ON THE USE OF REMOTE SENSING SATELLITE IMAGERY AND THEMATIC MAPPING FOR CULTURAL PURPOSES

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ABSTRACT: *Preservation and revitalization of our cultural and natural heritage has a vital role not only in understanding our past, but also in our future development as humans. This paper aims to present the current directions and the use of remote sensing satellite imagery in identifying different terrain forms, routes, objectives and analyzing their evolution over time both for cultural and environmental purposes. A case study was carried out to investigate the contribution of processing remote sensing images to the research and detection of an important former commercial connection between Europe and Asia, the old Silk Road. The analysis of the multi-spectral remote sensing data was performed with the help of innovative programs developed by PIESAT Information Technology Co Ltd. These softwares use an object-oriented analyzing method and have made a qualitative leap in image information extraction. The actuality of the paper is given by the fact that preserving cultural heritage and historical sites represents an important issue that must be taken into account when sustainable development projects are required for environmental policies.*

Keywords: *sustainable development; cultural heritage; remote sensing; environmental policies;*

1. Introduction

Images from remote sensing platforms are routinely used to highlight new environmental problems and spark debate about potential legislative solutions [1]. Furthermore, the monitoring and reporting requirements imposed by national policies as well as international treaties, conventions, and agreements are becoming increasingly beneficial for remote sensing products (such as aerial photography, airborne, and satellite imaging) [2]. The purpose of this paper is to present the creation of a thematic map to interpret the environment by observing geographical elements such as landforms, hydrographic networks, human settlements, and relics using remote sensing images. A thematic map is a multi-step process that aims to describe the geographical distribution of a phenomenon. Thematic maps serve several purposes, including capitalizing on human visual perception by recognizing objects. In the case study presented in this work, due to the visual perception, landforms existing in the remote sensing are recognized and highlighted. It is also designed to discover previously unknown patterns.

Remote sensing would not have existed without the art of photography, and in this sense, it can be said that the foundations of remote sensing were laid with the first photographs taken at height in 1858, and with it, the air-photogrammetry. In some countries in the late nineteenth century, topographical maps were created using aerial photographs [3].

In Romania, it is now necessary to set up a new system for documenting images in order to be able to process them with modern methods and techniques with the aim of digitalisation. This term is frequently used to refer to the conversion of analogue data into digital content.

2. Study area

Remote sensing imagery has the following characteristics: can provide macro-level information, fast and accurate in-depth data. So, the application of remote sensing technology in environmental studies can be

considered an innovative research tool and method with its unique advantages. The basic principle of remote sensing environmental studies is to detect and discover sites by analysing and identifying data as electromagnetic signals that are characteristic for environmental objects on the ground or underground. As shown in the remote sensing imagery obtained from the satellites described in Table 1. Datasets – remote sensing image, the Dunhuang desert region of China is presented. This area in North-western China is located at the crossroad of two major, vital and strategic trade routes within the Silk Road network (Fig. 1).

