Applied Mathematical Sciences, Vol. 8, 2014, no. 8, 391 - 396
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http://dx.doi.org/10.12988/ams.2014.311642

Stability of Some Segmentation Methods Based on Markov Random Fields for Analysis of Aero and Space Images

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Abstract

The paper is devoted to the stability of image segmentation methods based on Markov random fields for analysis of aero and space image with a Gaussian noise and blur. Segmentation problem is formulated in terms of finding a Bayes labeling of an Markov random field with maximum of a posteriori probability by the method of "simulated annealing". We study stability of variants of the algorithm using the Metropolis and Gibbs sampling, the system of neighborhoods with 8 and 24 neighbors and various coefficients of temperature reduction.

Keywords: Markov random fields, Gaussian noise, image segmentation, stability

1 Introduction

In the study of environmental monitoring problems arise various problems in analysis of aerial photographs and satellite imagery: control of anthropogenic impact on the forest-park zones, the detection and isolation of large fires in the forest, the detection and evaluation of large scale flooding zones. An important role in solving these problems is computer-based image analysis.

Segmentation is regarded as the problem of finding the configuration (two-dimensional random variable whose dimension is equal to the dimension of the analyzed image, on the set of labels $\{l1,\ l2\}$, where $l1$- pixel from texture 1 , and $l2$- pixel of texture 2) with a maximum a posteriori probability [2]:

$$P(f) = Z^{-1} e^{-\frac{1}{T}U(f)}.$$

Here f – configuration, $U(f)$ – the energy of a particular configuration, $Z = \sum_{f \in F} e^{-\frac{1}{T}U(f)}$ – normalized constant, T – factor, called the "temperature". The energy of the configuration is calculated as:

$$U(f) = \sum_{\{i,i`\} \in C2} \beta_{i,i`} f_i f_{i`}$$

Here C2 – the set of all pairs of neighboring pixels, f_i – the label assigned to pixel i in the f configuration, $\beta_{i,i`}$ – the coefficient of the interaction between two pixels that are at an appropriate spatial relation.
Global minimization algorithm is produced by "simulated annealing". We study different coefficients of temperature reduction.
There are two options: $T(t+1) = 0.99T(t)$ - graphs "MRF-1", and $T(t+1) = 0.95T(t)$ - graphs "MRF-2". The initial temperature is $T(0) = 10^9 Mm$, where M - amount of different labels , m - the number of pixels in the image. Also it's compared the system of neighborhoods with 8 and 24 adjacent pixels.

2 Method of research

For comparison we have chosen fragments of satellite images of earth's surface. They were segmented by hand for getting samples of the correct image segmentation. Areas with samples of textures were allocated separately. In these areas were extracted factors for the Markov random field ($\beta_{i,i`}$) for each of the studied texture (forest, field).
For each segmented image it have been calculated the proportion of correctly identified pixels. The average value of this quantity for a variety of test images is called quality of segmentation. Further segmentation of the test images was carried out at different levels of noise and was compared quality of automatic and manual segmentation.

3 Results

The graphs below show the function of quality of the image segmentation of noise level. «Quality» - is the quality of segmentation. «Noise level» for Gaussian noise is specified lambda, for the blur - neighborhood size (3x3, 5x5, 7x7, etc.). It have been studied various systems of neighborhoods. The graphs show "8 coh" and "24 coh" the neighborhood of which includes respectively 8 and 24 neighbor pixels.

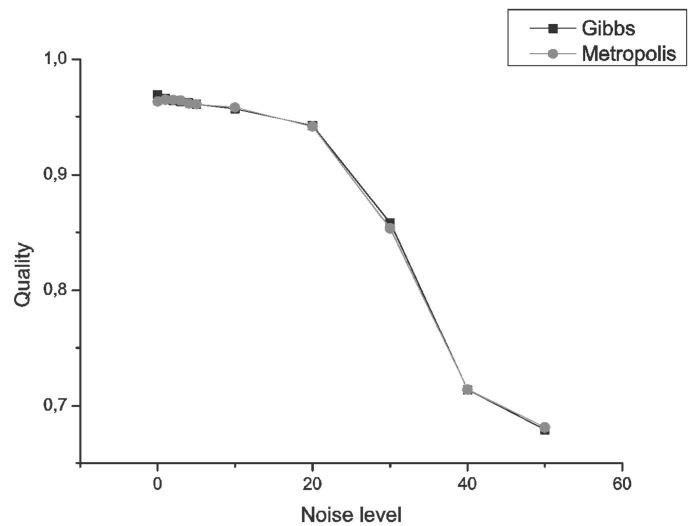

Fig.1. Gaussian noise. Metropolis and Gibbs sampling.

