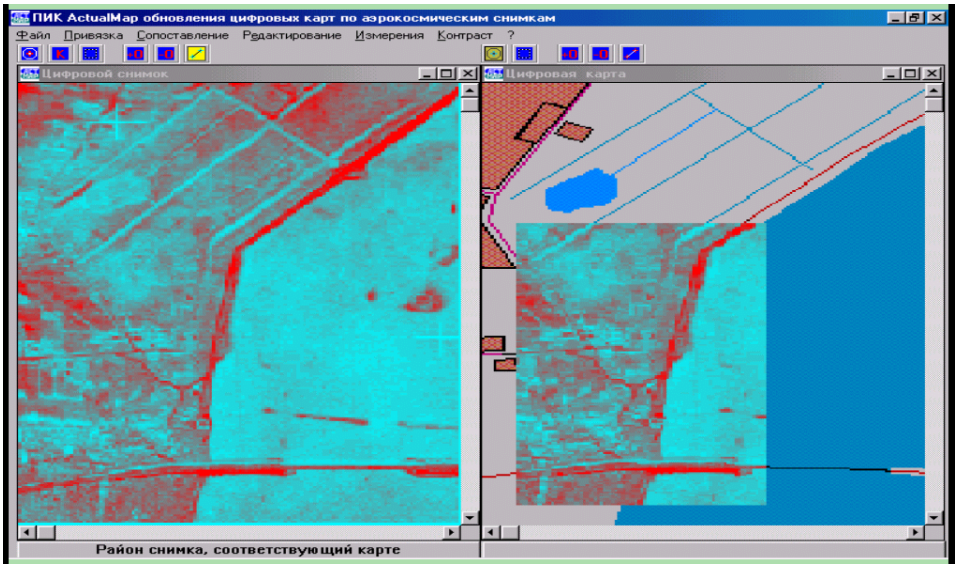

Fig.2. Extraction of image fragment and its superposition with map.

5) Matching of image and map fragments. Aim of the procedure is to establish polynomial dependence between coordinates of reference points of both images. We use matching algorithm based on modified polynomial approximation. Reference points are used to calculate coefficients of expressions and coefficients are used for calculating the coordinates of an arbitrary point on

the remote sensing image. This is an automatic procedure. To control the process of matching, we introduce the coordinates of control points, which take no part in finding the model parameters, and determine the discrepancies in the relative positions of elements on the transformed image.

The proposed method gives a smaller error in the determination of coordinates. For the same accuracy, the modified method needs less reference points that the standard method. In particular, the standard method based on a second - degree polynomial needs no lees than 6 reference points, whereas, the modified method needs only 4 reference points.

6) Extraction of changing in DM and forming a file of changed objects. Extraction of the required objects from RSI is performed by interactive or automatic techniques (contours for area objects, middle lines for elongated objects). Required object parameters (type, name, geometric, semantic characteristics and its links) are computed. Selected objects are displayed with DM and all information is recorded in updated map. In the result, updated DM is formed (Fig.3).

