

# A system for satellite images database management for the study of algorithms for natural objects monitoring

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**Abstract.** A system for managing a database of satellite images for the study of natural object monitoring algorithms has been developed. The prototype of such system consisting of seven interconnected tables was created using Microsoft Access 2007. These tables contain the satellite name, sensor type and its characteristics, information about the snapshots, their parameters and, the image area information, the availability of the vector and raster maps for the snapshot, and information on sub-satellite measurements. For the forest vegetation, a technique for field measurements has been developed to determine its species composition and coordinates using a GPS receiver. An example of filling the database with information on eight types of vegetation for the sites of the Sverdlovsk region and the environs of Yekaterinburg, as well as satellite images of Terra, Aqua, Landsat and SPOT-4 is given. The developed database allows to solve such tasks as selecting images of a certain area and object for a given shooting time from the selected satellite which is necessary for analyzing algorithms for monitoring and natural objects classification by the remote sensing data.

**Keywords:** Forest vegetation monitoring, vector layers, satellite images, information catalogue

## 1 Introduction

The directory of the forest vegetation images is to be created for investigation of the remote sensing data processing algorithms solving problems of forest cataloguing and monitoring. This also involves the development of methods of collection and storage of information about species composition and the forest areas location.

Creation of the directory of forest vegetation standard parts is possible if there is information about the breed mapping of forest stands. The lack of such information makes necessity to develop the methodology for selection of the standard areas and conduct the field studies to determine their coordinates and species composition. According to the results of measurement on the ground by means of the GPS receiver, the vector layers (shape-files) are to be formed that contain the forest formula and vegetation characteristics in the attribute

information. By this, the directory is created that contains a number of standard areas with different species, age composition of the vegetation and satellite images corresponding to them.

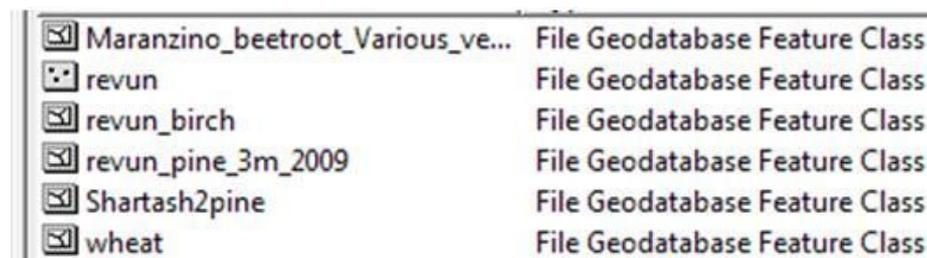
The present paper discusses a solution of these problems in Yekaterinburg and Sverdlovsk region, Russia. To determine characteristics of the forest areas, the measurements have been made in several terrain sectors located: near Shartash Lake (Yekaterinburg), in the natural parks Deer Streams (Nizhnie Sergi), Pripyshminskie Bory (Talitsa), and near Revun Rift on the Iset River (Kamensk-Uralskiy).

Formation of such directory of vegetation standard sites greatly simplifies the process of corresponding images selection. In the turn, this speeds up solving the problems of processing the classification and vegetation monitoring on the regional level.

## 2 Formation of the sub-satellite information

The areas with uniform vegetation structure have been selected on the terrain during the formation of the sub-satellite information. The structure of tree types on the percentage basis (the so-called forest formula) has been recorded for these areas. Their geographical coordinates were also measured using the GPS receiver Garmin eTrex Vista Cx [1]. The young vegetation was also characterized by the density and height growth. Moreover, the character of the underlying surface was recorded for the explored areas.

The measurements have been transferred to the PC memory. As a result, the directory has been created for the shape-files grouped according to the type of vegetation and their location. The fragment of such directory is shown in Fig. 1.



**Fig. 1.** A fragment of the directory of vegetation shape-files

For visualization, the created shape-file (vector layer) of labels made on the route has been combined with the raster layer, *i.e.*, the space image area, for which sub-satellite measurements have been carried out. For more precise alignment of the vector and raster layers, the automatic or manual mapping by the characteristic points (for example, on lakes or river bends) has been made.

The most important parameter is the shape-file attribute information, which initially includes the coordinates of the point, its projection coordinates, identification number, information about measuring device, the date and time of shooting, the height above sea level, and some additional information (Fig. 2).

