Software and Methodological Support of Remote Sensing Data Processing

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Abstract. The content of the cycle of disciplines providing training of specialists familiar with all stages of technology of obtaining and storing digital data, digital image processing and application of remote sensing data is presented. The cycle includes the following disciplines: «fundamentals of the remote sensing of the Earth», «radio electronic remote sensing systems», «remote sensing data processing software», «satellite technologies in geophysics», «digital terrain models». The methodological support of the cycle is developed, which allows using effectively the Space monitoring center of the Ural Federal University hardware and software in the educational process. This methodological support includes two textbooks published by the authors, guidelines for the use of remote sensing data processing software in educational and research work, four modular cycles of laboratory works on the basis of the Space monitoring center hardware and software, guidelines for the organization of project training. Three online courses on remote sensing data processing with the prospect of their posting on the open education platform have been developed. The examples performed by the students' lab works are «cataloging of ground truth information and satellite imagery for monitoring of natural objects», «forest fires detection using the remote sensing data», «building of digital elevation models using a satellite radar interferometry».

Keywords: Remote Sensing, Storage of Digital Data, Digital Image Processing, Hardware, Software, Textbooks, Online Courses, Project Training.

1 Introduction

Scientific and technical achievements of the last twenty years in the field of construction and development of the remote sensing systems have fundamentally changed the scope of their use. This is caused by the increase of satellite images resolution to the decimeter level, appearance of hyperspectral images, the development of unmanned aerial vehicles (drones) imagery, the introduction of radio interferometric and polarimetric modes of radar imaging. New types of information products have appeared, such as digital terrain models and 3D terrain models. The data of space surveys became available to a wide range of users and are actively used for emergency situations monitoring and forecasting, the development of territories, assessing agricultural land, and

cartography [1-4]. The versatile nature of the application of remote sensing data requires the training of specialists owning the knowledge of specialized hardware and software for obtaining and storing digital data, principles and technologies of digital image processing for a wide range of tasks. Therefore, the study of these issues has become part of the training of specialists in the field of radio electronics and information technologies. This required the development of appropriate textbooks, online courses and project training.

1 Composition and the content of the module

To solve the problem formulated in the introduction, a training module has been developed in the way, that combines such disciplines as «fundamentals of the remote sensing of the Earth», «radio electronic remote sensing systems», «remote sensing data processing software», «satellite technologies in geophysics», «digital terrain models».

Principles of operation of optoelectronic and radioelectronic systems of remote sensing, principles, methods and algorithms of formation and processing of multispectral and radar images are studied. Special attention is paid to the methods of space radar interferometry (InSAR/DInSAR), which allow building digital models of the terrain and fixing the surface displacement with centimeter accuracy [5]. Methods and algorithms of image quality improvement are studied. Special attention is paid to the thematic classification of images.

The content of the disciplines reflects the results of scientific research carried out at the Institute of Radioelectronics and Information Technologies – RTF of the Ural Federal University over the past 30 years. The practical part of the courses is based on the software and hardware of the Space monitoring center (SMC), established on the basis of IRIT-RTF in 2011. the following specialized software is used to work with data in the Center:

- ArcGIS ArcView geoinformation applications with specialized modules for geostatistical analysis, 3D-modeling and spatial analysis, MapInfo and MicroStation;
- Remote sensing data processing software packages: ENVI with SARscape Basic and SARscape InSAR space radar imaging modules; ERDAS Imagine, ScanEx Image Processor, PHOTOMOD Radar.

The installed specialized software includes a set of tools for carrying out a full cycle of data processing from signal reception, formation, orthorectification and spatial reference of the image to thematic processing and integration with GIS data.

2 Methodological support

To ensure the effective use of the equipment and software of the space monitoring Center in the educational process, an instrumental and software methodological complexes have been created, which include:

- Two textbooks published by the authors [6, 7];
- Training manual «radar remote sensing of the Earth data processing»;

- Guidelines for the use of software systems ScanEx Image Processor, PHOTOMOD Radar, ENVI, SARscape in educational and research work;
- Four modular cycles of laboratory work based on the equipment and software of the space monitoring Center;
- Guidelines for the organization of project training on the basis of SMC.

Three online courses «Satellite technologies in geophysics», «Computer technologies of remote sensing data processing» and «Digital terrain models» have been developed with the prospect of their placement on the open education platform.

3 Practical training and project training

The core of the software and methodological support is represented by modular cycles of laboratory works, which combine different types and levels of the remote sensing of the Earth data processing tasks. Works selected from different modules form the laboratory cycle for a particular discipline. The total number of laboratory works is more than twenty. Each module includes research laboratory works and laboratory works with elements of scientific research.

