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Algorithm of Monitoring of a Surface in Real Time by Pilotless Aircrafts

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Abstract: The model of the informational system for monitoring of a terrestrial surface by means of PLA real time is offered. It is presented, in the capacity of an instance, model of monitoring of ripeness of grain crops. Possibility of use of the offered system for monitoring of remote sections of a terrestrial surface real time is discussed.

Keywords: PLA, Monitoring, Emission Analysis, Plants

1. Introduction

Circumambient monitoring - complex system of long-term observations, an estimation and the forecast of a change of state of a circumambient under the influence of anthropogenous factors. As the primary goals of monitoring serve: observation over a biosphere condition, an estimation and the forecast of a condition of environment, revealing of factors and sources of anthropogenous affecting's on a circumambient, the forestalling of the created critical situations harmful or dangerous to ability to live and health of people and other live organisms.

Long-term experience of the analysis of the satellite information testifies to basic possibility of use of the data of multispectral satellite shooting for monitoring of a tract of forest, water medium, a condition of agricultural crops: definitions of structure of cultivated areas, parameters of a vegetative overlying strata, a condition of field crops and other informative signs [1-4].

Monitoring of remote sections of a terrestrial surface by pilotless aircrafts (PLA) with the subsequent analysis [3-4], promotes effective conducting activity and forecasting of desirable results in such branch sectors as the agriculture, animal industries, plant growing. Along with it, use PLA brings in advantages on periodicity, accuracy and localization of conducting of emission analysis of remote zones of a terrestrial surface.

2. Method

One of rather effective remedies of monitoring of locality and installations is monitoring in a visible range of a spectrum [5-7]. On this spectral range it is necessary a maximum of energy of the self-radiation (luminescence) which is let out by such land organic installations, as grassy and vegetative overlying stratas. Spectral monitoring of a terrestrial surface is connected not only with revealing of dynamics of natural sources, but also with the solution of the practical problems connected with economic activities.

2.1. Normalized Differential Vegetation Index

As the quantitative characteristic of a condition of vegetation normalized index NDVI (Normalized Differential Vegetation Index) serves. In a certain point of the image, NDVI is a relation of a difference intensity reflected light in the infra-red and red ranges of a spectrum to their sum. In red area of a spectrum there is a maximum of sorption of solar radiation a chlorophyll, and in a spectrum infra-red - a reflexional maximum cellular structures of sheet.

$$NDVI = (R_{ir}^{*} - R_{r}^{*})/(R_{ir}^{*} + R_{r}^{*}) \tag{1}$$

Where R_{ir}^{*} and R_{r}^{*} - factors of spectral luminance accordingly in short-range infra-red and red zones of a spectrum. In table 1 the specified factors for a various aspect of vegetation and magnitudes NDVI and R_{ir}^{*}, R_{r}^{*} counted on their values are presented.

Table 1. *Value of an index NDVI for various surfaces.*

Installation type	R_r^*	R_{ir}^*	NDVI
Dense vegetation	0.1	0.5	0.7
The rarefied vegetation	0.1	0.3	0.5
Open soil	0.25	0.3	0.025
Clouds	0.25	0.25	0
Snow and ice	0.375	0.35	-0.05
Water	0.02	0.01	-0.25
Artificial materials (beton, asphalt)	0.3	0. 1	-0.5

As a result of vegetation shooting on a surface it is computed NDVI and it is combined with a card of a surface in the form of color areas with various values NDVI (Figure 1).

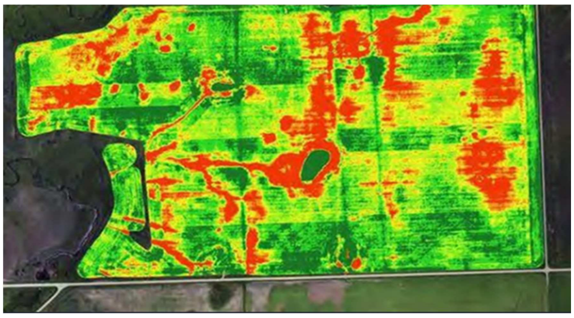


Figure 1. *Schematized curves of spectral luminance of a vegetative overlying stratum [4].*

However, use of space shooting most effectively for large administrative controls [1]. In too time at decision-making on places (in the agricultural factories), especially regarding definition of a time of cleaning grain, space monitoring does not possess necessary efficiency. Besides space shooting depends essentially on conditions (a cloud, level and an illumination angle). An essential deficiency of such system is duration of machining of the information. Use of the satellite data demands the certain software for an estimation of a condition of an overlying stratum, with reference to concrete installation [4]. All it restricts usability of such method to small sections of a surface. In case of the big surfaces (more 1000 hectares), the method is quite adequate for a monitoring problem solving.

For implementation of system of continuous monitoring of a surface real time it is offered to use a method of combination of emission analysis with transfer of the video image of a surface by means of PLA (quadcopter). Quadcopters possess that doubtless advantage that the regime of hanging and monitoring of sowings allow to use, up to daily, without specific conditions of shooting. The user has possibility, at own discretion, to pass the analysis for adoption of the operative solution [2].

