St. Petersburg Institute
for Informatics and Automation
of the Russian Academy of Sciences

Elimination of distorted images using the blur estimation at the automatic registration of meeting participants

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SPIIRAS

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Application spheres of the blur estimation

- Photo and video surveillance and registration
- Automatic control systems (industrial robots, autonomous vehicle)
- Systems modeling of objects and environment
- Human-computer interaction systems
- Quality control systems

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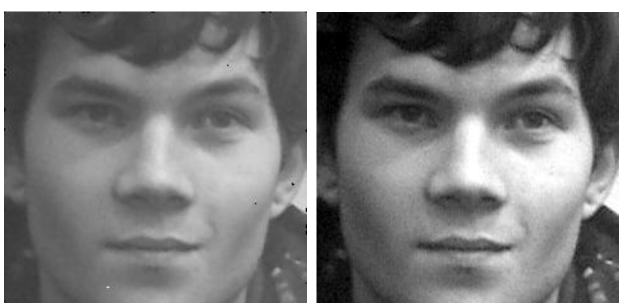
The ways to estimate image quality

- Brightness

- Tint

- Sharpness\ blur

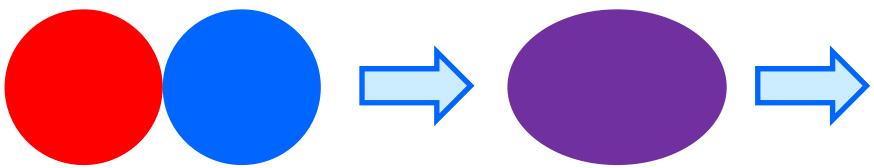
- Contrast



- Noisiness

The main causes of the image blur

- Limited resolution of recording equipment
- Defocusing
- Movement of the camera relative to the capturing object



A point is reproduced in the shape of a spot (blur circle), and two closely spaced points are merged into one observable point. Discrete image will be sharp (focused), if the blur circle diameter does not exceed the sampling of the observed image.

Classification of the focus estimation methods

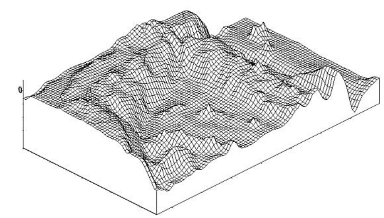
- Gradient (GRA)
- Laplacian (LAP)
- Wavelet transform (WAV)
- Statistical characteristics (STA)
- Discrete cosine transform (DCT)
- Miscellaneous methods (MIS)

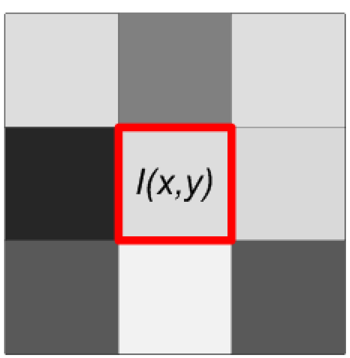
$$\vec{g} = grad\, I = \left(\frac{\partial I}{\partial x}, \frac{\partial I}{\partial y}\right)$$

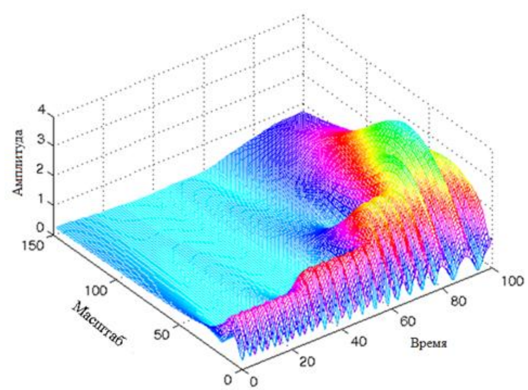
$$\Delta I = \left(\frac{\partial^2 I}{\partial x_2}, \frac{\partial^2 I}{\partial y_2}\right)$$

