Software for data visualization in the system of real-time satellite monitoring

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Abstract. Methods for creating multi-layered mapping representation for the real-time satellite monitoring systems, based on web-GIS technologies, are considered. The generated map can contain a set of raster and vector thematic layers of spatial data, additional information layers of images from below (a basic map – a substrate) and from above (a layer of labels) of user's thematic data. The client software provides interactivity of the created maps in a standard web browser. The configuration of the data presentation provides the ability to select spatial data format according to the client (vector or raster), control various display options (interactive legend, list of fields displayed in attribute tables). It also provides application of custom templates to display table information on layer objects, arrangement of data access rights - from opportunities to visualize a layer or map through a web browser to providing direct access to them through standard mapping WMS/WFS web services, web-based editing, or shape-file downloads. An integral part of thematic web maps, based on the geo-portal, is a customized rasterization and data caching service that provides a noticeable performance increase for "heavy" multi-layer maps. A set of mapping substrates, such as schematic maps, satellite images mosaics, digital terrain models, spatial data of outside web services are a good addition to maps on geoportal.

1 Introduction

Development of land remote sensing systems is currently conditioned by a combination of such factors as an increase in the number of spacecrafts and improvement of their performance characteristics, an increase in the availability of satellite information related to the development of the Internet: increase in speed and decrease in cost of access, the development of Web services and standards for the transfer of geospatial data [1]. New technologies for automation of receiving and processing remote sensing data, creation of super-large archives in specialized data centers have made it possible to arrange fundamentally new ways for satellite data operations, and to create a new generation of systems for real-time monitoring of the natural environment [2-4]. They are based on the geo-information web technologies, interactive online mapping systems with direct access to satellite information, provided with the ability to configure various parameters for visualizing geospatial data and generating complex analytical queries.

Technologies of geo-information web-systems and services are dynamically developing now [2-4]. One can find more than a hundred Russian geo-portals, dozens of geo-services,

web GIS, mapping services and data visualizers, including specialized solutions for satellite data operations. Along with the traditional tasks of ordinary visualization of terrain maps and satellite images mosaics, up-to-date systems provide the user with the flexibility to customize various parameters of mapping visualization, spatial data processing services [5-7].

The authors' research experience in the subject under consideration shows that a geo-information platform, which conceptually determines the architecture and capabilities of implemented solutions, acts as the core element in the development of software for monitoring the state of the environment on the basis of land remote sensing data. The basic trend now is the use of the workplace of the GIS solution' end user, based on a web browser, as well as embedding the necessary set of scripts to work with the system in geo-information Internet portals. In some cases, these solutions are auxiliary and perform mostly spatial data viewing functions [8-10].

2 Geoinformation platform

Up-to-date web GIS are built in the so-called service-oriented architecture, and they can be considered as a set of interrelated software tools for arranging spatial data such as import/export, cataloging, visualization, creation, processing, distribution, etc. The technological basis for such solutions is usually the libraries of software interfaces such as Google Maps API, Mapserver Mapscript, ScanEx GeoMixer, etc. [11, 12]. They provide access to the functions and context of the mapping elements of the web pages: map visualization tools, spatial metadata, for example a road network with traffic jam data, as well as terrain, points on the map, etc. [13, 14]. The software and hardware support of the satellite monitoring system is also developed in accordance with this approach, because it also represents a web-based GIS.

One of the first tasks in designing any application system is the choice of a technological arrangement (geo-information platform) for GIS development, including software, technologies for storing spatial data and processing them [15-17]. Currently, there are traditionally considered two alternatives in the choice of basic software: based on commercial or free (open source) software products. Without considering financial, philosophical and short-term aspects of this choice, today there is often practically no opposition between the two approaches considered. And the reason is that commercial and free GIS are now complementary thanks to the compatibility of data formats, information exchange standards based on Web services, etc. For example, it is possible to analyze spatial data in ESRI ArcGIS, then convert them to MapInfo for further delivery to the customer, using free Mapserver software for presentation on web pages, and form a spatial metadata catalog using GeoNetwork Open Source. At the same time, it is possible to use the open source PostgreSQL DBMS with the PostGIS extension module in order to store spatial data. For most of the tasks is almost equal in performance and functionality to ESRI ArcGIS Server or Oracle DBMS with the extension for working with spatial data Oracle Spatial. Thus, the competence of specialists who provide hardware support for the solutions becomes a determining factor here. Commercial products are usually simpler in the initial configuration, they immediately from the start. Free software also has its advantages, related to the openness of architecture and expansion capabilities.