2.2. Method SURF

To combine the image of a surface with its spectral characteristics, for example, a luminescence maximum, it is necessary to use the most adequate method of comparison. Most widely method SURF (Speeded Up Robust Features) which consists in the following [8-9] is applied.

The method applies pointwise characteristic features of the image, and in any way all available points (a method of histograms and average colors). SURF resolves 2 problems - selection of special points of the image and formation of their descriptors, invariant to scale and rotation. It means that representation of a key point will be identical, including if the sample changes the size or becomes turned. Besides it, immediately search of the main points should possess invariancy that the turned object possessed the same set of key points, as the sample.

In numerous tasks of image processing it is necessary to calculate brightness of a square-topped section of the image, for example, by means of the filter of Haar. Integral representation gives the chance to calculate very quickly total brightness of any rectangle, thus the calculation period does not depend in any way on the rectangle area.

Filters of Haar represent pointwise value of overfall of brightness on x axes and y accordingly. As filters of Haar possess a rectangular form, their values easily settle up by means of an integral matrix. Image - integral representation is a matrix which dimensionality converges with dimensionality of the initial image. Matrix components settle up under the following formula:

$$II(x, y) = \Sigma\Sigma I(i, j) \quad (2)$$

where $I(i, j)$ - brightness of pixel of the source image. Each element of a matrix $II(x, y)$ represents a dial-up of pixels in a rectangle. For calculation $II(x, y)$ it is convenient to use the recurrence formula

$$II(x, y) = I(x, y) - II(x-1, y-1) + II(x-1, y) + II(x, y-1) \quad (3)$$

taking into account the maximum value of a gradient. It allows to reduce calculation time considerably.

For calculation of descriptors of a special point it is necessary to install the main orientation of overfalls of brightness in a special point. The given concept is close to concept of a gradient, however SURF uses slightly other method of search of a vector of orientation.

At first pointwise gradients in the pixels allocated near to a special point settle up. For reviewing pixels in a circle of radius of a special point 6×s, where s - scale of a special point undertake.

2.3. Filters of Haar

Filters of Haar represent pointwise value of overfall of brightness according to a x axis and y accordingly. As filters of Haar possess a rectangular form, their values easily settle up by means of an integral matrix. For calculation of filter of any size 6 operations are required only. [10]. Values of filters of Haar (dx, dy) for each point are multiplied by weight and remembered in an array. Weight обуславливатеся as value гауссианы with center in a special point and a sigma equal 2×s. Weighing on гауссиану is necessary for cutting off of casual noises on distances far from a special point round center of coordinates.

For descriptor calculation, round a special point the square-topped area which has the size 20× s where s - scale in which the special point has been found out is formed. For the first octave, the area has the size 40×40 pixels. The square is guided along the priority direction calculated for a special point (the Figure 2).

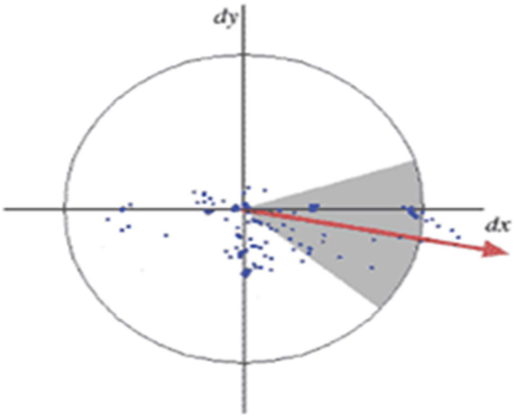


Figure 2. *The neighborhood of a special point.*

Then, the square breaks into smaller 16 quadrants. In each quadrant the regular grid 5×5 undertakes and for a grid point the gradient by means of the filter of Haar is searched. The size of the filter of Haar is accepted equal 2×s and for the first octave makes 4×4.

It is necessary to select that at calculation of the filter of Haar, the image does not rotate, the filter settles up in normal coordinates of the image. And here the received coordinates of a gradient (dx, dy) are turned on a corner which corresponds to square orientation. In total, for calculation of a descriptor of a special point, it is necessary to calculate 25 filters of Haar, in each of 16 quadrants. Only 400 filters of Haar. In view of that on the filter 6 actions are necessary, we receive that the descriptor manages a minimum in 2400 actions. After finding of 25 pointwise gradients of a quadrant, four values which are descriptor elements settle up. Two of them it is simply total gradient on a quadrant, and others 2 - the total of units of pointwise gradients. For the uniform monotonous areas - all values are close to zero. For repeating vertical strips - all values, except the second are close to zero. At brightness magnification in the x axis direction, the two first components possess great values. [10]