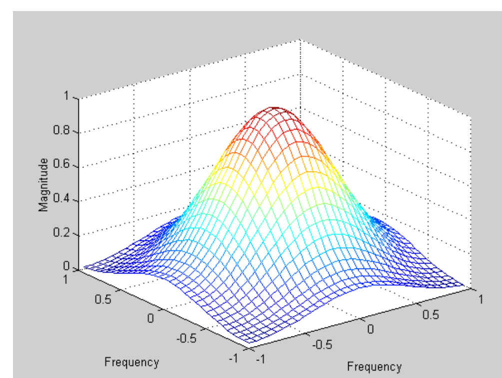
-1	-2	-1
0	0	0
1	2	1

-1	-2	-1
0	0	0
1	2	1





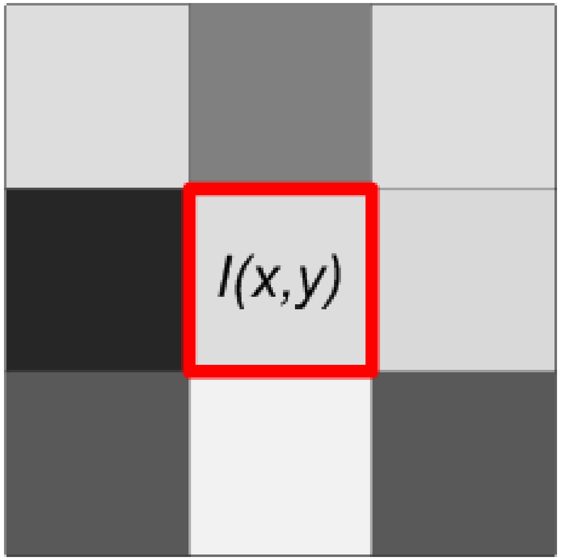




Local contrast measuring

The local contrast is calculated as the ratio of the intensity of each pixel *I(x,y)* of the grayscale image and the mean gray level in the neighborhood of this pixel μ*(x,y).*

$$R(x,y)=\begin{cases}\dfrac{\mu(x,y)}{I(x,y)}, I(x,y)\le\mu(x,y)\\[2ex]\dfrac{I(x,y)}{\mu(x,y)}, I(x,y)\ge\mu(x,y)\end{cases}$$



The image blur is the sum of values *R(x, y)* throughout the image or the selected area.

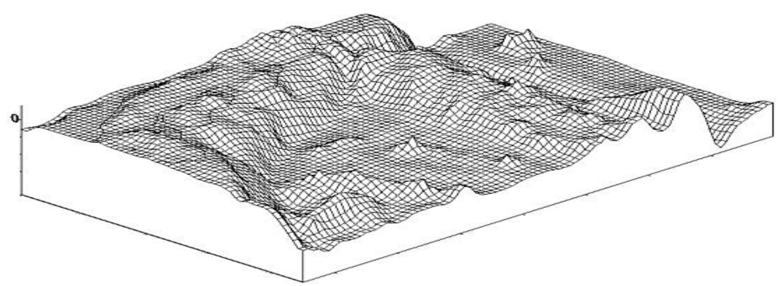
Local curvature measuring

The matrix of pixel brightness is represented as a three-dimensional surface, which coordinates are the two coordinates of each pixel and the value of its brightness. The surface curvature *f(x,y)* corresponds to the brightness transitions.

$$f\left(x,y\right)=ax+by+cx^{2}+dy^{2}.$$

$$a=M_{1}*I,\quad b=M_{1}^{'}*I,\quad c=\frac{3}{2}M_{2}*I-M_{2}^{'}*I,\quad d=\frac{3}{2}M_{2}^{'}*I-M_{2}^{'}*I.$$

$$M_{1}=\frac{1}{6}\begin{pmatrix}-1 & 0 & 1\\ -1 & 0 & 1\\ -1 & 0 & 1\end{pmatrix},\quad M_{2}=\frac{1}{5}\begin{pmatrix}1 & 0 & 1\\ 1 & 0 & 1\\ 1 & 0 & 1\end{pmatrix}.$$



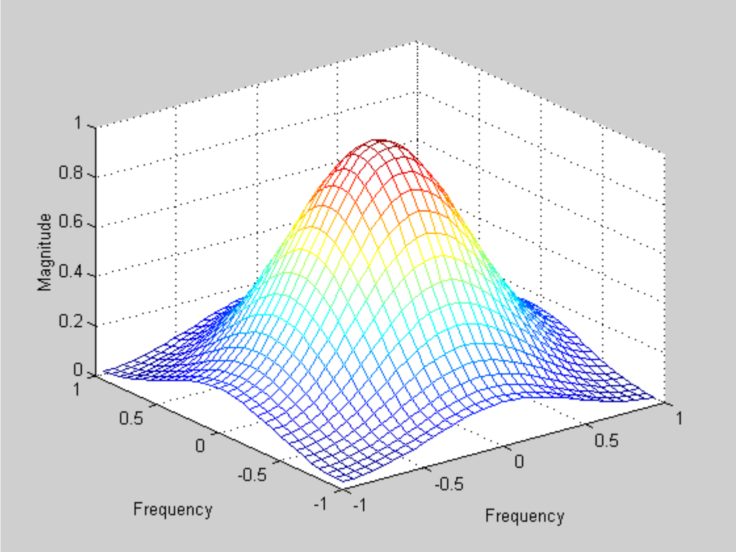
The sum of absolute values of *a, b, c, d* reveals the blur:

$$G=\left|a\right|+\left|b\right|+\left|c\right|+\left|d\right|.$$

NIQE - No-Reference Image Quality Estimation

- The pixel brightness of undistorted images tends to a normal distribution. Any noise, including blurring, leads to a deviation from the normal distribution.
- The idea of the method consists in comparing two multivariate Gaussian (MVG) models of features: calculated for the test image and constructed on the basis of a pre-arranged set of images.
- To build the MVG model the image is split into patches of *PxP* pixels. The patches of maximal local sharpness *δ(b)* are used:

$$\delta(b) = \sum_{(i,j)}\sum \sigma(i, j).$$



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NIQE - No-Reference Image Quality Estimation

The brightness coefficients of selected patches' pixels are normalized to reduce the dependence between the brightness coefficients of the neighboring pixels:

$$\hat{I}(i,j)=\frac{I(i,j)-\mu(i,j)}{\sigma(i,j)+1},$$

$$\mu(i,j)=\sum_{k=-K}^{K}\sum_{l=-L}^{L}w_{k,l}I(i+k,j+l),$$

$$\sigma(i,j)=\sqrt{\sum_{k=-K}^{K}\sum_{l=-L}^{L}w_{k,l}(I(i+k,j+l)-\mu(i,j))^{2}},$$

where $w = \{w_{k,l} \mid k = -K \ldots K, l = -L \ldots L\}$ is two-dimensional circularly symmetric Gaussian weighting function.

NIQE - No-Reference Image Quality Estimation

The deviation from the generalized Gaussian model of the image can be revealed by analyzing the products of pairs of normalized coefficients of adjacent pixel brightness in four directions: horizontal, vertical, main and secondary diagonals:

$$\hat{I}(i,j)\hat{I}(i,j+1),$$

$$\hat{I}(i,j)\hat{I}(i+1,j),$$

$$\hat{I}(i,j)\hat{I}(i+1,j+1),$$

$$\hat{I}(i,j)\hat{I}(i+1,j+1),$$

where $i \in \{1,2 \ldots M\}$, $j \in \{1,2 \ldots N\}$. These parameters follow the asymmetric generalized normal distribution.

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NIQE - No-Reference Image Quality Estimation

The features calculated above are used for construction of the MVG model, which is compared with another MVG model trained on a set of various images with known quality:

$$f_X(x_1,\ldots,x_k)=\frac{1}{(2\pi)^{\frac{k}{2}}|\Sigma|^{\frac{1}{2}}}\exp\left(-\frac{1}{2}(x-\nu)^T\Sigma^{-1}(x-\nu)\right).$$

where $(x_1,\ldots,x_k)$ is a set of calculated features, v and Σ are mean and covariance matrix of MVG model respectively.

The image quality coefficient:

$$D(\nu_1,\nu_2,\Sigma_1,\Sigma_2)=\sqrt{\left((\nu_1-\nu_2)^T\left(\frac{\Sigma_1+\Sigma_2}{2}\right)^{-1}(\nu_1-\nu_2)\right)},$$

where v_1, v_2 are mean vectors of template MVG model and of the test MVG model respectively, Σ_1, Σ_2 - covariance matrices.

Image Patch Selection Approaches

Description of the selected area	Example of segmentation
The whole image is analyzed without preliminary face detection	
The selected face area is analyzed the size of which is not less than 200x200 pixels	
The selected face area bounded by the size of 200x200 pixels is analyzed	

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Experiments

The experiment results of image blur estimation:

Method	Cathe-gory	Accuracy, %			Processing time, ms		
		Whole image	Face area	200×200 pixels	Whole image	Face area	200×200 pixels
Tenengrad	GRA	4	22	26	13,81	5,23	4,81
Local contrast	MIS	0	0	30	12,80	5,81	4,86
Local curvature	MIS	2	34	30	10,42	7,70	7,30
NIQE	STA	10	54	94	31,65	38,08	35,08

The annotated database consisted of 50 sharp and 50 blurred photos. The accuracy of every method is determined as a number of the sharp photos passed the threshold. The threshold was set heuristically using the blurred images coefficients.

Conclusion

- Preliminary assessment allows the system to exclude from the further analysis images of poor quality which carry no useful information. Thus the process memory and speed of automatic vision systems can be saved.
- The NIQE method showed the best results in blur detection with the accuracy of 54 – 94% depending on the processing image patch.
- The 200x200 image patch selection helped to increase the accuracy of the blur estimation methods.

Thank you for your attention!

- Welcome to a demonstration in SPIIRAS!

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