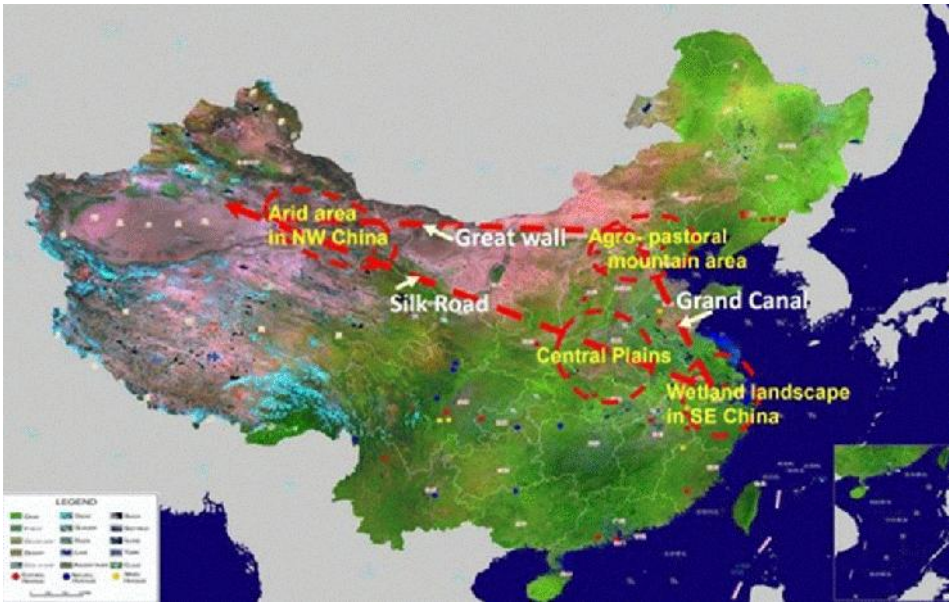

Fig. 1. Study area- The ancient Silk Road Route

This research area is an arid and semi-arid area being heavily affected by wind erosions (Fig. 2). Many dry /old channels, modern oases and ancient oases are scattered on the ground. In present, ancient oases are gradually replaced by Yardang landforms [4], and sand dunes, this being strong evidence that the Gobi Desert is the world's fastest growing desert [5]. The study area described previously, is nowadays mainly uninhabitable and not easily accessible which concludes that field investigations are very difficult to perform. However, a large number of evidence were found that are confirming the presence of human activity in this region, including ancient defensive walls, ancient roads and towers, ancient irrigation systems, etc. This area is located on the old Silk Road route. Since ancient times, the Silk Road has served as the main branch of China's connection to Europe. Although the Silk Road is considered to have existed as a trade route since prehistoric times, it is only mentioned for the first time at the beginning of the second century [6]. The Silk Road was also significant because it facilitated the development of trade systems between a number of different kingdoms and empires, enabling the world's first act toward globalization. Thereby, creating a thematic map of this region is a great example of the beneficial results that can be obtained by using remote sensing imagery for environmental studies, as for example: the surveillance of different landforms and the analysis of the evolution in time of the respective areas. Thematic applications are the main field of use of remote sensing and are based on the qualitative aspect of the information that appears in remote sensing images.

3. Materials and methods

The remote sensing process depends on seven elements: energy or lighting source,

Fig. 2. Description of the study area

radiation and atmosphere, target interaction, sensor energy recording, transmission, reception and processing, interpretation and analysis, application domain. The defining aspects of image processing, which is a very independent field, based on a rigorous mathematical theory, are interpretation, analysis, and the application domain. Moreover, digital image processing is a rapidly evolving field, with multiple applications in engineering, science, and economics and beyond. Over the last 10 years, there has been a growing interest in image morphology, colour image processing, compression, image recognition and analysis. Specialized programs are used to process satellite images, but they require licenses, which are often very expensive. In this case study on remote sensing image processing, the Chinese PIE software (Pixel Information Expert) was applied, "which is the flagship software product of PIESAT for remote sensing image and data processing" [7]. The environmental monitoring by remote sensing is mainly based on multi-spectral data. The most valuable characteristics of the remote sensing images used for processing are described in Table 1.

Table 1. Datasets – remote sensing image

Data Type	Satellite/Sensor	Data Quality	Resolution
Medium Resolution	Landsat-7/8ETM+/OLI	7 channel multispectral data+ panchromatic data	30−15
Medium-High Resolution	Gaofen 1 satellitePMS	4 channel multispectral data+ panchromatic data	8−2
High Resolution	Gaofen-2satellitePMS	4 channel multispectral data+ panchromatic data	4−1
Ultra-high Resolution	WorldView-3PMS	4 channel multispectral data+ panchromatic data	2−0.5

Remote sensing image processing is continually being improved and refined in order to enhance the quality of the results for the benefit of users and analysts. Thematic mapping is among the most common and important outputs of remote sensing. Thematic and land cover maps created using remote sensing photography can contribute to environmental monitoring, as well as management and planning tasks.