3. Results

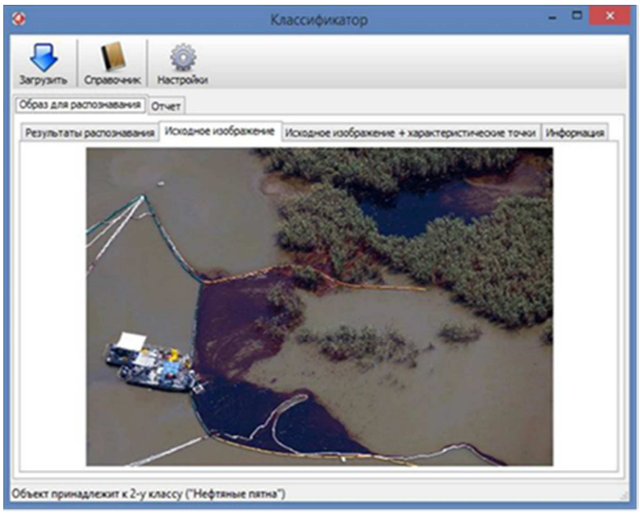
Algorithm basis is program TAnalyser. It serves for object class definition under its image. Classification is fulfilled as follows:

1. Images of objects are stored in a database and calculated for them, by method SURF, characteristic points (for each object the class is defined);
2. The user defines an input image for which it is necessary to calculate its class association;
3. For an input image characteristic points are calculated;
4. Comparing of characteristic points of input object with characteristic points of objects which are stored in a database is produced and the object with a correspondence maximum level is selected;
5. For object with the maximum correspondence the class is defined. The given class also grows out of algorithm operation.

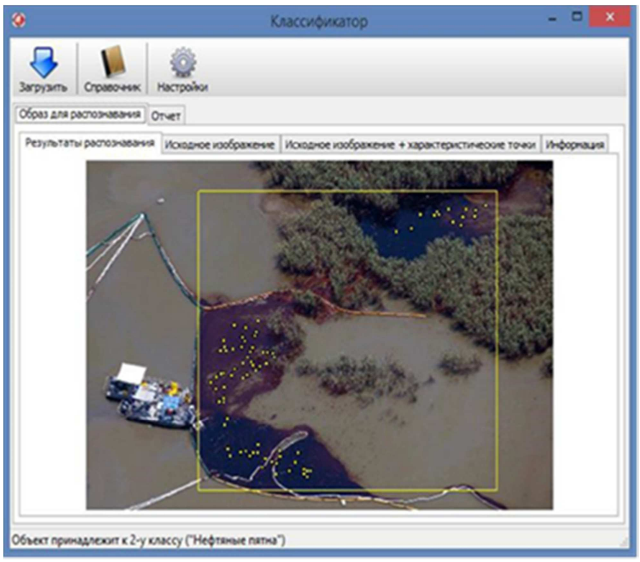
Modeling estimations of an operating time of algorithm for the image in the size 266×377 points and an amount of characteristic points 300 show that handling time makes 280 msec. It is quite enough of it for embedding in video a picture without an essential time delay of the image.

Such method gives the chance to carry out monitoring in a real-time mode. Its main advantage is program localization of points. It allows, depending on transit velocity of a video stream, to install demanded localization of a section of a surface that, in turn, gives the chance to use more floppy available resources of handling of the image on a notebook.

By way of illustration in a Figure 3 images of sections the surfaces having pollution and processed on algorithm TAnalyser are presented.



a)



b)

Figure 3. *a) - the raw image, b)- with characteristic points.*

Image processing allows to install precisely enough concentration of pollution and their localization. Such method gives the chance to carry out monitoring in a dynamic mode. It's main advantage is program localization of points. It allows, depending on transit velocity of video of a flow, to install demanded localization of a section of a surface that, in turn, gives the chance to use more floppy available resources of handling of the image on a notebook.

4. Discussion

For implementation of the declared principles it is offered to use quadcopter with load-carrying capacity not less than 2 kg. Such weight characteristic allows to use a video camera and a spectrometer of type SL40-2. The specified spectrometer possesses small weight – 470 g and the wide spectral interval registered in two channels. Thus it is necessary to mark that registration is produced on a ruler of photo detectors that allows to calibrated a spectrometer for necessary lengths of waves each shoulder.

For information display about value NDVI leading out of value of coefficient on the monitor screen in video of a picture of a section is possible weeding. Accepting, as model, a camera coverage in 6°, at flight height quadcopter in 100 m, we receive capture band width in 20 м, at height of flight of 500 m - 100 m. Proceeding from time of the continuous operation at 1 o'clock we receive the field review in 100 Hectares with resolution not worse 10 m.

5. Conclusion

The offered model of system of monitoring of a surface of land possesses essential advantage as allows to examine real time a surface with an estimation of a condition of a vegetative overlying stratum. Besides, the system is simple enough in apparatus modification and does not demand additional processing methods of the image. Using devices available in the market for video and emission analysis transfer it is possible to create the monitoring portable system without special expenses. To advantages of system, it is necessary to refer to high efficiency of monitoring. In addition to the satellite system, the offered system allows to size up continuously a condition of a vegetative overlying strata, to spend visual survey of remote sections of a surface.

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