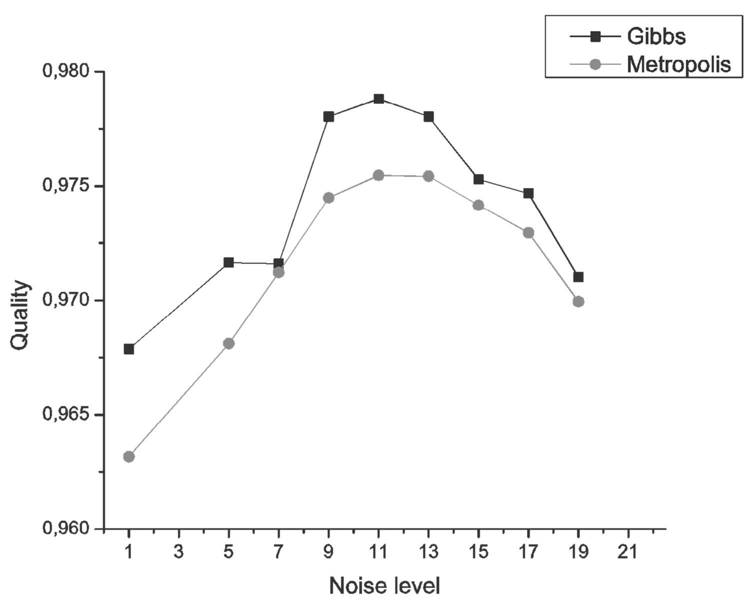

Fig.2. Blur. Metropolis and Gibbs sampling.

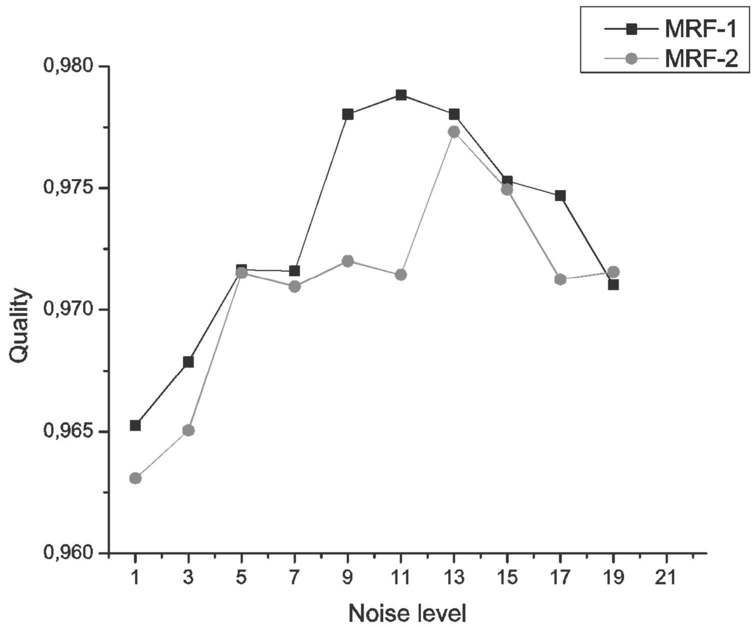

Fig.3. Blur. MRF-1 and MRF-2.

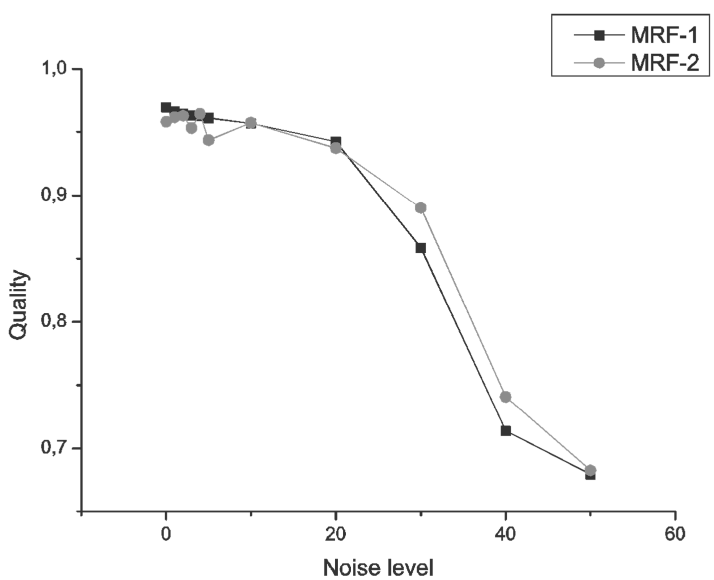

Fig.4. Gaussian noise. MRF-1 and MRF-2.