The employment of satellite or aircraft-based sensor technology enables the detection and categorization of objects on Earth, including the surface, atmosphere, and seas. Furthermore, digital processing of satellite pictures demands the availability of a high-performance digital station equipped with digital processing-specific hardware and software components for digital processing [8]. The digital processing modules available on these systems provide the following four categories of functions: preliminary image processing, image enhancement, image transformation, image classification and analysis.

Pre-processing, as the first step is aiming to correct errors that can occur during the image capturing procedure. Systematic errors, such as those caused by the curvature and rotation of the Earth, can be precisely modelled, and eliminated. Non-systematic errors can result from random fluctuations in parameters such as satellite position and speed, or sensor functionality.

Typical operations that can eliminate these errors are: noise reduction (noise is manifested by the absence of datasets in the image or by the presence of pixels with incorrect grey levels, compared to the pixels in the immediate vicinity), radiometric corrections (blurring effect) and geometric corrections.

Image classification, which represents the second step, has the main purpose to establish the belonging to specific classes of the pixel areas of a satellite image.

The supervised classification uses data from certain parts of the study area that allows to determine correspondences between the parameters of the image and a class of objects. It is necessary to determine the classification parameters, and the classification of the image elements.

The image is then categorised by examining at the reflectance of each pixel and allocating it to the class that contains the most commonalities [9]. Unsupervised classification uses only parameter vectors, therefore pixels that have similar values are identified and structured in groups, using specialized algorithms.

Unsupervised classification assigns categories to pixels fully autonomously and without the need of external data [10].

4. Results and discussions

4.1. Processing the remote sensing image using PIE-Basic software

PIE-Basic is a primary processing software of PIE (Pixel Information Expert) software series developed for professional application products, which provides general remote sensing. The first step in image processing using the PIE-BASIC program is the radiometric calibration. When the remote sensing sensor observes the electromagnetic energy radiated or reflected by the target, the spectral brightness will be distorted due to the characteristics of the photoelectric system of the remote sensor itself, the height of the sun, the terrain, and the atmospheric conditions. The process of eliminating the various distortions attached to the radiance in the image data is labelled as radiant correction.

Radiometric correction includes two parts: radiometric calibration and atmospheric correction, and supports data processing such as HJ CCD, GF1, GF2, GF6, ZY02C, ZY3, TH01, Landsat5/7/8.

Radiometric calibration is the process of using atmospheric correction technology to convert the grey pixels into physical quantities such as apparent radiance and apparent reflectance with the aim to correct the errors generated by the sensor itself. When using the program, the “Input File” uses the satellite image data that is going to be processed. The “Metadata File” is also used in the form of an “.xml” extension corresponding to the image, which can be read by default or customized by the user (Figure 3.a).

The purpose of atmospheric correction is to eliminate the influence of the atmosphere in form of solar radiations, absorption and scattering of target radiation, to obtain real physical model parameters such as target reflectivity, emissivity, and surface temperature. In most cases, atmospheric correction is also the process of inverting the true reflectivity of ground objects. (Fig. 3).

Image matching supposes combining and

overlapping two or more images acquired at different timings, different sensors (imaging equipment) or under different conditions (weather, light, camera position and angle etc.) (Fig.4).

ranges, and simultaneous interpretations. Due to the fact that the image is too large to perform the next steps of processing, an image clipping was performed (Fig. 5).