In the framework of practical and laboratory classes, the skills are developed to solve the entire range of problems of digital image processing obtained in remote sensing systems:

- formation of a high-resolution synthesized aperture (SAR) radar image fragment;
- elimination of radiometric and geometric distortions, image registration and transformation into a given projection;
- image enhancement (noise reduction, filtering, border highlighting, brightness and contrast adjustment, including histogram transformations);
- interferometric processing of radar data (InSAR), building of digital elevation model;
- combining data obtained in different spectral bands without reducing the resolution based on different methods of image fusion;
- cataloguing of ground-truth information and satellite images for monitoring of natural objects;
- selection of secondary decoding features (analysis of main components, calculation of vegetation indices, Thomas- Kauth transform («tasseled cap»), fractal analysis, texture analysis);
- thematic image processing, automatic decoding and identification of natural and technical objects (formation of mosaics or color-coded images, uncontrolled classification, cluster analysis, controlled supervised classification, selection of objects of a given shape, lineament analysis, ring structures, fires detection, etc.).

As an example, let us give the content of three laboratory works performed by students.

The purpose of the laboratory work «cataloging of ground truth information and satellite imagery for monitoring of natural objects» is the development of technology for

obtaining, structuring and storing information about objects extracted from remote sensing data. This laboratory work can optionally be supplemented by a task on a vector map of the studied objects creation using a GPS receiver. In addition, a search of remote sensing data on the Internet using the geoservices like USGS, ESA, LADSWEB may be proposed. After obtaining the necessary information, the methodology of working with the catalogue of subsatellite data and space images developed by the authors is studied [8]. This catalogue contains detailed information about the studied area and relevant remote sensing data of different processing levels. At the first stage, students fill in information about the parameters of the imaging equipment and images, information about objects of monitoring and the territories on which they are located, and information about the available raster and vector maps. A fragment of the «observed objects» table is shown in Fig. **Ошибка! Источник ссылки не найден.**, and the «Snapshots» table is in Fig. **Ошибка! Источник ссылки не найден.**.

Date	Object type	Object subtype	Area (sq m)	Territory name	Object characteristic
27.05.2010	forest	Pine	140	Mayakovsky Park	young forest
16.08.2010	forest	Larch	100	Stone Tents	Larch + Shrub
16.08.2010	forest	Birch	350	Shartash Forest Park	rare forest

Fig. 1. Table fragment monitoring Objects.

Snapshots							
Code	Snapshot name	Date	Time	Satellite	UL Corner	BR Corner	Clouds
1	LE71630202004188	06.07.2006	6:44:57	Landsat7	60.6E 58.5N	62.3E 56.8N	0%
2	LE71630202004220	08.08.2004	6:44:45	Landsat7	60.7E 58.7N	62.4E 56.7N	0%
3	LE71630202005142	22.05.2005	6:45:33	Landsat7	60.6E 58.6N	62.3E 56.8N	15%

Fig. 2. Table fragment Snapshots.

The second step is the information search in the catalogue. There are three types of queries: «select the information for a given object», «select images by date and satellite» and «select available images of the territory». So, for example, the request «select the information for a given object» (Fig. **Ошибка! Источник ссылки не найден.**) forms tables with the information about the observed object of interest and the available space images.

In the laboratory work «forest fires detection using the remote sensing data» the MOD14 algorithm is investigated [9]. At the same time, the ScanEx Image Processor software [10] selects thresholds for detecting thermal anomalies in a given territory, i.e. the MODIS spectroradiometer images for the territory of the Sverdlovsk region (Fig. **Ошибка! Источник ссылки не найден.**) at night (a) and daytime (b). In this laboratory work, students not only get acquainted with the basic algorithm for the allocation

of «hot pixels» in satellite images, but also acquire the skills to solve the almost important task of monitoring the fire situation.