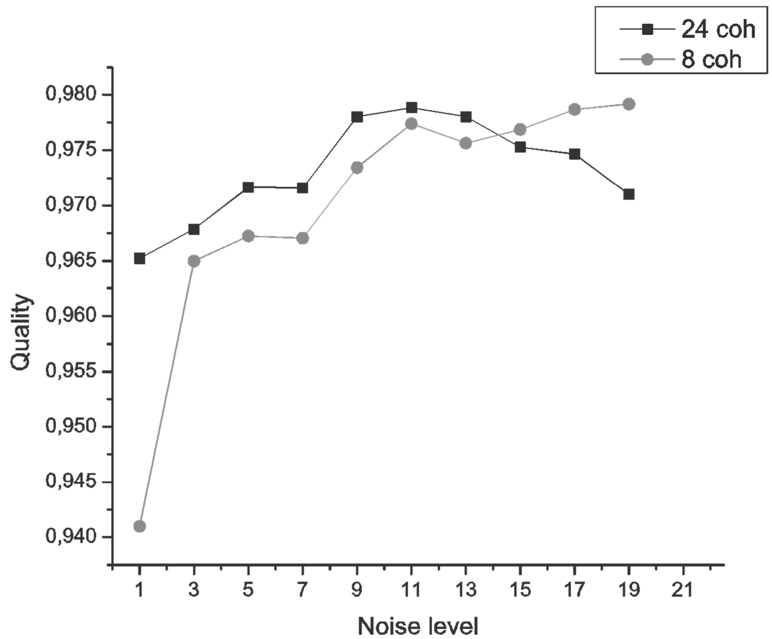

Fig.5. Blur. 24 - and 8 - connected neighborhood.

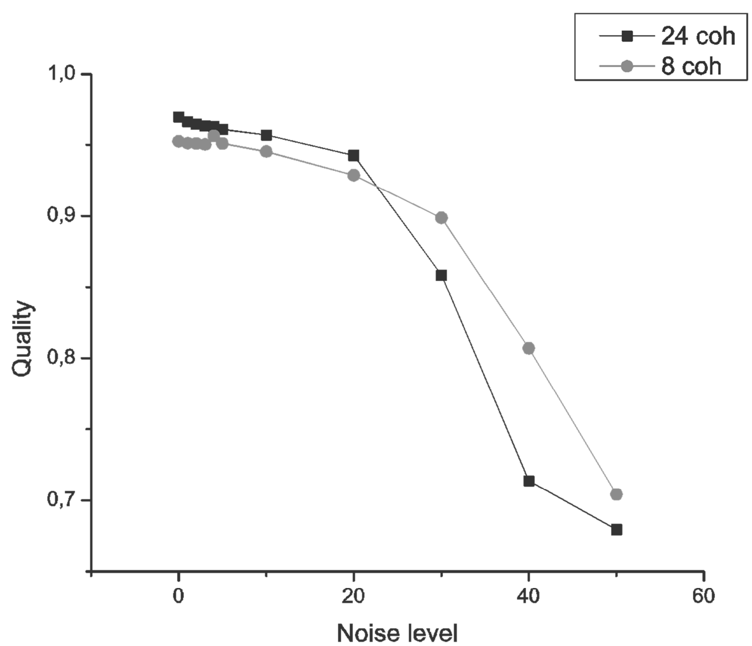

Fig.6. Gaussian noise. 24 - and 8 - connected neighborhood.

3 Results

The results show that the using of 24-neighborhood system gives better quality of segmentation compared with the 8-neighborhood one at low noise level. However, growing of noise level gives above quality of segmentation using 8-neighborhood system (Fig.5, Fig.6)
Blur in a small neighborhood of 3x3 removes local noise, thereby increasing the quality of segmentation. With the increase of a blur window, as it was expected, the quality of the segmentation is deteriorating. The best results have been achieved when blurring was in window of size 11x11. (Fig.5)
The different rate of change in temperature had no significant effect on the results of image segmentation after adding Gaussian noise. Regarding the blur quality of the segmentation algorithm MRF-1 was higher than quality of the algorithm MRF-2 (Fig.3, Fig.4). Shape of the graph for the MRF-2 shows that the rate of decreasing of temperature is too high (Fig.4)
Sampling algorithms had no significant effect on the results of image segmentation (Fig.1, Fig.2).

References

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[2]. S.Z. Li, Markov Random Field Modeling in Image Analysis, Springer-Verlag London Limited, 2009.

Received: November 15, 2013