One method of image processing and its numerical analysis

Aivars Lorencs, Juris Sinica- Sinavskis
Institute of Electronics and Computer Science
14 Dzerbenes st, Riga, LV-1006, Latvia
e-mail: jss@edi.lv

14th International Conference ELECTRONICS
May 19, 2010, Kaunas, Lithuania

Content of research

digital images – surface of brightness levels

linear regression models

fast processing (of digital images)

numerical analysis

classification of vectors, i.e., vector estimates of regression coefficients

Linear regression model and problem

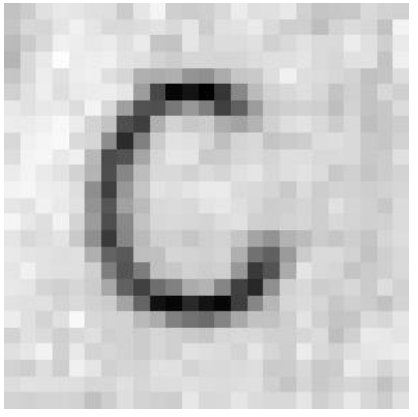
Linear regression model

$$f(x, y; \boldsymbol{\theta}) = \sum_{k=0}^{K} \theta_k \varphi_k(x, y) \quad , \qquad (1)$$

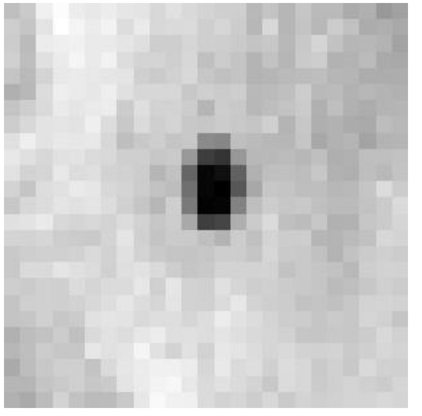
where θ_k are components of an unknown vector $\boldsymbol{\theta}$ (components are known as a regression coefficients).

The aim – ***improve approximation precision and classification quality***.

Categories of real scenes



Category 1: metal rings



Category 2: glass

Approximation precision measures

$\mathbf{A} = (a_{ij})$ - elements of digital image

$f_\nu(x_i, y_j; \hat{\boldsymbol{\theta}})$ - estimated regression function

Precision measures:

$$R_1(\mathbf{A}, M_{1,\nu}) = \sqrt{\sum_{i=1}^{25}\sum_{j=1}^{25}\left(a_{ij} - f_\nu(x_i, y_j; \hat{\boldsymbol{\theta}})\right)^2}$$

$$R_2(\mathbf{A}, M_{1,\nu}) = \frac{\boldsymbol{\alpha}^T \boldsymbol{\beta}}{\boldsymbol{\alpha}^T \boldsymbol{\alpha} + \boldsymbol{\beta}^T \boldsymbol{\beta} - \boldsymbol{\alpha}^T \boldsymbol{\beta}}$$

$$R_3(\mathbf{A}, M_{1,\nu}) = \frac{1}{2}\left(1 + \frac{\boldsymbol{\alpha}^T \boldsymbol{\beta}}{|\boldsymbol{\alpha}| \cdot |\boldsymbol{\beta}|}\right)$$

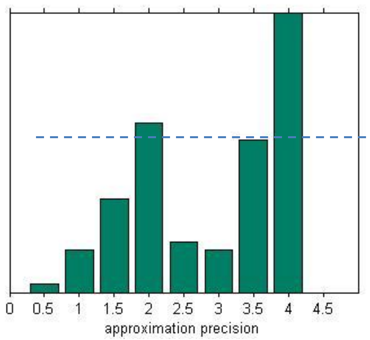
$\boldsymbol{\alpha}$ - vector of components of digital image elements

