Services for Analysing Series of Satellite Images for Estimating the Change Dynamics of Objects

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Abstract. To improve the efficiency of the use of remote sensing data in the tasks of managing territorial development, utility services have been implemented that allow us to catalog and simplify the use of methods for analysing remote sensing data as services. Services using reference vector techniques and neural networks of common Unet, FPN, Linknet and PSPNet architectures have been developed. Utility services allow for the regular and automatic processing of remote sensing data, including using scripts that link services and form a single processing process.

Keywords: Remote sensing; space images; neural networks; recognition training.

1   Introduction

Earth remote sensing data (ERS) are actively used in the tasks of managing territorial development, such as monitoring the socio-ecological and economic situation, estimate of the natural resource potential, carrying out architectural and design work, etc. Now large volumes of remote sensing data are collected.
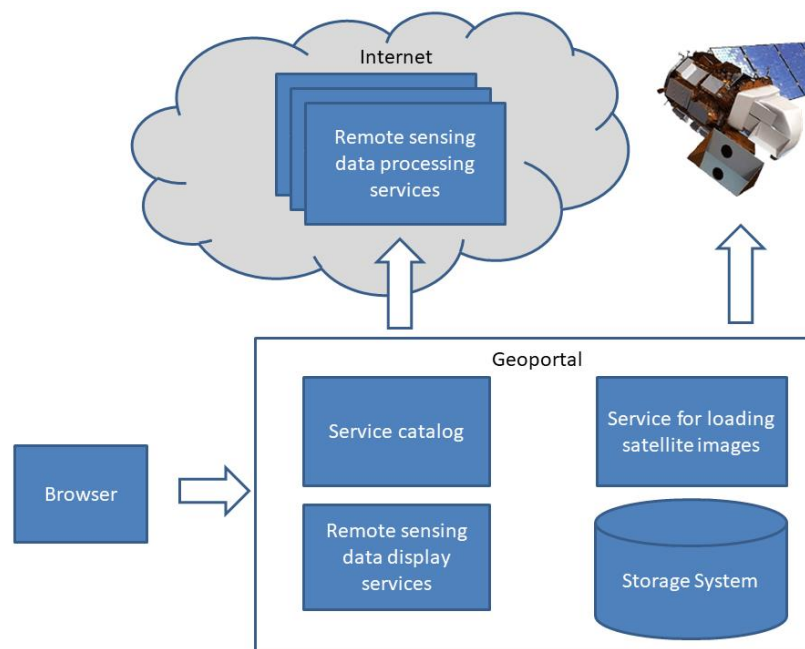

Figure 1. Remote sensing data processing infrastructure

Remote sensing methods are actively developing due to an increase of the number of sensors, and their resolution. However, use of the methods is not trivial. It takes a lot of time due to the fragmentation of data sources and processing methods, the need for manual configuration and installation of software.

Using remote sensing methods to solve the processing problem depends on many factors: the format, resolution, used sensor, analyzed area, processing goals, etc. A feature of existing methods is that methods that show good results in one territory may be inoperative when solving similar problems in other territories. For data processing methods that implement recognition with a teacher, the formation of training samples that take into account the territorial specificity is required.

Currently, a comprehensive analysis of remote sensing data for territorial development management tasks justifies the need for integration and systematic application of a combination of various remote sensing processing methods, many of which can be implemented as services, which simplifies their use. It is also required to create auxiliary services that allow cataloging and simplifying the use of processing and analysis services, as well as select the most suitable services for the task and territory. The implementation of remote sensing data analysis services and auxiliary services will simplify the use of remote sensing data, reduce the threshold for user entry and allow more active use of remote sensing data in territorial development management tasks.

2   Infrastructure features.

On the basis of the geoportal [1], some auxiliary functions have been developed at the Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences. The general scheme is shown in Figure 1. Consider them in more detail.