Attributes of "Deer Streams"										
FID	IDENT	LAT	LONG	Y PROJ	X PROJ	COMMENT	ALTITUDE	COUNTRY	CITY	DTYPE
0	298	56,535476	59,268011	56,535476	59,268011	27-MAR-11 13:19:07	280			1
1	294	56,535712	59,260795	56,535712	59,260795	27-MAR-11 13:09:42	309			1
2	297	56,535584	59,265285	56,535584	59,265285	27-MAR-11 13:16:05	279			1
3	288	56,530035	59,253971	56,530035	59,253971	27-MAR-11 12:38:24	318			1
4	2S4B4S	56,525113	59,238773	56,525113	59,238773	27-MAR-11 12:19:51	355			1
5	296	56,535912	59,263297	56,535912	59,263297	27-MAR-11 13:13:34	296			1
6	300	56,536503	59,263304	56,536503	59,263304	27-MAR-11 13:40:12	304			1
7	293	56,535109	59,257898	56,535109	59,257898	27-MAR-11 13:02:02	314			1
8	289	56,532348	59,252632	56,532348	59,252632	27-MAR-11 12:44:46	306			1
9	284	56,528128	59,247572	56,528128	59,247572	27-MAR-11 12:30:26	320			1
10	295	56,536001	59,262705	56,536001	59,262705	27-MAR-11 13:12:00	302			1
11	290	56,532689	59,253557	56,532689	59,253557	27-MAR-11 12:51:43	316			1
12	281	56,526724	59,242636	56,526724	59,242636	27-MAR-11 12:25:02	336			1
13	282	56,527078	59,24538	56,527078	59,24538	27-MAR-11 12:27:42	325			1
14	285	56,528909	59,248531	56,528909	59,248531	27-MAR-11 12:31:56	319			1
15	301	56,536403	59,262062	56,536403	59,262062	27-MAR-11 13:41:30	308			1
16	299	56,535681	59,264815	56,535681	59,264815	27-MAR-11 13:36:36	284			1
17	292	56,534769	59,256864	56,534769	59,256864	27-MAR-11 13:00:39	316			1
18	286	56,529504	59,249645	56,529504	59,249645	27-MAR-11 12:33:20	320			1
19	280	56,525268	59,226964	56,525268	59,226964	27-MAR-11 12:05:20	0			1

Fig. 2. Attribute Table to labels (natural park Deer Streams)

The information about vegetation has been added to the attribute table based on the records of its type carried out en-route simultaneously with the location determination using the GPS receiver. At the next stage, the shape-files consolidation has been performed according to the areas where measurements have been taken. These operations have been carried out on the geographical information system (GIS) ArcGIS [2].

The labels limiting the fields of the uniform type of vegetation in ArcGIS help to draw corresponding polygons. According to these polygons, parts from the space images are cut for the statistical and spectral analysis of their characteristics. The example of polygons for the Shartash Forest Park with the attribute information is shown in Fig. 3. Clicking any site, the line with the relevant information is highlighted in the table; for example, the birch growth in the selected blue area in Fig. 3.

Correspondingly, the information for any number of the standard areas is formed and entered into the table. This allows creating the directory that contains objects' characteristics that are necessary for studying the properties of their images.

It is necessary to have the appropriate database (DB) for the analysis of effectiveness of the vegetation classification algorithms. The specified database includes the images in vector form for seven standard areas in Yekaterinburg and Sverdlovsk region. It also contains the forest formula and other characteristics of vegetation for the areas as the attribute information. The Yekaterinburg re-

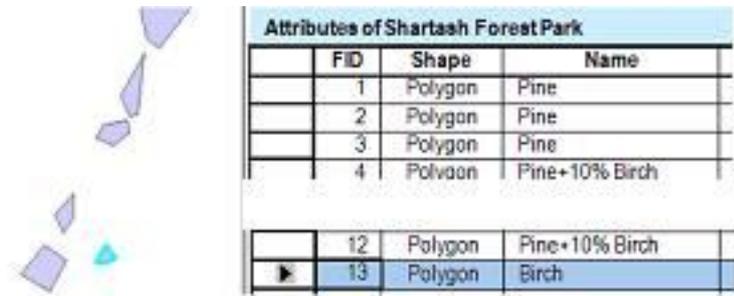


Fig. 3. Selected site and the attribute table for Shartash Forest Park

gion includes the following park zones: Stone Tents (ST), Shartash Forest Park (Sh), Russian Foresters Park (RF), Mayakovsky Park (M), and the Southwest Forest Park (SF). Sverdlovsk region includes the following zones: the forest park Pripyshminskie Bory around Talitsa (T) and vegetation areas near the Revun Rift on the Iset River (R). The vegetation sites in the natural park Deer Streams have been excluded from the consideration because of their small area.

According to this data, the directory containing a sufficiently large number of standard areas with different species and age composition of the vegetation is created. This data is presented in Fig. 4.

