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The Technology to Identify Firebreak Plowing Objects Based on the Satellite Data of the Earth Remote Sensing

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Abstract. This work describes the technology to identify firebreak plowing objects of agriculture fields based on the satellite data of the Earth Remote Sensing within the medium and high spatial resolution. The technology uses a model of the firebreak plowing object, vegetation indexes and spatial relations between objects.

1 Introduction

The risk of a fire hazard emergence on agriculture fields increases in the cereals harvesting season due to straw and unplowed lands.

Therefore, it is necessary to plow the boundaries of agriculture fields in order to reduce fire hazard risk [1]. This condition sets a task of the control over compliance with fire safety regulations.

This paper shows the use of information model in the technology of firebreak plowing objects (FPO) identification.

This technology is a set of methods and algorithms that allow recognizing the target objects based on satellite data of the Earth Remote Sensing at medium and high spatial resolution. Besides, it allows identifying the territories requiring control over existing or missing FPO according to [1].

2 Fire Plowing Model

Firebreak plowing objects on digital images of the Earth Remote Sensing (ERS) within medium and high spatial resolution are objects of open soil with a linear geometric structure. The length of FPO varies depending on the perimeter of plowed agriculture fields. Width of FPO should be at least 4 meters [1]. There are time constraints for receiving the necessary remote sensing data because the period of cereals harvesting in autumn season is 1-2 months. The FPO areshowed in Fig. 1 (a-c).

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a *b* *c*

Fig. 1. Fragments of ERS data (SPOT 6) obtained for different areas within Krasnoyarsk Territory. FPO are highlighted in red color.

To solve the FPO identification task described in [2], the use of consolidated stages of the ERS digital image processing was investigated as well as methods of supervised classification, such as the method of parallelepipeds; minimum distance classification method; maximum likelihood classification method.

Applying the consolidated stages of ERS image interpretation produces a sufficient number of type 1 classification errors (false positive) because the spectral specifications of target objects have values of spectral specifications of open soil.

A fragment of a segmented satellite image is showed in Fig 2.

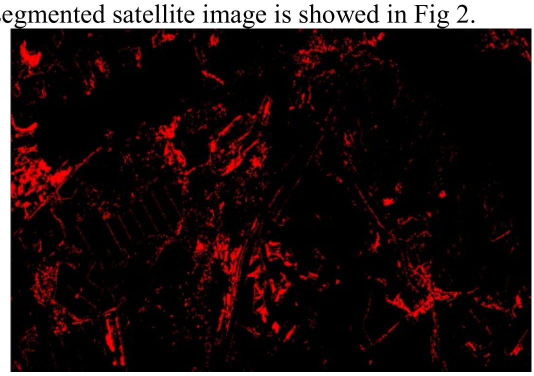


Fig. 2. A fragment of processed satellite image (segmented objects – red color, background – black color).

Thus, to solve the FPO identification task an image needs to be transformed from iconic processing level to relational structures level [3, 4] with calculation of metric, topological, spectral and spatial features of object, and also with creation of relations between objects.

A model of FPO as an identification object is described in [5].

FPO is an object with linear geometric structure [6] described by the following expression (1):

$$FPO = \langle M, T, L, N, E \rangle \tag{1}$$

where M is spatial multiple connection; T are constraints of object width; L are constraints of object length; N is range of NDVI values corresponding to open soil; E are spatial relations between FPO and neighbouring objects.

The following expression is used for calculation of NDVI for a satellite image (2):

$$NDVI = \frac{NIR - RED}{NIR + RED} \tag{2}$$

where *NDVI* is a value of normalized differential vegetation index of satellite image pixel; *NIR* is a value of the nearest infrared spectral channel (wavelength 0.76-1 micrometres); *RED* is a value of red spectral channel (wavelength 0.6-0.76 micrometres);

To solve the task of open soil segmentation it is required to define LP (ω) predicate based on the spectral feature (NDVI value). NDVI values for the open soil are within the range [7,8]:

$$0.025 \leq \text{NDVI} \leq 0.26 \tag{3}$$

Expression for LP (ω):

$$\text{LP}(\omega) = \begin{cases} \text{TRUE, if } 0.025 \leq \text{NDVI}\,(\text{f}(\text{x},\text{y})) \leq 0.26 \\ \text{FALSE, otherwise.} \end{cases} \tag{4}$$

where *f(x,y)* – function of brightness of satellite image pixel; *NDVI* – value of normalized differential vegetation index of satellite image point.

The rule for FPO classification is as follows: the selection of segments belongs to the set of located territories using predicate LP, moreover, the thickness of segments is greater than the specified threshold and the length is even more greater than thickness:

$$\bar{g}(\omega) = T(\omega) > \text{c}_1 \; AND \;\; \omega \in W_1 \; AND \;\; T(\omega) \ll L(\omega) \; AND \; LP(\omega) \tag{5}$$

where $T(\omega)$ – function of object thickness; $L(\omega)$ – function of object length; c_1 – set threshold of object thickness (4 meters for FPO); W_1 – multitude of located territories areas. Euclidean distance is the metrics of the classifier.

3 Interpretation of Agriculture Fields

One of the main tasks of agriculture field interpretation is determination of a set of features that separate agricultural fields from territories with natural vegetation.

The paper describes the differences between natural vegetation and several agriculture crops described in paper [9], such as duration of vegetation period, and interannual dynamics of green biomass. The vegetation index dynamic is used to estimate the start date of phenological phases of plants. Maximum vegetation index is suggested to correspond to blooming phase.