2.1   Catalog of services

Information about services is provided by the catalog of services. In addition to storing information about services, the catalog provides an interface for registering, searching and launching services. For the convenience and accuracy of filling out information about registered services, a special form was developed. Each service in the catalog is defined by the following parameters: name, type of service (WPS [2], REST [3], etc.), a list of computing nodes on which this service can run. The user also determines whether the service can be performed for a long time (more than 60 seconds). If the service is marked as long, the service catalog will interact with it in asynchronous mode. For example, for the WPS standard, when a service with a long execution is called, the URL of an XML file is returned, which displays the percentage of work done, and at the execution end of the WPS service, the result. When specifying the network address of a computing node, the system automatically polls which services this node provides (information about supported services is obtained using special commands of the relevant standards, for example GetCapabilities from the WPS standard). The user selects one of the services provided, and the system downloads a
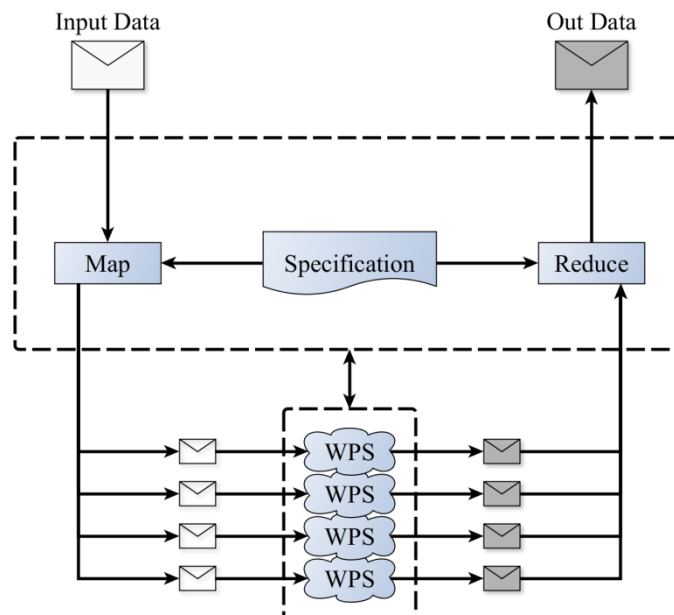
description of the service parameters and displays both input and output parameters. For each input parameter, the user selects a control (the control system is part of the geoportal) with which the parameters for this service will be entered. After saving the specified information in the catalog, the service is ready for use.

Figure 2. Web service execution parallelization scheme.

There is a module for executing services in the catalog. When executing remote sensing services, it is necessary to take into account the size of satellite images, especially of high and ultra-high resolution, which can be quite large. Image processing can take a long time. Some methods fully load space images into RAM. Accordingly, large images do not work correctly or use a swap file, which leads to a significant increase in processing time. In order to speed up the execution of the web service in time, reduce the requirements for the amount of RAM, it is proposed to divide the input data into spatial cells, process each cell on a separate computing node with the installed service, and then combine the results (similar to the MapReduce software model). Scheme for parallel execution of the web service is shown in Figure 2. For input parameters corresponding to the processed images, a specification is defined according to which the division into cells is performed (minimum and maximum size of the processing area, size of overlapping cells, etc.). For the output parameters, the specification of data aggregation (processor, conflict resolution, etc.) is determined. The geoportal module receives input parameters that are transmitted to the service input. Further, the parameters for which the specification is defined are separated. Then, copies of the service are launched on separate computing nodes with the transfer of the corresponding image cells. As the service copies are completed, data is collected, an aggregation handler is called to combine them, and the result is returned to the user.

Parallelizing the execution of a web service allows you to reduce the total execution time of the web service, as well as use the available hardware capacity to solve the task.

2.2   Data Storage System

The data storage system (SHD) provides the user with a web interface for working with files (space images, processing results, classifiers, etc.). When working with remote sensing data, a data storage system is a critical place because of its size. Constant expansion of the system volume is required.