Vegetation type	Territory						
	ST	Sh	RF	M	SF	T	R
Larch	x		x				
Poplar	x						
Birch		x			x		x
Pine	x	x	x	x	x	x	x
5P5B		x		x	x		
7P3B					x		
9P1B		x					x
5A5B						x	

Fig. 4. Composition of the directory of standard areas

As a result, the following vector files are formed with: pine in seven standard areas; larch in 2 areas; poplar in one area; birch in 3 areas; 5P5B (50% pine and 50% birch) in 3 areas; 7P3B in one area; 9P1B in 2 areas; and 5A5B (50% of aspen and birch 50%) in one area.

### 3 Database creation

Using the known coordinates of the generated standard areas, a database is created. This database contains the catalog of satellite images from the standard areas and sub-satellite vegetation data. This information is obtained from measurements on the ground, from the Internet, public archives, and other sources. This database also includes information about the satellites and instruments used to obtain the constituent snapshots. The database updates the information, which is necessary for executing the vegetation classification algorithms by collecting data from the remote sensors.

The database is created using application of the software Microsoft Access 2007. The database consists of several joined tables.

**Satellite:** contains a description the satellite name, sensor, its spatial resolution, the number of spectral channels, swath, frequency of recording, the start date, as well as a link to the source images.

**Snapshots:** lists the snapshots and their attribute information. The attribute information includes the name of the snapshot, the date and time of recording, the satellite, coordinates of the upper left and lower right corners of the snapshot, the percentage of cloud cover, region, province or city, location in the image, and allocation of the snapshot. The catalog includes the images of Sverdlovsk region with the percentage cloud cover no more than 80%.

**Objects:** shows the results of the sub-satellite measurements such as execution date, forest formula, description of the site and its size in pixels, and the name of territory where the measurements are made.

**Territories:** contains complete information about the natural object, including the location, category, and characteristics.

**Vector Maps:** includes complete details of the vector maps.

**Raster Maps:** includes complete details of the raster maps.

**Linker:** links the tables Snapshots and Raster Maps.

By using this directory, it is possible to perform the following tasks:

- selection of images from a predetermined portion;
- selection of images from a predetermined time interval;
- selection of images from the selected satellite on a certain date;
- selection of images, where there is one or more targeted objects.

The developed database simplifies the selection of targeted snapshots, that speeds up the process of their treatment.

**Satellite** table is shown in Fig. 5, and **Snapshots** table is shown in Fig. 6. **Objects** table is shown in Fig. 7, and **Territories** table is shown in Fig. 8.

Next **Vector Maps** (Fig. 9) and **Raster Maps** (Fig. 10) tables are presented. They are intended to view maps where the studied object is located.

Satellite							
Code	Satellite	Sensor	Launch	Swath (km)	Snapshot interval (day)	Data source	Technical remarks
1	Landsat 7	ETM+	15.04.1999	185	16	<a href="http://landsat.usgs.gov">http://landsat.usgs.gov</a>	7 spectral bands
2	Landsat 5	TM, MSS	01.03.1984	185	16	<a href="http://landsat.usgs.gov">http://landsat.usgs.gov</a>	7 spectral bands
3	Terra	MODIS	18.12.1999	2300	0.5	<a href="http://glovis.usgs.gov">http://glovis.usgs.gov</a>	36 spectral bands

Fig. 5. Satellite table fragment

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. 6. Snapshots table fragment

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. 7. Objects table fragment

Code	Territory name	Category	Location	Description	Vector map
1	Mayakovsky Park	City Park	Yekaterinburg city	open area	Mayakovsky Park
2	Stone Tents	City Park	Yekaterinburg city	open area	Stone Tents
3	Pripyshminskie Bory	National Park	Talitsa city	protected area	Sverdlovsk region

Fig. 8. Territories table fragment

Code	Name	Scale	Description	Data location
1	Sverdlovsk region	1:100 000		<a href="#">Z://Vector maps/</a>
2	Sverdlovsk region	1:200 000		<a href="#">Z://Vector maps/</a>
3	Yekaterinburg	1:10 000		<a href="#">Z://Vector maps/</a>

Fig. 9. Vector Maps table fragment

Code	Name	Scale	Description	Data location
1	Sverdlovsk region	1:850 000	Forest map	<a href="#">Z://Raster maps/</a>
2	Pripyshminskie Bory	1:500 000		<a href="#">Z://Raster maps/</a>
3	Yekaterinburg	1:33 000		<a href="#">Z://Raster maps/</a>

Fig. 10. Raster Maps table fragment

The link between the **Snapshots** and **Territories** tables is many-to-many. Therefore, this link is carried out through additional **Linker** table.

Three requests are performed in our directory. The first one is **Vegetation Type and Subtype Selection** (Fig. 11). It forms tables of selected subtype of vegetation (Fig. 12 and Fig. 13).