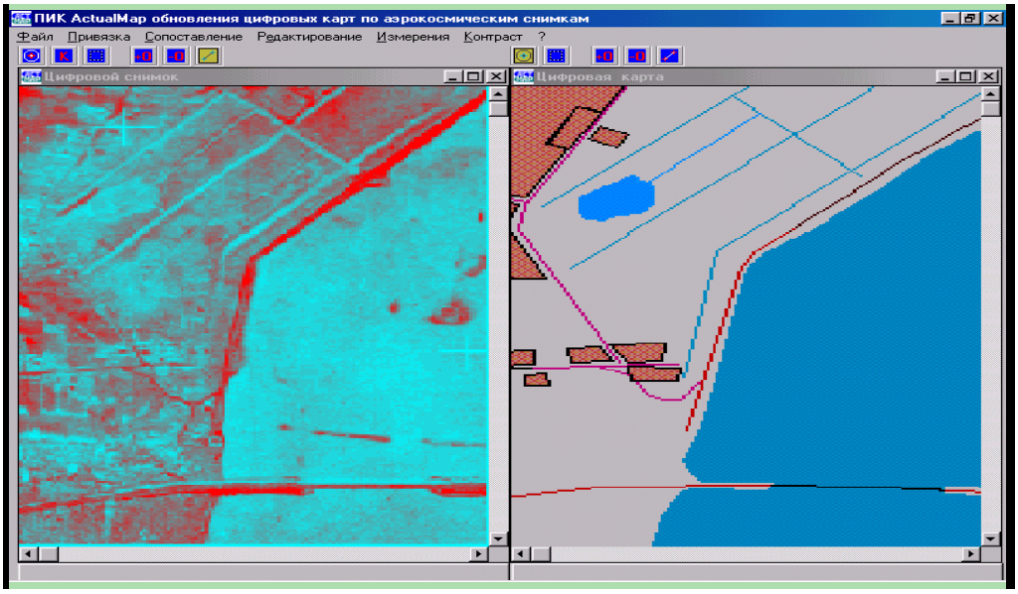

Fig.3. Updated DM by the extracted fragment

The developed procedure has been widely tested in GIS system for updating maps and solving many applied tasks.

4. APPLIED TASKS SOLVED WITH THE HELP OF DIGITAL MAPS AND GIS

We have long-term practical experience in creation of systems for joint interpretation of remote sensing and map images. The following applied tasks have been solved with the help of GIS:

- discovery of fires on the satellite images with calculation their coordinates on maps;
- evaluation of forest state to produce forest maps from satellite image (forest status monitoring);
- classification of forest by wood species and age;
- transport navigation system with digital map using including road network analysis;
- pollution spreading forecasting on digital map taking into account atmospheric conditions (wind propagation and others);
- control of territory flooding and modeling of its dynamics;
- hazard (extreme) situation modeling;

- modeling of territory pollution spreading dynamics under throwing out of poisonous substances (chlorine, ammonia etc.) into atmosphere as a result of explosion, fire, including accidents of transport means.

The practical systems solved these and other tasks have been developed and used in organizations of Belarus and many other countries. All practical results will be shown at Conference by means of PowerPoint presentation.

Some published books and journal papers on this topic:

1. Ablameyko S., T. Pridmore. Machine interpretation of line-drawing images, Springer, 2000, 285 p.
2. Ablameyko S. An introduction to interpretation of graphic images. - USA: SPIE Press, TT27, 1997. - 184 p.
3. Ablameyko S., Bereishik V., Frantkevich O., Paramonova N., Melnik E., Homenko M., Okun O., System for vectorization and interpretation of graphic images, Pattern Recognition and Image Analysis, Vol.3, No.1, pp.39-52, 1993.
4. Ablameyko, S.V. and Fisenko, L.A., Matching of remote sensing images to the cartographical base using reference points, Pattern Recognition and Image Analysis, Vol.4, No.4, p.446-450, 1994.
5. Ablameyko S., Beregov B., Kryuchkov A., Automatic map digitizing: problems and solution, IEE Computing and Control Engineering Journal, Vol.5, No.1, pp.33-39, 1994.
6. Lagunovsky D.M. and Ablameyko S.V., Fast Straight-Line Extraction in Aerial Images, Pattern Recognition and Image Analysis, Vol.6, No.3, pp.627-633, 1996.
7. Ablameyko S., Beregov B., Remote sensing image processing in geographical information systems, IEE Computing and Control Engineering Journal, Vol.7, No.4, 1996.
8. Lagunovsky D., Ablameyko S. Straight-line-based primitive extraction in grey-scale object recognition // Pattern Recognition Letters, 1999. – Vol. 20. - No. 10. - P. 1005-1014.
9. Ablameyko S., Bereishik V., Homenko M., Paramonova N., Patsko O. Interpretation of Colour Maps: a Combination of Automatic and Interactive Techniques, IEE Computing & Control Engineering Journal, 2001, Vol. 12, No. 4, P. 188-196.
10. Ablameyko S., Bereishik V., Homenko M., Lagunovsky D., Paramonova N. and Patsko O. A complete system for interpretation of color mars // International Journal of Image and Graphics. Vol. 2. No.3. 2002. – pp. 452-479.
11. Труды Первого (2003), Второго (2005), Третьего (2007) Белорусского космического конгресса, Минск, Беларусь: Мат. конгр. / ОИПИ НАН Беларуси.