2.3   Service for loading satellite images

Some tasks require regular processing of satellite images without human intervention, therefore, it is necessary to automate images loading from various sources that provide APIs. For this, a service has been developed that receives images from Landsat 5,7,8 sensors. The input parameters of the service are: the shooting period specified by the range of start and end dates; type of sensor; area of interest. The result of the service is a set of scenes. The service is based on the Landsat578 project (https://github.com/dgketchum/Landsat578). This project loads images in accordance with the WRS-1 and WRS-2 layout systems. Therefore, for the convenience of users, automatic detection of the number of scenes (path, row) corresponding to the region of interest was implemented. The service sequentially receives the layers of each scene, saves them in an archive and returns them to the user.

2.4   Remote sensing data display services

Services have been developed for displaying remote sensing data on a geoportal map. The first service implements the publication of raster data based on the WMS standard [2], which allows you to display cartographic information within the geoportal and on other resources and systems. Two parameters are input to the service: a raster file in the GEOTIFF format; map styles in JSON format. The map styles can be set in the following ways: gradient color change depending on the values; for each range of values its own color is set; RGB display in the presence of appropriate channels. As part of the geoportal, an editor has been developed to set the map styles. The service is developed on the basis of the open source system Mapserver [4]. To speed up data display based on caching maps in the form of tiles, Mapcache is used [5]. Often, remote sensing data is provided as a set of files corresponding to spectral channels. An informative way for the user is RGB display, in which channels are combined. The second service, Bands_to_RGB, builds an RGB file in the GEOTIFF format from three monochrome images corresponding to Landsat channels. The service is based on the gdal_merge_simple module (https://github.com/gina-alaska/dans-gdal-scripts#gdal_merge_simple).

3   Remote sensing data processing services

3.1   SRTM data processing service

The service creates slope and exposure maps. Before applying it is necessary to set the input parameters: extent – the size of the input raster, elevation – the name of the output raster, slope – the name of the output slope raster, aspect - the name of the output raster of the slope directions, cell_size – cell size (scale) of the resulting raster. The size of the input raster is determined automatically, through interaction with an interactive map, the user using the

Rectangle tool (frame) selects the region of interest. The service finds the corresponding areas of the source data files. Source SRTM data is stored in a storage system. The service glues and cuts the source files (forming the input raster), recalculates the scale in accordance with the desired by user, processes the input raster with bias and exposure tools. At the output of the service, the user receives three output files in the GEOTIFF format in the WGS84 coordinate system: output terrain raster, slope raster, slope direction raster. These files are stored on the storage system at the path specified by the user.

3.2   Vegetation Index Service NDVI

The user indicates the location of the source files and the path where the resulting file will be saved. The output file contains NDVI values in the range [-1; 1], if desired, you can change the range of output values to the range [0; 255] which is convenient for representing in grayscale.