Estimated vector of components of digital image elements

$$\boldsymbol{\beta} = \Big(f_\nu(x_1, y_1; \hat{\boldsymbol{\theta}}), f_\nu(x_1, y_2; \hat{\boldsymbol{\theta}}), \ldots, f_\nu(x_1, y_{25}; \hat{\boldsymbol{\theta}}), f_\nu(x_2, y_1; \hat{\boldsymbol{\theta}}), f_\nu(x_2, y_2; \hat{\boldsymbol{\theta}}), \ldots, f_\nu(x_2, y_{25}; \hat{\boldsymbol{\theta}}), \ldots, f_\nu(x_{25}, y_1; \hat{\boldsymbol{\theta}}),$$
$$f_\nu(x_{25}, y_2; \hat{\boldsymbol{\theta}}), \ldots, f_\nu(x_{25}, y_{25}; \hat{\boldsymbol{\theta}})\Big)^T$$

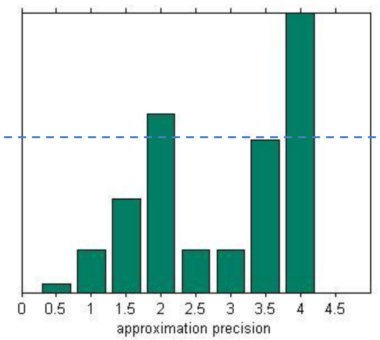
Histograms of precision measures

$R_1(\mathbf{A}, M_{1,1})$



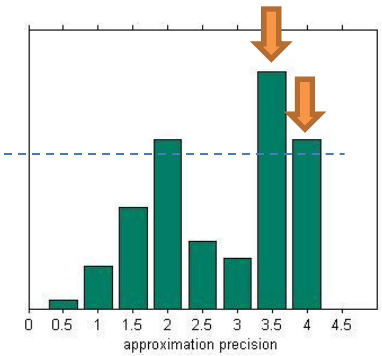
(A) – are used **9** basis functions

$R_1(\mathbf{A}, M_{1,2})$



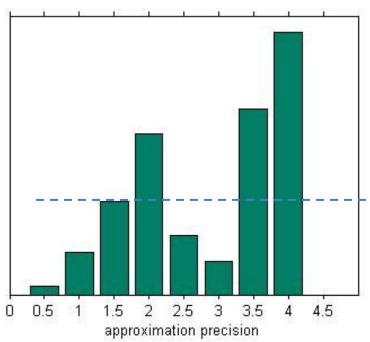
(B) – are used **25** basis functions

$R_1(\mathbf{A}, M_{1,3})$



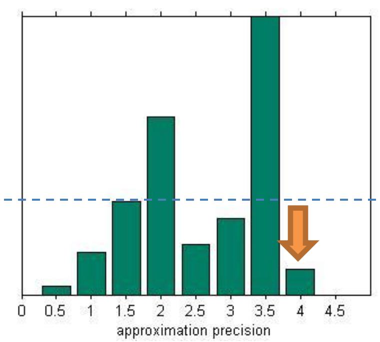
(C) – are used **49** basis functions

$R_1(\mathbf{A}, M_{2,1})$



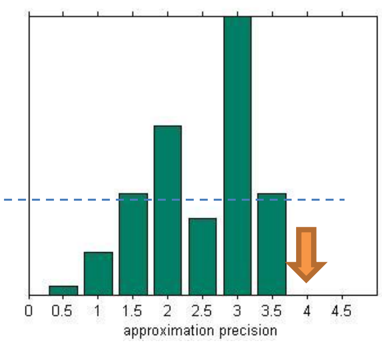
(A') – are used **9** basis functions

$R_1(\mathbf{A}, M_{2,2})$



(B') – are used **25** basis functions

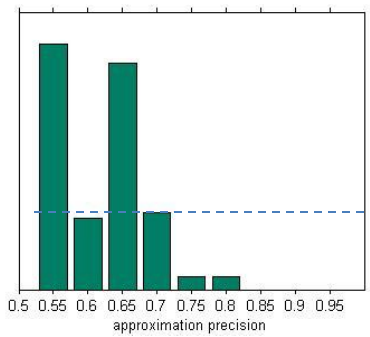
$R_1(\mathbf{A}, M_{2,3})$



(C') – are used **49** basis functions

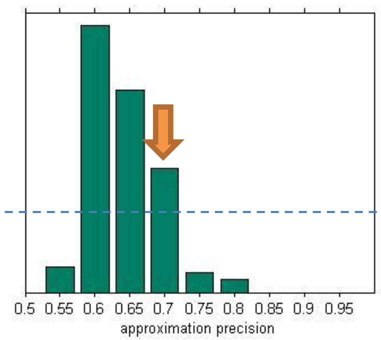
Histograms of precision measures

$R_3(\mathbf{A}, M_{1,1})$



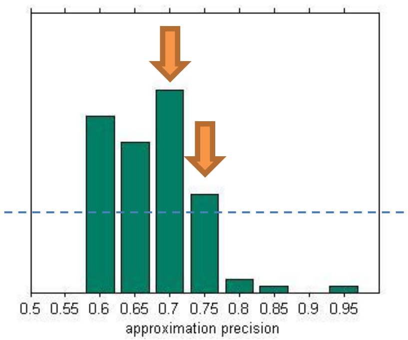
(A'') – are used **9** basis functions

$R_3(\mathbf{A}, M_{1,2})$



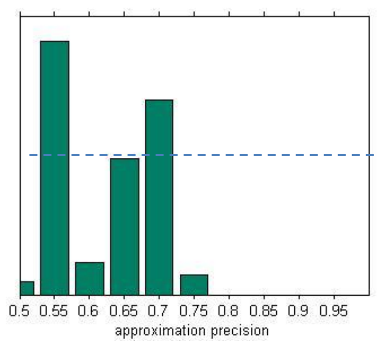
(B'') – are used **25** basis functions

$R_3(\mathbf{A}, M_{1,3})$



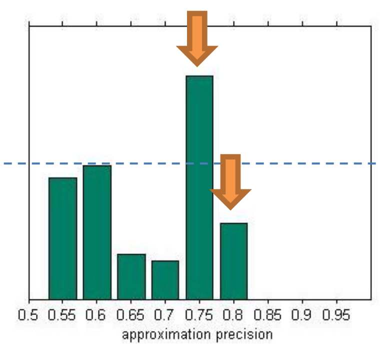
(C'') – are used **49** basis functions