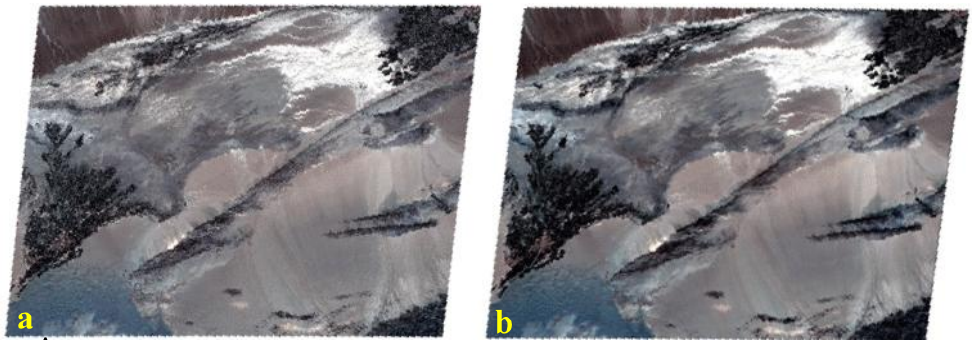

Fig. 3. a) after radiometric calibration; b) after atmospheric correction

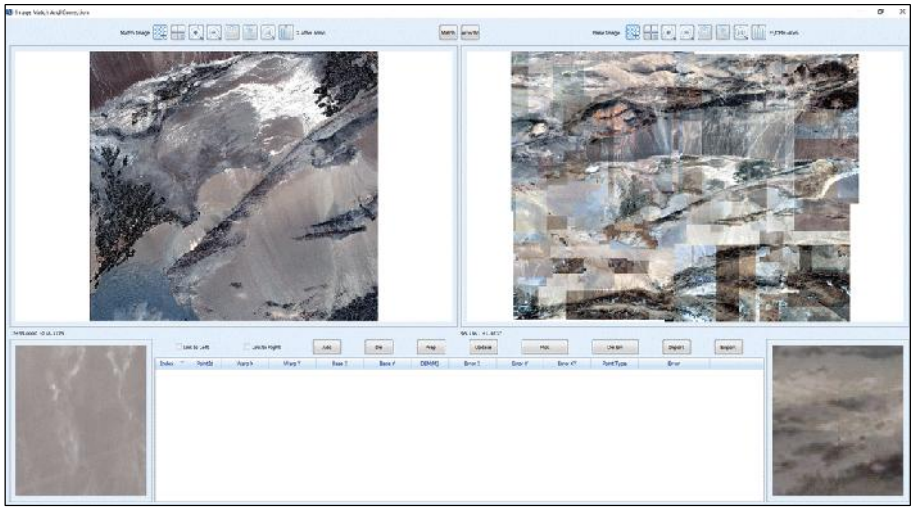

Fig. 4. The process of image matching

Throughout the image matching process, other images can be located with geographic coordinates in line with the geometric coordinates of the reference image.

Orthorectification is the process of correcting image, space and geometric distortion to generate multicentre projection plane Orthophoto Images.

After processing the orthorectification, the image has high accuracy and can meet the requirements for remote sensing mapping and base map updating. Moreover, it ensures the accuracy of geographic location of the same image in different sensors, different spectral

4.2. Processing the remote sensing image using PIE-SIAS software

PIE-SIAS scale-set image analysis software is a valuable tool of the PIE series. The software uses an autonomous core segmentation algorithm to support fast parallel processing, therefore the generated segmentation results can be used to support stepless scale transformation.

Using the PIE SIAS software, the land cover classification was obtained in a complex but complete manner. Firstly, the batch segmentation was performed (Fig. 6), then the

object-oriented classification was subsequently obtained managing the sample selection to create attributes for the land cover.

Fig. 5. Image clipping

Thematic maps, traditionally developed for specific themes that can describe geographic areas, can be considered a template for presenting relevant and valuable information because of the abstract but precise way of providing data. A thematic map's most common use is to describe the geographic distribution of one or more phenomena. In the mentioned case study, the map is created in order to uncover and recognise previously unknown patterns of natural and human environments. The thematic map obtained from this case study (Fig. 7) contains distinguishing elements such as: the title, which indicates the studied area, the legend, which suggests the elements that were identified after the analysis such as: vegetation, roads, oasis, mountains, rivers, dessert, and town areas.

Furthermore, the grid featured in the map's outer frame is the most important aspect of the map. Therefore, the thematic map is a presentation of environmental features in the Dunhuang area, with the purpose of identifying and stocking the natural and human-made aspects of the ancient Silk Road.