3.3   Remote sensing data segmentation service

Segmentation of raster images is performed by a library (https://github.com/qubvel/segmentation_models), based on the Keras [6] framework (TensorFlow [7]), which provides a high-level API for using neural networks of well-known architectures (Unet, FPN, Linknet, PSPNet) for the purpose of binary and multiclass segmentation. Using this library, it is possible to conduct training of a neural network or to load the scales of pre-trained models (VGG, ResNet, SE-ResNet, ResNeXt, SE-ResNeXt, SENet154, DenseNet, Inception, MobileNet, EfficientNet) for faster training. The current service implementation works on the U-net model and resnet34 scales. The service receives an input bitmap image of the RGB model, divides it into cells and classifies each of them. From the processed cells, an output raster is formed - a binary mask, with marked positions of objects. The cell size (32x32 pixels) corresponds to the desired objects and is selected in such a way that the neural network can correctly classify both the entire object and its part. Figure 3 shows the result of using the service to search for glacier locations.
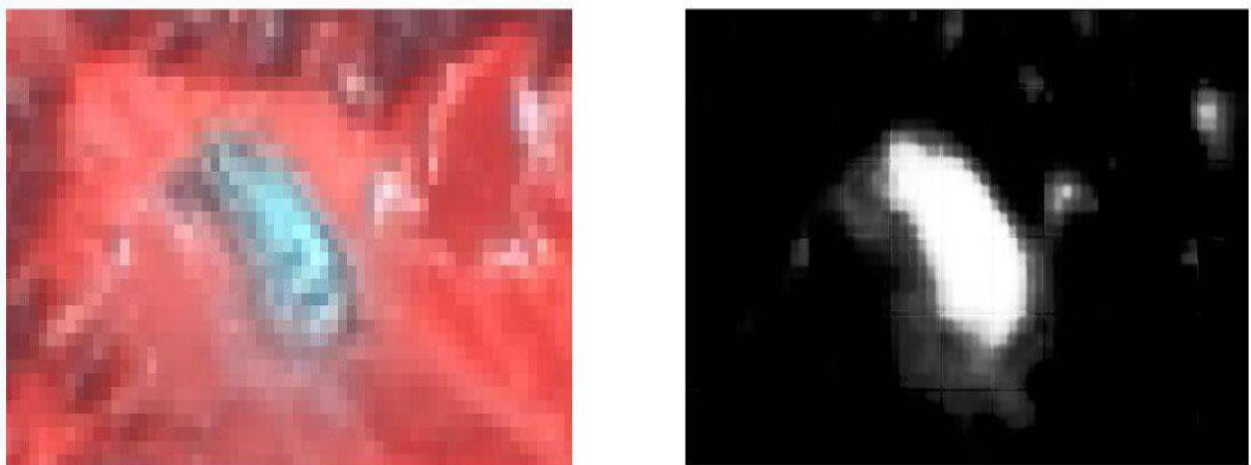

Figure 3. Landsat image and classification result

3.4   SVM service

A feature of the service implementation is that the image is represented as a vector of features. The feature vector is the characteristic of the frequencies of various elements entering the image area. The elements are textural (Local Binary Pattern method [8]) and spectral (pixel brightness values of the RGB color model) attributes. The combination of texture and spectral features allows you to get a more accurate result. For the implementation, the library SVM-light [9] was used. Figure 4 shows the result of the allocation of vegetation.
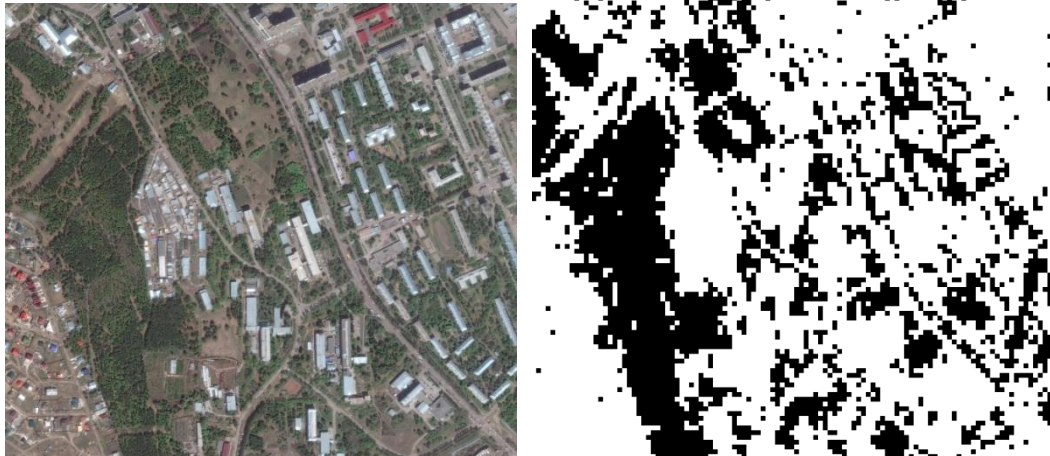
Figure 4. Original image on the left, classification result by SVM method on the right

4   Conclusion

Based on the developed support services, a set of remote sensing data processing services will be formed that are aimed at solving practical problems of territorial development management. Currently services have been implemented using the support vector method, a neural network based on the common architectures Unet, FPN, Linknet or PSPNet. The implemented services allow the regular and automatic use of services, including using scripts that connect the services and form a single processing process.

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