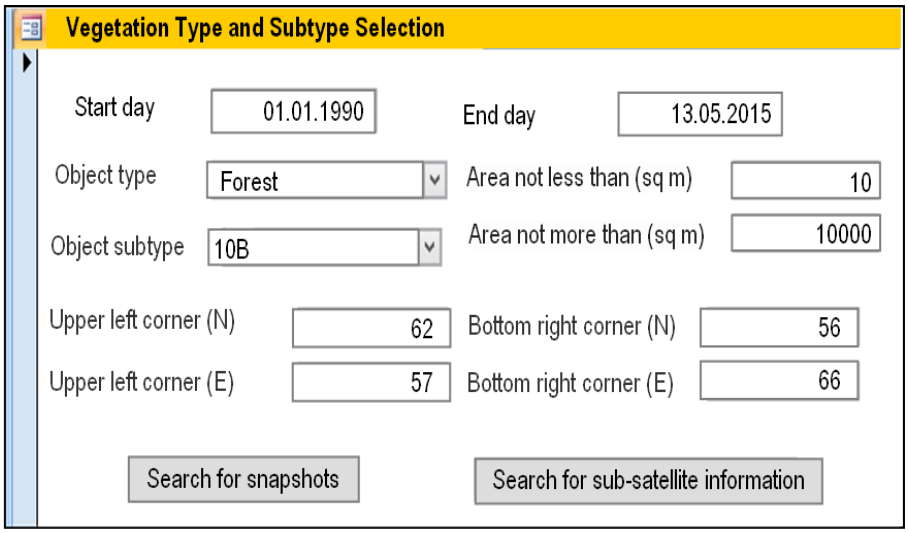
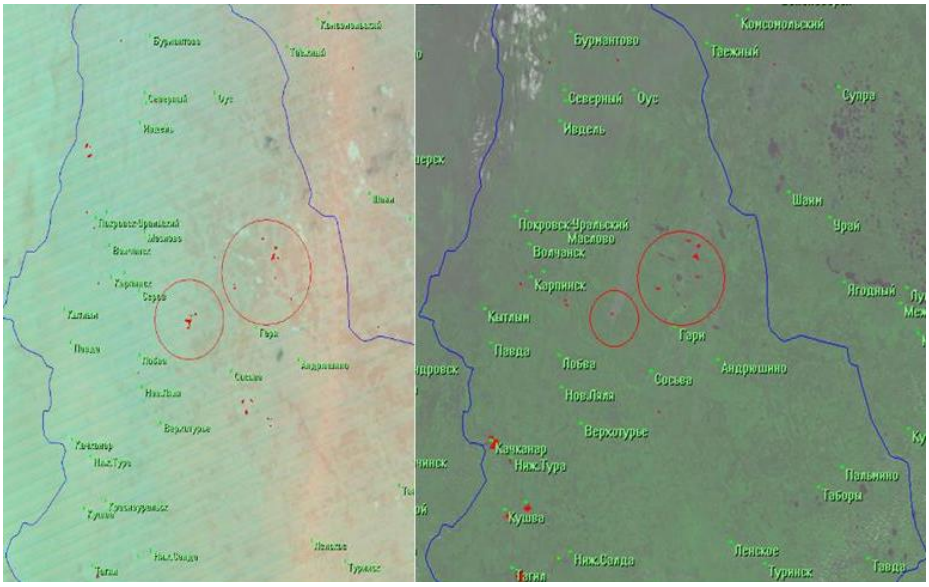


Fig. 3. Request to select information for a given object.



(a) (b)

Fig. 4. Detection of fires in 2010 in Sverdlovsk region by MOD14 algorithm based on MODIS image.

An important form of active learning in the cycle of disciplines is laboratory works with elements of a scientific research. Within the framework of the general methodology, the student individually chooses processing algorithms and their parameters. An example of such work is «building of digital elevation models using a satellite radar interferometry». In this work, students generate interferogram on the basis of a pair of RADARSAT-1 radar images by means of SARscape and ENVI software packages, carry out the correction of the phase ramp from the reference surface, filter the phase noise and unwrap of the interferometric phase. The subject of the research is the selection and optimization of parameters of filtering algorithms and phase unwrapping. An example of the constructed digital terrain model is shown in Fig. **Ошибка! Источник ссылки не найден.**.

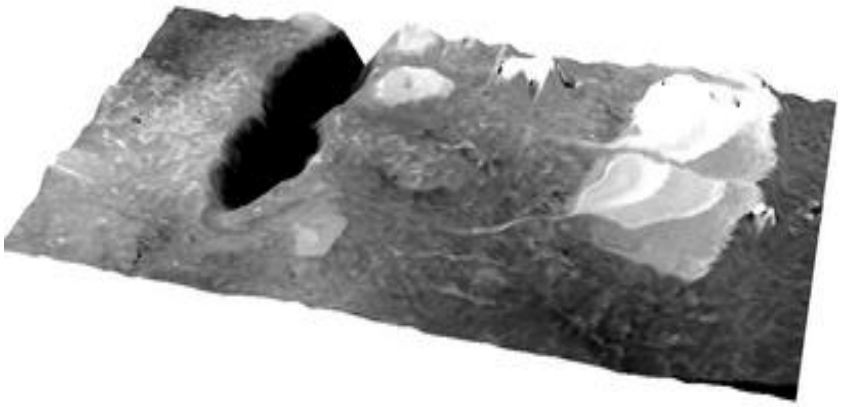


Fig. 5. Digital elevation model obtained as a result of interferometric processing.

In an educational & research laboratory of geoinformation technologies and remote sensing data processing students also conduct experimental parts of their project, which implies a real scientific research or engineering development under the guidance of a teacher (tutor).

4 Conclusion

The software and methodological support of the students' studies have been tested for the radio engineering (bachelor) and master's programs «Radioelectronic systems» and «Mathematical geophysics and geoinformatics». Since the processing and application of remote sensing data are based on the results obtained in various fields of science and information technology, the practical implementation of interdisciplinary relations has been one of the main tasks in the study of disciplines of the module. At the same time, the training of specialists possessing such competencies is based on the study of the specialized hardware and software of the Space monitoring Center of the Ural Federal University, on the study of methods for obtaining and storing digital data, as well as the

principles and technologies of digital image processing. The developed software and methodological support also made it possible to implement the basic principle of active learning *i.e.* learning through activity.

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