Pointing to the specific features of satellite monitoring systems, most of the algorithms for processing satellite data, developed in NASA, are available just in the source code. Specialists from all over the world are showing considerable interest in such resources, they can directly analyse existing methods of data processing and create their own modified algorithms. NASA is interested in constructive criticism and prompt correction of noticed errors.

3 The system for satellite data visualization

A geo-information web server was used as a software base for the catalog of satellite data. Its modular architecture allows developing the system already in the process of its operation, by adding new means of data access and also improving existing ones. The development is performed on the basis of free and open source software both in the GIS part and in all other development components. The described web application provides the user with means for filling and editing system data and metadata, searching and classifying the cartographic resources, analytical processing capabilities [18].

For the direct access to spatial data the Open Geospatial Consortium (OGC) protocols, such as Web Map Service (WMS), Web Map Tiling Service (WMTS) and others are used; they allow access to the geoportal resources from applied user programs directly such as ArcGIS, MapInfo, QGIS etc., as the support of these protocols is integrated into most of the modern geoinformation systems.

The server part of the system is implemented using the MVC design pattern (model-view-controller) and "Web 2.0" technologies [19]. Using this architecture involves splitting application data, the user interface, and control logic into three separate components: a model, a view, and a controller, so that each component can be modified independently. In the conditions of constant modernization of the system, continuous specification of technical requirements and statement of the task, these possibilities become very actual.

During the development of the system under consideration, several new software components and libraries were created that can be used (replicated) in other projects [20-22]. These are elements of the user interface, services for working with geospatial DBMS, applied cartographic mapping Web services, etc.

The basic functionality of the web GIS is provided by the software tools UMN Mapserver and MapGuide Open Source. Geospatial DBMS PostgreSQL/PostGIS, web content management system based on Drupal CMS and DokuWiki wiki system, a family of libraries for development of user interface and other system components for JavaScript programming languages, PHP – JQuery, Fusion, TinyMCE, ExtJS, MapScript, and many others are also used.

4 Satellite data catalog implementation

The priority investigation task at this stage was the development of software tools for working with satellite data catalogs. The developed software tools provide the solution of the priority tasks for the real-time processing of remote sensing data from the new UniScan satellite receiving complex at the FSC of the KSC of the SB RAS, which was put into operation in the spring 2017.

The basic software of the satellite receiving complex at FSC KSC of the SB RAS forms a set of standard products of the 1st level – channel images (brightness of spectral channels). Further tasks related to the extraction of useful information, thematic processing of data, are solved separately by means of special software.

The system of web-visualization of satellite information is based on sets of specially created collections of multi-scale images with the possibility to select on the web interface combinations of displayed channels on small scales and at the same time the availability of detailed data at the maximum available spatial resolution. The limitation in the choice of channel combinations at a detailed level is concerned with the saving of disk space. Thus, a compromise is realized between the class system "we work with swift examination and the system of the level "anything with maximum detailing". The created web interface provides viewing of the archive of satellite images. It implements the ability to select a spacecraft sensor, a predefined set of channels and products from each photo image for simple data

analysis. The capabilities of the developed software module allow combining any combination of channels available in the image without additional configuration of the server software.

The modular architecture of the system under consideration, the use of standard web services for data exchange between these modules, ensures the rapid adaptation of the existing software to the customer requirements, the replication of individual compo-nents, and their complementarity. In its turn, registration of created resources (satellite images), i.e. spatial data in the centralized catalog, provides the possibility of their simultaneous application in several developments. This service-oriented approach, based on the active implementation of web technologies into application information systems, is increasingly being used now.

LUT (Look Up Table) is used for creation of color images. This is a kind of "table of corrections" for making changes to each of the three channels. Previously, in order to improve image quality, a spectral transformation was used, which is based on working with a spectral diagram showing the relationship between the number of the image pixels and the spectral brightness values. The image contrast parameter changes during spectral transformations. To increase the contrast, a linear stretching of the histogram was used. It means that new values are assigned to all values of brightness in order to cover the entire possible range from 0 to 255. LUT allows you to change the brightness of image points when converting the image to 8 bits of 16 bits by linear interpolation between them. This enables the picture to become more bright. An example of a web interface is shown in Fig. 1.