Paper [10] describes 3 periods of vegetation seasons when spectral differences between natural vegetation and spring crops are maximal:

1: (May - first half of June) Minimal coefficients of reflectance, period of the sowing;

2: (end of July – beginning of August) Maximal coefficients of reflectance of grain crops in spectral channel with wavelength 0.841-0.876 micrometres, period of heading and blooming.

3: (end of August – September) Maximal coefficients of reflectance in spectral channels with wavelength 0.620-0.670 and 0.841-0.876 micrometres, period of the full wax ripeness and start of harvest.

The analysis shows that NDVI and perpendicular vegetation index (PVI) are used in most of algorithms for agriculture fields interpretation with methods of supervised classification [11,12,13].

4 Technology of FPO Identification

The technology based on the general approach of pattern recognition and image analysis [14]

The technology includes the following stages [15]:

- The selection of the input ERS data with account for cloudiness is performed based on the developed regional center of ERS [16] using antenna receiving complex;

- Preliminary processing of the input ERS data till 2A level and also georeference using reference points, atmospheric correction and estimation of cloudiness. The latter estimation is completed using the algorithm described in [17].

- interpretation of objects of the agriculture fields,forests, automobile roads and railways, power lines [1].

- Location of territories for further data processing;

- Segmentation of open soil objects;

- Classification of FPO pursuant with (5);

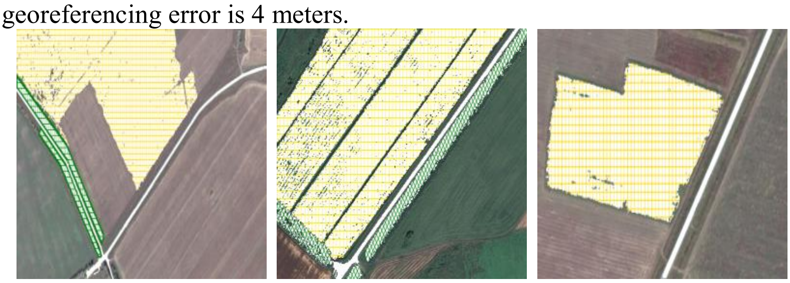
- Estimation of classification accuracy;

5 Experimental Research over Technology of FPO Identification

Pursuant to main stages of the technology the expert selected the input satellite ERS data with the value of cloudiness being 5% using the catalogue of the regional ERS center data (Fig. 1). The catalogue is available on the Internet: http://digitalatlas.ru/. The next step of the technology is preliminary data processing.

Interpretation of additional objects (forests, automobile roads, railways, power lines) has been performed by the expert with ground-based researches and GPS binding.

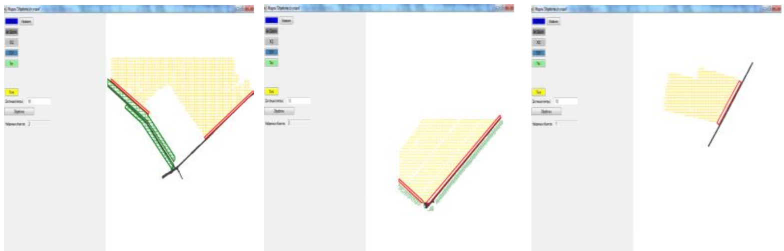
The resulted vector layers are marked on Fig. 3. The scale of vector data is 1:10000. Metrical georeferencing error is 4 meters.



a) b) c)

Fig. 3. Fragments of ERS data with classified objects (automobile roads – white color; agriculture fields – yellow color; forest – green color)

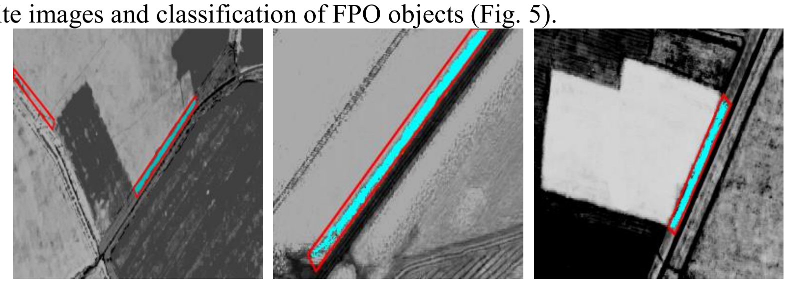
The interpretation of additional objects was followed by location of territories areas to search FPO objects. For the latter purpose vector layers have been loaded to developed program module to locate FPO objects, territories have been selected for followed interpretation after processing (Fig. 4).



a) b) c)

Fig. 4. Operation of the module for location of the FPO with selected territory areas for further data interpretation.

The next step of the technology is segmentation of open soil using the calculated NDVI for satellite images and classification of FPO objects (Fig. 5).



a) b) c)

Fig. 5. Images of the NDVI calculated on the basis of the satellite images with located territory areas for further interpretation (red color) and classified FPO object (blue color).

6 Conclusion

The technology of FPO identification has been developed using information model described in [5].

Over 100 satellite images with high spatial resolution picturing the agricultural areas within Krasnoyarsk Territory have been processed using the proposed technology. The resulted classification accuracy is 93%.

In addition, task solving allowed developing ancillary algorithms, methods, and software to identify FPO. Experimental research has been completed over the proposed technology within the agricultural areas of Krasnoyarsk Territory.

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