$R_3(\mathbf{A}, M_{2,1})$



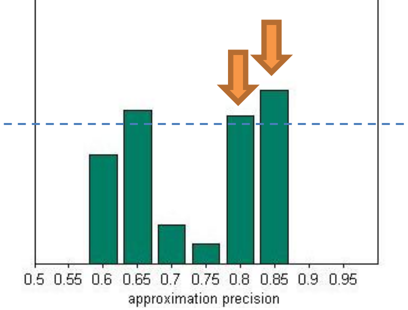
(A''') – are used **9** basis functions

$R_3(\mathbf{A}, M_{2,2})$



(B''') – are used **25** basis functions

$R_3(\mathbf{A}, M_{2,3})$



(C''') – are used **49** basis functions

Classification errors

Classification errors to images of category 1

Approximation function	Classification error
$f_1\left(x, y; \hat{\boldsymbol{\theta}}\right)$ – are used **9** basis functions	$(2;0)$
$f_2\left(x, y; \hat{\boldsymbol{\theta}}\right)$ – are used **25** basis functions	$(5;0)$
$f_3\left(x, y; \hat{\boldsymbol{\theta}}\right)$ – are used **49** basis functions	$(10;2)$

Classification errors to images of category 2

Approximation function	Classification error
$f_1\left(x, y; \hat{\boldsymbol{\theta}}\right)$ – are used **9** basis functions	$(7;0)$
$f_2\left(x, y; \hat{\boldsymbol{\theta}}\right)$ – are used **25** basis functions	$(36;0)$
$f_3\left(x, y; \hat{\boldsymbol{\theta}}\right)$ – are used **49** basis functions	$(82;0)$

Conclusions

1. numerical analysis clearly shows that linear regression method cannot be used for solving the practical tasks of image classification in a pure formal way
2. we notice that increased approximation precision of the model does not imply increased classification quality. This fact that more precise approximation model provided worse results is still difficult to explain
3. it may not be assumed that the regression method is well suited for classification of all types of digital images

*

the paper is preliminary scheduled for publishing in Electronics and Electrical Engineering, 2010 No. 7 (103).