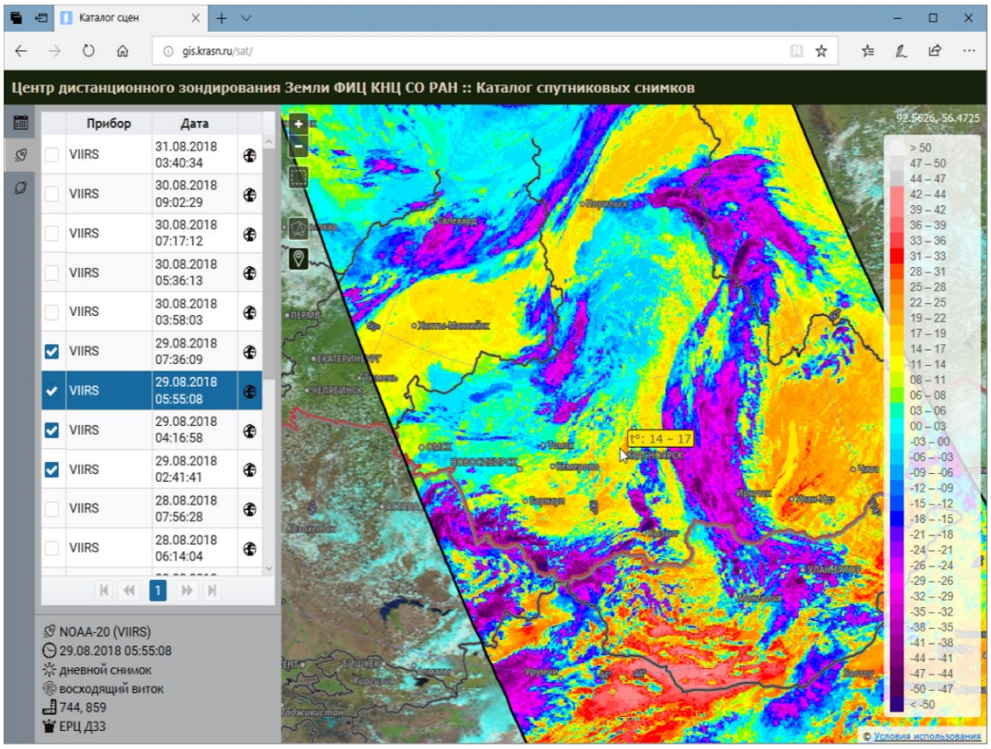

Fig. 1. The interface of the satellite images catalog of FSC KSC SB RAS

The basic tasks of development at this stage are the implementation of methods and algorithms for processing satellite data. The technological features of dealing with raster data are predetermined by the need to quickly display large files. The experiments with various formats and their parameters have shown that the optimal choice in terms of minimizing the display time in a web browser is the TIFF format with geolocation (GeoTIFF), using the TILES structure (the image consists of a set of independently stored one-type fragments), previously calculated pyramidal overview layers OVERVIEW. All the above processing steps are performed by the GDAL library utilities.

The developed software tools provide the solution of the priority tasks of the real-time processing of incoming remote sensing data, their cataloging, and interactive visualization using a web application. The following data were considered: MODIS TERRA/AQUA, SUOMI NPP/NOAA-20.

A set of server applications for the preliminary processing of satellite data was prepared for quickly and easily search in the catalog of satellite data and for minimizing the load on the server software and hardware. It includes the following processing steps:

1. Conversion of the original raster data to GeoTIFF format with the transformation of the original projection into the Lambert Azimuthal Equal Area (EPSG code: 3576), which is mandatory for the Open Geospatial Consortium services.
2. Creation for all scenes a catalog of color images in coarse resolution ("swift examination") in raster PNG format with transparency. Such images are used for quick overview of satellite data registered in the catalog with simultaneously visualization of a set of such ("swift examination") in a web browser window, with scaling on the client side, without reloading/retrieving data via the Internet.
3. Creation of multi-scale set of multi-channel images of GeoTIFF format. Each image, created in a certain spatial resolution, contains several practically significant channels, from which a certain set of color composite images are generated in the web application in parallel with the background processes. For example, for the TERRA/MODIS sensor, the multi-channel image contains 1 , 2, 3, 4, 7, 31 channels, and on this basis a set of commonly used composite RGB images is dynamically formed: 1-4-3 ("natural colors"), 7-2-1 ("Fires"), 3-6-7 ("Snow and Ice"), as well as single-channel images with palettes – 31 ("Temperature"), 2-1/2+1 (NDVI) .

Conclusion

Development of the effective software and hardware tools for the tasks of regional satellite monitoring based on the technologies of geo-information web systems has the significant importance. The developed approach can serve as a basis in solving actual applied problems related to the current and future needs of the Krasnoyarsk Region, based on use of land remote sensing data, up-to-date infrastructure of spatial data for effective social and economic progress and innovation development, improving competitiveness and ensuring safe living.

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