

# The objective assessment of the image quality based on the geometrical concentration

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**Abstract.** The method of the objective evaluation of the satellite images based on the calculation of the geometrical concentration using triangulation Delaunay is proposed. Such assessment allows to estimate the degree of the image distortion and can be used for indexing and filtration data in the satellite images catalogues.

## 1 Introduction

The important stage of the remote sensing data processing is the search and selection of initial data with specific requirements. One of such requirement is minimal number of the noise defects, which distorted the satellite image. Photometric distortions of space images can be of different nature: imaging equipment interference, the interference associated with atmospheric optics, noises in the receiving path of remote sensors. An example of such distortions is cloudiness cover for industrial, social and agriculture studied objects.

In the first case, the distortions can be eliminated by radiometric and atmosphere corrections, in the second case the specialist have to taking into account the cloudiness during selection of initial data.

The volumes of remote sensing data rises year by year in the regional and federal satellite images warehouses. It requires the development new criteria and metrics for searching and filtration huge volumes of the data, with using not only time-spatial properties, but using the level of relational structures of images with semantics and relationships between objects.

This paper contains the new metric of the satellite image quality based on the geometrical concentration calculation of the segmented objects on the example of cloudiness.

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## 2 The measurement of the image quality

The subjective expert assessments are used for estimation of the image quality and for construction of the objective assessments based on the average scores (mean opinion score - MOS) [1]. However, today, the objective assessments without experts are most interest, such as:

- Peak Signal to Noise Ratio (PSNR) [2] defined with using Mean Square Error (MSE).
- Minkowski distance [3].
- Structural SIMilarity (SSIM) [4].

The described above metrics based on comparing of the 2 images: initial and distorted, but such assessments do not reflect the physiology of human perception. On the other hand, it is difficult to use such metrics because it is impossible to obtain two satellite images of the same area with the same conditions.

One of the metric of the satellite image quality is assessment of cloudiness on the image as criterion of the image distortion. The typical method is following: first stage is segmentation of image with cloudiness recognition, then the binary mask is built, and after that the cloudiness percent is calculated using following statement:

$$P = \frac{S_1}{S} 100\%, \quad (1)$$

where  $P$  – the cloudiness percent;  
 $S_1$  – the number of cloudy pixels of the binary image;  
 $S$  – the total number of pixels of the binary image.

This metric of cloudiness is used in many interfaces of the remote sensing catalogs as search criterion:

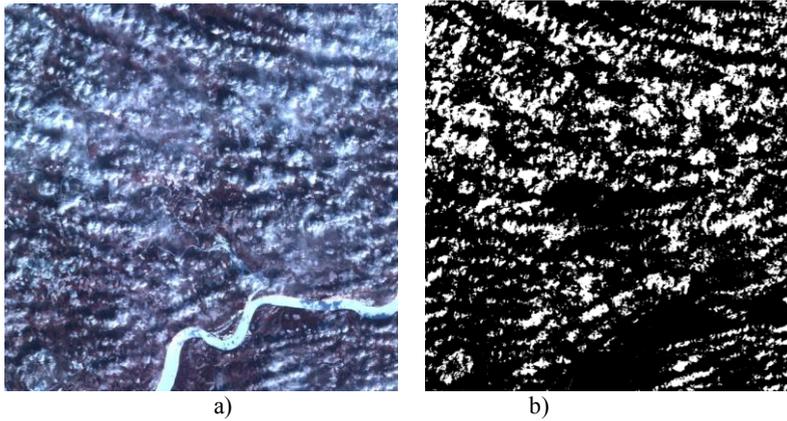
- <https://gptl.ru/> – Roscosmos Geoportal (Satellite images service).
- <http://www.ntsomz.ru> – Research Center for Earth Operative Monitoring.
- <http://catalog.scanex.ru> – Satellite Image Catalogue of Scanex Company.
- <http://digitalatlas.ru> – Satellite Image Catalogue of Institute of space and informational technologies of Siberian Federal University.

But this approach does not reflect the cloud distribution in the image [5, 6]. We propose the objective assessment of the satellite image quality without initial image based on the geometrical concentration calculation of the segmented objects on the example of cloudiness.

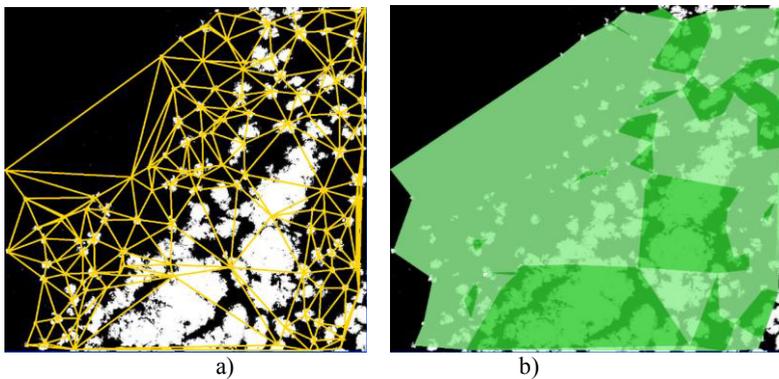
## 3 The objective assessment of the image quality based on the geometrical concentration

The algorithm of the measurement of the satellite image quality based on the cloudiness detection using geometrical concentration is described in [5,6,7], it considers the cloudiness as distorted objects.