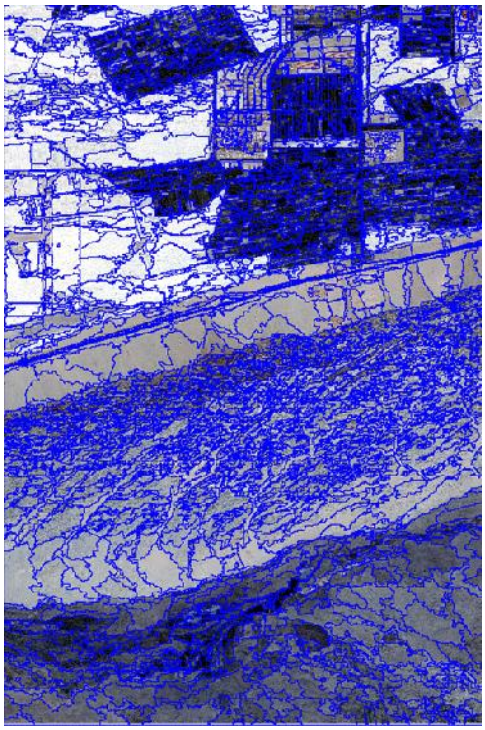

Fig. 6. The process of batch segmentation

5. Conclusions

Remote sensing, as depicted in this case study, is a valuable method for identifying and monitoring the physical attributes of an environment by measuring radiations that are reflected and transmitted remotely by a satellite or an aerial imaging aircraft. The advantages of gathering remote data are various, and they include the following:

- Remote sensing imagery has the potential to collect information across wide geographical regions in order to define natural characteristics or physical objects on the ground. This allows us to analyse surfaces and objects methodically and track their changes over time, as well as combine this data with others;
- Remote sensing allows for easy collection of data over a variety of scales and resolutions. Although the precision of

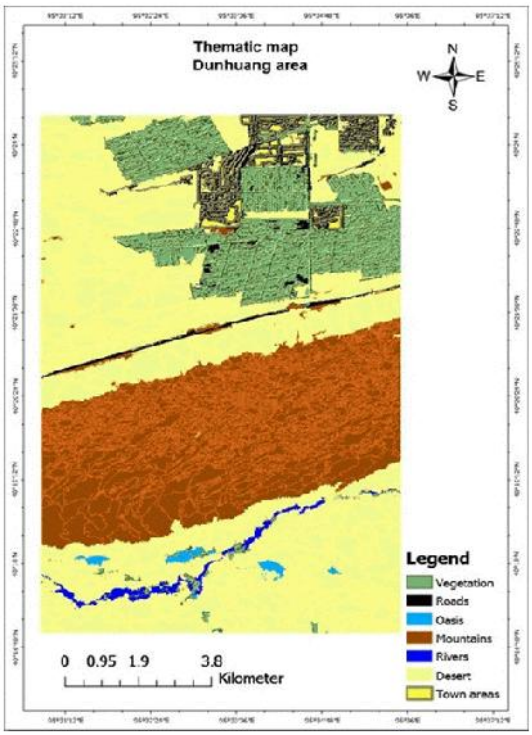

Fig. 7. The final result - thematic map

traditional remote sensing data collection is quite poor, there are nowadays new and innovative commercial solutions that can provide very satisfying resolutions as of 0.5m;

- There is no specific limit on the amount of information that may be extracted from a single remote sensing image;
- Monitoring environmental degradation, and environmental condition assessment are all reasonably automated applications, and no further interpretations are needed;
- Environmental remote sensing focuses on monitoring, but the capacity to anticipate environmental changes is still limited;

Nevertheless, remote sensing demands special kind of knowledge in order to analyse and interpret the images. This aspect is in a certain way expensive, and the processing time is quite long, but the obtained results are beneficial and valuable. The eventual implementation of these trainings into university courses will increase the chances of further development of this application domain of remote sensing.

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