**Vegetation Type and Subtype Selection**

Start day: 01.01.1990      End day: 13.05.2015

Object type: Forest      Area not less than (sq m): 10

Object subtype: 10B      Area not more than (sq m): 10000

Upper left corner (N): 62      Bottom right corner (N): 56

Upper left corner (E): 57      Bottom right corner (E): 66

Search for snapshots      Search for sub-satellite information

Fig. 11. Vegetation Type and Subtype Selection form

Date	Object type	Object subtype	Area (sq m)	Territory name	Coordinates
01.10.2009	forest	10B	350	Shartash Forest Park	56.86N 60.67E
27.05.2010	forest	10B	650	Mayakovsky Park	56.81N 60.64E
16.08.2010	forest	10B	500	Stone Tents	56.85N 60.66E

Fig. 12. Implementation of the request by clicking the **Sub-Satellite Information Search** button

Measurement date	Object type	Object subtype	Territory name	Snapshot name	Snapshot date
01.10.2009	forest	10B	Shartash Forest Park	LE51630202007140	20.05.2007
01.10.2009	forest	10B	Shartash Forest Park	LE51640202007179	28.06.2007

Fig. 13. Implementation of the request by clicking the **Snapshots Search** button

The request **Selection of Snapshots by Date and by Satellite** is required to enter the start and end dates, as well as the type of the satellite. The placement of the snapshot and the list of territory objects displayed on it are shown in request results (Fig. 14).

Fig. 14. Selection of Snapshots by Date and by Satellite request execution

The third request **Territory Snapshots for Certain Period Selection** is required to enter a date range and territory name (Fig. 15).

The sequence for entering new information depends on the type of information being added. In order to enter new sub-satellite data, it is first necessary to check whether the **Territories** table already has the area where the measurements are taken and, if not, add it. After that, the parameters of the objects and their location are entered into the **Objects** table. Finally, users can link a new territory to the **Snapshots** table or can link the snapshots to a specific site in the **Territories** table. If the territory where the measurements were made already exists in the database, the users only need to add the new sub-satellite information for it.

Snapshot name	Date	Time	Satellite
LE51650182005199	18.07.2006		LANDSAT 5
LE51650182005295	22.10.2006		LANDSAT 5
LE51650182007234	22.08.2007		LANDSAT 5
LE51650182010210	29.07.2010		LANDSAT 5
LE51650181991277	04.10.1991		LANDSAT 5
LE51650182005174	23.06.2006		LANDSAT 5
LE51670182010176	25.06.2010		LANDSAT 5
LE71630202004188ASN01	06.07.2006	6:44:57	LANDSAT 7
LE71630202004220ASN01	08.08.2004	6:44:45	LANDSAT 7
LE71630202005142ASN00	22.05.2005	6:45:33	LANDSAT 7
LE71630202007180ASN01	29.06.2007	6:46:12	LANDSAT 7
LE71630202009169ASN00	18.06.2009	6:46:22	LANDSAT 7
LE71640202000200SGS00	18.07.2000	6:53:33	LANDSAT 7
LE71640202001170SGS00	19.06.2001	6:51:38	LANDSAT 7
LE71640202004243ASN01	30.08.2004	6:52:50	LANDSAT 7
LE71640202005197ASN00	19.07.2005	6:33:44	LANDSAT 7
LE71640202005200ASN00	19.07.2006	6:44:52	LANDSAT 7
LE71640202009192ASN00	11.07.2009	6:52:30	LANDSAT 7

Fig. 15. Results of Territory Snapshots for Certain Period Selection request for natural park Deer Streams

Upon receipt of the new images, it is first necessary to check the existence of the satellite in the **Satellites** table and, if it does not exist, to add it. Then it is necessary to add the new images into the **Snapshots** table. If cloud cover is more than 80%, the addition of these new images is blocked, and the user will receive a warning message.

#### 4 Conclusion

The article presents the results of the development a imagery database for natural objects monitoring in Microsoft Access 2007. The database contains a catalog of images from the satellites Terra, Aqua [3], Landsat 5, Landsat 7 [4], SPOT 4 [5] and Almaz 1 [6] with recording their location on an external medium. It also contains the characteristics of images and satellites (satellite launch date, image resolution, spectral range, *etc.*). Finally, this database contains information about the parameters of the observed objects, including their size, location and type of vegetation. The prototype catalog was developed for standard vegetation areas containing information about their coordinates, vegetation composition, characteristics of their state and time of field measurements. The catalog was

filled with the vector files for eight types of forest vegetation for seven objects located in the Sverdlovsk region and the city of Yekaterinburg. To fill the catalog a procedure for creating vector layers (shp-files) has been developed, which is based on the results of sub-satellite measurements by the GPS receiver. When transferring data to a PC, these images are supplemented with the information about the attributes containing the forest formula and the vegetation characteristics. The developed database is capable for performing such tasks as selecting images for a specific area, object, time interval or satellite. It can also help in the study of algorithms for classifying vegetation and monitoring the fire situation [7, 8].

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