It can be used for the construction of the objective metric as the search and filtration criterion in the satellite image catalogue. This metric will allow to estimate the image quality from the point of view of the human visual perception and its applicability for the subsequent processing of the image.



**Fig. 1.** Satellite images: a) Initial satellite image with the cloudiness percent 11%; б) Binary mask of the cloudiness.

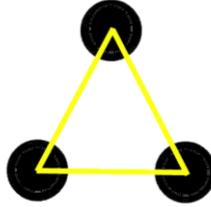


**Fig. 2.** a) Calculated Delaunay triangulation (yellow color); б) Calculated geometrical concentration (low, middle, high – the gradation of green color accordingly); The binary mask of cloudiness – white color; background – black color;

The concept of calculation of the geometrical concentration and density of objects based on the using the Delaunay triangulation, also Voronoi diagram can be applied [10]. The first stage of image processing is segmentation for detection of the objects of cloudiness with using algorithm for the clouds extraction [5], with the binary mask of cloudiness creation. The next step is the Delaunay triangulation construction using binary mask of cloudiness (Fig. 2a). The next step is the geometrical concentration calculation. The coefficient of the geometrical concentration of the objects on the plane  $c_i(t^i)$  [8,9] is calculated using statement (2) for the estimation of the clouds distribution in the satellite image Fig.3.

$$c_i(t^i) = \frac{\Delta NS_i}{NS_i}, \quad (2)$$

where  $t^i$  – the target class of object;  $\Delta NS_i$  – the triangular area of the geometrical centers of three target objects (clouds), which are located at the minimum Euclidian distance from each other;  $NS_i$  – the sum of the objects areas.



**Fig. 3.** Calculation of the geometrical concentration of the objects on the plane.

The measurement of triangulation elements with using (2) allows to detect of the images regions with high, middle and low geometrical concentration of objects (Fig. 2b).

The thresholds for the calculation of geometrical concentration were obtained after the images analysis of the satellite image catalogue [7]:

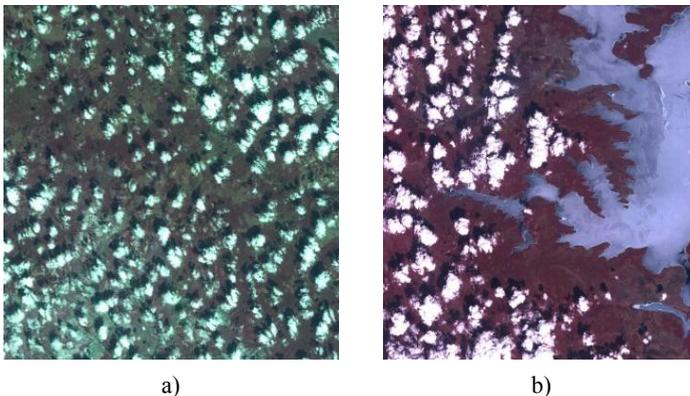
- 0 – 0,05 low geometrical concentration  $C1$ ;
- 0,05 – 1 middle geometrical concentration  $C2$ ;
- 1 – max high geometrical concentration  $C3$ .

The objective metric for the search and filtration of the images in the satellite image catalogue will be calculated as a ratio of a middle and high concentration area of a cloudiness to a total area of whole image:

$$K = \frac{S_{c2} + S_{c3}}{S_a} * 100\%, \quad (3)$$

where  $S_{c2}$  – middle concentration area;  
 $S_{c3}$  – high concentration area;  
 $S_a$  – total area of the whole image.

The calculated metric  $K$  for Fig.2 is equal = 38% but the cloudiness percent  $P = 23\%$ .



**Fig. 4.** Satellite images with the cloudiness percent 11%.

The calculated metric for the image on the Fig. 4a  $K = 77\%$ , but for the image on the Fig. 4b  $K = 43\%$ . In spite of the equality of the cloudiness percent for the images on the Fig.4, the metric  $K$  shows the difference of the image distortion by cloudiness. The comparison of the  $K$  values for the Fig. 4a and Fig. 4b shows that image on the Fig. 4b is less distorted and more appropriated for the subsequent image processing.

This  $K$  estimation shows the degree of the image distortion by defects and can be built into the interface of the satellite images catalogue as an addition metric for the data filtrations.

## 4 Conclusion

New metric based on the geometric concentration calculation can be implemented as the search and filtration criterion in the satellite images catalogue. Such metric will allow to estimate the image quality from the point of view of the human visual perception and its applicability for the subsequent processing of the image.

The implementation this metric as the filtration criterion will simplify to selection satellite images by operators, it will lead to decline of the number of the unappropriated images with big value of metric  $K$ , on the other hand it can increase the number of target images with the big cloudiness percent but with low  $K$  value.

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